Childhood obesity in Malta: contributions of the obesogenic environment

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ABSTRACT

Background. There is a high prevalence of childhood obesity in Malta. The aim of this research is to gain insight into the environmental drivers of childhood obesity in Malta, and identify opportunities for an environmental approach to obesity prevention.

Methods. This thesis comprises: (i) a contextual analysis of childhood obesity and the policy response in Malta; (ii) an overview of systematic reviews to identify environmental components of effective prevention interventions; (iii) an assessment of Maltese television advertising; (iv) an environmental audit of the food and built environment; (v) semi-structured interviews and focus groups with key informants; and (vi) microsimulation modelling to forecast the future health and economic burden of obesity in Malta.

Results. Numerous environmental factors at multiple levels deter healthy dietary and physical activity behaviour among Maltese children. These include an obesogenic built environment that provides few opportunities for play or active transport, and a food environment characterised by easy access to, and heavy promotion of, energy-dense foods and beverages. The contextual analysis and environmental audit revealed several obesogenic aspects of the environment in Malta, such as substantial promotion of food high in fat, sugar and salt to children on local TV channels and a price premium for certain healthy food options in grocery stores. Thematic analysis of qualitative data revealed numerous barriers to healthy behaviours for Maltese children, including parental concerns about traffic hazard leading to restricted physical activity, and familal dietary patterns which encourage over-consumption of food. Interviews with food industry and public health actors also highlighted ‘framings’ of obesity that closely matched those described in the international literature. Microsimulation modelling illustrated the substantial financial savings and reductions in non-communicable disease incidence if population weight reduction were to be achieved.

Conclusions. An obesogenic environment underlies the problem of childhood obesity in Malta. The socio-ecological approach used in this research highlighted key areas for intervention and illustrated the importance of taking context into account when designing national obesity-prevention efforts.

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This journey would not have been possible without my wonderful wife Keti. I have been sustained by her endless support, love, and willingness to be my most constructive critic. Keti, I could not have done this without you.

List of Abbreviations

% BF	Percent Body Fat
ANGELO	Analysis Grid for Environments linked to Obesity
AVMSD	Audio-visual Media Services Directive
BA	Broadcasting Authority, Malta
BMI	Body Mass Index
CAP	Common Agricultural Policy
CDC	Center for Disease Control
CHD	Coronary Heart Disease
CI	Confidence Interval
COSI	Childhood Obesity Surveillance Initiative
CVD	Cardiovascular Disease
DES	Directorate for Educational Services
DHIR	Directorate for Health Information and Research
DQSE	Directorate for Quality and Standards in Education
EBPM	Evidence Based Policy Making
EHD	Environmental Health Directorate
EHES	European Health Examination Survey (pilot)
EHIS	European Health Interview Survey
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FNAP	Food and Nutrition Policy and Action Plan for Malta
FOOD-EPI	Food Environment Performance Index
F&V	Fruit and Vegetables
F&B	Food and Beverages
GDP	Gross Domestic Product
HBSC	Health Behaviour in School-Aged Children Survey
HELP	Healthy Eating Lifestyle Plan
HFSS	High Fat, Sugar and Salt
HLG	High Level Group (Nutrition and Physical Activity)
HP&DPD	Health Promotion and Disease Prevention Directorate
IASO	International Association for the Study of Obesity (now known as World Obesity)
INFORMAS	International Network for Food and Obesity / Non-communicable Diseases

	Research, Monitoring and Action Support
ICCO	Intersectoral Committee to Counteract Obesity
IOTF	International Obesity Task Force
HBSC	Health Behaviour in School Aged Children
MSA	Multiple Streams Approach
NACFN	National Advisory Committee on Food and Nutrition
NEMS-S	Nutrition Environment Measures Survey in Stores
NICE	National Institute for Health and Clinical Excellence
NCD	Non-Communicable Disease
NMC	National Minimum Curriculum
NSO	National Statistics Office, Malta
PA	Physical Activity
PE	Physical Education
PET	Punctuated Equilibrium Theory
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
RCT	Randomised Controlled Trial
RP	Research Paper
SES	Socio-Economic Status
SPSS	SPSS® statistics package
SR	Systematic Review
SSBs	Sugar Sweetened Beverages
TPPI	Today Public Policy Institute
UREC	University of Malta's Research Ethics Committee
UoM	University of Malta
WHO	World Health Organization

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CHAPTER 1. INTRODUCTION

Obesity has become a critical public health challenge globally as prevalence continues to rise [1–3]. Worldwide, the proportion of adults who are overweight or obese increased by around 8% between 1980 and 2013 [3], with over 600 million adults considered to be obese in 2015 [4]. The increase in worldwide prevalence has also been substantial amongst children and adolescents, with around 23.8% of boys and 22.6% of girls being overweight and obese in 2013 [3]. No single country has managed to definitively halt or reverse this trend, leading to obesity being labelled as a global 'pandemic' [5] with dire implications for human health and societal productivity [6]. Childhood obesity in particular has received substantial attention from governments and organisations worldwide [7], as 42 million children under five years of age [4] and over 200 million school-aged children are estimated to be overweight or obese [8]. Childhood has been described as a crucial period for the establishment of health and wellbeing throughout the life course, emphasising the need for effective public health action at this early age [9]. As in other countries, Malta has experienced a rapid increase in childhood obesity prevalence in recent decades [10]. This thesis seeks to gain an understanding of the environmental drivers of childhood obesity in Malta, to explore the factors informing the current policy response and other dynamics at play, and to highlight opportunities for applying an ecological approach to obesity prevention and control in Malta. The following chapter introduces the rationale behind selecting Malta as a case country, outlined the aims and objectives of this dissertation, its overall structure and my contribution to its various sections.

1.1 Thesis rationale

Maltese children and adults are amongst the most overweight and obese in the WHO European region. Unless prompt action is taken to curb this trend, it is likely to translate into substantial obesity-related disease morbidity and mortality over the coming decades. My interest in this topic stems from the fact that, despite growing recognition and awareness of the problem, there has been very little field research conducted on environmental drivers that may be contributing to the problem in Malta. More robust research on obesity-related behaviours and the environmental drivers that facilitate and maintain such behaviours is required to inform, support and lay the groundwork for effective obesity-prevention interventions and policies [11,12]. In turn, such research requires a baseline assessment of the physical, political, economic and socio-cultural dimensions of the Maltese environment. A combination of objective and subjective measurements of these environmental aspects are important if the environment's relationship with weight gain and obesity is to be adequately assessed [13–15]. This dissertation aims to address this research gap, generating contextually relevant data that can be used by Maltese decision-makers to modify their approach to this endemic public health issue. Comparisons between key stakeholders' subjective perceptions of the environment and measured objective observations may also highlight areas for action or future research.

1.2 Malta: an island in the Mediterranean

The Maltese archipelago consists of three islands covering an area of 316 km^2, located in the centre of the Mediterranean Sea approximately halfway between the southern tip of Sicily and the North African coastline. The two main islands of Malta and Gozo are inhabited, having a population of around 425,000 in 2013 [16]. The Maltese population is relatively homogenous, although migration from other ethnic groups is on the increase. [17] Life expectancy at birth is currently around 83.1 and 78.8 years for females and males respectively, similar to that of Greece but lower than that of other southern European countries such as Cyprus, Italy and Spain [2]. Currently, approximately 50% of Malta's total land area is dedicated to agricultural pursuits, whereas a third consists of urban/industrial land cover [18]. The provision of urban green space and other recreational facilities in Malta's towns and villages is particularly low, estimated to be around 2.4m^2 per person [19]. Malta is a parliamentary representative democratic republic having a President as the constitutional head of state, whereas the Prime Minister is the head of Government and the cabinet. The Parliament has legislative power, with the Speaker of the House presiding over the unicameral House of Representatives [20]. Malta has been a member of the European Union since 2004. The islands' historical background has had a profound influence on the built and social environment and population characteristics. Over the past two millennia, Malta has been a colony of the Phoenicians, the Romans, the Moors, the Normans and the Spanish, before enjoying a relatively long period of peace under the rule of the Order of Knights of St. John (1530 – 1798) and the British (1800 – 1964) [21]. Throughout the twentieth century, the British in particular fostered a philosophy of free trading that suited Malta's status as a strategically-positioned naval dockyard and service provider [22]. Malta gained independence from Britain in 1964 and became a Republic a decade later. Since then, the Maltese economy has progressed from one harnessed to the needs of the British colonial administration up to the mid-1960s, to a market-driven economy with an emphasis on higher value added economic activities in services, notably financial services and tourism. Malta's climate, topography and small land mass; its proximity to, and historical cultural and commercial links with, neighbouring Italy; the influence of British colonial rule between 1800 and 1964; and the impact of tourism, media and globalisation in the decades post-1960 have all had profound impacts on Malta's food system and the population's dietary behaviour. Malta has imported most of its food throughout recorded history and continues to do so today [23]. The necessity of adapting to the demands of foreign palates has inevitably moulded Maltese nutritional habits as foods palatable to British military personnel and tourists competed with 'typical' Mediterranean influences from the Italian peninsula [24]. As shown later on in Research Paper 1 (Contextual analysis), tourist industry growth in recent decades may also have contributed to the consumption of convenience foods, consolidating the shift away from a traditional Maltese diet [24].

1.3 Aims and objectives

There is increasing evidence suggesting that increasing obesity rates result from individual's exposure to the 'obesogenic environment' – which has been described as '*the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations'* [5,25]. This is also likely to be the case in Malta. Therefore, the aim of this research is to address the research question "*Is there an obesogenic environment contributing to the high rate of childhood obesity observed in Malta, and what opportunities exist to address this public health problem using an environmental approach?"* The specific objectives of my research are to:

1. describe the upstream and downstream drivers of childhood obesity in Malta
2. review the evidence on effective environmental interventions to address childhood obesity
3. describe and assess the obesogenic elements characterising select local communities
4. understand the views of key stakeholders around childhood obesity in Malta, the ways in which they frame obesity, and explore barriers to physical activity and healthy dietary behaviour among children
5. assess the long-term health and economic burden of childhood obesity in Malta and evaluate the impact of preventive interventions to reduce childhood obesity
6. develop recommendations for adopting an environmental approach to address childhood obesity in Malta

1.3.1 Rationale for a mixed methods approach

Currently, there is a lack of knowledge around potential environmental contributions to excess weight among children in Malta. In turn, this limits the type of interventions under active consideration by policymakers to address the problem. This exploratory study applies a socio-ecological approach to aid in the identification of environmental drivers of childhood obesity, and brings together a number of methods to investigate and characterise the obesogenic environment in

Malta. I adopted a mixed-method research design that combines complementary quantitative and qualitative techniques, primarily to obtain method and data triangulation and hence increase the validity and reliability of the findings [26]. Although quantitative information on the built environment is crucial for developing an objective analysis of the situation, the use of inductive qualitative methods permits a deeper understanding of the environment as experienced by individuals, including potential barriers to and facilitators of healthier behaviour. In turn, this will provide a broad spectrum of evidence to policymakers, guiding the development of effective population-level environmental interventions.

1.4 Structure of the thesis

This dissertation will be presented in the form of a 'paper style' thesis, where results are presented in a number of research papers that have either already been published in peer-reviewed journals, or are currently under review, or that are in a format that is ready for submission to a journal. These have been included within relevant chapters after an introductory section - 'preamble' - that links to previous chapters in order to present a coherent overall narrative and outlines how each paper relates to one or more objectives of this thesis. Each paper is organized according to standard peer-reviewed journal guidelines. Discussion of findings and limitations are included in the individual research papers. This thesis is structured into seven chapters, with each chapter relating to one or more research objective (Table 1).

Chapter	Research Paper	Objective(s)	Status of publication
1. Introduction	N/A		
Theoretical Foundation and Methods	N/A		
3. Childhood Obesity in Malta	*Paper 1*: An obesogenic island in the Mediterranean: mapping potential drivers of obesity in Malta	1	Published: *Public Health Nutrition*; Dec 2015
	Paper 2: Environmental components of childhood obesity prevention interventions: an overview of systematic reviews	2	Published (early view): *Obesity Reviews;* July 2016
4. Environmental Audit	*Paper 3*: Television food advertising to children in Malta	1, 3	Published: *Health Promotion Int.;* Oct 2015
	Paper 4: Food environments in Malta: associations with store size and area-level deprivation	1, 3	Under review: *Food Policy*
	Paper 5: Product assortment in grocery stores: application of the GroPromo tool	1, 3	Target journal: *Journal of Nutrition Education and Behaviour*
Key Informant Interviews and Focus Groups	*Paper 6*: Barriers to children's healthy food habits: a qualitative study of the Maltese food environment	1, 4	Target journal: *Social Science and Medicine*
	Paper 7: Barriers to Maltese children's physical activity: a qualitative study	1, 4	Target journal: *Social Science and Medicine*
	Paper 8: Framing Childhood Obesity in Malta: Narratives, Attributions and Support for Current Approaches	1, 4	Target journal: *Obesity Reviews*
Forecasting the future of obesity in Malta	*Paper 9*: Health and Economic Consequences of Projected Obesity Trends in Malta	5	Under review: *Public Health Nutrition*
7. Discussion	N/A	6	

Table 1. Thesis outline

1.4.1 Overview of Chapters

Chapter 1: Introduction

In Chapter 1 I introduce the reasons for selecting Malta as country example for investigation, the aims and objectives of this research, and the overall structure of the thesis.

Chapter 2: Theoretical Foundation and Methods

Chapter 2 presents the theories, models and conceptual frameworks that inform and guide my research on childhood obesity and the obesogenic environment. It offers a comprehensive overview and justification of the methods used to conduct the quantitative and qualitative aspects of this research.

Chapter 3: Childhood Obesity in Malta

This chapter briefly outlines the prevalence, aetiology and consequences of childhood obesity in Malta. It also reports on the policy response to obesity in Malta thus far. Two papers are included in this chapter: Research Paper 1 is a contextual analysis characterising potential drivers of obesity in Malta that focuses on multiple environmental dimensions of the obesogenic environment. Research Paper 2 presents and critically analyses findings of an overview of systematic reviews that examines interventions to tackle overweight and obesity in children that have an environmental component.

Chapter 4: Environmental Audit

In chapter 4 I discuss quantitative findings on Malta's potentially obesogenic environment. Three papers are included in this chapter. Research Paper 3 investigates television advertising aimed at children in Malta. Research Paper 4 objectively characterises the community and consumer food environment, and Research Paper 5 addresses the promotional environment in stores. Findings from an environmental audit of the built environment are also briefly presented in this chapter.

Chapter 5: Key informant interviews and Focus Groups

This chapter presents qualitative findings resulting from a series of semi-structured interviews and focus groups with key stakeholders. Three papers are included in this chapter. Barriers to children's and adolescents' healthy dietary behaviour and physical activity are explored in Research Papers 6 and 7 respectively. The contrasting 'obesity frames' or narratives around obesity of two key stakeholder groups are presented in Research Paper 8.

Chapter 6: Forecasting the future of obesity in Malta

Research Paper 9 presents results of a microsimulation modelling exercise to forecast the health and economic burden of unchecked obesity, and the impact of interventions to address obesity.

Chapter 7: Discussion

The final chapter summarises and discusses the findings from the preceding chapters and component research papers. It includes overall study limitations and strengths, implications for policymakers, and recommendations for future research in this field.

1.4.2 Contribution of the candidate to the thesis

I developed the research question, selected methods and collected all the data for this thesis. I adapted a number of existing instruments for the collection of quantitative data on the obesogenic environment in Malta. I led the design and data collection for the qualitative research aspect of my research. My supervisor Dr. Cécile Knai provided input on the research questions and overall methodological approach. The nine research papers included in subsequent chapters summarize my research activity. I am first author on all articles, having taken the lead on writing the manuscripts and acted as corresponding author during the submission process, drafting the responses to reviewers' comments and making changes to the various manuscript versions. Dr. Cécile Knai critically revised and co-authored all the manuscripts. These have been published, are under review, or will be submitted as independent contributions to the literature, however the publications are ordered in such a way as to present a coherent project and minimize repetition across articles. Members of my Advisory Committee and other staff members at the LSHTM also collaborated on several research papers. Input on methodological approach for Research Paper 1 (Contextual Analysis) was provided by Harry Rutter, whereas Professor Mark Petticrew and Ketevan Glonti provided input on Research Paper 2 (Overview of systematic reviews). Dr. Sascha Reiff, Dr. Charmaine Gauci and Dr. Joanna Spiteri provided input on Research Paper 3 (Television advertising). Triantafyllos Pliakas provided guidance for Research Papers 4 (Environmental audit: NEMS-S) and 5 (Environmental audit: GroPromo). Professor Mark Petticrew also collaborated on Research Paper 8 (Framings of obesity). Lastly, Dr. Laura Webber, Dr. Zaid Chalabi, Dr. Neville Calleja and Dorothy Gauci contributed to Research Paper 9 (Microsimulation modelling). All collaborators are also co-authors of the relevant manuscripts. The forms outlining the specific contributions of the candidate and co-authors for each research paper are included at the end of this thesis.

CHAPTER 2. THEORETICAL FOUNDATION AND METHODS

In this chapter, I first discuss the theoretical elements informing this research, and then outline the methods used to collect primary data employing mixed methods. More specific information on the actual instruments and tools used may be found in the respective research papers presented in subsequent chapters.

2.1 Theoretical foundation

Theories aid in the understanding of intangibles, enabling researchers to explore complicated problems through different perspectives and providing a framework within which to position their insights and conduct their analysis [27]. Obesity has been described as a complex disease, and that an individual's risk of becoming overweight or obese is determined by the interaction of a plethora of genetic, behavioural and environmental factors [5,7]. As the surge in childhood obesity prevalence raises questions about the scale and rapidity of the rise and what can be done to halt or reverse the trend, an expanding body of evidence suggests that 'obesogenic' elements of our environment and individual behaviours interact in a complex dynamic that ultimately results in excess weight gain. A number of theoretical models and frameworks have been developed to facilitate our understanding of the interaction between environment and behaviour, and to enable comprehension of policy processes which may be relevant for obesity. In the section below I will provide a critical overview of models that have guided my research, outline the reasons why the theories were selected, and relate these to my research goals.

2.1.1 Socio-Ecological Models

Although most thinking around obesity remains grounded within an individual, behavioural approach, in recent years there seems to have been a growing movement in public health towards a more sophisticated socio-ecological approach. Socio-ecological models or theories of health concentrate on the broader structural and social contexts around the individual, departing from the predominant view of obesity as a personal issue requiring treatment and taking into consideration interrelated biological, behavioural and environmental influences on an individual's weight. Thus, economic, cultural, and political forces that are external to the individual may be taken into consideration as having an influence on obesity [13,28]. For example, Bronfenbrenner's Ecological Systems Theory (EST) [29–31] articulates how the development of a child's characteristics is determined by the child's inherent qualities (i.e. biological factors such genes; or behavioural factors such as habits, emotions, and beliefs) and their interactions with the child's external environments within which a child is embedded (Figure 1). The term 'environments' refers to any event or condition external to the individual, whereas 'interaction' refers to reciprocal exchanges between an individual and other individuals or inanimate objects that inhabit its immediate surroundings. The theory stresses the importance of studying a child's development in the context of multiple environments or ecosystems which influence, and are influenced by, the child. These environments are envisaged as nested within each other, starting from the most intimate ecological home system or environment (terms used interchangeably), moving outward to the larger school system and ultimately to the most over-arching system of society and culture. Each of these systems interact with and influence each other, as well as all aspects of the child's life. Bronfenbrenner conceived of five interlocking levels of influence, characterised from the most intimate to the broadest as:

i. *the microsystem*: the smallest, most immediate environment within which a child functions, comprising interactions at home with family members; at school with peers or teachers; and within the community
ii. *the mesosystem*: encompassing interactions or linkages between the different microsystems surrounding the child
iii. *the exosystem*: refers to the linkages and processes that may occur between two or more settings, at least one of which does not contain the developing child but still affects it indirectly through stimulating events at the microsystem level. For example, parental workplaces, the larger neighbourhood and extended family members fall within this system.
iv. *the macrosystem*: this represents the largest, most distant collection of individuals and places that still exert significant influence on the child. It refers to the cultural, societal and institutional values that are manifested in the micro-, meso- and exosystems, being composed of the belief systems, bodies of knowledge, material resources, customs, lifestyles, cultural patterns and values, political and economic systems etc.
v. *the chronosystem*: this temporal dimension reflects consistency or change in underlying systems over time. Such change can happen not only in the characteristics of an individual, but also in the person's immediate or broader environment such as changes in family structure, parental employment status, place of residence and broader societal changes such as economic downturns or wars.

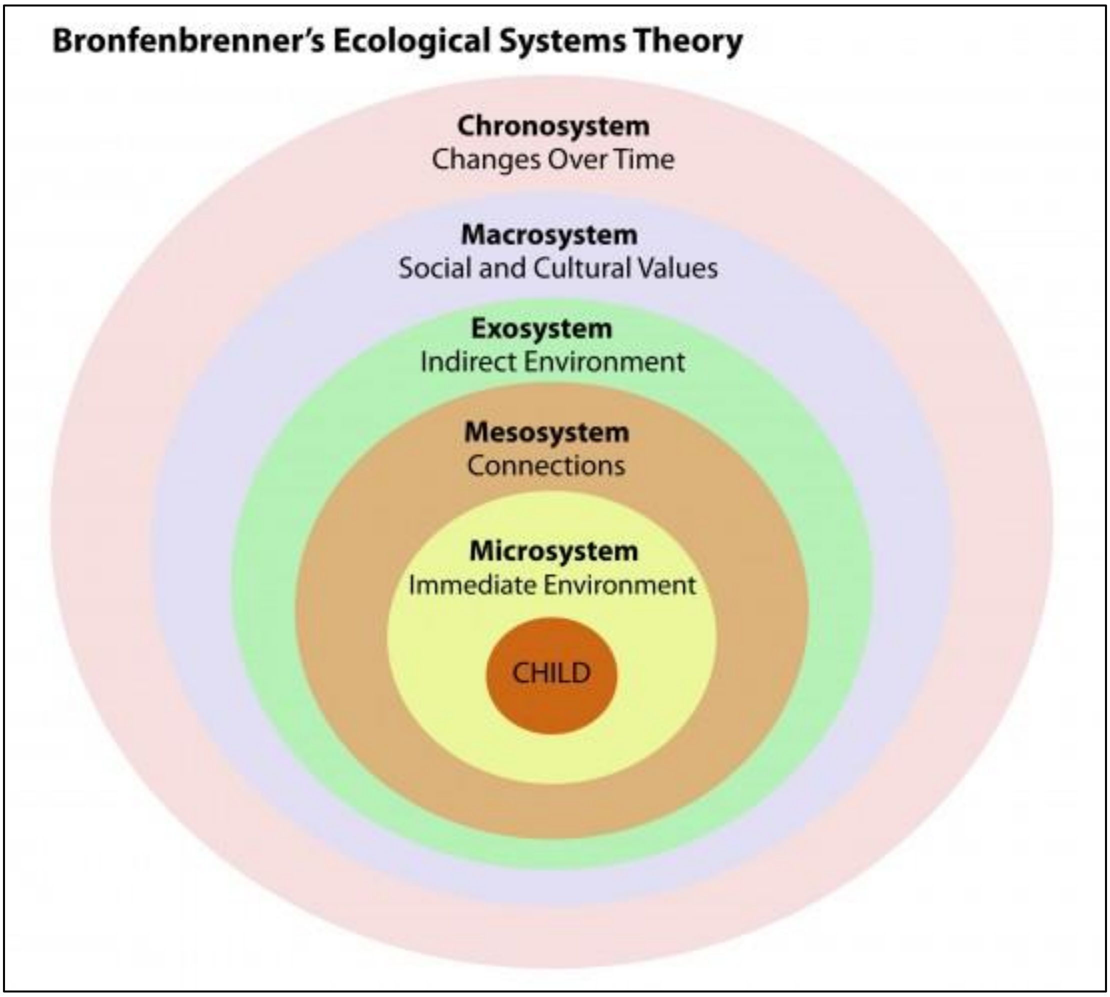

Figure 1. Bronfenbrenner's Ecological Systems theory

The Ecological Systems Theory has been used as the basis for ecological health promotion models that reflect the Dahlgren and Whitehead socioeconomic model of health [32], as well as for several theoretical frameworks that try to conceptualise how obesity develops during childhood, such as Davison and Birch's contextual model of the development of childhood overweight [33] and Harrison et al.'s Six-Cs model of contributors to overweight and obesity in childhood [34]. Davison and Birch's model (Figure 2) is briefly discussed below to provide a guiding structure for the evaluation of child risk factors or behavioural patterns such as dietary habits, physical activity levels, and sedentary behaviour that can place a child at risk of overweight. The impact of these factors on the development of obesity is moderated by child characteristics such as age, gender, and genetic susceptibility to weight gain; and shaped by parenting styles and family characteristics including family dietary and physical activity patterns, nutritional knowledge, feeding styles, and interactions with peers [33]. The characteristics of more 'distant' environments may also indirectly influence child weight status due to their influence on parenting practices and children's behaviours. They include demographic factors such as ethnicity, parental working hours, leisure time availability etc.; the school (e.g. structured break times for activity and the dietary quality of lunches eaten at school), and characteristics of the broader community environment such as neighbourhood geography, availability of recreational facilities, food labelling laws, country climate and topography.

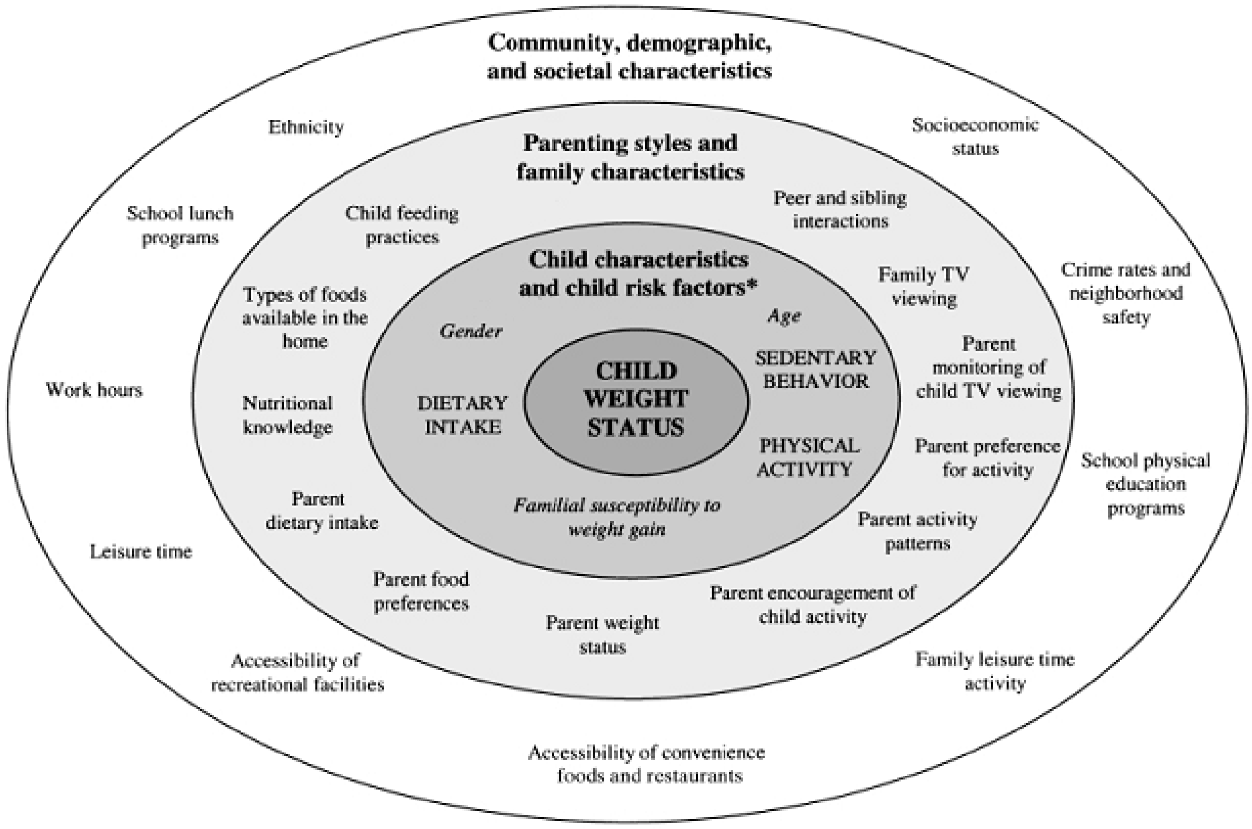

Figure 2. Davison and Birch's ecological model of predictors of childhood overweight
*Child risk factors refer to child behaviours associated with the development of overweight.

2.1.2 Policy theories

Theories are crucial for the study of complex policy processes. Such processes are complex because they involve interactions among a large number of stakeholders seeking political influence within specific contextual settings; unexpected events (e.g. political, cultural etc.); and a complicated mixture of policies spanning multiple levels of government [35]. The use of theories allows scholars to highlight the most important items for study and exploring the relationships between them. The application of multiple theories helps prevent both 'theory tenacity' (persistent belief in a theory in spite of evidence to the contrary) and confirmation bias (a tendency to seek confirming evidence) [36]. Furthermore, health promotion research is inherently political in nature, so that policy making has significant implications for public health research, and vice versa [37]. Converting recommendations arising from research into tangible action is a dynamic and complicated social process involving several actors and constant change within a politically charged context. Obesity reduction, for example, is not a politically neutral issue: macro-level environmental interventions that are effective at a population level are likely to be controversial or require substantial political support and involvement [38]. Consequently, researchers can no longer afford to distance themselves from active engagement with policy and politics [39]. Understanding policy dimensions of health may allow health researchers to become involved in, and attempt to directly influence, the policy-making process (rather than simply providing data and being external to the process). It may also help researchers conduct better research and evaluation as lessons are learnt from previous mistakes; gain insight into what worked for other issues such as tobacco control or addressing social inequality [40,41]; anticipate opportunities and constraints on government action; and design more effective policies and programs [42]. Following a review of policy theories which could lend themselves to this research, two particularly relevant theories will be briefly examined and applied to the policy process in Malta: the Punctuated Equilibrium Theory (PET) and Multiple Streams Approach (MSA).

2.1.2.1 Punctuated Equilibrium Theory

PET as applied to policy is founded in the longitudinal study of US political institutions by Baumgartner [43,44]. Although PET traces its origins to evolutionary biology and was originally applied to the US political system, it has since been used extensively to describe policy change in many countries [45]. According to PET, political systems and processes are typically stable and static (in equilibrium), experiencing relatively few and minute incremental changes over prolonged periods of time. However, as public understanding of existing problems involve and new knowledge accumulates, they occasionally undergo radical, large-scale shifts referred to as 'punctuations' [35,45]. PET places the policy process on a dual foundation of political institutions and bounded rationalist decision-making and emphasises two elements of the policy process: agenda setting and issue definition [35]. Bounded rationality emphasises that decision-makers are subject to cognitive limitations when making choices, and can only pay attention to a few issues at any one time. Thus policymakers practice selective attention in that their decision-making environment must be simplified by ignoring most issues or ideas (negative feedback) while promoting a few to the top of their agenda (positive feedback) [46]. Political systems operate in a similar manner, so that at their highest level they cannot consider all issues facing them simultaneously. Instead, issues are 'delegated' to political subsystems, typically composed of experts, which hold a 'policy monopoly' over decision-making related to that particular issue during periods of stasis. As issues are defined in different ways in public discourse, they rise and fall in importance within the public agenda. Negative feedback results in long periods of equilibrium or stasis since existing policy is least likely to change when the issue receives minimal attention from policymakers. Positive feedback, on the other hand, may produce ‘punctuations’ as policymakers pay the issue more attention than usual, making policy change more likely [46]. In addition, policymakers and interest groups at multiple levels of government often pay attention to a particular issue at the same time, achieving a ‘critical mass’ of attention that shifts policymakers’ attention from competing problems. It is only when issues spill over into the broader macro-political sphere for some reason that dramatic shifts in policy occur [35].

2.1.2.2 Multiple Streams Approach

Another theoretical framework that offers an explanation for policy-making by government under conditions of ambiguity (i.e. “a state of having many ways of thinking about the same circumstances or phenomena” [47]) is the Multiple Streams Approach (MSA). Kingdon first outlined the MSA framework to offer insight into the dynamics of the US policy process in 1995 [48], deriving inspiration from Cohen et al.’s 1972 ‘garbage can’ model of choice [49]. Essentially, choice is conceptualised as a garbage can into which participants place largely unrelated problems and solutions. The process is beyond any individual control and highly interactive, reflecting the dynamic, complex and chaotic nature of political life. As such, the approach is similar to that of complexity theories where the emphasis is on dynamic interactions, feedback mechanisms, an element of randomness and constant evolution (non-stationarity) [35]. In such situations, rational choice in favour of or against a particular policy is difficult, because the context is not well known. Policy cycles are simplistically portrayed as undergoing ordered stages where policymakers identify problems, task bureaucracies with performing a comprehensive analysis to identify solutions, and then select the “best solution” according to their aims and values (as one would expect in a rational approach to policy-making). Instead, policymaker aims and policy problems are ambiguous and bureaucrats struggle to research issues and generate viable solutions quickly [45]. Choices are made before all possibilities have been considered due to limited time and cognitive ability.

MSA conceptualises this as three independent streams flowing through the policy system: problems, politics and policies [48]. The problem stream refers to policy issues considered as requiring attention which policymakers and citizens want addressed. Events may draw attention to problems, and attention may be fixed by the media or ‘policy entrepreneurs’ [50]. Obesity is one of many such problems. The policy stream is described by Kingdon as a ‘primeval soup’ of specialist-generated, competing ideas which evolve over time. There are many possible solutions to problems, but only a few ideas receive serious consideration, with cost, technical feasibility, and value acceptability amongst the criteria for consideration [35]. Lastly, the politics stream consists of three main elements: the national mood, pressure group campaigns and administrative or legal turnover. The way in which these elements apply to Malta is explored in Chapter 3.

The confluence of all three streams into a single package at critical points in time offers a ‘policy window’ which greatly enhances the likelihood of policymakers adopting a particular policy. So-called ‘policy entrepreneurs’ are individuals or organizations that can couple these streams using a variety of strategies with specific goals in mind. When windows open, policy entrepreneurs must immediately seize the opportunity to initiate action, else the opportunity is lost [35]. Hence entrepreneurs need to be both persistent and skilled at attaching problems to solutions and finding politicians receptive to their ideas. Policymakers are viewed as being subject to manipulation by policy entrepreneurs, therefore those entrepreneurs with greater access to policymakers, more resources to push their proposals and more skilled at employing strategies to influence policymakers are more likely to be successful. It is likely that countries with a small population such as Malta are advantaged in this regard, as there are fewer levels of bureaucracy standing between policymakers and entrepreneurs. Furthermore, there may be a social and cultural cohesion that makes it easier to design and test innovative policies that can then be adapted by larger and more complex countries [51]. I will elaborate further on the application of these theories to Malta in the subsequent chapter.

2.2 Methods

When I started this research in September 2012, there was limited data available on the broader environmental drivers of childhood obesity in Malta. In order to begin exploring the relationship between the obesogenic neighbourhood environment and individual behaviour, features of the built environment need to be operationally defined and systematically characterised in a reliable and valid manner [13]. Some qualitative research on socioecological factors influencing food choice in Maltese schoolchildren had been published [52], however no attempt had been made to objectively characterise obesogenic elements of the Maltese environment. Thus, I set out to address this gap in knowledge by conducting an environmental audit of representative localities across Malta, with the intention of providing a snapshot of potentially obesogenic environments in which children live and play.

2.2.1 Quantitative instruments: EURO-PREVOB and INFORMAS

Measuring environmental aspects of diet and physical activity is becoming increasingly popular as the link between area of residence and obesity-related health behaviour is elucidated [53,54]. A number of studies have developed instruments to measure the 'obesogenicity' of environments, often focusing on either diet [55–57] or physical activity [58–60] alone. Traditionally, this is done through field audits, however, the use of remote sensing facilities such as Google Street View is increasingly being advocated in order to save time and resources [61]. Since neither Google Street View nor any other type of remote sensing facility is currently available in Malta, I reviewed the literature to identify field audit tools that can be applied to Malta. Two studies in particular have developed tools that objectively assessed multiple environmental factors (i.e. through systematic observation, as opposed to subjective perceptions) in more than one country. The 'Consortium for the PREVention of OBesity through effective nutrition and physical activity actions' (EURO-PREVOB) study focused specifically on the obesogenicity of communities and was carried out in a number of European countries [62]. The 'Environmental Profile of a Community's Health' study similarly tested an instrument to measure environmental determinants across five non-European countries, focusing on cardiovascular disease factors such as smoking as well as physical activity and diet [63]. I adopted the EURO-PREVOB community questionnaire in view of its testing in five European countries, its focus on obesity and the obesogenicity of environments, its practicality and feasibility in terms of the limited human resources required, and its flexibility in terms of sampling procedures [62]. EURO-PREVOB field audit methods were used to conduct an environmental audit of the built environment. In addition, shortly before commencing fieldwork in 2014, the International Network for Food and Obesity / Non-communicable Diseases Research, Monitoring and Action Support (INFORMAS) [64] published recommendations for a similar benchmarking approach to monitoring of the food environment at country level. INFORMAS proposes that a contextual analysis should first be undertaken for each country to determine local needs in relation to monitoring food environments and the level of data to be collected in individual countries. The INFORMAS framework includes two 'process' modules that monitor the policies and actions of the public and private sectors; seven 'impact' modules that monitor the key characteristics of food environments; and three 'outcome' modules that monitor dietary quality, risk factors and noncommunicable disease morbidity and mortality. Monitoring frameworks and indicators have been developed allowing for stepwise approaches ('minimal', 'expanded', 'optimal') to data collection and analysis. The EURO-PREVOB methodology is composed of two key elements, a policy checklist and a community questionnaire to aid in the systematic assessment of the food and built environment. These required collection of data on policy and the food environment (but not the built environment) that is broadly similar to that outlined in the 'minimal' approach of several INFORMAS 'impact' modules [65–68]. Upon assessing the feasibility of expanding my fieldwork to encompass both EURO-PREVOB and INFORMAS variables, I realised that collecting data using the overlapping methods described in these two frameworks would be both feasible and useful for the collection of internationally comparable data. The INFORMAS data collection methods are still in development, however sufficient detail was presented in the concept papers to enable key elements of the relevant modules to be appended onto the core EURO-PREVOB instruments. In the section below I outline the key elements of the instruments used during this research.

2.2.2 Policy checklist

In addition to developing instruments intended to aid objective assessment of the environment, the EURO-PREVOB study developed a policy checklist used to document and assess the existing public health policy environment in terms of nutrition, physical activity, obesity and inequalities in obesity. More specifically, it aids the review and analysis of existing policy initiatives with a potential impact on nutrition and physical activity (e.g. public health nutrition, agricultural, economic, transport, built environment, social and school policies) at both the macro- and micro-setting levels (Appendix 2A). The policy checklist was useful to guide the contextual analysis (Research Paper 1).

2.2.3 Community questionnaire

The EURO-PREVOB community questionnaire guides the objective identification and characterisation of food and built environment indicators through direct observation. The EURO-PREVOB protocol recommends collecting data across ten communities of differing socioeconomic level (i.e. two communities from each quintile of socioeconomic deprivation) sampled using a multi-stage sampling framework. Direct measurement of the food and built environments in these localities involved an assessment of the *community and consumer food environments* [69]; and the *built environment* (i.e. existence and quality of cycle lanes, public open spaces, public transport stops, traffic volume, road crossings, pavements/sidewalks and level of attractiveness) at the community level (Appendix 2B).

Sampling framework

Selection of localities for auditing was intended to be random yet representative. Malta is commonly divided into six districts or regions for statistical purposes, and socioeconomic data for this level of detail exists. However, socioeconomic data are not available at locality (i.e. town or village) level. Local public health professionals and the National Statistics Office (NSO) in Malta were consulted to identify the most appropriate sampling procedure to enable testing for socioeconomic differences across food and built environment variables; the ranking of localities by socioeconomic status (SES) was recommended. In order to do so, a proxy for median socioeconomic deprivation of each locality in Malta and Gozo was derived. The frequency of means-tested social assistance and unemployment benefit recipients registered in each locality was divided by the total number of residents in the same locality, and the resulting ratio used to 'rank' localities. Thus towns or villages with the lowest value were ranked as having the highest median SE level, and vice versa. Results reflected the researcher's and medical statistician's expectations, and it was decided to use the rankings as a basis for selection of localities for auditing. The ranked list was divided into SES quintiles in accordance with the EURO-PREVOB protocol, and two localities within each quintile were randomly selected by probability proportional to size (for a total of ten localities).

Initial pilot testing of the EURO-PREVOB community questionnaire in a locality having a mix of residential neighbourhoods demonstrated the feasibility of the audit. It also indicated that larger grocery stores might not be present within the audited area as these tend to lie on the outskirts of residential neighbourhoods. Thus the 0.25 km^2 area for appraisal proposed in the fieldworker manual was extended to around 0.5 km^2 per locality to ensure that the audit was as comprehensive as possible. Lastly, a walking route around residential areas in each locality was planned using Google Earth™ software [70]. Where possible, secondary state schools were used as a locus for the audit (i.e. area to be explored encompassed a state secondary school). This was done so that the subjective perceptions and views of schoolchildren attending these state secondary schools who live in these localities could be reflected against objective observations of their community food environment. As the principal investigator for this research, I conducted fieldwork in all audited localities myself to ensure consistency in data collection.

2.2.3.1 Food environment

Although the community questionnaire outlined procedures for assessing the availability and price of certain foods and beverages in grocery stores, INFORMAS protocols recommended the use of validated instruments to provide data comparable across countries. The Nutrition Environment

Measures Survey (NEMS-S) instrument [57] is one such tool designed to assess aspects of the in-store environment. I completed an online training course offered by the developers of the tool to optimise the data collection process [71]. The course covered consumer nutrition basics, enumeration of food outlets in a neighbourhood, completion of NEMS-S observational measures in grocery stores (i.e. systematic assessment of the availability, quality and price of key indicator food and beverage items), customisation of the tool, and analysis/presentation of results.
The EURO-PREVOB community questionnaire also included collection of data on the display of specific food products and presence of advertising material aimed at children within grocery stores. However, these were deemed to be rather limited in scope and utility. Following a preliminary review of the literature around food promotion in stores, I decided to adopt a more systematic approach to data collection that allows comparison with data from other countries, in line with the INFORMAS approach [65,72]. Thus, the GroPromo instrument [72] was used to assess product placement and promotions within grocery stores in Malta. Further information on the specific methods used for each aspect of the audit related to the food environment is available in the method sections of Research Papers 4 (Environmental audit: NEMS-S) and 5 (Environmental audit: GroPromo).

2.2.3.2 Advertising on local television channels

The EURO-PREVOB community questionnaire also included collection of data on the nature and extent of television advertising during children's television hours, however the protocol called for data to be collected for three hours on Saturday mornings only. Following a preliminary review of the literature around food promotion on television, a broader, more systematic approach to collection of television advertising data was deemed to be necessary in order for any findings to be relevant for policymakers. The adoption of such an approach also allows for cross-country comparisons to be made, in line with INFORMAS recommendations [65]. Detailed methods are presented in research Paper 3.

2.2.3.3 Built environment

Built environment data collection within the EURO-PREVOB community questionnaire focused on observation of the following indicators of environmental quality:

1. cycling infrastructure (presence and quality of cycle lanes)
2. public open spaces (presence and quality of parks, playgrounds/playing areas)
3. pedestrian aids (presence and quality of pedestrian crossings and pavements)
4. traffic volume

5. public transport (bus stop presence and quality, and bus frequency)

Each quality indicator was assigned a grade ranging from 1 (best) to 4 (worst) (Appendix 2B). I also photographically documented the indicators using a smartphone. A Google Earth image of the audited areas is available in Appendix 5A.

The selection of methods to be used for this research crystallized following publication of the INFORMAS articles. The NEMS-S, GroPromo and television advertising data collection protocols described above have been successfully applied in several countries, hence applying these instruments to Malta led to the collection of comparable data. These are more likely to be of interest to an international audience and to Maltese policymakers. Furthermore, it is likely that publication of these data in the peer-reviewed literature would give added legitimacy to this research, increasing the likelihood of exerting a positive influence upon policy-making in Malta. This does not in any way diminish the importance or relevance of other information – such as built environment indicators - which were nevertheless considered to be less suitable for publication in an academic journal. With this in mind, section 4.1 of this thesis briefly summarizes the built environment findings in place of a research paper. The observed characteristics of the built urban environment in audited localities are presented in table form in Appendix 4.

2.2.4 Key informant interviews and focus groups

In parallel to the objective environmental audit, qualitative research techniques were employed to elicit expert and lay views regarding the drivers of childhood obesity, narratives around perceived responsibility for this issue, and perceived barriers to healthy dietary and physical activity behaviour among children. This was done through: 1) *interviews* with key informants to generate knowledge about the interests and influence of stakeholders around childhood obesity in Malta; and 2) *focus groups* with schoolchildren and parent groups in the communities selected for auditing in order to provide insight into their lifestyles, behaviours and related attitudes, beliefs and knowledge.

2.2.4.1 Stakeholder interviews

Stakeholders are individuals or organizations having an interest in a specific issue, exerting active or passive influence on the decision-making and implementation process around the issue. Childhood obesity policy encompasses a wide range of stakeholders within categories such as government agencies, non-governmental organizations, industry, and representatives of academic institutions [15].

Knowledge of their potentially competing agendas and resources is crucial to understand the context within which the childhood obesity prevention in Malta occurs and to illustrate the debate around childhood obesity in Malta.

Identification of stakeholders

The INFORMAS communication strategy presents recommendations on the range of stakeholders and audiences involved in knowledge exchange around the quality of the food environment who might be approached for interviewing [15]. Using these as a starting point, together with insight from my review of the literature, application of the EURO-PREVOB policy checklist, and using my network of professional contacts, a preliminary list of thirty-five stakeholders was drawn up. These included policymakers around public health, urban planning, education and the economy; academics in the field of nutrition and physical activity; researchers; non-governmental organizations (NGOs) representing health, consumers, and children; and food industry representatives. Additional stakeholders were also identified through snowball sampling, bringing the final number of interviewees to 73. Thematic analysis was carried out in parallel with conducting interviews, until saturation of data was achieved [73,74]. Table 2 shows the range of sectors and organizations approached. Stakeholders were consulted on their role in contributing to or preventing childhood obesity; their views regarding potential drivers of obesity; their possible involvement or desire to be involved in policy-making related to obesity, nutrition or physical activity; and their recommendations on how to address adult and childhood obesity.

Category	Representative(s) of
	Foundation for Social Welfare Services, Ministry for the Family and Social Solidarity Malta Competition and Consumer Affairs Authority Malta Environment and Planning Authority, Office of the Prime Minister Members of Parliament Ministry for Education and Employment Ministry for Energy and Health Ministry for Finance Ministry for Sustainable Development, the Environment and Climate Change Office of the Chief Medical Officer Superintendence of Public Health Transport Malta, Ministry for Transport and Infrastructure
Non-governmental organizations	Bicycling Advocacy Group Broadcasting Authority Commissioner for Children Institute of Maltese Journalists Interdiocesan Environment Commission Local Council Association Malta Diabetes Association Malta Health Network Maltese Sports Council Malta Union of Teachers The Maltese Chamber for Architects and Civil Engineers
Academia and Education	Department of Food Studies and Environmental Health, Faculty of Health Sciences, UoM Department of Health, Physical Education and Consumer Studies, Faculty of Health Sciences, UoM Department of Public Health, Faculty of Medicine and Surgery, UoM Health and Safety Unit, Directorate for Educational Services, Ministry for Education Institute for Climate Change and Sustainable Development, UoM Institute for Physical Education and Sports, UoM Institute for Tourism, Travel and Culture, UoM Institute of Tourism Studies Home Economics Seminar Centre Assistant Head of School, Secondary state school Head of School, Primary/Secondary state school
Industry	Aquaculture General Retailers and Traders' Union Food importers Food manufacturers Malta Hotel and Restaurants Association Restaurateurs Soft drink manufacturers
Health Professionals	Dieticians Malta Association of Physiotherapists Malta Association of Public Health Medicine Paediatricians Primary Care (General Practice)
Other	The Today Public Policy Institute World Health Organization

Table 2. Sectors interviewed

*UoM, University of Malta

2.2.4.2 Focus groups with children and parents

The other key qualitative component of my research consists of focus groups with secondary school-aged children and parents, to gain insight into their lifestyles, nutrition and physical activity-related behaviours, and perceptions about environmental influences on these behaviours. A focus group is a moderated discussion group of between six to twelve participants lasting around one to two hours that allows the facilitator to elicit their opinions, beliefs, attitudes and perceptions about a topic in an interactive group setting [75]. While focus group participants are not necessarily representative of the population, the group's dynamics and interactions provide a potentially deeper and richer set of data than that generated during an interview [75,76]. Using focus groups to interview children makes sense from a number of perspectives. Although group dynamics or dominance of the discussion by forceful children may influence individual freedom of expression, the fact that children are in the presence of known persons is likely to encourage their participation. To a child, participating within the 'safety' of a focus group is also possibly less intimidating than a face-to-face interview, stimulating discussion [75]. To facilitate interaction, each focus group consisted of children attending the same school, of the same age, and who lived in the localities where an environmental audit had taken place. In most cases, children had already established friendships with other participants. This helped to create an atmosphere of shared experience, where children and adolescents could reinforce (or contradict) each other's statements based on their own day-to-day interactions within their school and community. An advantage of working with older children is that these are often more independent and more articulate than younger children, and thus were more likely to provide more useful information on their environment than primary schoolchildren. Older children are also more likely to purchase foods that they pay for inside of or nearby to their schools [77,78]. Initially all primary and secondary schools (i.e. state, independent and church schools) were considered for inclusion. However, limited resources meant that only state secondary school students were approached for participation. While recognizing that this might limit the generalizability of the findings to younger schoolchildren and those who do not attend state schools (reportedly around 31% of all students [79]), participants represented a mix of educational and socioeconomic backgrounds and findings arising from these focus groups provide useful insight on the experienced reality of the environment in audited localities.

Parents are also key moderators of their children's risk of obesity, and their views were considered to be equally important. I had intended to recruit parents through parent-teacher associations within the same schools, but finding suitable locations and times when busy parents could meet proved difficult. Only one focus group with ten parents was assembled, and further attempts to bring parents together were unsuccessful. However, many interviewed stakeholders were themselves parents and often shared their experiences and perspectives of the obesogenic environment through the lens of parenthood.

Topic guide

Interviews and focus groups were semi-structured, with a topic guide informed by the ANGELO framework [25] and the national obesity strategy [80] being used to structure the discussion (Appendix *7*) while retaining sufficient flexibility to encourage unsolicited answers and personal opinions [75]. A preliminary topic guide was piloted on a small number of researchers at the LSHTM to assess ease of administration, language and length, and also modified in an iterative fashion during the course of conducting interviews as patterns and key themes emerged.

Ethical considerations

Maintaining anonymity, particularly at higher levels of political influence, can be a problem in Malta due to its small size. For this reason, I have refrained from identifying individuals throughout this thesis. The governmental, non-governmental and industry entities whose representatives I interviewed are identified in Table 2. However, illustrative quotes in Research Papers 6 (Barriers to appropriate dietary behaviour), 7 (Barriers to PA) and 8 (Framings of obesity) are attributed specifically to the sector and sub-sector that the interviewees represent. Data were stored securely using password-protected folders. A coding framework accessible solely by the researcher was designed to protect confidentiality, and identifier data will be destroyed once the study is completed. Identifier information on focus group participants was not collected to preserve anonymity. This research was approved by the London School of Hygiene and Tropical Medicine Research Ethics Committee (reference number: 6485).

Data analysis and reporting

Qualitative data was processed and analysed using the principles of thematic content analysis, considered appropriate as it is explicitly relevant to applied policy research [75,81]. More specifically, the Framework Method outlined by Gale et al. was adopted in this research [82]. This is a flexible tool that permitted a systematic search for patterns to be carried out, facilitating constant comparison of data within a matrix in order to develop themes. The 'Standards for Reporting Qualitative Research' criteria were adopted to improve reporting in Research Papers 6-8 [83].

2.2.5 Microsimulation modelling

Modelling contributes to policy making around the prevention of obesity and other NCDs by providing insight into the potential health and economic effects of policy decisions. This aspect of my research was the result of a collaborative process with the Public Health Modelling group within the UK Health Forum. I conducted microsimulation modelling to assess the long-term health and economic burden of childhood obesity in Malta in response to objective 5. The microsimulation procedure simulates virtual individuals within a population in accordance with known population statistics and projections, using Monte-Carlo methods. In the course of the simulation individuals age and reproduce, and their risk and disease profiles change. NCDs, including obesity, are modelled by applying the latest incidence, prevalence, survival and mortality statistics. Relative risks define the relationship between obesity risk factors, individuals' background characteristics and a risk of developing an obesity-related disease. Detailed methods are presented in Research Paper 9.

RESULTS CHAPTERS

CHAPTER 3. CHILDHOOD OBESITY IN MALTA

3.1 Prevalence, aetiology and consequences

Overweight and obesity refer to abnormal or excessive fat accumulation [4]. Childhood and adolescence are particularly critical periods for potential adipose tissue proliferation and weight gain [84]. Obese children have been shown to have more fat cells of greater mean size than do normal-weight children [85]. Such accumulation of adipose tissue at an early age is often maintained in the longer term into adolescence and adulthood [86–90], carrying with it considerable physical and mental health consequences, as well as substantial cost implications for the healthcare system.

A number of anthropometric measures of body fat content have been developed, including body mass index (BMI), waist circumference, waist-to-height ratio, skin fold thickness, percent body fat, bioelectrical impedance, magnetic resonance imaging and dual-energy X-ray absorptiometry [7]. In Malta, most nationally representative data on obesity measure weight status using BMI, adopting the World Health Organization (WHO) definitions of obesity to classify prevalence. BMI is a simple, commonly used index used to classify obesity and overweight in adults at a population level. It is defined as an individual's weight in kilograms divided by the square of height in metres (kg/m^2) and provides a useful, if rough, guide to the weight status of adults of all ages [4]. Although there is international consensus regarding WHO definitions of adult overweight and obesity as measured using BMI, there is less agreement regarding the classification of childhood overweight and obesity [91]. Three commonly used classifications are the International Obesity Task Force (IOTF) BMI-for-age standards for defining overweight and obesity under the age of 18 [92,93]; the Center for Disease Control and Prevention (CDC) 2000 growth charts [94]; and the WHO classification [95]. The classification system that will be utilised throughout the remainder of this text is the International Obesity Task Force (IOTF) standard, which was recently revised to a allow the expression of cut-off points as BMI centiles, allowing them to be directly compared to the WHO cut-offs [92].

3.1.1 Prevalence

A number of studies aimed at determining overweight and obesity prevalence amongst school-aged children and adult residents of the Maltese islands have been carried out and are briefly outlined below. These indicate that policies aimed at reducing obesity have thus far failed to halt or reverse incidence in the population. A broader, deeper understanding of local drivers of obesity, and a shift in the policy approach related to obesity, may be required for obesity prevention measures to achieve the desired effect.

3.1.1.1 Overweight and obesity in children

Malta has participated in four successive rounds of the Health Behaviour in School Aged Children (HBSC) initiative in 2001/2002 [96], 2005/2006 [97], 2009/2010 [98,99] and 2013/2014 [100]. This is an international study conducted in collaboration with the WHO Regional Office for Europe that includes self-reported BMI for 11, 13 and 15 year-old children, with overweight and obesity prevalence calculated using both World Health Organization (WHO) child growth standards [101] and IOTF BMI cut-offs [92]. Maltese adolescents have been consistently ranked high up on the list of countries having the most overweight and obese adolescents. In 2006 approximately 15% of 13-year olds were above the 95th weight percentile, with rates being generally higher than the previous findings of the same study carried out in 2002 [97]. By 2014, Malta had the highest proportion of obese or overweight children amongst all age groups (28%, 27% and 27% of 11, 13 and 15 year-old children respectively according to IOTF BMI cut-offs) from the 42 participating countries [100].

Malta also participated in the 2007/2008 [102] and 2009/2010 [103] rounds of the WHO European Childhood Obesity Surveillance Initiative (COSI), where the BMI of children entering primary schools at six years of age was measured. Again, Malta was grouped into the cluster of countries having the highest level of overweight. A comparison of objective anthropometric BMI data for a national cohort of children born in 2001 revealed a steady increase in the prevalence of overweight. In 2007, 40.1% and 31.5% of six to seven year-old boys and girls respectively were found to be overweight or obese, according to World Health Organization (WHO) Child Growth Reference criteria. This proportion increased to 47.9% and 39.5% of boys and girls respectively just three years later, when the same children were measured again at around nine years of age during a follow-up study [104]. A more recent representative study amongst 10-11 year-old Maltese children using measured data revealed that 20.4% of children were overweight and 14.2% obese, according to IOTF standards (or 23.1% overweight and 20.9% obese according to WHO standards) with males significantly more likely than females to be overweight or obese [105]. In order to help shape national obesity prevention policy, a national survey aiming to measure BMI of all 46,000 primary and secondary school students aged between five and 16 was launched in 2015 [106].

3.1.1.2 Overweight and obesity in adults

Maltese adults are amongst the most overweight within the WHO European region (Figure 3) [2,107]. A nationally representative survey among individuals over 15 years of age, conducted in 2008 using self-reported data, indicated that 58.5% were overweight (BMI >25kg/m^2) and 22.3% were obese (BMI >30kg/m^2) [108]. A pilot survey making use of measured data suggests that this is an underestimation of the true obesity burden, showing that 29.8% of adults over 19 years of age were obese and a further 47.2% were overweight [109]. When compared to other EU states, Malta has the highest rate of obesity amongst adult males and the third highest rate amongst females [110].

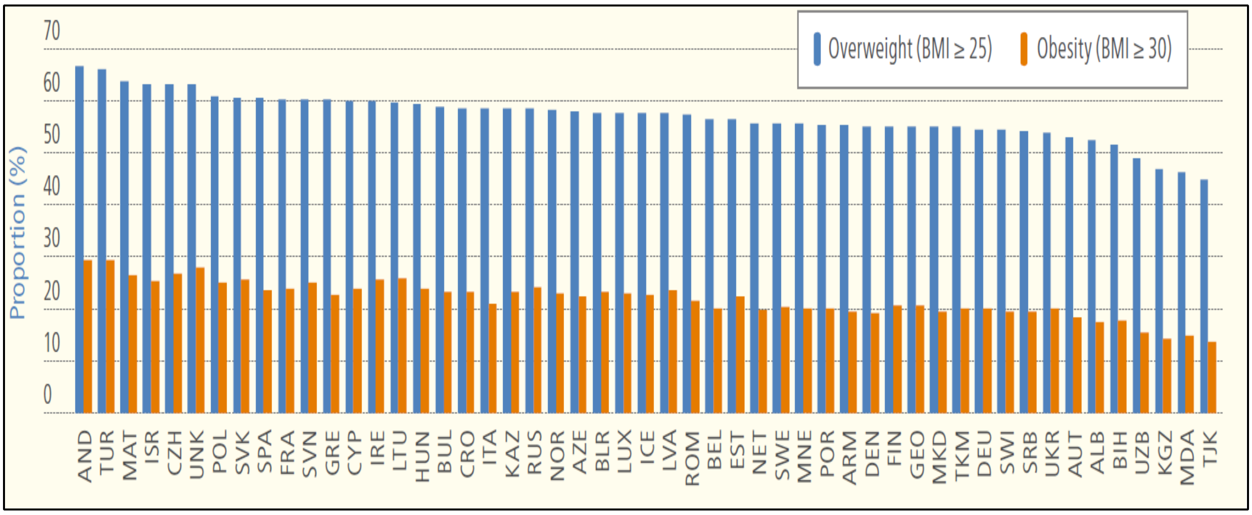

Figure 3. Age-standardized prevalence estimates for adult overweight and obesity, 2014
*Malta (MAT); Source: The European Health Report 2015: Targets and beyond – reaching new frontiers in evidence. WHO, Copenhagen: UN City, 2015 [2]

3.1.2 Consequences of obesity

Obesity is associated with a range of adverse health outcomes including a range of metabolic and cardiovascular diseases and several types of cancer [111], and there is a well-established link between obesity, poor health outcomes and all-cause mortality [107,112–114]. Prospective studies have shown an 8% increase in the risk of coronary heart disease (CHD) for each unit increase in BMI [115]. Cohort studies have also shown that becoming obese by middle age has significant effects on mortality and life expectancy [116]. Having a body mass index (BMI) higher than 30 and less than 35 was found to result in a reduction in life expectancy at birth of 2 to 4 years, whereas life expectancy of morbidly obese (BMI of 40 to 50) middle-aged adults was shortened by 8 to 10 years [116]. The effects on life expectancy of becoming obese in childhood are not entirely clear [117], however many of the health consequences that characterize obesity during adulthood are preceded by detrimental metabolic and vascular abnormalities which occur with increased frequency in obese children and adolescents [7,118]. For example, there is evidence to suggest that elements of the metabolic syndrome which precede cardiovascular disease (CVD) such as hypertension, dyslipidaemia and impaired glucose tolerance occur more frequently in obese than in normal weight children [119], and that precursors of CVD manifesting themselves during childhood may be maintained into adulthood and throughout the life course [120].

Obesity has also been shown to significantly impact mental and emotional health of adults and children alike [121,122]. There is moderate to strong evidence for a bi-directional association between obesity and depression in adolescents and adults [123–125], although the evidence is less clear for children. Negative societal attitudes toward obese individuals lead to discrimination and stigmatization in the personal and professional arenas [126–128]. Obesity bias is of particular concern in children and adolescents who may be at a particularly vulnerable stage of their psychosocial, academic and emotional development [121]. Obese adolescents have lower self-esteem and experience significantly higher rates of sadness or loneliness than their peers, and are more likely to engage in high-risk behaviours such as smoking or alcohol consumption [129]. They are also more likely to become obese adults with lower incomes who experience higher degrees of social exclusion [130].

The cost implications of obesity include its substantial impact on healthcare expenditures and provision of social care to individuals with obesity-related disease [131]. Treating and managing NCDs is costly, and there is also an indirect economic impact due to lost productivity from illness or premature death [7]. The cost attributable to obesity has been estimated to be around £5.1 billion annually in the UK [132], and its global economic impact has been estimated at around $2.0 trillion or 2.8% of global GDP, approximately equivalent to the global impact from smoking [133].

3.1.2.1 Health and economic consequences of obesity in Malta

NCDs are responsible for around 82% of deaths in Malta [110], and several NCDs have a direct or indirect link with obesity. In 2013, diseases of the circulatory system (including ischaemic heart disease, stroke and heart failure) and neoplasms collectively accounted for the 40.1% and 26.9% of adult deaths respectively, while type 2 diabetes accounted for 3.2% of all deaths [134]. Despite a consistent downward trend possibly due to earlier diagnosis and better treatment, age standardised mortality rates for diabetes and disease of the circulatory system in Malta are consistently higher than the EU average in both males and females [134]. Around 10.7% of the Maltese population was estimated to have diabetes in 2015 [135], a prevalence rate similar to that observed during a 2010 pilot examination survey [109], while 32% of the population were identified with high blood pressure in

2010 [109]. No reliable data for prevalence of hypercholesterolemia is available. In 2013, obesity-related colorectal, pancreatic and prostate cancers were among the leading causes of cancer-related deaths in males; whereas breast, colorectal and pancreatic cancer were the leading causes of deaths due to cancer in females [136]. Although there is little local research on the mental and emotional impact of obesity on individuals, discrimination and marginalization of obese children by their peers is also evident in Malta, particularly in older children who are no longer buffered by protective parental strategies [137,138]. The potential health and economic impacts of unchecked obesity in Malta are outlined in Research Paper 9 (Microsimulation modelling).

3.1.3 Aetiology

Genetic and biological factors may play a significant role in the development of obesity. The concept of the 'thrifty genotype' proposes a genetic predisposition toward efficient energy storage as a result of selective evolution [139]: one which is maladaptive within the context of an existing 'obesogenic' environment [140]. Obesity has been shown to be partially inheritable [141,142] as individuals display large variations in their susceptibility to weight gain under conditions of positive energy balance [143,144], whereas twin studies have further demonstrated that obesity is under substantial genetic control [145]. However, changes in the genetic make-up of the population are unlikely to be a satisfactory explanation for the rapid increase in prevalence of obesity over the past decades [140]. Studies on migrants, which show greater obesity rates in first, second and third generation immigrants to developed countries when compared to their counterparts in their country of origin, provide evidence to support a strong influence of environmental factors on obesity rates [146].

Changes in children's dietary patterns and eating habits are likely to be key factors leading to the increasing prevalence of overweight and obesity. Cross-sectional and longitudinal studies have shown positive associations between high total daily energy intake and childhood overweight [147–150], whereas the consumption of high levels of fat has been associated with development of obesity independently of overall energy intake [151–153]. However, assessing the extent of contribution of diet to weight status is complex, as individual eating patterns, fat intake, food preferences and food choices all play a role in determining overall caloric intake [33,154]. Snacking whilst watching television [155], increasing portion sizes [156], and the consumption of energy-dense fast food [157] have also been linked to higher caloric intake, yet findings from longitudinal studies assessing the relationship between dietary factors and development of obesity have been inconsistent [158]. Furthermore, accurate measurement of dietary intake in children is notoriously challenging, relying on subjective data or parent proxy reports which are prone to under-reporting [159].

Physical activity (PA) also plays a role in risk of developing overweight and obesity. It has been suggested that there is a low likelihood of achieving meaningful weight reduction through increased PA alone, without restricting energy intake [160,161]. However, PA – including activities undertaken while working, playing, carrying out household chores, travelling, and engaging in leisure activity [162,163] – is an important consideration in the energy balance equation. Participation in moderate PA has been found to protect against obesity, being associated with a lower BMI [164]. Studies have also shown that engaging in moderate to high levels of PA increases energy expenditure and promotes a negative energy balance, as well as having a significant positive impact on insulin sensitivity and reducing the risk of cardiovascular disease [165–169]. A recent meta-analysis showed that exercise improved BMI z-score in overweight and obese children and adolescents [170], but the evidence is inconclusive, and it is likely that the role of prescribed PA in prevention of weight gain remains modest [171].

Sedentary behaviours are distinct from physical activity in that they refer to activities that do not increase energy expenditure above rest and require minimal exertion from the participant, such as sitting, television (TV) viewing and media use. Such sedentary behaviours may encourage excessive energy intake through increased exposure to advertising for nutrient-poor, energy dense foods [65,172–174]; enable 'mindless' eating or snacking with poor portion control [175]; and reduce the resting metabolic rate [176]. Studies have indicated a strong dose-response relationship between prevalence of obesity and hours of television viewed [164,177–179], although it is unclear whether there is a direct causal relation between the two. Sedentary behaviour may also displace participation in PA [171,180], however it is possible for children to have high levels of both sedentary behaviour and physical activity: the two are not mutually exclusive.

The above factors, including diet, PA and sedentariness, are profoundly influenced by the environment surrounding an individual [5,13,181]. The obesogenic environment has been broadly categorised into the macro-environment, referring to the broader structural contexts around the wider population that determine obesity prevalence among the population; and the micro-environment, which refers to those proximal contexts within which individuals live such as the home, work or school [25]. Along with biological and behavioural influences, the micro-environment determines the risk of obesity at the individual level [182]. The two environmental levels interact with each other to directly or indirectly influence individual behaviour [183], and are briefly outlined below. Environmental drivers of childhood obesity in Malta are further elaborated upon in Research Paper 1 (Contextual analysis) [184].

3.1.3.1 The Micro-environment

Children spend the majority of their time at home, at school, and in their neighbourhoods, hence these are key micro-environments ripe for investigation. Younger children's risk of obesity is particularly influenced by their home environment, as they are more dependent on their parents for survival [7,154]. Children's eating behaviours evolve within the constraints of the family context including parent-child feeding styles [89]; parental (particularly maternal) nutritional knowledge; parental food preferences; and the choice of foods made available to children [154]. These in turn are determined by broader cultural and economic factors including the cost convenience, taste and availability of food [154]. Parental physical activity levels and familial television viewing habits are also likely to play a key role in influencing the energy expenditure side of the energy balance equation [87,185].

The school is yet another critical environment that influences risk of developing obesity which has been given substantial attention [186,187]. School nutrition and physical education policies; availability and price of different foods and beverages in school canteens or vending machines; the absence or presence of water fountains; availability of nutrition education in the curriculum; the number, quality and duration of Physical Education (PE) lessons; availability of sports equipment and myriad other opportunities to influence children's and adolescents' dietary and PA behaviour during school hours exist [188,189].

Lastly, several aspects of the neighbourhood environment have been linked with children's diet, PA or weight status including presence of fast food stores [190,191]; walkability and distance from school [192,193]; social ties, crime levels and perceptions of safety [194]; and perceptions of access to parks, playgrounds and gyms [194]. This suggests that neighbourhood environments may be an important level at which to intervene to reduce risk of childhood obesity.

3.1.3.2 The Macro-environment

More distal environmental factors contributing to an obesogenic environment that is not conducive to the maintenance of energy balance include socio-ecological factors such as socio-economic status, ethnicity and parental education, perhaps due to the cost, time or accessibility barriers that individuals with low incomes or education face with regards to opportunities for engaging in PA or accessing nutritious food [195–199]. Analysis of the most recent household budgetary data in Malta illustrates such inequalities, highlighting how the proportion of income spent on food and non-alcoholic beverages varies dramatically depending on income level: expenditure accounted for more than 30% of total household consumption expenditure for households in the lowest net income octile, compared to 17.4% for the highest net income households [200].

At a national level, education and health systems; government policy around agricultural land use; urban planning and transport policies and infrastructure (including land use mix, presence of green spaces, pedestrian and cycling infrastructure, public transport availability etc.); economic instruments such as food taxes and subsidies; food labelling regulations; and societal attitudes and beliefs interact to mediate individual diet and physical activity behaviour [13,25]. For example, increased availability of cheap, energy-dense food and large portion sizes offered in restaurants may synergistically interact with less active lifestyles due to mechanization of workplaces, more frequent car use and more sedentary behaviour during leisure time due to the proliferation of electronic devices, resulting in an increase in population obesity levels. At an even higher level, national and global trade policies influencing food production, distribution and prices; as well as marketing of food (e.g. fast food advertising) also play a role [5,7,25]. If the macro-environment is obesogenic, then population obesity levels may be expected to increase and interventions aimed at influencing individual behaviour are likely to be ineffectual [182]. Comparisons with the public health experience of tobacco control have been drawn, suggesting that a combination of interventional, educational, economic and regulatory approaches simultaneously addressing multiple facets of the environment which were successful in the area of tobacco control can also be applied to obesity [201–203]. Such strategies are likely to become increasingly relevant, particularly following the disappointing lack of progress achieved through efforts at voluntary self-regulation by the industry [204–206]. A benefit of inducing change at multiple levels consistent with an ecological approach is that relatively small changes to the overall environment may induce permanent, sustainable behavioural changes of much greater magnitude which benefit all those exposed to the altered context [207].

3.2 Dietary, physical activity and sedentary behaviour of the Maltese

Individual behaviours that contribute to obesity were briefly illustrated in the previous chapter. Information on the dietary habits and PA levels of the Maltese population is not readily available, consisting almost entirely of self-reported cross-sectional data. What is known about current behaviours among Maltese adults and children is outlined below.

3.2.1 Dietary, physical activity and sedentary behaviours of children and adolescents

Thus far, most knowledge of Maltese children's dietary behaviour derives from successive rounds of self-reported HBSC data, which presents information on a few key dietary indicators including breakfast, fruit and vegetable, and soft drink consumption. Overall, the dietary patterns of secondary school-aged children are a cause for concern. In the latest (2014) round, as in previous years, the proportion of children of all age categories consuming breakfast daily was lower than the HBSC average [100]. Around 50% to 55% of children aged 11, 13 and 15 consumed breakfast daily, with consumption decreasing as children grow older. Daily self-reported consumption of both fruit and vegetables seems to have increased over the past decade, remaining consistently higher among girls than boys across all ages. However, while consumption decreased in older compared to younger boys, consumption increased (in the case of vegetables) or remained relatively constant (in the case of fruit) amongst girls. Fruit consumption is similar to the HBSC average whereas vegetable consumption among Maltese children is lower than the mean for other HBSC countries [100]. Soft drink consumption remains high, with Maltese children leading the country rankings in terms of self-reported consumption as of 2014 [100]. In 2010, 49% and 34% of 15-year-old boys and girls respectively consumed soft drinks daily, compared to the HBSC average of 28% of boys and 22% of girls of the same age. The same report indicated that 44% of 11-year-old boys and girls consumed soft drinks on a daily basis. Overall consumption seems to have decreased slightly since 2010 and stabilised at below 40% across ages [98,100]. The most recent data from 2014 shows that 39% and 34% of 11-year-old boys and girls respectively consume soft drinks daily; similarly, 37% and 39% of 15-year-old boys and girls do so [100]. A 2014 study conducted amongst adolescents in secondary schools indicated that packed school lunches tend to consist of bread with ham, cheese and/or butter fillings, and that the food typically bought by schoolchildren (particularly boys) from tuck shops is often high in salt, sugar and fats [208]. A large scale survey of food preferences among a sample of 1,088 seven to eight year-old children showed that foods rich in carbohydrates were the preferred foods for almost two thirds of respondents, with pasta and pizza being particularly popular. Red meat and meat products were the preferred foods of almost a third of respondents'. Soft drink intake levels were similar to those seen in older children with 50% of respondents reporting daily consumption. Chips were also popular food items [52]. Unhealthy food preferences of Maltese children seem to be forming at a young age and risk being maintained throughout the life course.

Data on PA and sedentary behaviour patterns and their association with obesity in Maltese children is limited. The latest self-reported HBSC data indicates low PA levels overall, with only 9%

and 16% of 15 year old girls and boys respectively reporting at least one hour of moderate-to-vigorous PA (MVPA) daily [100]. This in turn was a sharp decrease from PA levels of 11 year old children (21% and 28% of 11 year-old girls and boys achieving one hour of daily MVPA respectively) [100]. Trend data suggests that the situation among older secondary schoolchildren is deteriorating over time, as the previous (2010) round of the HBSC survey showed that 13% of 15 year old girls and 19% of 15 year old boys achieved the daily MVPA target [98]. Only two studies where daily PA of 10-12 year olds was objectively measured using accelerometers have been conducted thus far. These indicated that total PA was generally very low and significantly lower for girls than boys at all times on weekdays and on weekends until the late evening [209,210]. Researchers also observed significant differences in overall PA and MVPA between normal weight and overweight/obese boys and girls. Girls were significantly less active than boys throughout the week and spent more time in front of a screen (e.g. watching TV or in front of a computer), whereas obese children of both genders engaged in significantly less PA than their non-obese peers after school [209,210]. Only 39% of boys and 10% of girls in this sample met the WHO recommendation of one hour of daily MVPA [211]. The majority of participants also engaged in highly sedentary behaviour: a quarter of children exceeded two hours of screen time during weekends and 50% exceeded this threshold on weekdays [210].

3.2.2 Dietary and physical activity habits of adults

Information on adult food intake thus far has been provided through three nationally representative studies: a food consumption survey conducted in 2010 [212], and two Health Interview Surveys conducted in 2002 and 2008 [213,214]. Results showed that the Maltese consume large quantities of sweets and sugary foods, whereas consumption of vegetables is relatively low [110,214]. Three quarters of respondents reported consuming fruits daily (although no information on quantity is available), whereas half reported consuming vegetables at least once a day [214]. Biscuits, chocolates or sweets are the preferred breakfast and snack choices, whereas the most popular foods consumed during lunch or dinner seem to be bread, pasta, chicken and beef [212]. Daily soft drink consumption was reportedly highest in younger adult age groups (<35 years) and in the elderly (65+ years), and was significantly inversely related to level of education. No quantitative data on food consumption or micronutrient deficiencies have yet been collected, although a second national food consumption survey launched in October 2015 is expected to provide quantitative data on the foods and beverages actually consumed by the Maltese population by 2018. Maltese adults' PA levels have not been extensively researched, however the combined proportion of inactive adults of both sexes has been estimated to be around 72%, the highest amongst all countries investigated in a 2012 Lancet study, and estimated to be responsible for almost one-fifth of all deaths [215]. In contrast, self-reported data from 2008 suggests that 56.5% of adults were physically inactive [214]. In this study, PA levels were observed to decrease with increasing age and exhibited a gender bias where males were more active than females.

3.3 Obesity in Malta: A Contextual Analysis

Preamble to Research Paper 1

The situation outlined in the previous section highlights an urgent need for research on potential drivers of obesity – particularly childhood obesity – in Malta. In response to objective 1 and guided by the theoretical models outlined in the previous chapter, I undertook a contextual analysis of elements of the environment that may contribute to the high prevalence of childhood obesity in Malta. This was also in line with the INFORMAS recommendation to carry out an initial country-level contextual analysis in order to outline country characteristics and factors influencing food environments and obesity prior to commencing monitoring and benchmarking research activity. The analysis showed that only a few local studies exploring the topic have been published in the peer-reviewed scientific literature, although some relevant data were available in the grey literature. A lack of both quantitative and qualitative information on the various dimensions of the potentially obesogenic Maltese environment was evident.

Besides being an important first step towards understanding the broader context around childhood obesity in Malta, the contextual analysis also helped to inform the selection of key informants for interviewing and the topic guide used for the qualitative aspect of this research. In addition, the comprehensive literature search laid the groundwork for the quantitative and qualitative aspects of this research and 'set the scene' for subsequent chapters. It also led to the first original article arising from my research [216], which utilizes the ANGELO (Analysis Grid for Environments Linked to Obesity) [25] framework to discuss Malta's potentially obesogenic environment across several dimensions and settings. Egger and Swinburn's application of the ecological model to obesity [182], provides a useful framework for assessing the plethora of contextual factors influencing childhood obesity in Malta in a systematic manner. Their model proposes that obesity is a "normal response to an abnormal environment", going on to describe a diagnostic conceptual framework for analysis of environmental influences on obesity that could be applied to a number of settings to aid identification and prioritisation of areas for environmental intervention [25,217]. The framework categorises 'obesogenic' influences into two 'levels' of environment: the *micro-*

environment within which individuals typically interact on a daily basis (such as the home, school, workplace, neighbourhood); and the broader *macro-environment* which tends to be outside direct individual control. These include large, geographically diffuse sectors such as the education and health systems, government and private sectors, the food industry and supporting infrastructure. Each environmental level in turn comprises four possible dimensions. The physical dimension describes urban design, land use and transportation [218], as well as the natural environment's impact on behaviour (e.g. climate and terrain quality affecting PA levels). The economic and political dimensions encompass factors such as income, education, socioeconomic status for the former, and national or regional policies and regulations for the latter. Sociocultural factors refer to the broader context within which individuals live, such as societal norms about nutrition and family behaviour. Thus, the article highlights the potential drivers of childhood obesity in Malta, the investigation of which will be one of the objectives of this thesis. It has attracted attention from the local media, generating useful debate about the obesogenicity of the environment in Malta [219].

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SECTION A – Student Details

Student	Daniel Cauchi
Principal Supervisor	Cécile Knai
Thesis Title	Childhood obesity in Malta: contributions of the obesogenic environment

SECTION B – Paper already published

Where was the work published?	Public Health Nutrition		
When was the work published?	December 2015		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion	N/A		
Have you retained the copyright for the work?*	No	Was the work subject to academic peer review?	Yes

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Student Signature: D Cauchi **Date:** 29/07/2016

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Research Paper 1

An obesogenic island in the Mediterranean: mapping potential drivers of obesity in Malta

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Author contribution: I formulated the research question, designed the study, conducted the literature search, and analyzed the data. I drafted the manuscript and made revisions based on comments from Cécile Knai and Harry Rutter.

Abstract

Objectives. The prevalence of childhood and adult obesity in Malta is among the highest in the world. Although increasingly recognised as a public health problem with substantial future economic implications for the national health and social care systems, understanding the context underlying the burden of obesity is necessary for the development of appropriate counter-strategies.

*Design***.** We conducted a contextual analysis to explore factors that may have potentially contributed to the establishment of an obesogenic environment in Malta. A search of the literature published between 1990 and 2013 was conducted in MEDLINE and EMBASE. Twenty-two full-text articles were retrieved. Additional publications were identified following recommendations by Maltese public health experts; a review of relevant websites; and thorough hand searching of back-issues of the Malta Medical Journal since 1990.

Setting. Malta

Subjects. Whole population, with a focus on children

*Results***.** Results are organised and presented using the ANalysis Grid for Elements Linked to Obesity (ANGELO) framework. Physical, economic, policy and socio-cultural dimensions of the Maltese obesogenic environment are explored.

Conclusions. Malta's obesity rates may be the result of an obesogenic environment characterised by limited infrastructure for active living combined with an energy-dense food supply. Further research is required to identify and quantify the strength of interactions between these potential environmental drivers of obesity, in order to enable appropriate counter-measures to be developed.

Introduction

The rapid rise in overweight and obesity rates over recent decades is increasingly recognised as a complex and costly public health problem of global magnitude [86,87,220]. The prevalence of childhood and adult obesity in Malta is among the highest worldwide [108,221,222]. Obesity is a precursor of non-communicable diseases including ischaemic heart disease, cerebrovascular disease and several types of cancer that collectively account for the majority of deaths in Malta [223]. In 2010 over 40% of a national cohort of ten-year old children were classified as either overweight or obese according to

International Obesity Task Force (IOTF, now known as World Obesity / Policy and Prevention[1]) criteria, a substantial increase from the 26% prevalence measured three years previously [104,224]. Other studies using different methods have reported similar findings in younger as well as older Maltese children [97,99,225]. The economic implications for the national health and social care systems are significant, with estimated annual direct costs attributable to the consequences of overweight and obesity in the population aged 15 and over of around €20 million in 2008. This included medical expenses such as in-patient stays, day-patient stays, and GP and specialist consultations but excluded costs related to medication, surgery, ancillary services and loss of income. Assuming no change in the proportion of overweight and obese individuals in the population, the projected cost for 2020 would increase by around €6 million. However, the authors cautioned that increasing overweight and obesity rates in recent years suggest that these calculations are likely to grossly underestimate the true cost [226].

In light of this situation, the Maltese government has launched a number of strategy and policy documents outlining targets and measures intended to increase physical activity and improve nutrition across the population [19,80,110,227,228]. These include a national obesity strategy that outlines a range of possible economic and fiscal measures, targeted multidisciplinary programmes and changes to the environment [80]; on-going education reforms aiming to modify the school nutrition environment and positively affect time allocated to physical activity during or after school hours [110,229,230]; and policies to improve the local physical environment taking into account environmental, economic, social, cultural and infrastructural considerations [19]. However, while political commitments to address obesity in Malta seem to heed the call for a shift in emphasis from treatment of already obese children to prevention and policy-level changes, actions promoting major changes to the physical, economic and social environment have not been implemented, with the majority of current measures predominantly focusing on improving consumer knowledge. The 'obesogenic' environment is defined as "*the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations*". Tackling this obesogenicity requires system-wide environmental interventions that complement educational and behavioural measures in order to create supportive environments [25]. Population-level environmental interventions are cost-effective measures to achieve lasting reductions in obesity because they become incorporated into structures, systems, policies, and sociocultural norms [25,231,232]. However, it

[1] World Obesity / Policy & Prevention (formerly IOTF) is a global network of experts working to alert the world to the growing health crisis caused by soaring levels of obesity. Source: http://www.worldobesity.org/what-we-do/policy-prevention/

is likely that strategies to combat obesity will be more effective if they are appropriate to the national context [5,233]. A recently published framework for monitoring and benchmarking of food environments recommends that an initial country-level contextual analysis be carried out [64] to outline country characteristics and factors influencing food composition or nutrient profiles [234]; food prices [67]; as well as the status of existing government and private sector policies and actions related to food environments, obesity and non-communicable disease [235]. This paper maps out potential drivers of obesity in Malta and outlines areas where further research would be beneficial.

Methods

We conducted a contextual analysis to explore factors contributing to the establishment of an obesogenic environment in Malta, informed by a review of the literature around obesity, physical activity and nutrition in Malta published between 1990 and 2013. Two electronic databases (Medline and EMBASE) were searched using the following key search terms: 'Malta', 'obesity', 'nutrition', 'food', and 'physical activity'; 109 articles were identified. After reviewing abstracts 87 papers were rejected, and twenty-two full-text articles were retrieved. Additional publications were identified following recommendations by Maltese public health experts; a review of relevant Maltese websites; and thorough hand searching of back-issues of the Malta Medical Journal since 1990. Results are organised and presented using the ANalysis Grid for Elements Linked to Obesity (ANGELO) framework [25]. This diagnostic tool, which has been used to conceptualise the obesogenic environment and prioritise action points for obesity prevention in communities [217], outlines two levels of environment: the micro-environment within which individuals typically interact on a daily basis (such as the home, school, workplace, neighbourhood); and the broader macro-environments which tend to be outside direct individual control. These include large, geographically diffuse sectors such as the education and health systems, government and private sectors, and the food industry. Each environmental level in turn comprises four possible dimensions that potentially affect population-level nutrition and physical activity. The physical dimension describes factors such as urban design, transportation, and the home or neighbourhood built environment. The economic and policy dimensions encompass factors such as income, education, and socioeconomic status at the micro-level; and national or regional policies and regulations at the macro-level. Socio-cultural factors refer to the broader context within which individuals live, such as societal norms about nutrition and family behaviour. These four dimensions interact to influence people's diet and PA choices, and will be explored in a narrative fashion to illustrate why Malta could be described as an 'obesogenic' island in the Mediterranean.

Results

Factors affecting nutrition and physical activity are presented separately below for the macro and micro environments.

The Macro-Environment

Factors affecting nutrition

Historical context and the nutrition transition in Malta

Malta's small size, colonial heritage, its longstanding cultural and commercial links with and proximity to mainland Europe, and long-standing dependence on imported foodstuffs have fundamentally conditioned the food system and dietary norms of the Maltese [23]. Tourism, media and the effect of globalisation in the decades since 1960 have also had an impact on consumption of convenience and luxury foods [24]. Thus, despite its central Mediterranean location, the diet prevalent in Malta cannot be said to be truly 'Mediterranean' [236–238], instead exhibiting "…diet and health patterns more typical of Northern Europe than of the Mediterranean" [239].

Colonial Impact

An 1839 British colonial government report described the diet of the Maltese as consisting mainly of bread, seasonal vegetables and occasional fish, with minimal animal produce [240]. This is very similar to the traditional Mediterranean diet that has been shown to significantly reduce incidence of cardiovascular disease [241] and which is typically high in olive oil, nut, vegetable, pulses, cereal and fruit intake with moderate amounts of fish but low meat or dairy product intake [242–247]. Since then, the Maltese economy has progressed from one harnessed to the needs of the British colonial administration, to a diversified open-market economy that is mainly export-driven, with an emphasis on manufacturing, financial services and tourism. Following a process of trade liberalisation initiated in 1989 [24] which facilitated the fast food industry's penetration into the local market, Malta joined the European Union in 2004 and is classified as a high income country by the World Bank.

The nutrition transition

Table 3 shows that between 1961 and 2009, overall energy availability (in kcal) increased by approximately 21%, supporting claims that daily calorie intake in Malta increased significantly during the latter half of the 20th century even as consumption of fatty foods exceeded that consumed in Northern European countries [248]. It is likely that the historical influences outlined above; systematic changes to global food production and distribution systems; improving economic conditions and a dependence on foreign imports have consolidated the shift away from the traditional Mediterranean diet [249,250] and led to the adoption of a more 'Westernised' diet high in refined carbohydrates, meat, saturated fatty acids and salt [237,238,251]. Thus, a century and a half later, a 1986 WHO report portrayed the Maltese diet as an unhealthy one rich in fats and sugar and low in fibre, designating the Maltese as a high-risk group for non-communicable disease [252]. An increase in the variety of available foods; all-year-round availability of food items that were previously only available during the local growing season, and increased accessibility of energy-dense food products [110] in a cultural environment where food occupies a central role has had predictable results. Results from a food consumption study conducted in 2010 indicate that overall vegetable and fruit intake is low, while pasta, bread and meat intake is substantial [212]. Similarly, previous research on Maltese children's diet showed that intake of carbohydrate-based foods such as pasta, pizza and fast food style meals was pervasive, as was consumption of breakfast cereals and soft-drinks. On the other hand, very few Maltese children consume sufficient fruit and vegetables [52]. Health Behaviour in School-aged Children (HBSC) studies have shown that between 2002 and 2010, self-reported daily fruit and vegetable consumption has generally decreased while daily soft drink consumption has increased among 11, 13 and 15 year olds. However, only reductions in fruit consumption among 11-year-old girls and 15-year-old boys were significant at the 95% confidence level (17% reduction, $z = 2.57$, $p = 0.01$; and 12% reduction, $z = 2.06$, $p = 0.04$ respectively) [96–98]. Household expenditure data might suggest a similar trend for the general population. Figure 4 indicates that domestic (i.e. excluding tourist) expenditure on food relative to total domestic expenditure has decreased by around 25% since 1995, while Figure 5 illustrates domestic expenditure on different food categories as a proportion of total expenditure on food and beverages. Expenditure on meat has since risen slowly but steadily since 1995, in contrast to a gradual decline in expenditure on bread and cereals. Spending on confectionery and sugary products has consistently increased in recent years, even as expenditure on vegetables has decreased.

	1961	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
Cereals	1259	1270	1213	1228	1170	1054	1001	1035	1079	1114	1086
Starchy Roots	85	71	27	55	54	58	55	104	132	114	99
Sugar and Sweeteners	367	421	510	506	527	498	499	487	505	514	529
Pulses	116	121	121	80	35	41	47	51	53	50	47
Treenuts	8	10	8	7	9	12	17	21	24	30	28
Oil crops	17	20	19	18	22	22	29	36	36	40	41
Vegetable Oils	199	236	257	218	266	301	316	258	194	166	213
Vegetables	50	55	67	77	83	83	86	86	122	131	141
Fruits	63	61	68	75	75	80	93	127	117	118	105
Alcoholic Beverages	25	28	46	61	89	78	89	99	98	93	103
Meat	136	131	160	184	224	225	236	266	277	298	327
Animal Fats	172	161	195	194	231	217	182	177	198	194	161
Eggs	31	38	48	63	70	63	63	66	58	47	53
Milk	255	246	258	289	325	298	287	270	316	300	286
Fish, Seafood	23	21	21	26	36	30	33	39	55	61	65
Miscellaneous	8	11	16	9	15	17	10	5	9	9	11
Total	2846	2935	3077	3138	3258	3098	3074	3187	3348	3366	3368

To convert kcal to KJ, multiply by 4.184

Table 3. Major sources of dietary energy (kcal), 1961-2010, Malta*

* Five-year moving average; Source: FAOSTAT[253]

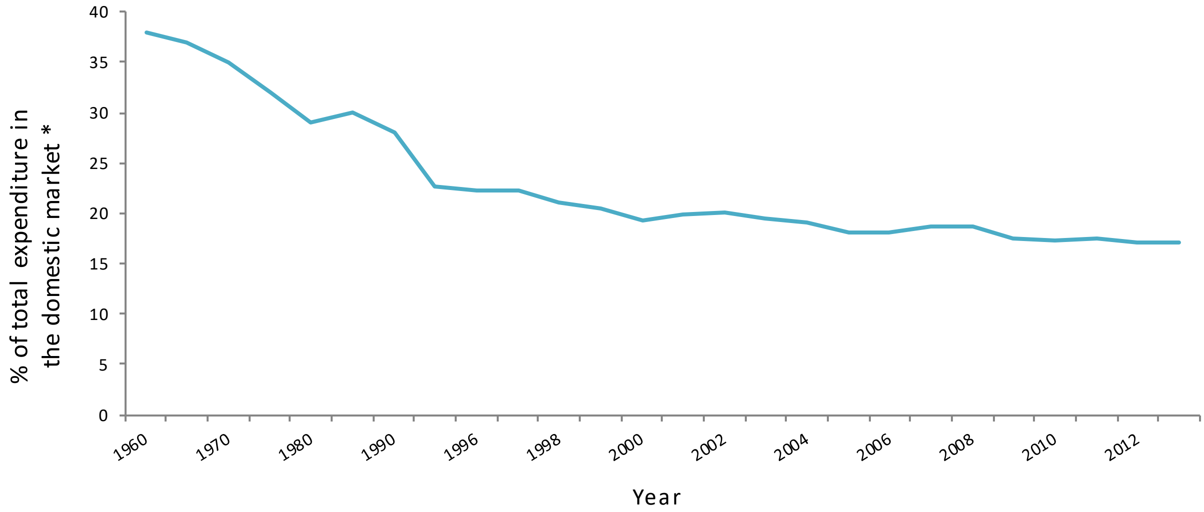


Figure 4. Expenditure on foods and non-alcoholic beverages as a percentage of total household expenditure, 1960-2013, Malta*

* Excludes expenditure by tourists
Source: household expenditure data, Malta (1960-2013) supplied by National Statistics Office, Valletta, (personal communication, 2014).

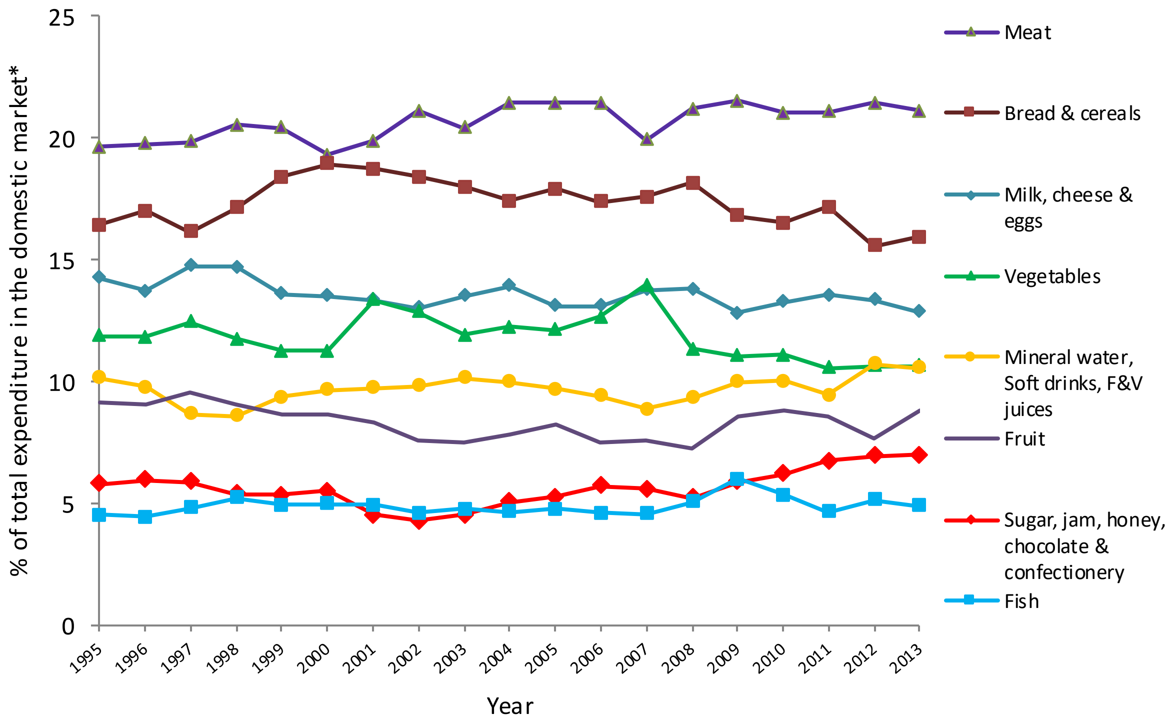


Figure 5. Expenditure on selected food items as a percentage of total household expenditure on foods and non-alcoholic beverages, 1995-2013, Malta*

* Excludes expenditure by tourists
Source: household expenditure data, Malta (1960-2013) supplied by National Statistics Office, Valletta, (personal communication, 2014).

Although Food Balance Sheets[2] data should be interpreted with caution considering the proportionately large number of tourists visiting Malta compared to the permanent resident population, data in Figure 6 show a steady increase in the availability of meat and sugar/confectionery. Vegetable, fruit and fish availability have risen slightly, whereas availability of dairy products has remained mostly stable. At the same time, there has been a decline in availability of cereals. Supplies of both protein and fat have steadily increased by 38.8% and 26.8% respectively since the 1960s (Figure 7(a) and (b)), with a proportionally greater share derived from animal products.

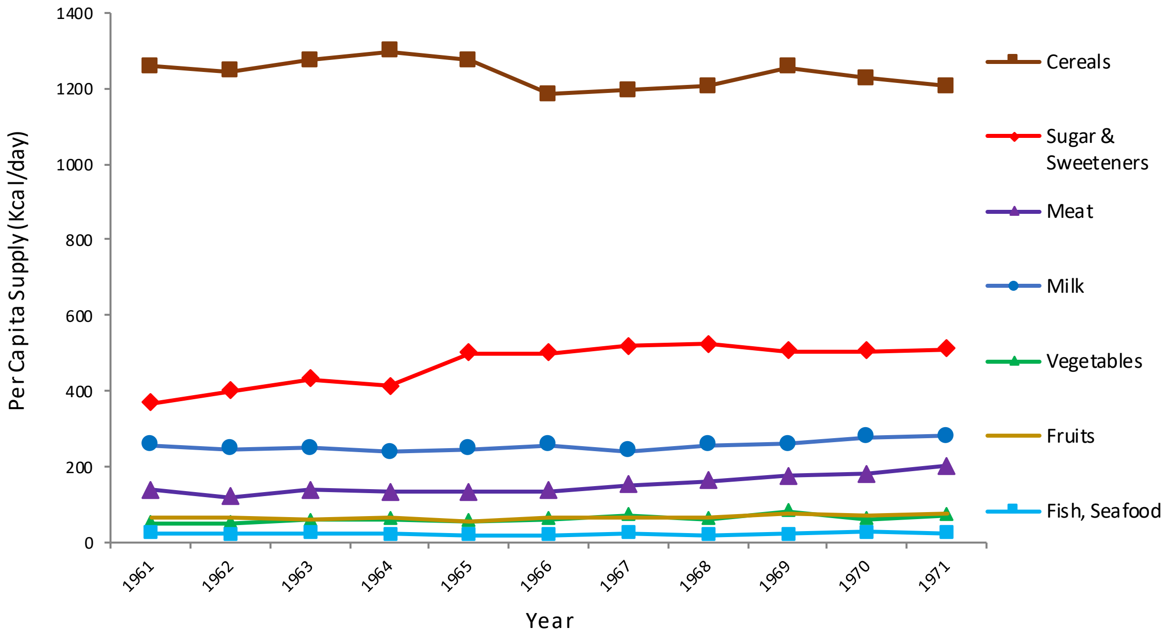
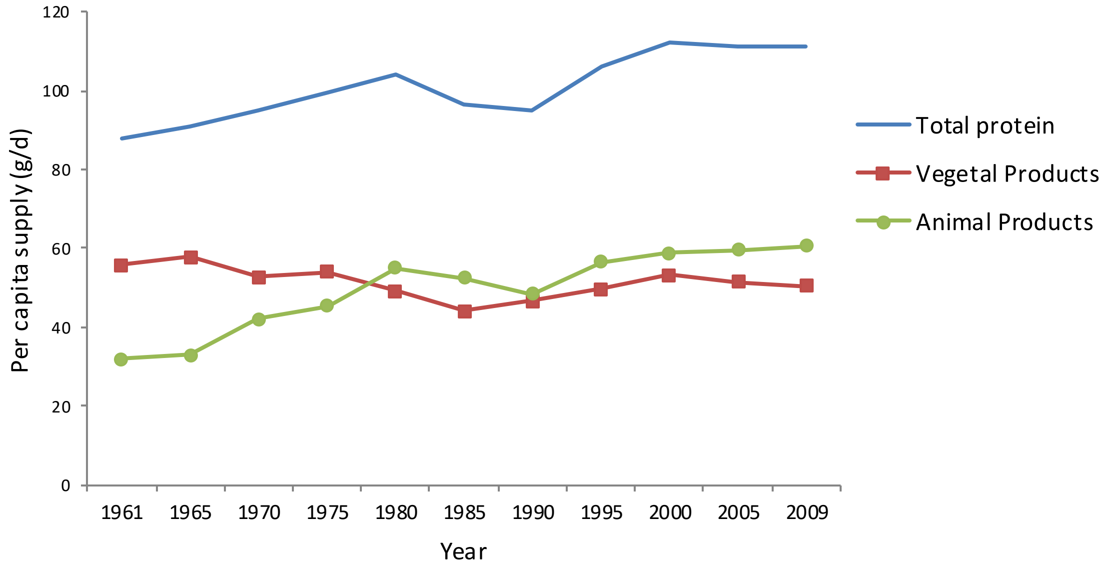


Figure 6. Per capita supply of selected food categories (kcal/d), 1961-2009, Malta
Source: FAOSTAT [253]

[2] Food Balance Sheets (FBS) are compiled yearly by the Food and Agriculture Organisation of the UN (FAO), with country-level data on the production and trade of food commodities. A supply/utilization account is prepared for each commodity. The food component refers to the total amount of the commodity available for human consumption. The FAO FBS also provide total food availability estimates by aggregating the food component of all commodities. These values and population estimates are used to derive and express per-person daily dietary energy and protein and fat supplies (http://faostat3.fao.org/faostat-gateway/go/to/mes/glossary/*/E)



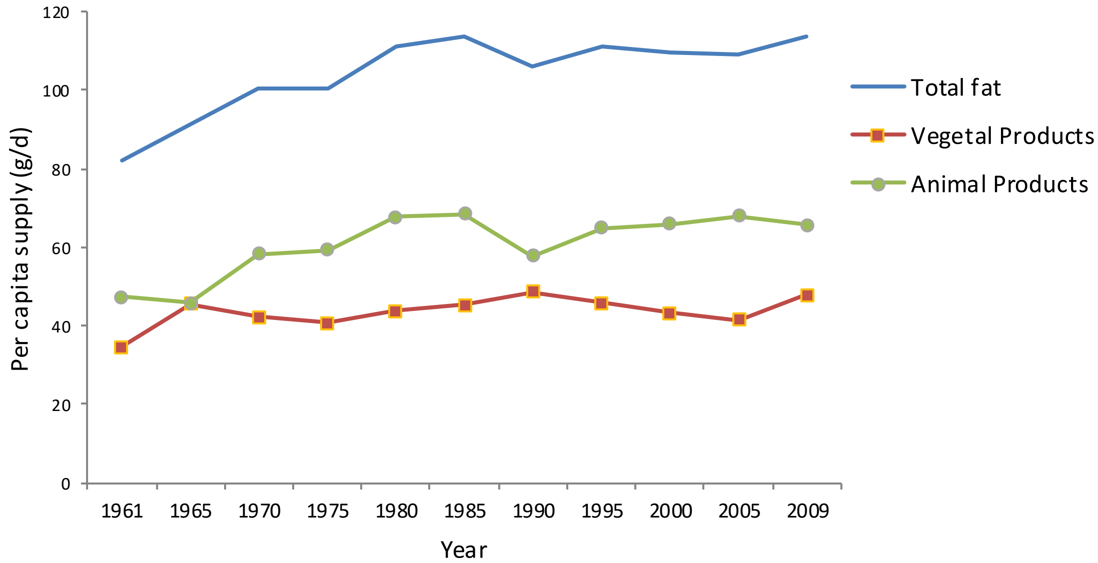


Figure 7. Per capita supply of (a) protein (g/d) and (b) fat (g/d), 1961-2009, Malta
Source: FAOSTAT [253]

Other socio-cultural aspects

Malta underwent a sudden shift from food shortage – particularly during the Second World War when meat and foods rich in fats and sugar were practically unobtainable – to one of affluence, while at the same time the cultural identity shifted from Mediterranean to Anglo-Saxon [251]. Large numbers of Maltese workers who emigrated during the 1950s and 1960s returned decades later with Western food preferences established during their stay in host countries such as Australia, Canada, the USA and the UK [254]. In addition, for many years during and after World War II, Malta was greatly dependent on foreign monetary and commodity aid, including imported foods. This may have negatively impacted the type and quality of food available at the time, and encouraged the establishment of unhealthy dietary practices. The Maltese consume large amounts of cheddar cheese, sugar, corned beef and condensed milk – unusual in the Mediterranean region [24]. Although not a producer of sugar, Malta's per capita supply of sugar is the highest in the EU (Figure 8) and among the highest in the world (FAOSTAT 2013 [253]) indicating that sugar could be a major source of calories in the Maltese diet [238].

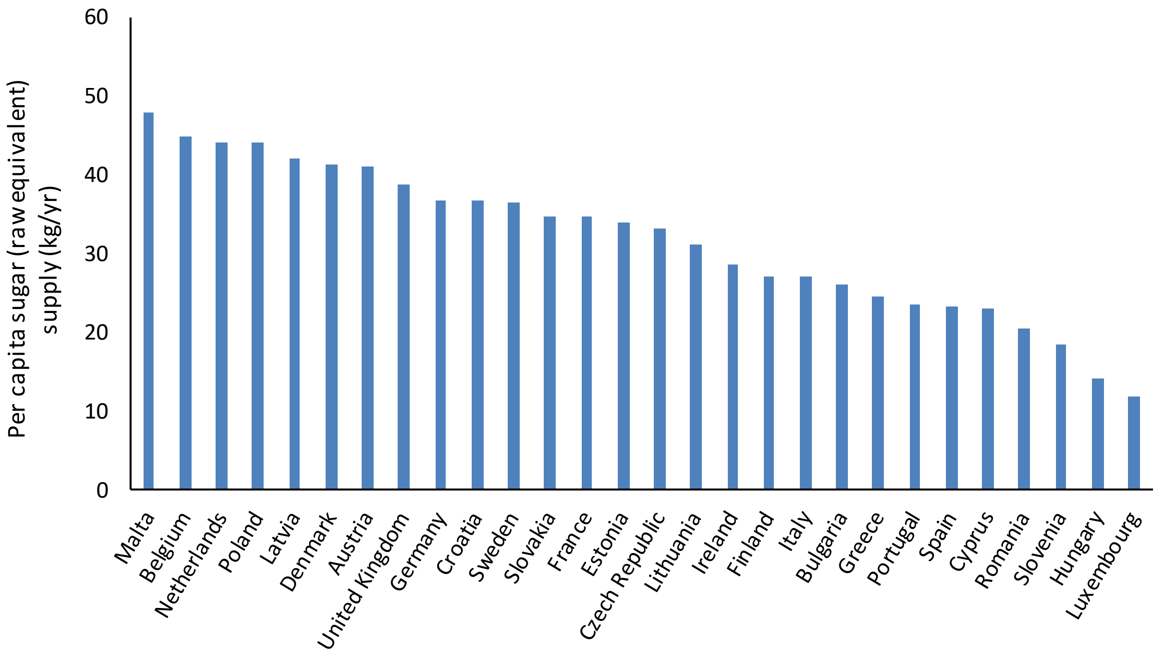


Figure 8. Per capita supply of sugar (raw equivalent) to EU-28 countries, 2011
Source: FAOSTAT [253]

Thus, in spite of increasing awareness of what constitutes a healthy diet, such a 'socially learned' attitude towards food might have been perpetuated from one generation to the next [255] and remains the norm today. Additionally, the Maltese embrace a number of obesogenic cultural norms, such as a marked preference for large portion sizes [212]; a tendency to eat out with family [52,256]; and frequent engagement in religious, public or family-oriented feasts and celebrations that are traditionally characterised by an abundance of food. Village feasts are distinctive cultural traditions that have been commercialised by the food industry, with a plethora of Maltese and foreign fast food such as hot-dogs, burgers, ice-creams, kebabs, chips, nougat, fried pastry and other foods rich in saturated fats and sugars [254].

Food advertising aimed at children

Television viewing reduces energy expenditure through displacement of physical activity, is associated with increased energy intake from snacking, and entails exposure to food advertising [257]. Local research suggests that a majority of primary school children regularly exert pressure on parents to purchase foods advertised on TV [256]. The introduction of cable TV to the islands in 1991 increased the selection of local and foreign (Italian, British and American) programming and advertising to children [52]. Studies have suggested that food marketing targeting children is pervasive in Malta, particularly through point-collection schemes, sponsorship of school events and children's TV programmes, distribution of free materials in schools, offering 'free' gifts with fast food meals and TV food advertising [258]. A content analysis of food advertising on Maltese TV stations during children's viewing hours revealed systematic promotion of fast foods, breakfast cereals, fruit squash mixers and confectionery items [259].

Factors affecting physical activity

Topography and climate

Malta is one of the most densely populated countries in the world [260], and this has been reflected in significantly changing land use over time. Currently, there is a relatively high proportion of urban/industrial land cover (29.7% of the total land area in 2008, up from 21.5% in 2000. This represents a rate of development around three times the EU average; 51% of the Maltese islands is devoted to agricultural use and the remaining 18% covered by natural vegetation [18]. It may be argued that excessive land development has reduced the availability of outdoor spaces where children can be active. Certainly, population participation in sports remains alarmingly low [228] with around 72% of the adult population characterised as being physically inactive in a recent international study [215]. Additionally, Malta's typical Mediterranean climate is characterised by hot, dry summers and mild, rainy winters [260]. Temperatures in summer can exceed 35°C, with high levels of humidity often making the outdoors uncomfortable. High temperatures are associated with reduced physical activity [261], hence climate may also contribute to the low levels of physical activity observed.

Transport preferences

In spite of a fiscal regime imposing relatively high taxation on car registration and purchase of polluting cars together with high fuel costs, Malta has one of the highest per capita car ownership levels in the EU: 607 cars per 1,000 inhabitants in 2009 [262]. 19.6% of households own three cars or more [263]. In spite of Malta's small size and lack of significant inter-city distances that in other countries account for a large proportion of kilometres travelled per passenger, data indicates that three quarters (74.6%) of all journeys are undertaken using private passenger cars [263]. This has been attributed to a 'car culture' which 'embraces and aspires to car ownership'; cars offer greater freedom than public transport with the added bonus of being a status symbol. High car usage and the lack of efficient public transport options have fostered the perception that there is no choice in transport, a mind-set which is exacerbated by social status, peer pressure and culture [264]. Malta's high motor vehicle density has exerted pressure on national transport infrastructure leading to significant capacity problems and traffic bottlenecks outside of peak hours that further incapacitate the public transport system. The Public Transport Reform launched in 2011 was intended to kick-start a shift towards public transport use. However the reform did not achieve the desired effect, culminating in the transport system's re-nationalisation in December 2013 [265]. Concurrently, levels of both walking and cycling in Malta are low [266]. This has been attributed to a range of factors including Malta's hilly topography and sub-tropical climate, poor road conditions coupled with a lack of cycling infrastructure, road congestion, air and noise pollution, and high levels of perceived road danger [263,264].

Taxation and subsidies

Governmental efforts to exert control on supply and availability of unhealthy food products, have been rendered mostly ineffective by trade agreements, common markets and trans-national marketing of food products and food chains [110]. However, the feasibility of fiscal incentives to encourage healthy nutrition, increase the availability of healthy food outlets and restrict outlets selling fast foods are currently being explored by the Maltese government [80]. Malta is also a signatory to the European Charter on Counteracting Obesity [267], which emphasised the importance of subsidies, reformulation and marketing restrictions.

The Micro-Environment

Factors affecting nutrition

Children tend to have limited autonomy in their food intake and physical activity levels, with the majority of their choices determined by their parents and immediate family, and to a lesser extent their peers [268]. A study on Maltese 8-10 year olds showed that children most liked eating pasta, pizza, chips, fruit and burgers, whilst their least liked foods were vegetables, meat, fish, soup and fruit [256]. They are also heavy consumers of soft drinks [52].

Community food environment

Although self-sufficient in the production of most fresh vegetables, milk and eggs, Malta is partially dependent on imports of meat and potatoes and completely dependent on imports of grain, flour and sugar. Around 71% of the island's food requirements are imported [253,262], and this may have shaped Maltese eating habits in a process of food acculturation [255]. Limited research on factors influencing the broader food environment in Malta exists [23,24]. There have been informal calls for action to limit proliferation of fast food establishments or street hawkers outside schools, often frequented by children and parents immediately after school hours [269]. Small grocery stores offering fresh fruit and vegetable produce in some villages have gradually disappeared, as customers were attracted by competitive prices and wider choices offered by larger outlets. However, roving vendors selling fruit and vegetables are popular in many villages, possibly enhancing access to fresh food access for certain households [110]. A more recent phenomenon is the presence of mobile vendors selling doughnuts, ice cream and sweets – often directly targeting children by parking in the vicinity of schools – announcing their presence with loud jingles or catchy phrases, and which have proved to be extremely popular [269]. Mobile vendors have been shown to impact children's snacking opportunities [98]. In many villages, such food outlets provide a convenient alternative to cooking fresh meals. Figure 9 shows a rapid increase in the overall number of trading licenses issued to confectionery stores; 'pastizzeria' outlets (stores selling cheap pastry products high in fat and sugar content and baked on-site, such as cheesecakes or sausage rolls), and – more recently – to mobile vendors selling doughnuts. The introduction and proliferation of major fast food chain outlets in Malta since 1995 has been followed by heavy marketing in the Maltese mass media [256,259]. It is not unusual for children to be taken to such outlets as a treat for good behaviour [52].

Educational settings

The 2007 Healthy Eating and Lifestyle Plan (HELP) document outlines steps to be taken in schools to promote healthy lifestyles for Maltese students, providing voluntary guidelines to a health-promoting school environment and curriculum. It recommends regulation of foods sold in state school canteens or vending machines, as well as school policies to control content of students' packed lunches (school meals are not provided to school children in Malta) [230]. It is currently being revised prior to its introduction as standard policy in state schools. However, HELP cannot exert control over the retail environment outside schools, where children often purchase snacks [256].

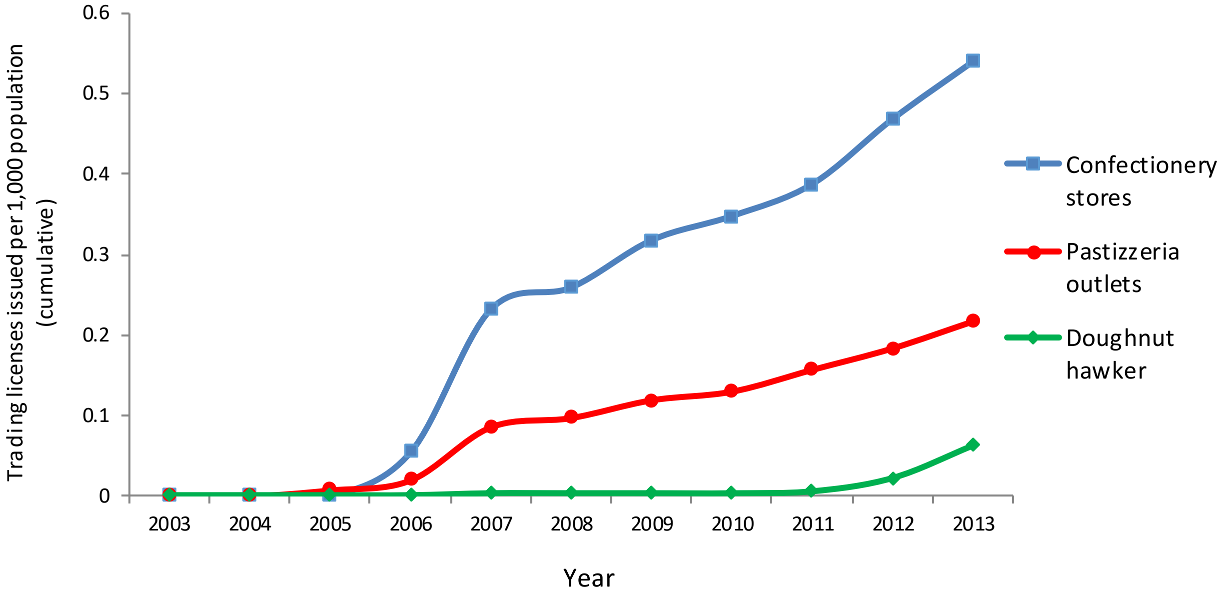


Figure 9. New trading licenses per 1,000 population issued between 2003 and 2013 for selected food outlets/mobile vendors, Malta (cumulative)*

* New trading licenses allowing food to be sold on-site, issued by the Environmental Health Directorate between 01/01/2003 and 31/12/2013 (showing vendors operational as of 31/01/2014)
Source: Environmental Health Directorate, Msida, Malta (personal communication, 2014)

Other efforts to improve schoolchildren's nutrition within the school setting include the provision of free milk daily to primary state-school students; the introduction of a 'Breakfast Club' offering a free healthy breakfast to children of working parents who attend state schools; and a EU co-funded 'School Fruit and Vegetable scheme' where a portion of pre-packed fresh fruit or vegetable is given weekly to all primary schoolchildren in Malta [270]. The 1999 Maltese National Minimum Curriculum (NMC) stipulated lessons on nutrition and specifies a number of hours of physical education (PE) weekly, yet these are often sacrificed in favour of other academic subjects deemed to be of greater priority [271]. Currently, PE policies are not consistently enforced across schools, and these activities are timetabled for a range between 60 minutes a week in certain church schools to more than 120 minutes a week in independent schools [272]. Starting in September 2014, a compulsory subject (Physical Health Education) comprising elements of physical education and Home Economics was introduced to all primary and secondary school students, based on the rationale that compulsory certification might improve participation rates and decrease physical inactivity in schools [229].

Social and educational status

Parental social and educational status are strongly associated with obesity [197,273–275]. The 2005/2006 WHO Health Behaviour in School-aged Children (HBSC) Survey [97] demonstrated an inverse association between family affluence and self-reported overweight and obesity amongst European children. An inverse relationship between educational level and obesity in Malta was shown in the 2008 Health Interview Survey and other studies [214,222]. Economic considerations may impact familial food choices particularly during times of financial hardship: one consequence of economic insecurity as a result of the recent financial crisis is the relatively high proportion of Maltese having part as well as full time jobs [276]. This may leave less time for parents to cook healthy food or accompany children outdoors, potentially leading to unhealthy food choices and lack of exercise opportunities [277].

Home food environment

Eating behaviours and physical activity of Maltese adolescents are particularly variable and tend to be influenced by both individual and environmental factors [278,279], as well as familial patterns of overweight [154]. Parental overweight status is itself a strong predictive risk factor for childhood obesity particularly in deprived families, whereas parental leanness seems to confer protection against development of childhood overweight regardless of family socioeconomic status [87,280]. This has significant implications for Maltese children given the large proportion of overweight and obese adults in the population. Little is known about consumption in the home, however it has been suggested that snacks are eaten in addition to, rather than displacing, set meals in Malta, resulting in a high frequency and level of food consumption [52].

Factors affecting physical activity

We found little information on policies or interventions that might influence physical activity levels of Maltese children in the community and at home; the majority of studies and policies identified in the literature review focused on the food environment.

Physical activity in the community and at home

Gross Domestic Product and public sector expenditure on health have been positively associated with increased leisure time physical activity [281]. Government investment in recreational and sport facilities in Malta has gained momentum with a number of sports facilities inaugurated over the past two decades. Local sporting events are often subsidised by the government, and access to fitness facilities in state-run leisure centres is heavily subsidised in a bid to encourage attendance [228].

Additionally, outdoor fitness centres are being created to provide space for physical activity (C. Gauci, personal communication, June 5, 2014). Although studies on the extent of sedentariness in Maltese children are lacking, the highly prevalent use of TV and gaming technology as 'babysitting' devices has been identified as a target for action in the Healthy Weight for Life Strategy [80].

Discussion

The health and economic costs of excess weight in Malta continue to rise, leading to a situation where the morbidity and mortality burden of obesity-related disease such as diabetes and cardiovascular disease are higher than the European average [110,223,254]. This may have been driven by a strongly obesogenic environment, with multiple drivers across different settings, sectors and the life-course of unhealthy eating and low levels of physical activity. However, data characterizing the links between these various environmental components and childhood obesity is currently lacking or difficult to access. There is a clear need for an integrated whole system approach that considers both health and non-health sectors (including trade, agriculture, transport, and urban planning) in order to create synergies that support sustainability of actions and policies [38]. The role of public health action should be to restore a level playing field in which physical, socio-cultural, economic and policy drivers are shifted to create healthy defaults, making healthier choices the easiest choices [282]. For example, the burgeoning agro-tourism sector in the Maltese islands might be encouraged to capitalise on its 'healthy lifestyle' message by offering cycling tours, which in turn would benefit from construction of cycle lanes between areas of interest. Encouraging active travel through provision of appropriate infrastructure would also benefit local mobility, thus creating a self-sustaining system that promotes an active lifestyle for all. Such multi-component, community-based initiatives have been reasonably successful in preventing obesity in children [283,284], and provide best-practice evidence for interventions that can be applied to Malta. Crucially, they are aimed at both changing children's behaviour directly, and at altering their environment. We have applied the ANGELO framework to structure discussion of obesogenic factors in the Maltese environment emerging from our review.

Economic factors

Figure 6 indicates that food availability in Malta is increasing slowly but steadily even as proportional domestic expenditure on food decreases; however, this may simply reflect improving income levels in the general population [233]. As yet, no nationally representative food consumption data are available for Malta, making it difficult to derive conclusions about proportional expenditure or nutritional habits at population level. A qualitative food consumption survey conducted in 2010 does not provide information on actual quantities of food consumed. FBS data are based on food import, export and production data, and hence should be interpreted with caution in view of potential seasonal increases in food supply in response to tourist demand. Establishing a national survey mechanism to collect trend data on food consumption (including children) and food pricing would enhance our knowledge of food habits and the influence of prices on food consumption, enabling the development of evidence-based nutrition policy recommendations targeting specific sections of the population. Other economic considerations operate at the micro-level. For example, Maltese schoolchildren are often given money to purchase their own snacks on school days [256], leading to potentially unhealthy snack purchases dependent on cost, availability and taste. Family lifestyle and socioeconomic status are also likely to influence accessibility, variety and quality of food eaten by children; as well as their access to sports and recreational facilities (e.g. through parental willingness to pay for sports equipment or club membership fees).

Physical factors

While schools remain a key setting for provision of structured physical activity to Maltese children, actual time spent being physically active during a physical education lesson is limited to a small fraction of the total time allocated [271]. Regular auditing of actual time spent being physically active should be carried out in all schools on a regular basis, and ideally more sessions allocated for physical activity [284]. The introduction of a new compulsory subject combining healthy eating, physical activity and body image in secondary school curricula may help foster healthy dietary habits and enhance overall levels of physical activity, and is a recommended component of best practice interventions [284]. This will complement an existing scheme that aims to shape children's food preferences and promote sustainable consumption of fruit and vegetables through once-weekly distribution of free fruit and vegetables portions in primary schools [270]. At a population level, it remains to be seen whether the desired shift away from car usage towards public transport can be achieved. Furthermore, we did not find evidence of policies aiming to encourage alternative forms of urban mobility (such as through the provision of bicycle lanes) or to increase levels of physical activity in the community or at home. Further studies exploring the feasibility and effectiveness of interventions in these areas would be useful.

Socio-cultural factors

Eating habits and food preferences are established at a young age and maintained into adolescence [285,286]. Food norms are passed on across generations through a process of socialisation, moulding children's preferences [255]. In turn, preferences may influence intake either directly through children's requests to adult food providers, or indirectly through adults' fulfilment of perceived children's preferences. Best practice recommendations to create an environment and culture that supports children eating nutritious foods and being active from an early age include provision of support to school staff for the implementation of health-promotion strategies and activities, and the engagement of parents to offer complementary action within the home (e.g. discourage screen-based activities) [287].

Systematic advertising of sugar sweetened beverages may help explain Maltese children's preference for soft drinks over water [52] and the high rate of soft drink consumption in Malta – second only to Mexico [288] – however there is a lack of evidence to support such conjectures. An analysis of online media advertising targeted at children has not yet been carried out in Malta. Additionally, a comprehensive content analysis of television and other audio-visual media advertising that expands upon the single dissertation study tackling the topic [259] would help formulate targeted policy responses to inappropriate advertising to children. Both multi-faceted school based programmes with active physical education components as described above, and initiatives to reduce TV advertising of high fat and/or high sugar food and drinks to children, have been found to be highly cost effective interventions [289]. At the same time, fast food outlets continue to proliferate, advertise and innovate in response to consumer demand [290], further compounding the change in nutrition habits. Although 'pastizzerias' and confectionery stores have been around for decades, could their recent apparent proliferation be due to changing consumer preferences, followed by a market response to demand? For example, children with working mothers may be more likely to watch more television and eat prepared food than children with mothers who do not work outside of the home, or to stop at a junk food outlet on their way to private tuition lessons after school [52]. It is difficult to clarify the links between the evolving food environment, nutritional and physical activity habits and their impact on obesity rates when baseline quantitative data are lacking. Although the evidence base on associations between neighbourhood environment and weight status is mixed [249,291], local research on the potential impact of neighbourhood built and food environment on lifestyle might open up alternative avenues for policymakers in Malta to explore. Furthermore, Malta is visited by more than a million tourists annually [260] adding yet another layer to this complex issue. It may be the case that tourism has facilitated the assimilation of non-native foods, either by mere exposure to discourse around non-Maltese cuisines or by actual provision of such cuisine in local catering establishments [52]. Working with industry to encourage reformulation of food – and limit portion sizes – served at catering establishments may be an integral component of an overall strategy seeking to reduce food intake at population level.

Policy factors

The policy environment at both macro and micro-level influences behaviour. Thus informal household rules regulating time spent watching TV, playing video games or other sedentary activities; and rules around food such as eating meals together as a family or limiting snacks may critically shape children's attitudes towards food and physical activity levels through their lives [34]. More broadly, state-imposed regulations around food labelling and advertising aimed at children may directly or indirectly impact children's risk of overweight and obesity [231]. Currently no national standards on labelling of food items to facilitate healthy food choice exist, although the National Obesity Strategy suggests a need for such standards and EU legislation entered into application in December 2014 [292]. Additionally, there has been little in the way of policy response to reduce the impact of advertising on children [80].

Conclusion

Many aspects of the physical, social, economic and cultural environment in Malta favour a positive energy balance, characterised by limited infrastructure for active living combined with an energy-dense food supply. Alleviating the future health and economic burden of obesity-related disease will require a deeper understanding of the ways in which Malta's geo-political background, cultural identity, physical environment and other drivers of obesity have changed over time. The collection of trend data related to food consumption, physical activity, and changes to the built environment will enable the strength of interactions between these drivers to be quantified and appropriate counter-measures to be developed.

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End of Research Paper 1

3.4 Policy response to obesity in Malta

Public health policymakers in Malta have responded to the issue of obesity. The policy process around obesity in Malta has been underway since the mid-1980s [24,293,294], and seems to have accelerated in pace in recent years. A brief description and timeline (Figure 10) of the policy process relevant to childhood obesity is outlined below. Over the past three decades, the Maltese health authorities have published a number of policy documents that initially focused on altering dietary patterns. These were subsequently complemented by specific strategies to increase physical activity and reduce obesity. However, such interventions often emphasise individual behavioural change and clinical management of childhood obesity, which are of limited effectiveness [295,296].

The policy theories outlined in Section 2.1.2 Policy theories help to frame and disentangle elements of the policy process around obesity in Malta. The Multiple Streams Approach conceptualizes the policy process as three independent streams flowing through the policy system: problems, politics and policies [48]. Obesity is a 'problem' or issue that may in part have come to the attention of policymakers following a combination of events that received media and policy entrepreneur attention. For example, the 1986 and 1988 conferences on nutrition in Malta focused attention on NCDs and the role of diet [297] (Figure 10), whereas more recently, research on the prevalence and burden of obesity have been picked up by the local media [298–301]. Newspaper publications also regularly direct public attention towards the issue, usually following exposure regarding the severity of obesity in Malta by the international media [302]. Maltese adults have been called amongst the laziest and most car-dependent in the world [298,303–305] and there has been substantial online debate on the topic [219,298,304,306,307]. Thus, obesity gradually moved higher up the policy agenda in Malta, leading policymakers to start looking for potential solutions to the problem (i.e. the policy stream). Thus far, the political subsystem charged with managing the issue of obesity in Malta has been dominated by entities within the Ministry for Health. The Health Promotion and Disease Prevention Directorate (HP&DPD) in particular has driven the policy process around obesity for decades. As the links between obesity and the environment are recognised, a more inter-sectoral approach to health policy making is slowly being adopted, and HP&DPD is increasingly reinventing itself as an entity whose focus is to create links between sectors and stakeholders with the aim of improving health. At a higher level, EU and WHO interest in tackling obesity has had a significant impact on the policy process in Malta. Princen and Rhinhard (2006) describe how agenda-setting in the EU takes place in two ways: 'from above' through high-level political institutions urging EU action, and 'from below' through policy experts formulating specific proposals in low-level groups and working parties [308]. Thus, joining the EU has brought significant health reforms [309] and is likely to have resulted in obesity being given greater importance (i.e. being driven higher up the agenda) within the broader political environment due to Malta's participation in EU High Level Working Groups and other policy-making fora on the topic. However, despite increasing recognition that policies outside of the health sector have a significant impact on the health of a population and health inequalities [5,310,311], the majority of policies proposed in the national obesity strategy consist of politically acceptable educational campaigns or behavioural intervention that do little to challenge the status quo (Appendix 1).

Lastly, the politics stream consists of three main elements: the national mood, pressure group campaigns and administrative or legal turnover. Public opinion and public support for policy, in particular, have been shown to be crucial for obesity policy in the United States (US) [312–314]. Few would deny that obesity is a public health problem and a cause for concern in Malta, yet public opinion regarding the topic has not been studied and is relatively unknown. The main forum for expression of public opinion on potential solutions to obesity thus far has been the comment section of online newspaper articles [315–317]. Current opinion may even be inimical to public health policy, as illustrated by a recent episode where a major newspaper's April fool's publication suggesting that the EU was about to ban pastizzi (a typical savoury Maltese delicacy) due to their high fat content generated an unusually high number of comments and allegedly boosted pastizzi sales [318]. Of the three elements in the political stream, the combination of national mood and turnover in government exerts the most powerful effect on the agenda [35]. More research on public opinion and beliefs around causation of obesity and about the range of potential public health measures to target obesity would be helpful, as these have been linked with support for obesity policy in the US [312,314].

Punctuated Equilibrium Theory also offers a useful framework for tracing policy progress over time. As illustrated in the policy timeline in Figure 10, obesity-related policy in Malta also underwent long periods of political stability punctuated by short yet intense periods of dynamic change. Two key conferences occurring in the late 1980s stimulated public and political interest in the nutrition of the Maltese population and eventually led to the development of landmark policies aimed at improving health in the early 1990s. This was followed by two decades of relative stability, supplemented by the occasional 'incremental' change in the policy environment. The surge in policy activity from 2010 onwards suggests that Malta is undergoing another 'punctuation' in the policy process as obesity rises higher up the political agenda, abetted by external and internal influences which have shifted attention towards the problem. External influences include Malta's active participation in EU- and WHO-Europe-led efforts to tackle obesity and improve population health [110], whereas internal influences include public concern about the rising rates of obesity and political concern over its contribution to present and future healthcare costs. A more in-depth discussion of nutrition and obesity-related policies follows below.

3.4.1 Policies from 1980 to 2009

3.4.1.1 Nutrition Policies

The foundations for a national nutrition policy were laid during a joint WHO/Department of Health Nutrition Conference in 1986 where dietary evidence from a number of sources (including the 1984 MONICA survey, the first study to assess Maltese dietary habits and NCD prevalence, including prevalence of obesity) was reviewed [319]. The debate highlighted the Maltese population's poor dietary habits and concluded that the consumption of sugars and fats should be reduced, whilst fibre intake should increase [320]. A number of strategies to achieve these objectives were proposed, including measures to increase knowledge and awareness about food; improve food safety and quality; and enhance availability of certain foods through changes to food production [294]. Specifically, recommendations for substituting fish and poultry for beef; replacing high-fat dairy products with low-fat alternatives; reducing egg consumption and increasing consumption of fresh fruit, vegetables and whole grains at population level were made [294]. These remain valid proposals today. Consequently, a multi-sectoral National Advisory Committee on Food and Nutrition (NACFN) consisting of government, industry and consumer representatives was set up with the task of formulating a nutrition policy for Malta [24]. These events were followed by a second Nutrition Conference in 1988 which emphasised the need for political support for actions within the sphere of nutrition [294,321]. The two conferences stimulated considerable public debate around, and political awareness of, the high risk health status of the general population and the contribution of poor dietary habits to the NCD burden in Malta, giving rise to calls for population-level intervention programs [24,297]. This eventually led to Cabinet approval of Malta's first Food and Nutrition policy that same year [321,322]. At the time, the focus was not on excess weight *per se,* and there was little mention of obesity. Instead, the link between poor diet and the emergence of NCDs was highlighted. The policy made concrete recommendations aimed at improving Maltese dietary habits, and included quantitative nutrient goals at population level. It also emphasised the need for interventions during childhood, although at the time these were limited to educational campaigns and school curriculum modifications [322]:

> *"Awareness must start from the early ages. The necessary education on nutrition in schools must be provided to both boys and girls."* [The Malta Food and Nutrition Policy, 1990]

The Food and Nutrition policy was a milestone of public health nutrition policy in Malta. It provided a mandate for action and proposed a clear description of the organisational structures required for successful implementation [238]. At the time there was limited awareness of the contribution of environmental factors to obesity, and this is to some extent reflected in the policy document's content. There is a clear focus on enhancing nutritional awareness and dietary knowledge, yet even so several actions aimed at modifying the obesogenic environment were proposed. These included providing nutritional training to teachers and primary health care workers; regulating hawkers and licensing tuck shops in the school setting; subsidies on the distribution and production of locally produced food items; and introducing controls and nutritional specifications for imported foods. Unfortunately, few of these areas for action were successfully implemented over the next decade. For example, government efforts to exert effective controls on the supply and availability of foods on the local market were hindered by trade agreements, the common market, international marketing of food products and the proliferation of fast food outlets [110].

Promotion of breastfeeding was also perceived to be a means of reducing the NCD burden. Malta's first national policy on breastfeeding was based on the Innocenti Declaration of 1990 which appealed to governments to support, protect and promote breastfeeding [323]. Its stated aim was to re-establish and reinforce a breastfeeding culture aimed at promoting breastfeeding from birth and improving infant and young child feeding practices [324]. It set an ambitious long-term target of 90% exclusive breastfeeding on discharge and 80% at 4 months, to be achieved through measures such as the establishment of a hospital-based breastfeeding policy by 2000; establishing surveillance mechanisms to monitor breastfeeding rates and promoting public awareness of the importance of breastfeeding through education campaigns and curricular changes in primary and secondary schools [324].

The school setting also received attention during this period. The 2007 Healthy Eating Lifestyle Plan (HELP) acknowledged the importance of providing a supportive school environment to encourage a healthy lifestyle and promote healthy choices early on in life and represented an attempt to regulate the political, socio-cultural and physical dimensions of the school environment [230]. Aimed primarily at state schools, the guidelines were extensively taken up by and improved upon by independent and church schools. HELP contained a number of recommendations that focused on modifying the school environment rather than altering student behaviour. For example, besides introducing curricular changes to highlight "*health, diet, nutrition, food, safety and hygiene, food preparation and cooking and [promote] physical exercise as part of a healthy lifestyle*", the guidelines also established 'Food and Beverage Standards' intended to enhance the nutritional value of food provided in schools whilst prohibiting nutrient-poor food. Such nutrient and food-based standards have been shown to be effective elsewhere, and may play an important role in promoting dietary health [325]. This list of prohibited and acceptable foods was accompanied by product nutrient thresholds for fats, saturated fats, total sugars and salt. Notably, the nutrient standards were meant to apply to all food and drink provision within the school setting, including products sold in tuck shops, vending machines and catering provided during special events. There are some apparent inconsistencies within HELP, such as considering foods high in fat, sugar and salt (HFSS) such as pizza with a 'healthy' topping, pies and cereal bars to be acceptable food items for sale in school tuck shops. Furthermore, the nutrient standards were simply percentage-based maximum thresholds for fats, total carbohydrates or sugars listed as footnotes within the document. State schools were provided with guidance on how to draft and implement their own healthy eating lifestyle plans, and a 'Health School Nutrition Audit Board' that could conduct periodic audits was established to promote compliance with HELP standards and regulations. Some consideration of regulation was also in evidence: the guidelines recommended that tuck shop contracts be in compliance with the nutrient standards, and offered support and guidance to Heads of Schools when drawing up and monitoring such contracts. There was also mention of other initiatives such as establishment of a legal framework that would restrict food items offered by shops/hawkers operating in the vicinity of schools; regulation of media advertising to children to ensure consistency with nutrition messages promoted in schools; and protocols to ensure that senior school representatives would be involved at the planning stage of any new schools being built in order to facilitate the provision of a healthy eating environment which is conducive to healthy eating [230]. Ultimately, however, the HELP guidelines remained just that: guidelines. Implementation across state schools was erratic, and no enforcement was undertaken [269]. During my fieldwork with state school students in 2014, I was informed by students that a substantial proportion of secondary school canteens or tuck shops sold foods such as pizza, sausage rolls, pastizzi, ice cream, sweets, savoury snacks and so on. Primary schools (which do not have tuck shops) seem to have adhered to HELP guidelines more stringently than secondary schools.

Malta joined the European Union (EU) in May 2004, paving the way for the country's active participation in several EU-led efforts to improve population health. These included participating in the High Level Group on Nutrition and Physical Activity and the Vienna declaration on Nutrition and Noncommunicable Diseases [326]. Since EU legislation regarding trade agreements now apply to Malta, EU accession also implied an end to efforts to control food imports at country level. Malta's efforts to address population nutrition and obesity continue to operate within the framework of the EU. For example, Malta has transposed a food labelling regulation making 'back-of-pack' nutrition labelling mandatory (i.e. manufacturers are obliged to provide information on the energy value and 6 nutrients; fat, saturates, carbohydrate, sugars, protein and salt, expressed per 100g or per 100ml of product) [327].

3.4.1.2 Physical Activity Policies

Upon its enactment into law in January 2003, the Sports Act of 2002 [328] established a framework for the regulation of sports in Malta through the creation of a governmental organization called the Malta Sports Council (KMS), which was charged with the responsibility of promoting population participation in sport. KMS (now known as SportMalta) is the entity responsible for monitoring and evaluation of all sports organizations and activities. It is also responsible for the maintenance of public sports facilities including a number of sports complexes and sports grounds, as well as providing government-subsidised services aimed at increasing physical activity levels of children and adolescents on weekends during the scholastic year (SkolaSport) and during the summer months (SkolaSajf). "Reshaping sports – towards personal development, health and success" (2007) is the most recent physical activity-related policy, intended to broaden accessibility of sports activities, promote sports, and educate people about the health and social benefits of exercising [228]. Although some emphasis is made on increasing the provision and accessibility of sports facilities to facilitate physical activity, it does not contain quantitative objectives or plans for evaluation.

3.4.1.3 Miscellaneous policies with the potential to influence obesity

Given the importance of factors external to health upon obesity, it is important to consider policies affecting sectors that indirectly influence nutrition and physical activity behaviour. For example, policies related to transport and the environment may impact physical activity levels. The National Environmental Health Action Plan (NEHAP) functions as a policy framework document to implement more sustainable transport alternatives, including encouraging the use of more active forms of transport [329]. The National Environment Policy [19] additionally emphasizes the environment as a priority in all aspects of life including transport, town-centre management, and the provision of public spaces to increase physical activity. It specifically considers the contribution of the urban environment to countering obesity, stating the need for *"providing safe opportunities for regular exercise in order to reduce national levels of obesity"* when outlining plans for the upgrading and additional provision of public open space. Although the policy outlines a number of qualitative goals to be achieved and the evaluative mechanisms through which progress can be traced, no timeline or quantitative targets are presented.

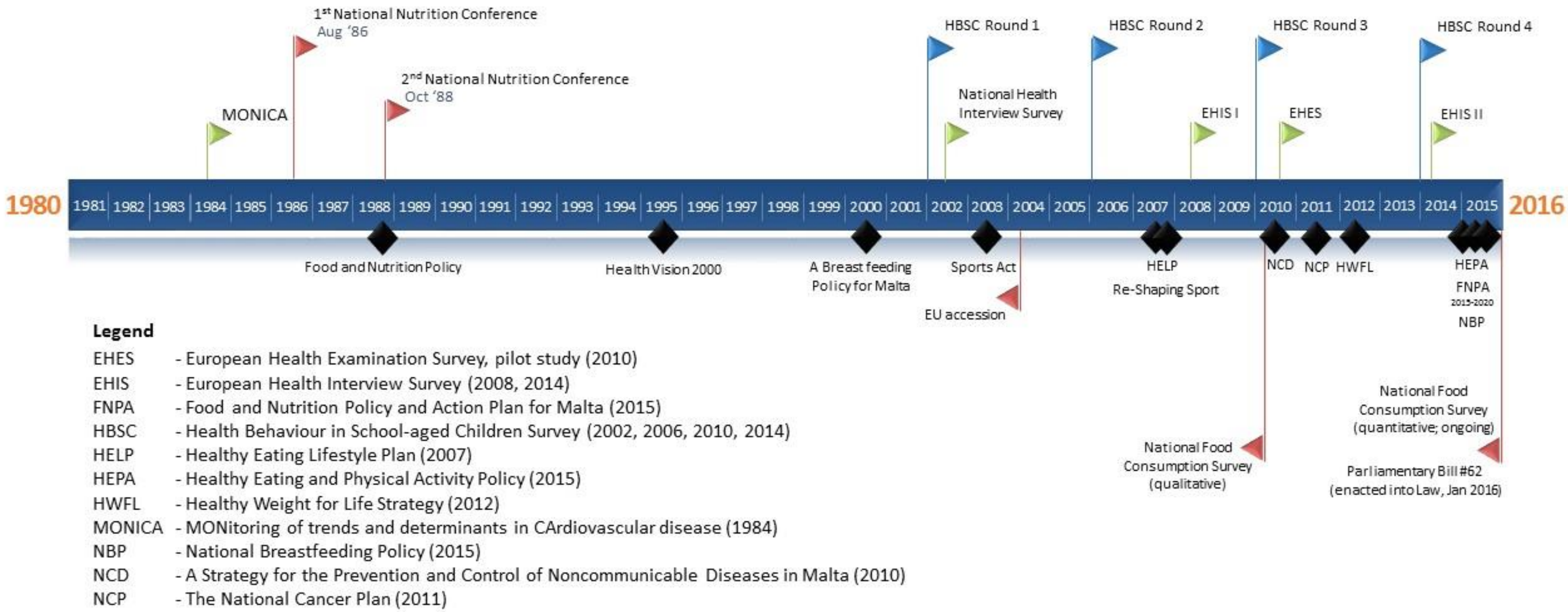

Figure 10. Timeline for policies and events related to obesity prevention in Malta
Source: author

3.4.2 Policies from 2010 to 2015

3.4.2.1 Nutrition Policies

From a nutrition policy perspective, the initial burst of policy activity towards the end of the 1980s and the early 1990s was followed by a relatively static period spanning almost two decades. Malta's participation in two rounds of the HBSC and completion of a National Health Interview Survey targeting adults were the main health research events of note. There was also a degree of policy implementation and consolidation. A country case report presented during the 1992 FAO/WHO International Conference on Nutrition indicated some initial progress regarding achievement of population nutrient goals and, crucially, identified schoolchildren as a particularly vulnerable population group [330]. Nutrition education was embedded within the National Minimum Curriculum (NMC) of secondary schoolchildren starting from 1990. The Nutrition Unit within the Health Promotion Department took over the advisory role of the NACFN in the early 1990s [331] and launched a number of educational and media campaigns that met with some success [319]. However, evaluation of the situation in the early 1990s indicated that elevated "hidden sugar" consumption through soft drinks and chocolate/confectionery was a cause for concern, and that the 1986 recommendations were still applicable [238,319]. The landmark 1995 publication 'Health Vision 2000' reiterated calls for inter-sectoral collaboration and the need for political commitment in order to achieve population nutrient intake targets [321], but was not a nutrition policy *per se*. It was only in 2015 that two additional policies focusing on nutrition were published, as outlined below.

Firstly, the school-based Healthy Eating and Physical Activity Policy (HEPA) [332] is an update of the 2007 HELP document, yet in some ways it fails to build on the HELP policy of 2007. The introduction of free breakfast clubs for children attending state schools was a welcome development, as were policy statements that schools should place restrictions on the availability, sponsorship and marketing of HFSS products while ensuring free access and promotion of plain water throughout the school day. However, measurable objectives are absent, representing a step backwards from the previous HELP policy. HEPA's potential impact is potentially limited as it is mandatory for state schools but voluntary for independent and church schools, where a substantial proportion of Malta's schoolchildren are enrolled. One positive development is that adherence of school canteens and tuck shops to HEPA nutrition standards will henceforth be monitored and enforced by Environmental Health Directorate inspectors, as recommended by a national performance audit to improve nutrition in schools [269,332].

Secondly, the Food and Nutrition Policy and Action Plan for Malta 2015-2020 (FNAP) [110] was developed as a comprehensive revision of the 1990 Nutrition Policy. In line with the WHO European

Health Policy – Health 2020 [333], the action plan adopts a life course approach to nutrition and recognizes the negative impact of social inequities on adequate population nutrition. It highlights the need for an intersectoral and cross-Ministerial approach to health with a focus on children's health and tackling obesity, stating that ongoing health awareness campaigns and free weight reduction programmes driven by the health sector have been insufficient to reverse obesity trends. Two of the five priority actions listed have an environmental component: (i) 'to improve the availability and accessibility of drinking water in schools'; and (ii) 'to reduce the availability and intake of foods high in fat, sugar and salt in schools'. Additionally, the policy recommends that media service providers develop codes of conduct regarding inappropriate promotion of HFSS foods to children; that health professionals receive training on nutrition information delivery; and that feasibility studies on fiscal policies that may encourage consumption of healthy food are carried out [110]. Such measures sound encouragingly 'upstream' in scope, however the priorities for action identified above are both school-based and relatively easy to implement, suggesting that the least contentious measures were prioritised.

Lastly, the National Breastfeeding Policy was updated in 2015 to reflect current scientific evidence amid concern that Malta currently has the fourth lowest breastfeeding rate in Europe [334]. Although there have been improvements in the rate of exclusive and mixed breastfeeding, from 45% in 1995 to 71% in 2012, the rate of exclusive breastfeeding upon discharge from hospital after delivery remains substantially lower than the 90% target envisaged in the original breast feeding plan (55% of mothers) [334]. Encouragingly, the policy places substantial emphasis on population-level measures to improve breastfeeding rates that supplement hospital-based breastfeeding policies, training of health care professionals and educational initiatives to promote breastfeeding in the community. More specifically, it highlights how Malta is in the process of enacting legislation based on the International Code of Marketing of Breastmilk Substitutes [335], which aims to prevent the inappropriate marketing of formula milk. Adherence to this and related 'maternity protection' legislation will be monitored using specified indicators by an independent body with the right to prosecute breaches of the law. Furthermore, the distribution of free formula milk to low income families is due to be phased out and replaced with incentives and initiatives to promote and support breastfeeding [334].

3.4.2.2 Physical Activity Policies

No new strategies to tackle sport have been published since 2007, however the Sports Act of 2002 [328] is currently under revision.

3.4.2.3 Miscellaneous policies with the potential to influence obesity

The launch of the Noncommunicable Disease Strategy in 2010 [227] marked a shift in public health emphasis from health service delivery and improving hospital services towards prioritization of prevention. The strategy explicitly highlighted the need for inter-sectoral collaboration in order to improve the socio-economic environment of the population as a whole through addressing wider social determinants of NCDs such as poverty, unemployment and unequal access to educational opportunities. Objectives were proposed for three NCD risk factors that are of direct relevance to obesity (i.e. obesity, physical inactivity and unhealthy diets), yet the actions proposed to achieve these goals are mostly educational or health promotional in nature. The document highlights a number of legislative, fiscal and regulatory initiatives (e.g. food reformulation; taxes and subsidies etc.) as being potentially effective interventions that enhance school, workplace and community environments, but stops short of specifying whether such population-level measures would be considered for implementation.

Obesity and unhealthy diets were also briefly discussed as risk factors contributing to certain cancers in the National Cancer Plan launched in 2011 [336]. Again, although some proposed actions were environmental in scope (e.g. enforcing the ban on sale of junk food in school canteens; promoting availability of fruit and vegetables; conducting feasibility assessment of a ban on trans-fats in cooking oils etc.) they were vaguely defined and no concrete objectives or timelines were outlined. The cancer plan also proposed the adoption of a national strategy to tackle obesity. The Healthy Weight for Life Strategy [80] was published in February 2012, a few months before I commenced my research degree. It provides a useful background against which to assess findings arising from my research, and is described in further detail in the next section.

During June 2014, a member of Malta's Opposition party proposed a parliamentary bill (Bill no. 62) that aimed to "to establish and ensure an inter-ministerial lifelong approach favouring physical education and healthy balanced diets for a healthy lifestyle reducing the level of obesity throughout all age groups" [337]. The bill was enacted into law in January 2016. It establishes a multidisciplinary 'Advisory Council On Healthy Lifestyles' composed of representatives from public health, education, local councils, police, medical professionals, nutritionists, KMS, social welfare, and commerce which will advise various Ministries (including those responsible for Health, Education, Local Councils, and Home Affairs) on matters related to healthy lifestyles. The Act specifies measures of varying scope and breadth, ranging from increasing the use and accessibility of sports facilities within or adjacent to schools by students and establishing a comprehensive list of food items that may be sold or consumed on school premises, to allocating funds to all local councils in Malta for the installation of outdoor gym equipment in public open spaces. A number of other population-level interventions are recommended. Significantly, the Act proposes substantial financial penalties for individuals contravening any provisions or regulations established by the Advisory Council. As such, it entails a decisively more regulatory, broadly environmental approach to tackling obesity, and its implementation may presage a welcome shift away from policymakers' prior focus on health education.

3.4.3 The Healthy Weight for Life Strategy

The Healthy Weight for Life Strategy (HWFL) [80] is the national obesity strategy for Malta and as such is of key interest. The Intersectoral Committee for Counteracting Obesity (ICCO) was set up in 2006 following the Istanbul Charter for Counteracting Obesity [267] and tasked with addressing the key determinants of obesity. ICCO members represented a spectrum of sectors from across government and non-government entities including health, education, agriculture, finance, transport, environment, urban development, broadcasting media and catering sectors. As discussed in Chapter 2, representatives from these and other relevant sectors were approached and a semi-structured interview requested as part of this research. Quantitative targets of the strategy are presented in Table 4, whereas a list of specific measures through which these targets are to be achieved can be found in Appendix 1.

The fact that specific, measurable targets are presented is a positive features of this strategy. A 'Healthy Weight for Life Implementation Group' was established and is held responsible for monitoring and evaluation, ensuring that all actions are achieved within the set timeframe and within budget. However, there is a disproportionate emphasis on behavioural measures to address obesity, rather than population-level, environmental measures (e.g. changes to legislation or structural factors). Of the 79 measures shown in Appendix 1, 47% (n = 37) were classified as being behavioural interventions, 26% (n = 21) as environmental in scope, whereas a further 8% (n = 6) contain both behavioural and environmental components. The remainder (n = 15) could not be easily categorised. Besides being given less importance overall, in most cases the environmental measures are actually calls for feasibility studies to be conducted, in order to determine the acceptability and economic or behavioural impact of a specific intervention. For example, the strategy contains a recommendation to assess the feasibility and potential impacts of subsidies/taxes on unspecified food and drink products. It also proposes conducting studies to assess the feasibility of regulatory measures to restrict children's access to nutritionally inappropriate meals/snack foods from retail outlets located outside of school premises. Although it is encouraging that such actions are being considered, the general impression given is that such actions will not actively be pursued until more evidence around their acceptability is available. Much more prominence is given to promotional and educational actions that are easier to implement and perhaps more politically palatable.

Overall Targets	Target population
Reduction in the self-reported proportion of the adult population who are overweight from 36% to at least 33%	Adults
Reduction in the self-reported proportion of the adult population who are obese from 22% to at least 18%	Adults
Reduction in the proportion of 7 year olds who are overweight and obese from 32% to 27%	Children
Maintenance of the proportion of obese 13 year olds (above the 95th weight centile) below 15%	Adolescents
Nutrition Targets	
Reduce the frequency of intake of processed meat products, which currently stands at 15% daily by 5%	Whole population
Increase the frequency of intake of fish by reducing the percentage of the population who never consume fish by 20% from the current level of 41.6%	Whole population
Increase the proportion of the population who consume vegetables on a daily basis by 25% especially in younger age groups	Whole population
Reduce the consumption of sweets, sweet pastries, and sugared soft drinks of six times a week or more by 10%	Whole population
Reduce salt consumption by 10% in the population	Whole population
Reduce the mean daily intake of animal fat per capita by 10%	Whole population
Physical Activity Targets	
To increase the proportion of the Maltese population who carry out moderate or high level of physical activity daily or on most days, from the current 43.5% to 70%	Whole population
To reduce the proportion of children and adolescents who never perform any exercise by 5%	Children and Adolescents
To increase the proportion of young people performing regular exercise from 37% to (at least) 50% by 2015 and 80% by 2020	Children and Adolescents

Table 4. 'Healthy Weight for Life' strategy targets (by 2020)

3.4.4 Ongoing measures to improve nutrition and physical activity levels in Malta

Physical activity

As described earlier, PE lessons are provided to all children within the school setting at least once a week [229], whereas Home Economics was offered to students as an optional subject. This is now changing, as in 2014-2015 the two previously separate subjects were merged into a single overarching 'Physical and Health Education' curriculum, which is being introduced in a step-wise fashion within secondary schools [338]. Five weekly lessons are offered, with three lessons focusing on PE and two lessons dedicated to Home Economics on alternate weeks. Between Form 3 and Form 5 (i.e. the last three years of secondary school education), Physical and Health Education will be reduced to three weekly lessons. Unlike other academic subjects, it will not be examinable at the end of the scholastic year but will involve continuous assessment throughout the year.

Programmes intended to promote PA in children outside of the school environment are mostly administered by SportMalta. This entity offers several programmes aimed at children between 4 to 16 years of age, including: (i) #OnTheMove (Skolasport) – a weekend programme held during the school year which includes training in basic skills, educational gymnastics, physical education and sport; (ii) #OnTheMove (Summer) – which aims to encourage children to remain active during the summer holidays and includes swimming lessons, indoor games, adventure sport and sailing; (iii) and Girls on the Move – an evening weekday and weekend programme aimed at encouraging 9 to 16 year old girls' participation in individual PA and team sports within a safe and supportive environment [339]. The Maltese Government also provides a one-time grant for purchasing of bicycles in order to encourage use of active modes of transport [340].

Nutrition

National health promotion and educational campaigns aimed at raising awareness about healthy diets and PA take place on a regular basis, typically led by HP&DPD [341]. Directorate staff regularly set up stalls at national and community-level events where promotional brochures on healthy eating and physical activity are distributed; anthropometric measurements taken; and advice offered to the public. These have been aimed at the general population or targeted specific population sub-groups, and have variously focused on promoting the Mediterranean diet, seasonal fruit and vegetable consumption, fish intake, and regulation of portion sizes [110]. There are also skill-building initiatives offered to local councils focusing on enhancing healthy cooking skills and budgeting in a bid to encourage behaviour change. Free community-based aerobics courses and weight management classes for overweight and obese adults that focus on information-dissemination and development of skills to improve diet and increase PA are provided by trained professionals [342]. More recently, new approaches such as the presence of HP&DPD staff at local Farmers' Markets to provide information and recipes that include the seasonal fruit and vegetable ingredients being sold have been adopted [110].

At hospital, parent-craft classes and a breastfeeding walk-in clinic are offered to prospective parents and breastfeeding mothers respectively [110]. A Presidential initiative led to the establishment of 'Dar Kenn Għal Saħħtek' [343,344] in 2014. This represented a new concept for Malta, where hospital-based obesity management tends to be fragmented and medicalised. The facility offers a holistic approach to treatment of patients with eating disorders and obesity within a community-based, combined residential and semi-residential setting. A multidisciplinary strategy that includes psychological, nutritional and familial interventions is in place to supplement the tightly structured organization of patients' activities and meals. Whilst this is a treatment facility for the morbidly obese rather than a population-based preventive intervention, the holistic approach with family involvement represents a relatively new direction for Malta.

A small number of partially EU-funded initiatives are also implemented by the government. The 'School Fruit and Vegetable Scheme' provides a small container of pre-sliced seasonal fruit or vegetables to all kindergarten and primary schoolchildren in Malta once a week, with the aim of exposing children to fruit and vegetables (F&V) at a stage when eating habits are still being formed [270]. It is hoped that this will translate into increased familiarity with, and enhanced taste preference for, diverse fruit and vegetables over time. All primary schools and certain secondary schools also participate in the 'EU School Milk Scheme', which partially reimburses schools for distribution of free milk to students [345]. Its scope is similar to that of the F&V scheme in that it aims to enhance access to fresh milk, increase milk intake among children, and promote children's long-term preference for milk and away from highly processed products. Indeed, one of the stated aims of the scheme is to improve public health and combat obesity [345]. The 'Aid to the Deprived' scheme refers to the distribution of food products to eligible vulnerable groups in the community, such as the unemployed, the homeless, disadvantaged children and families living below the poverty line [346]. The food products themselves are not particularly nutritious, often consisting of cereals, rice, pasta and jam. Indeed, the scheme specifically excludes the distribution of fresh food items such as fish, vegetables and fruit [110].

Lastly, dietary choices for the population lie largely outside the influence of the health sector, in areas such as trade, marketing, fiscal policies, agriculture, and the media [347]. The food industry, media, advertising and retail sectors in particular may significantly influence consumer dietary choices [348]. Most relevant national legislation in these areas are gradually being amended in line with EU legislation. For example, the EU directive on Audiovisual Media Services [349] which aims to regulate marketing of HFSS foods and which has been transposed within the Broadcasting Act (Chapter 350 of the Laws of Malta) [350] is currently being implemented. The Broadcasting Act itself encompasses a Legal Notice (The Broadcasting Code for the Protection of Minors) that makes reference to misleading and deceptive advertising to minors, including HFSS food promotion: "*advertisements for confectionery and snack foods shall not suggest that such products may be substituted for balanced meals*" [351]. The implication of adopting such legislation is discussed elsewhere [352]. Food reformulation, trade and fiscal policies have been proposed as tools to influence population nutrition in a number of international fora, including the European Charter on Counteracting Obesity (2006) and the Vienna Declaration (2013) [267,326]. The need to conduct studies regarding the feasibility of such economic policies is briefly discussed without committing to practical measures in the FNAP, however no such policies are currently in place at national level. The policy review did not reveal any industry-wide voluntary guidelines on food trade, marketing or distribution (e.g. similar to the UK's Public Health Responsibility Deal [353]) in Malta, although it is possible that individual companies may have drawn up and implemented their own guidelines without making them publicly available. Malta does not yet have a policy that aims to reduce the impact of the marketing of HFSS foods to children, although such regulation is a recommendation of the FNAP [110]. Nevertheless, the Health Promotion and Disease Prevention Directorate seeks to lead by example by following a policy to reduce the impact of non-broadcast forms of advertising of HFSS foods to children. For example, HFSS foods are not allowed to be used as sponsorship for health campaigns or any initiative that takes place within schools, or that involves children.

3.5 Overview of Systematic Reviews

Preamble to Research Paper 2

In late 2015, the Today Public Policy Institute (TPPI), an independent think tank, published a report on the state of obesity, nutrition and physical activity in Malta [305]. The report was critical of current policy and highlighted the need for a broader environmental approach to be adopted:

> *"Delivering change requires more than good intentions. Effective measures require a population-based, multi-sectoral, multidisciplinary, and culturally relevant approach. Such interventions will need to cut across many public policy areas, especially health, social*

welfare, education and, not least, road design and transport. Preventive measures should also be broad-based inasmuch as they should be family-centred on home lives and extend to the living environment."

The report was also critical of what the authors perceived to be an excessive search for definitive evidence by Maltese authorities, combined with a reluctance to actually implement measures that would induce change:

"… there is too much to lose by waiting for conclusive scientific evidence and… much to be gained by using the present evidence as incentive for instituting public health approaches across the life course... As stated in a recent McKinsey report [133]*: "We should experiment with solutions and try them out rather than waiting for perfect proof of what works, especially in the many areas where interventions are low risk. We have enough knowledge to be taking more action than we are currently taking*."

This criticism resonates with the underlying rationale for conducting this research. The overview of policies reported upon in the previous section clearly highlights how the problem of childhood obesity in Malta to date has mainly been tackled at the individual level, where educational initiatives promoting behavioural change are prioritised over an ecological approach that would address the broader determinants of obesity [110]. The Maltese Healthy Weight for Life Strategy [80] to address obesity represents a positive step towards shifting this emphasis from behavioural to broader environmental, population-level measures, but implementation and evaluation of non-behavioural measures has thus far been limited.

The contextual analysis and overview of policy commitments on childhood obesity presented in the previous sections revealed a striking contrast between the high prevalence of childhood obesity and the paucity of the local knowledge base that may inform prevention efforts in Malta. They underscored the need to identify environmental policies and interventions that are applicable to the whole population, taking into account the local context. The preliminary literature search undertaken at the start of this research revealed numerous systematic reviews that summarised the effects of built or policy environmental change on PA, dietary behaviour or weight outcomes in children. The very profusion of reviews means that distilling the available evidence into clearly defined, policy-relevant recommendations could be daunting for inexperienced researchers or policymakers.

The ecological systems theory proposed by Bronfenbrenner and expanded upon by Stokols [29,354] suggests that interventions targeting the environment may be more effective than behavioural interventions targeted at individuals. Environmental interventions are designed to alter the context in which people live, thus creating conditions that more supportive of healthy behavioural choices and which influence individual-level behaviours among a large groups of people, making them more efficient. This leads on to the question of what can be done to tackle obesogenic environments: what is the evidence on effective interventions to create environments that support healthier eating and physical activity choices among children? (objective 2). Systematic reviews are useful decision-making tools that objectively summarize large amounts of information in a format that is of relevance to health practitioners, policymakers and researchers in order to guide health policy, clinical guidelines and research efforts [355,356]. However, questions have been raised as to whether they are efficient or appropriate approaches to informing decision-making, as they may not be helpful for individuals seeking to assemble and integrate evidence in order to arrive to a policy decision [357]. The applicability of review findings to practice has also been called into question, with some reviews being criticized for lacking the context-specific detail that is essential for knowledge-translation [358]. In addition, all systematic reviews are not equal. Their methodological quality may vary, leading to potentially misleading conclusions and recommendations.

Instead, policymakers may prefer to search for and use a wider range of evidence to assess what has been done in the past, under which settings, and the consequences thereof, prior to making an informed judgement. Given the challenges of locating data for public health interventions, the policymaker is faced with a potentially daunting and labour intensive task. Narrowing one's focus might facilitate the search, however evidence suggests that undertaking a comprehensive search may provide unique evidence and insights that would not be obtained using more focused methods [359,360]. Furthermore, review findings often fail to provide substantive recommendations for policy and practice [361]. Thus, given the large number of relevant systematic reviews, increasing interest among Maltese policymakers towards adopting a socio-ecological approach to addressing obesity, and the dearth of recommendations for population-level environmental interventions for the prevention of obesity in children, it was felt that this was an area ripe for further practice-relevant research.

In recent years, the concept of 'overview of systematic reviews' has gained popularity as a possible alternative to conducting systematic reviews on topics which have already been extensively researched. These have the objective of summarizing evidence regarding a single condition from multiple systematic reviews of interventions and outcomes [362,363]. This approach was undertaken for this thesis, and is presented here. The following article offers specific recommendations on which environmental interventions to prevent childhood obesity that have been successful elsewhere can be applied to Malta, based on a comprehensive review of the existing evidence. Compiling this literature may help to facilitate accessibility of good quality and relevant research evidence around childhood obesity prevention. This is a key factor influencing the use of evidence in policy [364], and would allow policymakers and public health professionals to quickly and comprehensively review their options. With this in mind, the overview of systematic reviews presented below was designed to respond to a growing need for easily accessible information on multi-component, multi-level childhood obesity prevention strategies that focus on whole populations.

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SECTION A – Student Details

Student	Daniel Cauchi
Principal Supervisor	Cécile Knai
Thesis Title	Childhood obesity in Malta: contributions of the obesogenic environment

SECTION B – Paper already published

Where was the work published?	Obesity Reviews		
When was the work published?	19 July 2016 (early view)		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion	N/A		
Have you retained the copyright for the work?*	No	Was the work subject to academic peer review?	Yes

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Stage of publication	

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	See full details of author contributions on the next page.

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Research Paper 2

Environmental components of childhood obesity prevention interventions: an overview of systematic reviews

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Author contribution: I formulated the research question and designed the study with Ketevan Glonti and Cécile Knai. I conducted the literature search, and independently reviewed, screened, coded and analysed the data. Ketevan Glonti was an independent reviewer and Cécile Knai arbitrated in cases of disagreement. I drafted the manuscript and made revisions based on comments from Ketevan Glonti, Cécile Knai and Mark Petticrew.

Abstract

Childhood obesity has a complex multi-factorial aetiology grounded in environmental and individual level factors that affect behaviour and outcomes. An ecological, systems-based approach to addressing childhood obesity is increasingly being advocated. The primary aim of this review is to summarise the evidence reported in systematic reviews on the effectiveness of population-level childhood obesity prevention interventions which have an environmental component. We conducted a systematic review of reviews published since 1995, employing a standardized search strategy in nine databases. Inclusion criteria required that reviews be systematic and evaluated at least one population-level, environmental intervention in any setting aimed at preventing or reducing obesity in children (5-18 years). Sixty-three reviews were included, ten of which were of high quality. Results show modest impact of a broad range of environmental strategies on anthropometric outcomes. Systematic reviews vary in methodological quality, and not all relevant primary studies may be included in each review. To ensure relevance of our findings to practice, we also report on relevant underlying primary studies, providing policy-relevant recommendations based on the evidence reviewed. Greater standardization of review methods and reporting structures will benefit policymakers and public health professionals seeking informed decision-making.

Introduction

Childhood obesity is a global public health challenge due to concerns about increasing prevalence [1,2], the likelihood of obesity tracking into adolescence and adulthood [86–88], and its association with a range of adverse health outcomes [107,112]. Increasingly, an ecological, systems-based approach to addressing obesity that acknowledges its complex multi-factorial aetiology and recognizes the policy, environmental, and individual level factors that influence behaviour and outcomes is being advocated [38,182]. This entails recognition of a broad range of physical, socio-cultural, economic and political dimensions within which individuals are embedded, as well as attributes and behaviours of individuals themselves [365]. Education-based interventions to address childhood obesity have had little success [11,366] as changing human behaviour within an 'obesogenic' environment that does not support healthy choices is difficult to achieve and sustain [25]. Multi-component interventions where several environmental aspects are addressed simultaneously may lead to more sustainable results [38,367]. Childhood and adolescence are particularly vulnerable life stages requiring protective social and public health policies [368]. This is an additional challenge for decision-makers often seeking easy solutions for rapid implementation during their relatively short term in office, and represents an all the more pressing rationale for providing them with up-to-date evidence on the range and effectiveness of environmental, population-level interventions to prevent or help reverse childhood overweight and obesity. We focus on synthesising systematic reviews as they can be useful decision-making tools that objectively summarize large amounts of information in a format that is of relevance to health practitioners, policymakers and researchers in order to guide health policy, clinical guidelines and research efforts [355,356]. The applicability of review findings to practice has also been called into question, with reviews often being criticized for their narrow scope and for lacking context-specific details that are essential for knowledge-translation into policies [358,369]. To ensure relevance of our findings to practice, we also investigate and report on relevant underlying primary studies, providing policy-relevant recommendations based on the evidence reviewed.

Existing systematic reviews

Several reviews summarising the effects of built or policy environmental change on obesity outcomes have been published [370–377]. The Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre) has mapped out systematic reviews (SRs) on social and environmental interventions to address childhood obesity [378], and a number of overviews of systematic reviews [362,363] on school-based childhood obesity interventions [358,379–381] are available. Overviews on the impact of the built environment on physical activity have also been conducted [382,383], however, to the best of our knowledge, no overview of reviews focusing specifically on environmental interventions to prevent or reduce excess weight in children exists.

Aim of this review

The primary aim of this review is to summarise the evidence reported in SRs on the range and effectiveness of population-level interventions aimed at preventing overweight or obesity in children which have an environmental component. We adopted a broad interpretation of what is meant by an ‘environmental intervention’, defined as a strategy that involves changing the physical surroundings and social, economic or organizational systems to facilitate healthy choices and enable people to adopt healthy behaviours without requiring significant motivation on the part of the individual. ‘Effectiveness’ was defined as achieving a beneficial or protective, statistically significant, anthropometric outcome. A secondary aim is to assess and critique the methodological quality of included systematic reviews.

Methods

An overview of systematic reviews was conducted. Reviews were judged to be systematic if they synthesised peer-reviewed articles; explicitly reported pre-defined objectives, search strategy details and inclusion and exclusion criteria; and clearly identified all included studies. The full text of potentially eligible environmental interventions reported upon in included SRs was also reviewed, and relevant study data extracted.

Search strategy

We conducted a search of free text terms and subject headings from January 1995 to May 2015, using the Population, Intervention, Comparison and Outcome model [384], to describe the target population (healthy children and adolescents), intervention (population-level prevention of obesity), comparison (SRs), and outcome (anthropometric outcomes). The initial search string was developed in Medline (Appendix 3A) and further refined for use in the different databases: Database of Abstracts of Reviews of Effects (DARE), Medline, Embase, PsychINFO, CINAHL PLUS, SCOPUS, Social Policy and Practice Database, Database of promoting health effectiveness reviews (DoPHER), and CENTRAL. Reference lists of identified SRs were manually searched to identify any additional reviews. A grey literature search in TRIP and Google Scholar was performed. Project websites and those of collaborative groups that conduct SRs of public health interventions (e.g. EPPI-Centre [378]; the Community Guide [385]; Health Systems Evidence [386]; Health Evidence Network [387]; Agency for Healthcare Research and Quality [388]; Centre for Reviews and Dissemination [389]; and the National Institute for Health and Care Excellence [390]) were also searched for relevant publications, and their bibliography reviewed. No language restrictions were applied.

Inclusion and exclusion criteria

Systematic reviews were required to be: published between January 1995 and March 2015; reviewing interventions to prevent obesity and overweight in children and adolescents aged 5 - <18 years; assessing at least one population-level intervention with an environmental component; and reporting anthropometric outcome data on the effectiveness of interventions (i.e. using a standardized or accepted measure of obesity such as body mass index (BMI), BMI z-score, waist circumference (WC), skin fold thickness (SFT), percentage body fat (% BF), overweight or obesity prevalence and other anthropometric measures associated with obesity [391]).

SRs were excluded if they assessed interventions: aimed at adults only; which did not include any anthropometric outcomes, or where the only outcome of interest was behaviour modification (i.e. increasing physical activity, decreasing sedentariness or improving diet); aimed solely at treatment of existing obesity or expressly targeted weight loss (e.g. pharmacological interventions; bariatric surgery; metabolic or weight loss clinics) or aimed at participants with diagnosed complications linked to obesity; and that solely involved interaction between health professionals and individuals or groups within a clinical setting. SRs focusing on treatment of existing obesity were excluded as it is typically harder to lose weight than to prevent an initial weight gain. Since our main interest was population-level preventive environmental interventions, SRs exclusively assessing studies conducted in controlled clinical or laboratory settings were not considered relevant. In the case of reviews that contained a mix of interventions (e.g. aimed at both adults and children; reviewed both treatment and preventive interventions; or reported both behavioural and/or anthropometric outcomes), only data of preventive primary studies aimed at children and which had clearly defined anthropometric outcomes were extracted. Interventions in the included SRs could be multi-component or single-component. Multi-component interventions that combined individual and population-level elements were considered eligible if the population-level component was judged to be more than simple reinforcement of an individual-level intervention.

SRs were included if at least one reviewed primary study described a structural/policy change to the state, community, school, and/or home as a major component of a population-level, obesity-prevention intervention. Policies could be either formal legislative or organizational in scope [392]. Eligible policies within the school setting included changes in school lunch nutrition standards or banning of vending machines. Provision of physical activity (PA) opportunities after school hours was considered to be a population-level environmental intervention, as these can potentially be made available to children living around the school neighbourhood who are not themselves students at the school. However, for the purposes of this overview, modification of school curricula to improve dietary or PA behaviour (e.g. increasing the number, duration or quality of physical education (PE) or nutrition education lessons during school hours through staff training or employing professionally-trained staff; increase in recess time etc.) in isolation of complementary environmental approaches was not considered to be eligible as such interventions have already been adequately described elsewhere [379–381]. Additionally, evidence suggests that studies promoting healthier behaviour rather than focusing on reducing adiposity are less effective at reducing anthropometric outcomes [393,394]. Eligible community interventions included modifications to the built environment (e.g. creation of walking pathways), whereas acceptable alterations to the home environment could include installation of television monitors. We also included exergaming interventions, as this novel approach to modifying children's leisure-time behaviour can potentially be delivered at population level. Conversely, interventions that focused solely on imparting information and knowledge (e.g. educational campaigns; nutrition classes) were ineligible because such interventions aim to directly alter individual behaviour, rather than modify children's surroundings.

Systematic review selection and data extraction

DC and KG independently examined titles, abstracts and full-text articles, and extracted data, resolving any disagreement through discussion with a third author (CK). Within each review, interventions having an eligible environmental component that reported on outcomes of interest were identified. The methodological approach of each review (databases searched; language restrictions; inclusion and exclusion criteria; synthesis method; quality evaluation of trials; stated implications for practice and research; limitations; and funding sources) and documented primary review outcome indicators and main findings were recorded. All review-level data can be found in Appendix 3. To avoid biased post hoc decisions, a review protocol based on Cochrane handbook recommendations [395] was published on PROSPERO [396] prior to starting the review process.

Quality of included reviews

Two reviewers (DC and KG) independently assessed the methodological quality of the included reviews using the 'Assessment of Multiple Systematic Reviews' (AMSTAR) tool [397]. Reviews were categorised into high (AMSTAR score 8 – 11), medium (5 – 7) or low (0 – 4) based on the Canadian Agency for Drugs and Technologies in Health evaluation criteria [398]. Any disagreement was resolved through consensus.

Identifying relevant primary studies included in the reviews

Most reviews only reported on the direction of effect on outcomes and did not report on the magnitude of effect, making it necessary to review the full text of primary studies in order to identify whether an intervention had a desirable or significant effect. Thus a list of all eligible primary studies (n=76) included in the included reviews was compiled in order to cross-check eligibility, assess clarity of information provided in SRs and to compile a comprehensive, useful list of existing environmental options. We collected information on study design, study setting (school, community, home, state), characteristics of participants (including sample size, age), type of intervention (including type, intervention duration, length of follow-up, intervention components and source of funding), and outcome data (including difference in change from baseline for intervention vs control, direction and significance of effect). Effects without p-values, confidence intervals or a written statement regarding statistical significance were classified as non-significant. For multiple anthropometric outcomes, one or more statistically-significant benefit in any relevant outcome was counted as an overall beneficial study regardless of the number of non-significant outcomes, and vice-versa. All extracted intervention-level data can be found in Appendix 3F. We did not report on quality of primary studies.

To correct for potential discrepancies between reported results for eligible environmental interventions, it was necessary to review the full text of each eligible primary study summarized in SRs. We were interested in the extent to which primary studies with environmental components were correctly identified or described as such in different SRs. In other words, would a policymaker assessing the evidence on environmental obesity-prevention interventions be able to identify the studies of interest within an SR? We found that in many reviews, primary studies might not necessarily be classified outright as being environmental in nature, yet careful assessment of the information provided in the SR would enable an environmental component to be identified. The converse is also possible. For example, the study by James et al. 2004 [399] is classified in at least one SR [400] as having an environmental component, yet we determined the intervention to be cognitive and behavioural in nature.

Results

Review characteristics

We included sixty three systematic reviews in our study (Figure 11). These searched databases up to 2014, reporting on a wide range of primary studies. Seven reviews focussed specifically on policies or environmental strategies, five explored mainly behavioural interventions, four looked at exergaming or active video games as their intervention of interest, and two concentrated on educational interventions in the school. The remainder (n=45) summarised the effects of a broad mix of interventions. The overall aim of all SRs was broadly to summarise obesity prevention studies – however there was substantial heterogeneity in terms of setting, population of interest, type of intervention assessed, outcomes considered, review methodology, presentation of results and interpretation of findings (Appendix 3C and Appendix 3D). Eighteen of the reviews were meta-analyses, while the remaining 45 SRs provided a narrative synthesis of results. Twenty-eight SRs restricted their search to articles published in English only, eight SRs did not report on language in their search strategy, while the remainder widened their search to two or more languages. When analysed by setting, 28 assessed school-based studies exclusively [186,187,189,401–425], six summarised community-based interventions [374,426–430], two reviews discussed home or family based interventions [431,432], and the remainder (n = 27) did not specify study settings in their search strategy [284,393,400,433–455]. Most reviews (62%, n=39) assessed quality of the primary studies.

Review quality

Over four-fifths (84%) of the included reviews were assessed to be of low (n = 23) or medium (n = 30) quality according to AMSTAR criteria (Appendix 3E). Ten reviews, six of which were meta-analyses, were judged to be of high quality [284,400,408,421,426,432,436,437,444,449].

Summary of potentially effective environmental strategies according to high quality reviews

Fewer than half (n = 26 or 42%) of all SRs specifically discussed built or policy environmental strategies, with most stating that such strategies show promise but require further rigorous assessment and evaluation of social, psychosocial, behavioural, and anthropometric outcomes to prove benefit (Table 5). Overall, reviews were cautious about providing definitive recommendations on which environmental strategies should be implemented. This was due to the often suboptimal methodological quality of primary studies and the challenge of distinguishing which specific components of interventions were necessary to achieve positive outcomes [284,436]. Thus, few SRs provided clear statements on the importance of environmental strategies to address childhood obesity, and findings were mixed. However, some environmental interventions were highlighted across high-quality reviews as being particularly promising and likely to be effective in preventing or reducing overweight and obesity in children, especially if part of long-term comprehensive efforts [421]. These included increased PA sessions [284]; purchase of PE equipment [408]; improvements in nutritional quality of the food supply in schools [284]; creation of environments and cultural practices that support consumption of healthier foods and PA at school [284,408] and at home [284,421,432,437]; and capacity building or professional development for teachers to implement health promotion strategies and activities [284].

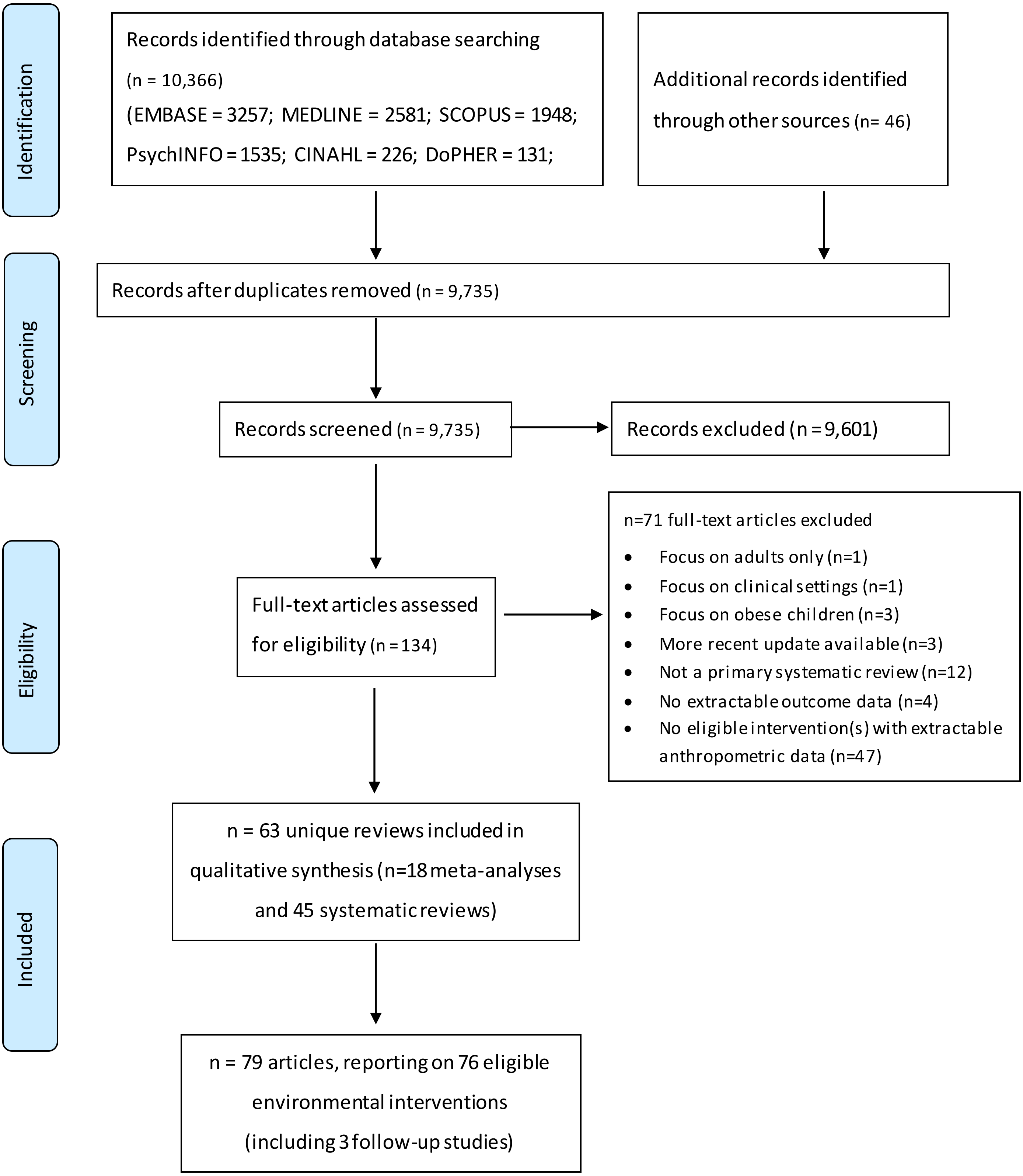

Figure 11. PRISMA flowchart

Source: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *Sys*tematic Reviews and *Me*ta-*A*nalyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

Environmental interventions…	No. of reviews	References: first author and year of publication
are promising, effective strategies that can support and increase effectiveness of other obesity prevention programmes	10	Avery 2015, Brandt 2010, De Bourdeaudhuij 2010, Ickes 2014, Katz 2008, Kesten 2011, Kropski 2008, Peterson 2007, Sharma 2007, Sobol-Goldberg 2013
should be prioritised or at least considered for obesity prevention	7	Beauchamp 2014, Budd 2006, Ickes 2014, Kamath 2008, Sharma 2007, Showell 2013, Stice 2006, Waters 2011
minimise health inequalities	1	Beauchamp 2014
[specific examples of environmental interventions provided]	15	Avery 2015, Beauchamp 2014, Brandt 2010, Budd 2006, Chriqui 2014, De Bourdeaudhuij 2010, de Sa 2008, Kamath 2008, Katz 2008, Kropski 2008, Li 2008, Peterson 2007, Sharma 2007, Showell 2013, Waters 2011
are of unclear effectiveness or viability	2	Marsh 2014, Towns 2014
require further rigorous assessment/evaluation of associated policy and environmental, social, psychosocial, behavioural, and biological outcomes	10	Calancie 2015, Chriqui 2013, de Sa 2008, Ickes 2014, Jaime 2009, Katz 2008, Peterson 2007, Reilly 2003, Stice 2006, Waters 2011
need for more widespread recognition of environmental influences operating counter to school activities	5	Budd 2006, De Bourdeaudhuij 2010, Katz 2008, Peterson 2007, Stice 2006
need for research to explore feasibility, cost and effectiveness of environmental strategies	4	Calancie 2015, Jaime 2009, Knowlden 2013, Showell 2013
need for research on options outside of the school	9	Calancie 2015, Chriqui 2013, Chriqui 2014, de Sa 2008, Jaime 2009, Kesten 2011, Knowlden 2013, Peterson 2007, Reilly 2003
need for improved longitudinal data with obesity-related outcomes	4	Chriqui 2014, De Bourdeaudhuij 2010, Jaime 2009, Katz 2008

Table 5. Systematic review comments on environmental strategies to prevent childhood obesity

Effect Sizes reported in Meta-Analyses

The meta-analyses identified in our search reported BMI/zBMI reduction effect sizes (ES) for interventions aiming to prevent obesity in children. While it is not possible to extract the contribution to overall effect size of specific environmental elements within these interventions, the meta-analyses reported a wide range of effect sizes for different types, settings and duration of interventions. Across all settings, strategies targeting sedentary behaviour emerged as the most consistently successful [405,411,449,455], with ES ranging from -0.14 [-0.23, -0.05] [455] to -0.35 [-0.63, -0.06] [411]. The impact of physical activity interventions was unclear [284,400,411,424], as ES ranged from potential increases in BMI +1.87 [1.31, 2.42] [411] to reductions of -0.11 [-0.19, -0.02] [284]; whereas dietary interventions [284,400,405,411] showed a consistently modest beneficial impact, with an ES ranging from -0.02 [-0.07, 0.02][424] to -0.39 [-0.56, -0.23][411]. Williams et al. calculated effect sizes on BMI for provision of school breakfast or lunch to students in isolation [424]. Effect sizes for these interventions varied from a disappointing BMI increase of +0.04 [-0.19, 0.27] following the introduction of school lunches, to a minimal reduction in student BMI of -0.08 [-0.14, -0.02] following the introduction of a healthy school breakfast. Possibly reflecting the wide spread of ES above, meta-analyses assessing combined dietary and PA interventions [284,400,411,424,436,449] calculated more modest ES ranging from 0.00 [-0.47, 0.47] [424] (no impact) to a small reduction in children's BMI of -0.18 [-0.27,-0.09] [284]. With regards to the settings where interventions took place, Wolfenden et al. [430] reported a minor but beneficial (ES: -0.09 [-0.16, 0.02]) impact resulting from community-based interventions of any type, whereas a number of meta-analyses of school-based interventions [284,410,411,413,419,421,422,424] reported a mix of results, with ES ranging from +0.17 [-0.38, 0.72] [410] to -029 [-0.45, -0.14] [411]. Duration of intervention [284,393,400,405,422] also seems to positively influence intervention outcome, as interventions lasting more than 12 months showed ES ranging from -0.095 [422] to -0.12 [-0.21, -0.03] [284]. Lastly, specific components of interventions reviewed in meta-analyses included parental involvement [405,421,422], which resulted in small but consistently positive ES ranging from -0.094 [p = <0.001] [422] to -0.151 [-0.334, 0.031] [421]; and substitution of SSB with zero-calorie replacements [444,450], where results are less clear (ES: +0.06 [-0.01, 0.13] [444] to -0.17 [-0.39, 0.05] [450]).

Primary studies

Appendix 3F reports on primary study characteristics including the range of environmental strategies undertaken and their effect on anthropometric outcomes, whereas *Appendix 3*G illustrates the overlap of all eligible primary studies (n = 76) across all SRs. Around half (48%; n = 37) of the primary studies did not result in a significant desirable effect on anthropometric outcomes (i.e. improvement in outcome of intervention compared to control), with some studies showing significant worsening outcomes for the intervention group [456–458] or mixed results [459–461]. Few RCTs consisted of purely environmental strategies or reported outcome data that can be attributed to environmental change directly. Most studies incorporated modifications to the environment as part of an overall strategy that included nutrition/PE education and curricular changes, and hence it is difficult to disentangle the impact of the environmental component from the overall impact.

Effective environmental strategies discussed in systematic reviews

A total of forty eligible primary studies across all SRs demonstrated a significant beneficial or protective effect on one of the anthropometric measures of childhood overweight and obesity (see Appendix 3F for study outcomes), and were reviewed in further detail to identify potentially effective environmental components. Almost all were primarily school-based, with the exception of two interventions that mainly took place in the home [462,463]. The majority contained an educational or information-dissemination component aimed at reinforcing the overall aim of each study. Environmental programme components - with or without additional behavioural and educational components - which appear to have contributed to the beneficial effects observed are outlined below. Anthropometric outcomes (changes from baseline for intervention groups compared to control groups) are provided where the intervention consisted mainly of a single environmental element.

- **Improvement of overall school food environment:** measures included implementation of school nutrition standards/policies; removal of vending machines selling sugar sweetened beverages (SSB) or snacks high in fat, sugar or salt (HFSS); banning sales of HFSS food; reformulation of school lunches to reduce fat content [459,460,464–469]
- **Purchase of new PE/sports equipment:** this was made available during recess and at other times throughout the school day, as well as during PE lessons [465,467,468,470–474]
- **Daily formal PA session organized after-school:** typically lasting 90 minutes to two hours, involving a substantial proportion of time spent doing MVPA, with or without a healthy snack provided to participants [466,475–479]. Three studies assessing impact of two-hour after-school interventions reported improvements in BMI ranging from -0.16 [-0.40, 0.07] [478] to -0.45 [-0.79, -0.12] [475]; and differences in percentage body fat (%BF) from -0.76 [-1.42, -0.09] [478,479] to -2.01 [-2.98, -1.04] [475]
- **Provision of free or low-cost fruit:** ensuring that fruit [471,474,480] and freshly made fruit juices [480] were available at school, and at home

- **Availability of school playgrounds for structured/unstructured PA after regular school hours** [467,468,480,481]
- **Provision of free/low cost water in school:** either through installation of water fountains, provision of water bottles or through lowering the cost of bottled water compared to other drinks in the school canteen [471,473,474,482–484]. An intervention focusing solely on enhancing water provision in schools reported a small reduction in zBMI (-0.004 [-0.045, 0.036]) and a significant reduction in the risk of overweight (31% reduction, p = 0.04) among the intervention group [484]
- **Provision of a healthy breakfast at school:** (BMI: -0.11 (P=<0.05) in boys; -0.02 (P = <0.05 in girls) [485]
- **Substitution of sweetened beverages**: replacement of SSB with artificially sweetened, zero-calorie substitute (BMI: between -0.13 [-0.21, -0.05; p = 0.001] and -0.14 [-0.54 to -0.26] [462,486]
- **Reduction in screen time**: at home through the installation of an electronic television time manager device to limit TV watching (BMI: -0.45 [-0.73, -0.17; p = 0.002] [463]

Adjunct elements commonly adopted in the above studies and which are likely to contribute to overall effectiveness, but which our inclusion criteria precluded from further assessment, include: an increase in opportunities for PA during the school day [466,467,471–474,481]; increase in number, duration or quality (e.g. proportion of time spent doing MVPA) of PE lessons [459,460,465]; parental involvement [469,471,472] and provision of training for food service staff or PE teachers [470]. Few identifiable patterns emerged regarding single or multi-component interventions which failed to show any significant beneficial anthropometric outcomes. All active videogame studies, and all after-school PA programmes of less than 90 minutes duration, did not have a significant impact. Multi-level primary studies that had achieved significant positive results in certain contexts and settings (e.g. comprising components such as nutritional changes in schools or increased opportunities for PA, as shown above) failed to show effectiveness elsewhere, suggesting that contextual factors might have an important role in determining intervention success.

Discussion

This study provides a broad and comprehensive overview of environmental strategies to prevent childhood obesity at population level. Most interventions had at best a small to modest impact on childhood anthropometric outcomes (Appendix 3F). Single-level interventions that focus on reducing screen time or increasing time spent performing MVPA may also be particularly beneficial. There was no clear link between the number and range of components of an intervention, and effectiveness of outcomes. However, our findings provide some support for consideration of obesity-prevention interventions having one or more environmental components, which may be particularly attractive for increasingly autonomous adolescents who may not respond to conventional nutrition education and behavioural counselling [487,488]. It is now important to understand which of these strategies can be combined into an ideal package at population level [284]. Most SRs did not provide clear recommendations regarding environmental components that should be considered for implementation by policymakers. At primary study level, the main focus was on school-based programmes, with few studies assessing potential environmental influences in the home, community or country setting.

A comparison of SR conclusions suggests that most SRs are cautious about summarising the evidence regarding the relative effectiveness of environmental components, or fail entirely to do so. With few notable exceptions, such as the SR by Waters et al. [284], review authors provide limited descriptions of individual studies without identifying which intervention elements might be most effective. Hence, they are likely to be of limited use to policymakers looking for concrete suggestions regarding which elements are most likely to successfully stop or reverse childhood obesity. This led to our analysis of primary studies within SRs in an attempt to identify those components which achieved the largest magnitude of effect. However, any statement of effectiveness emerging from these studies must be interpreted with caution given the overall methodological challenges and lack of detail provided even in the higher quality reviews and primary studies. In addition, observed changes in weight outcomes in preventive studies having a normal population distribution may be subject to interpretation. For example, in studies where increases in BMI were observed, it is often difficult to discern whether these were due to normal child growth that is within acceptable limits; reflective of normalization of weight outcomes for previously underweight children; or due to an increase in muscle mass. A comparison of intervention effectiveness and cost-effectiveness was beyond the scope of this research, although questions remain regarding whether subjective judgements on the magnitude of a study's impact are useful or acceptable (e.g. is a 10% reduction in risk of population obesity a less or more beneficial outcome than a 0.1 reduction in population BMI?); or whether the ratio of study cost to benefit provided should be considered when evaluating interventions. Furthermore, heterogeneity of data; generic lack information on costs; the wide range of programme components reviewed; and the difficulties of disentangling the individual contribution of distinct strategies packaged within multi-component programmes to the final magnitude of effect means that it is not possible to distinguish which of these components are the most beneficial. These problems limit our ability to conclude that one strategy or combinations of strategies are more important than others in the prevention of childhood obesity [489]. We sought to identify a shortlist of environmental components having at least some evidence of successful implementation, and identified several strategies that show promise. This is not to say that they will always be effective, or that they can be easily scaled up to population level. Although the 1999 study by Robinson et al. aiming to reduce sedentary behaviour at home by installing a TV locking device was particularly effective, similar studies failed to show a significant impact [490] or even resulted in higher BMI [491,492]. There are also issues around acceptability, long-term sustainability and economic viability of scaling up such interventions [489].

Gaps in the research

Our results enable us to identify a number of gaps in the existing evidence. We confirm that relatively little review-level evidence is available on the impact of environmental interventions on children and adolescents, and most of what is available concerns school-based interventions [378]. We purposely selected only reviews which reported anthropometric outcomes – and presented only relevant adiposity-related data for the identified primary studies– because achieving improved nutrition and PA levels does not necessarily translate into improved anthropometric outcomes, and the latter tend to be the main outcomes of interest to policymakers. While this resulted in a good number of reviews for inclusion, preliminary searches showed that there is a dearth of high-quality reviews focusing specifically on upstream environmental approaches to tackling childhood obesity. In addition, few SRs of any quality explicitly addressed macro-level interventions such as the introduction of school food and beverage policies [189,407,439,440] or implementation of broad community-based strategies [374,428]. It is unclear whether this is a genuine gap in the literature or a direct consequence of few relevant primary studies having been published in this area. In addition, the search strategy adopted by each review tends to inherently limit the range of primary studies included, and hence the scope of review conclusions and recommendations. In any case, we echo previous calls for further primary and secondary research into this key paradigm of population-level obesity prevention [284,411].

Implications for Research and Practice

Policy/environmental approaches to addressing childhood obesity show promise and should be strongly recommended for obesity prevention; however more studies, ideally large, longitudinal natural experiments conducted outside of the school environment with sufficient sampling power to ascertain effect sizes with some confidence, should be carried out [284,443,493]. The fact that almost a third of reviews focused on school-based studies indicates that schools are considered to be key sites for childhood and adolescent obesity prevention interventions, presumably because children spend a substantial portion of their day there, and the relative ease with which interventions can be trialled. However, interventions in schools that were successful in reducing obesity at first glance have been shown to lose their effect during the summer [456] and are often difficult to sustain among the same population in the longer term. Thus, engagement of the community and environmental support within the home are essential aspects of successful interventions. Studies should also implement more rigorous analysis and evaluation of associated social, psychosocial, behavioural, and biological outcomes, particularly adiposity outcomes. Undertaking formal economic evaluations would also add substantially to the utility of a study for policymakers [284], yet these are rarely performed, and there is little review-level economic data in this regard.

Limitations

Publication bias may be a potential limitation of this overview. Other SRs might exist but have not been submitted or accepted for publication and therefore could not be identified during our search. We are also aware that since the searches for this overview were carried out in March 2015, other reviews on this topic may have been published. Our criteria with regards to what constitutes an 'environmental' intervention meant that a large number of primary studies focusing on improving PE lessons during school hours, which possibly contributes towards achieving desirable anthropometric outcomes, were excluded. Quality appraisal of included reviews using the AMSTAR tool presented a number of issues which have also been raised by other assessors [494]. For example, only four reviews (including two Cochrane reviews) achieved a 'yes' rating in the 'conflict of interest included' criterion, which specifies that sources of funding or support for both the review itself as well as for each of the included studies should be reported. It is debatable whether indicating source of funding for primary studies reflects quality of reporting, rather than methodological quality of the review itself. Additionally, we encountered some difficulty in ascertaining multiple publications evaluating the same study, particularly in the case of long term studies. It was rarely immediately clear that publications were contiguous unless the project name was used in the title of the article, as in the case of the Medical College of Georgia FitKid Project [456,478] or APPLE project [473,474] publications. In other cases, including ICAPS [481] or the Dutch Obesity Prevention Intervention in Teenagers [459,460], references to previous publications were buried in the full text. Our exclusion of non-anthropometric outcomes means that impact of interventions on other potentially valid outcomes such as improvements in PA or nutrition behaviour, VO2 max, blood pressure and blood cholesterol levels were not assessed. However, there is evidence to suggest that these do not necessarily translate into reduced BMI [394,495].

Like Woodman et al., we had expected to find greater overlap of primary studies between reviews, and agree with their view that this can be attributed to differences in inclusion criteria and outcome assessments of SRs rather than erroneous search strategies [361]. Where unique primary studies were included in multiple reviews, their intervention design and findings were not necessarily consistently reported, potentially leading to type II errors during this overview process. Furthermore, inconsistencies in the definition of what constitutes an 'environmental' component of an intervention were seen. We suggest that the reporting structure of SRs could be improved by specifying the types of strategies (e.g. cognitive, educational, behavioural, parental, environmental) that included interventions employ, perhaps in table form as done by Sobol-Goldberg et al. [421] or Kamath et al. [400]. We found this approach particularly useful because it enabled us to directly assess the primary studies of interest, rather than go through the description of all included studies to judge whether one of its components was environmental in nature. On the other hand, this experience highlights the challenge of understanding what is meant by an 'environmental intervention': how is the term operationalized when conducting the review? Few SRs provided a clear, explicit definition, with most opting for, at most, a brief illustrative example [374]. More detailed and pragmatic frameworks for describing primary studies would be valuable [378].

Our methods led to the exclusion of a number of high quality SRs which implicitly or explicitly addressed environmental interventions, such as those by Matson-Koffman et al. [373] and Wang et al. [493]. These failed to provide sufficient descriptive or outcome data for us to clearly identify which included interventions were environmental in nature or whether they had any impact on obesity-related outcomes in school-aged children. However, to 'test' the comprehensiveness of our approach to identify primary studies using review-level data, we compared the primary studies included in the Wang et al. review with our final list of 76 eligible primary studies having an environmental component (Appendix 3F). Wang et al. identify ten studies as having an environmental component in the main text of their article. Five of these were included in our list because they overlapped with SRs that we had included in our overview. Three primary studies were not eligible according to our inclusion criteria. However, our approach missed two relevant primary studies with clearly reported environmental components and anthropometric outcomes [496,497] that were reported in Wang et al.'s article. The intervention by Pettman et al. (2014) [496] had not been reported upon in any of the SRs included in our study. However, the study by Chang et al. (2010) [497] had been cited the review by Bleich et al. (2010) [428] that we had included in our overview, but which was described by the review authors as having “social marketing, strategic partnerships, knowledge mobilization, strategies in multiple sectors” elements. There was no indication of any environmental component for this intervention. Based solely on the study description provided by Bleich et al.’s reporting, and taking into consideration that the SR had clearly described several other primary interventions as being ‘environmental’ in nature (or described a study component in sufficient detail to enable its classification as ‘environmental’ overview authors), we did not look at the full text of the Chang et al. (2010) study and thus missed the opportunity to include it in our list of environmental interventions. This highlights one of the disadvantages of using review-level evidence to inform policy: the evidence obtained is only as useful as the quality of presentation of data in the reviews.

Strengths

There are several strengths of this study. As many decisions as possible were made a priori to limit potential bias throughout the overview. All stages of the overview (i.e., inclusion criteria, exclusion criteria, data extraction, AMSTAR tables) were conducted in duplicate to minimize error. Our search strategy was sensitive and inclusive of several databases and grey literature, and our definition of ‘environmental interventions’ was broad. No language restrictions were applied. Consequently, the reviews analysed here, and the list of primary obesity prevention studies having an environmental component derived from this overview, are likely to represent the majority of relevant reviews and interventions available at the time of our search.

Conclusions

Environmental interventions may be modestly effective in addressing childhood obesity. However, there is a dearth of research into the feasibility and effectiveness of implementing environmental strategies in non-school settings, and information on programme cost that may be of use to policymakers seeking to translate evidence into practice is lacking. Most reviews suffered from poor methodology and presentation, making it difficult to assess the true effects of interventions on adiposity outcomes and necessitating retrieval of full texts of primary studies to ensure comprehensiveness.

Author contributions

DC performed the systematic review search, reviewed articles for inclusion, extracted data, generated tables and drafted the manuscript. KG independently reviewed articles for inclusion, extracted data, and reviewed and edited text. CK helped develop the research question, designed and piloted the extraction form for a portion of included articles, and reviewed and edited text. MP helped develop the research question and reviewed and edited text.

Conflict of Interest Statement

Partial financial support for this study was provided to DC by a PhD scholarship grant from the Malta Government Scholarship Scheme. The funding agreement ensured the authors' independence in designing, writing, and publishing this study. KG, CK and MP have no conflict of interest to declare.

Differences between protocol and review

There were some differences between the protocol published in March 2015 [396] and the methods outlined in this article. The inclusion criteria of this overview were revised to include systematic reviews published from 1995 up to April 2015, instead of from the year 2000 up to August 2013 as specified in the protocol. No language restrictions were applied to the database searches. Finally, in light of the large number of eligible systematic reviews initially identified, it was decided to restrict our primary outcomes of interest to weight/anthropometric outcomes only, and to exclude systematic reviews where the main or only outcomes of interest were physical activity or dietary outcomes.

End of Research Paper 2

CHAPTER 4. ENVIRONMENTAL AUDIT

Given that the dramatic rise in worldwide obesity rates in recent decades can only be reasonably explained by changes in the environment, there has been growing international recognition of the importance of altering obesogenic food and built environments to create more supportive settings [498–502]. Policymakers in Malta are also aware of this necessity. The relatively recent obesity and nutrition strategies published by the government both call for investigation into whether an 'obesogenic' environment is actually present in Malta [80,110]. The contextual analysis undertaken for this thesis uncovered a dearth of information on the built and food environment - important aspects of a potentially 'obesogenic environment' – in Malta. However, little was known about the state of these environmental characteristics in Malta at the start of this research. Thus, I set out to measure and characterise these environments in order to: (a) compile baseline data which will be of use to policymakers considering environmental, population-level interventions to address the problem of childhood – as well as population – obesity in Malta; (b) respond to calls by Maltese public health policymakers for more research on the food environment [80] (c) explore, where possible, whether there are any significant socioeconomic differences in these environments which may be contributing to inequalities in obesity and health. Thus, in the following sections I will present results that respond to objective 3 of this thesis, namely: (a) findings related to the built environment arising from the environmental audit; (b) Research Paper 3, which focuses on measuring the promotional environment around food and beverages on television to children; (c) Research Papers 4 (Environmental audit: NEMS-S) and 5 (Environmental audit: GroPromo), which focus on characterising the Maltese food environment. Systematic documentation of environments using objective measures may contribute to a more comprehensive understanding of influences going beyond subjective individual perceptions, consistent with an ecological approach.

4.1 Exploring the built environment

In chapter 3 I briefly described physical environmental influences on PA behaviour [503]. Research suggests that neighbourhood environments are an important level at which to intervene to prevent childhood obesity [194]. Urban planning literature indicates a clear link between aspects of the physical or built environment and PA at the community level [383], although the effect on weight outcomes is equivocal [504]. Specific features of the built environment that have been associated with PA behaviour include urban design and population density [505]; neighbourhood 'walkability' (i.e. often defined as a combination of three factors: intersection density or connectivity, land use mix and population density [506]); availability of and access to recreational areas or public open spaces that provide opportunities for PA [507]; and availability of public transport [218,508,509]. The underlying mechanisms through which such factors impact PA have not yet been fully elucidated [193,506], but it has been suggested that areas with high connectivity might encourage more walking and cycling for transportation [510], whereas neighbourhoods with limited availability of spaces for recreation, difficult topography and those perceived as being unsafe may hinder PA [510]. Similarly, the presence of adequate pedestrian facilities, public transportation and cycling infrastructure may help facilitate walking and cycling as means of transportation [510], whereas lack of access to public transport facilities or recreational areas may be a barrier to PA. Since children often perform specific activities on a regular basis (e.g. attending school; after-school tuition; catechism lessons; sports activities etc.), initiatives targeting the built environment that encourage walking or cycling to these activities may enhance their levels of PA [511]. Furthermore, PA in young children has been shown to be affected by the appearance and perceived safety of playgrounds as well as the availability and quality of playground equipment [512,513].

There is also a socioeconomic dimension to the relationship between the built environment and PA behaviour. Although no research in this field has been carried out in Malta, differences in the built environment across different types of neighbourhoods have been identified elsewhere [62,514,515]. For example, deprived neighbourhoods may have fewer areas for recreation leading to less activity among residents who need to travel further to make use of these resources [510]. There may also be more unsightly incivilities (such as litter, graffiti, poorly-maintained infrastructure etc.) and concern about crime in deprived areas than in more affluent neighbourhoods, impacting residents' desire to be active outdoors [510]. Thus, urban interventions to make neighbourhoods safer, more walkable and having a greater variety of PA resources might increase PA activity in youth [511].

Collection of built environment data for Malta through EURO-PREVOB methodology indicated that adopting this approach for Malta is feasible. The lack of published, objective built environment data for Malta means that this research may serve as a baseline against which changes to the urban form can be compared over time. Eventually, longitudinal research combining built environment indicator data for neighbourhoods or localities in Malta with data on PA behaviour and weight status among children living in these localities (e.g. accelerometer studies) may highlight associations between the built environment, PA and obesity in Maltese children. Until then, these results may help to identify areas where aspects of the urban environment may be improved to enhance PA and reduce SE inequalities.

4.1.1 Summary of Analyses

Results of the built environmental audit are presented in table form in Appendix 4. Kruskal-Wallis tests were performed to detect differences across SE quintiles and SE tertiles (except for differences in the number and quality of cycle lanes, which could not be statistically tested due to the generally low number or absence of such facilities). No significant difference across SE quintiles was identified for any built environment indicator. When data was aggregated into SE tertiles, where tertile 1 represents the most affluent neighbourhoods and tertile 3 the most deprived neighbourhoods, differences in bus stop density per km^2 emerged ($X^2(2) = 6.23$; $p = 0.044$). Pairwise comparisons revealed statistically significant differences ($X^2(2) = 5.25$; $p = 0.039$) between tertile 1 (8/km^2) and tertile 3 (2.75/km^2), but not between any other group combination. Differences in pavement quality were also revealed ($X^2(2) = 6.09$; $p = 0.048$), and post-hoc analysis revealed statistically significant differences between tertile 1 (8.12) and tertile 3 (2.88) ($X^2(2)= 6.08$; $p = 0.048$), but not between any other group combination.

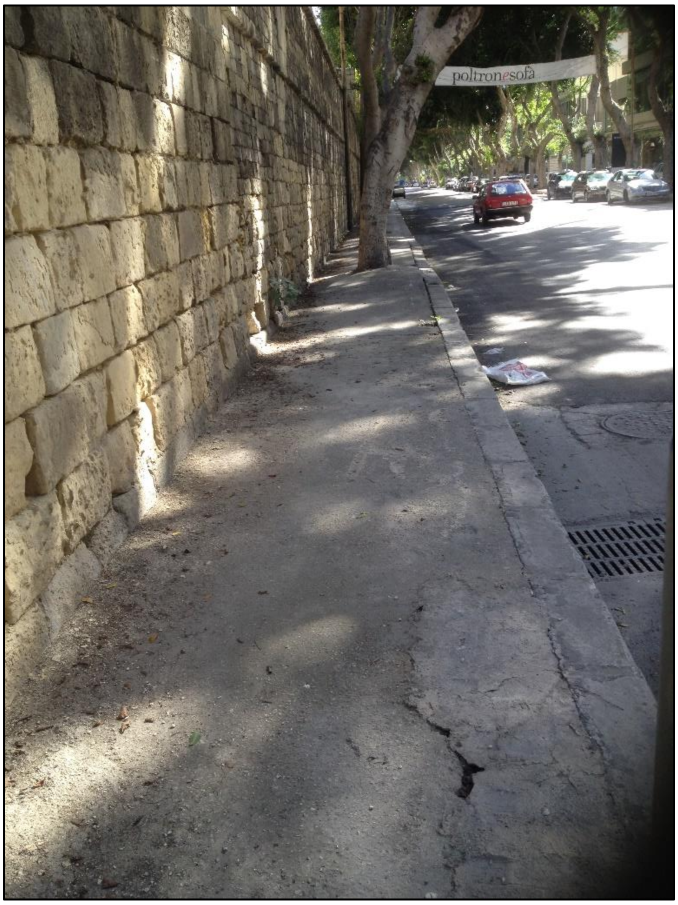

Figure 12. Damaged pavement; limited walkability due to tree growth

4.1.2 Conclusion

The relation between neighbourhood effects, PA behaviour and obesity is not linear and often difficult to conceptualise [516–519]. The dearth of cycle lanes or other cycling amenities within residential urban neighbourhoods across Malta that is clearly demonstrated in this study has received strong criticism elsewhere, including the recently published National Transport Strategy [520]. In Chapter 5 of this thesis, numerous stakeholders also frequently refer to this gap in transport infrastructure. Contrary to expectations, no significant differences by SE quintile – the main unit of analysis of comparison prescribed by EURO-PREVOB - were found for any of the built environment indicators assessed. This may be due to the fact that only two localities were assessed in each quintile, resulting in few observations in each unit. However, differences in the expected direction were observed when data was aggregated into tertiles. The finding that low SE localities had significantly less access to public transport is of particular interest. Based on the literature, low SES residents in urban areas might be expected to use public transport more frequently than residents of affluent areas [506]. Given that bus stop density is regulated by Transport Malta (the authority responsible for public transport route design in Malta) in response to observed demand for public transport, the relative sparsity of bus stops in low SE areas could indicate that residents in these localities are not regular bus users and perhaps more likely to walk or make use of private vehicles to get from place to place. Alternatively, the discrepancy could indicate that deprived areas are less adequately served by public transport in Malta. On the other hand, the lower quality of pavements observed in low SE localities might reduce the walkability of these neighborhoods and suggest that maintenance of pedestrian amenities may not be a priority for local council associations in these localities. Although cross-sectional data cannot be used to infer causality, these data warrant further research into the neighbourhood determinants of PA in Malta using a larger sample size, ideally in combination with data on PA behaviour of individuals living in these localities.

These results may inform public health policymakers about physical environmental factors that potentially influencing obesity-related behaviour in Malta, and highlight areas requiring action. This objective assessment of the built environment also complements the qualitative findings reported in Chapter 5.

4.2 The Food environment

Preamble to Research Paper 3

The contextual analysis presented in Research Paper 1 indicated a need for more objective data to assess aspects of the current obesogenic environment in Malta [216]. Food advertising aimed at children was identified as an environmental factor with a potentially significant impact on children's dietary behaviour. Watching television is a key sedentary behaviour and an important source of food advertising to children. The association between time spent watching television and risk of childhood obesity has led the American Academy of Paediatrics to recommend that TV viewing among children should be limited to 2 hours per day [179]. A nationally representative US study on a cohort of 10 to 15-year-olds showed that children watching more than five hours of television daily were almost five times more likely to be overweight than those watching less than two hours daily. The study concluded that an estimated 60% of the risk of overweight incidence could be attributed to excess television viewing time [177]. A recent meta-analysis of the experimental evidence around the relationship between food promotion exposure on television or digital platforms and actual food intake was associated with significantly greater consumption in children (but not in adults). [521] Such evidence supports public health calls for more regulation of television advertising to reduce children's exposure to unhealthy food promotion, including recommendations by Public Health England and the WHO [522,523]. Moreover, other studies have shown that self-regulation by the food industry or advertisers might not be an appropriate compromise. Evaluations of self-regulation of television advertising in Spain [524] and in the UK [525] revealed that children's exposure to HFSS food advertising remained the same or even increased despite good adherence to the regulations. This may be due to the fact that such regulations mainly apply to children's programmes: in reality, children may view programmes such as dramas and entertainment shows that do not fall within this classification, and which hence are not subject to the regulations [525].

Malta does not yet have legislation to reduce the impact of HFSS food marketing to children, although policies to reduce the impact of non-broadcast marketing (e.g. sponsorships for school events) are observed by the government. However, there seems to be significant interest among Maltese policymakers in adopting a tighter regulatory approach to marketing of HFSS food and SSBs on television. Both the national obesity and nutrition strategies make explicit references to regulation of audiovisual advertising of HFSS food to children as a key measure that should be considered to address childhood obesity in Malta [80,110]. Monitoring of population exposure to food and beverage promotions, and analysis of their content, is necessary to generate evidence to determine appropriate and effective policy responses [65]. No concerted, systematic effort to assess television exposure had been carried out in Malta prior to this research. Thus, there was significant scope to conduct a cross-sectional, observational study to assess television advertising patterns on local television. Study findings are presented in the article below. These have direct policy implications because they enable the identification of the most appropriate time frame for any restrictions; the article's findings will also inform the implementation of the Audiovisual Media Services Directive (Directive 2010/13/EU) in Malta [Gauci, C. HP&DPD, personal communication].

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SECTION A – Student Details

Student	Daniel Cauchi
Principal Supervisor	Cécile Knai
Thesis Title	Childhood obesity in Malta: contributions of the obesogenic environment

SECTION B – Paper already published

Where was the work published?	Health Promotion International		
When was the work published?	25 October 2015		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion	N/A		
Have you retained the copyright for the work?*	No	Was the work subject to academic peer review?	Yes

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Student Signature: D Cauchi **Date:** 29/07/2016

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Research Paper 3

Television food advertising to children in Malta

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Author contribution: I formulated the research question and designed the study. I formatted the dataset for analysis with input from Sascha Reiff and Joanna Spiteri. I drafted the manuscript and made revisions based on comments from all co-authors.

Abstract

Objective. To undertake a cross-sectional survey of the extent and nature of food and beverage advertising to children on Maltese national television stations.

Design. Seven national free-to-air channels were recorded for seven consecutive days in March 2014 between 07:00-22:00 hours. Advertisements were coded according to predefined categories, with a focus on advertisements aired during 'peak' children's viewing times, defined as periods during which more than 25% of children were likely to be watching television on any channel. Food and beverage advertisements were classified as core (healthy), non-core (unhealthy) or miscellaneous foods.

Setting. Malta

Sample. Whole population, with a focus on children

Results. Food and drinks were the most heavily advertised product category (26.9% of all advertisements) across all channels. The proportion of non-core food/drink advertisements was significantly greater during peak compared to non-peak children's viewing times (52% vs 44.6%; $p=<0.001$). A majority of advertisements aimed at children are for non-core foods, and are typically shown during family-oriented programmes in the late evening rather than being restricted to children's programmes. 'Taste', 'enjoyment' and 'peer status' were the primary persuasive appeals used in adolescent and child-focused advertisements.

Conclusions. This first content analysis of television advertising in Malta suggests that there is scope for the implementation of statutory regulation regarding advertising of foods high in fat, sugar and salt (HFSS) during times when children are likely to watch television, rather than during children's programmes only. Ongoing, systematic monitoring is essential for evaluation of the effectiveness of regulations designed to reduce children's exposure to HFSS food advertising on television.

Introduction

Excess weight in children is of significant public health concern globally and in Malta, a small Mediterranean island republic [7,10,104]. Overweight and obese children are known to have a high risk of suffering from a range of adverse non-communicable diseases [7]. There is a well-established association between time spent watching television and body weight [526,527]. Television watching is a sedentary behaviour, and there might be a concomitant tendency to consume energy-dense snack foods during viewing [528]. Marketing of unhealthy foods and beverages to children may adversely affect children's dietary choices and energy intake by influencing their food preferences, knowledge, attitudes, purchasing behaviour, and purchasing requests to parents [527–529]. Reducing children's exposure to the promotion of unhealthy foods and beverages high in saturated fats, trans-fat, free sugars or salt (HFSS) has been recognized as a key target for childhood obesity prevention policy [530]. In many countries, HFSS foods such as sugar-sweetened breakfast cereals, soft drinks, confectionery and high fat snacks are frequently advertised to children on television [531]. Children under 8 years of age are particularly vulnerable to such promotion, as they have limited cognitive ability to discriminate entertainment content from commercial content [532]. Older children also tend to accept commercial claims uncritically [533,534]. In 2010 the World Health Organization (WHO) released a set of recommendations to guide Member States' efforts in development of policies on food marketing communications in order to reduce the impact of HFSS foods and beverage promotion to children, including a recommendation for the establishment of monitoring and evaluation systems to ensure that policy objectives are reached [522]. Regulatory changes have been implemented in a number of countries as regulation of food marketing is increasingly recognized as a promising avenue for intervention [535].

Contextual factors and the policy environment

To date, there has been limited discourse on regulation of HFSS food and beverage advertising in Malta. A recently updated Food and Nutrition Policy and Action Plan [110] recommends that media service providers develop codes of conduct regarding inappropriate promotion of HFSS foods to children, in line with Article 9(2) of the Audiovisual Media Services Directive (AVMSD) of the European Union [349]. The Broadcasting Act encompasses a Legal Notice that makes reference to misleading and deceptive advertising to minors, including HFSS food promotion [351]. Television is still regarded as the media platform preferred by food marketers, although its dominance is gradually decreasing [527]. In 2010 in Malta, around 60% of Maltese children aged 11 to 15 years reported watching television for more than 2 hours daily on weekdays [536]. A Broadcasting Authority of Malta (BA) audience assessment survey suggests that around 62% of the Maltese population regularly followed a television station in 2014; this was true across gender and age groups. Almost three-fourths of respondents listed one of the seven free-to-air national television channels as their preferred station, suggesting that a substantial proportion of the Maltese population still watch local television regularly [537].

The aim of this study was to conduct a cross-sectional survey to assess the extent of exposure and nature of food and beverage advertising across national free-to-air television stations in Malta, in order to establish whether the problem of unhealthy food promotion within television exists. To our knowledge, this is the first such study conducted in Malta. The overall proportion of food advertisements and the balance of 'healthy' versus 'unhealthy' foods, as well as variations in advertising patterns by station; viewing times; and day of the week were analysed. The use of persuasive techniques in food and beverage advertisements was explored.

Material and Methods

Recording

Television transmission was recorded from 07:00-22:00 hours daily for all seven national free-to-air television stations broadcasting during the week between 10th and 16th March, 2014, in accordance with the guidelines outlined by the International Network for Food and Obesity/non-communicable diseases, Research, Monitoring and Action Support (INFORMAS) group [65]. These were TVM and TVM 2 (Public Service channels); ONE TV and NET TV (political-commercial channels); and fLiving, SMASH TV and XEJK TV (commercial channels). The second week of March was selected as being a period representative of usual advertising patterns that did not contain any special events or holiday periods.

Coding

Television station broadcasts were recorded and scanned by the BA, and all advertising content was subsequently forwarded to the authors. Thirty hours of content selected at random were coded independently by two of the authors, DC and SR, according to predefined criteria [538–540]. Inter-rater reliability for classification of advertisements as either 'food' or 'non-food' was very high (100% agreement), whereas 92% agreement for classification of food advertisement category and target audience was achieved. Inter-rater reliability for coding of primary persuasive technique was 81%. Disagreements were resolved by discussion. Subsequently, coding of remaining hours was carried out by DC and SR according to standard procedure in order to achieve consistency. Where more than one food product was shown, the most dominant product was coded, whereas the first product shown was coded when multiple products were given equal importance. Other coding categories included channel, programme category (e.g. drama, news, discussion/current affairs, based on an in-house classification issued by the BA) around which the advertisement was shown; the type of product advertised (e.g. food/drink, fashion, furniture); time of day; and whether the advert was aired during children's peak or non-peak viewing times.

Food and beverage advertisements

Advertisements showing food and beverages were categorized into 29 sub-categories (Table 6). In general, nutrient-dense items low in excess energy that are required daily to meet nutritional requirements (such as bread, fruit and vegetables) were considered to be 'core' foods, whereas energy dense, nutrient-poor HFSS foods such as fast food, high sugar/low fibre breakfast cereal and sweets were classified as 'non-core' foods. All other items such as tea, coffee, and generic supermarket advertisements for multiple items were classified as 'miscellaneous' [538,541,542]. Food advertisements were further screened for three persuasive marketing techniques: premium offers (such as competitions, vouchers, price reductions); celebrity endorsement and use of cartoon/branded characters. Additionally, each food advert was coded for the primary/most dominant persuasive appeal used (such as fun, taste, price) and the primary target of each advert based on the general direction and content of the advert (e.g. dialogue, complexity, used of child actors or cartoons) [543].

Definition of children and children's viewing hours

Country definitions of children in broadcasting regulatory frameworks vary considerably [544]. Currently, the Broadcasting Act defines a minor as an individual less than 18 years of age. Clearly, age is a primary determinant of exposure to particular television programs and advertisements. This has been recognized by the BA as a contentious issue influencing debate around vulnerability of older minors to the persuasive effects of advertising, and a consultation process to lower this threshold to 16 years is underway [545]. Definitions of children's viewing hours also vary [530,531], although audience viewing data suggests that children's television viewing is often not confined to designated children's programmes [538]. We adopted a previously-used definition of peak children's viewing times as being those periods during which more than 25% of children were likely to be watching television on any channel [538,539]. These were between 07:00-08:00 and 16:00-21:00 on weekdays, and 19:00-21:00 on weekends, based on average audience viewing patterns over the previous year and the existing 21:00 watershed enforced by the BA [546]. Other time periods were considered to be 'non-peak'.

Definition of fast food restaurant

Restaurant advertisements comprised a significant proportion of overall advertising, and were categorized as either 'fast food' or 'non fast-food' based on a classification system developed by Lake and colleagues [547] and adapted by Burgoine et al [548]. We felt the need to create an additional category for non-fast food (sit-down) restaurants/meal advertisements beyond the 28 categories outlined by Kelly et al. [538,541] in order to accommodate advertisements for establishments where the broad emphasis was on the wide choice of food offered, rather than HFSS food specifically. In view of concerns that adopting a restrictive definition of fast food outlets (e.g. limiting outlets to multinational franchises only) might underestimate true exposure to fast food [549,550], we considered a fast food restaurant to be an outlet where pre-prepared or processed HFSS food is predominantly ordered and paid for at the counter and lacking a waiter service. Establishments advertising wedding catering services (predominantly consisting of HFSS finger food) and traditional sit-down restaurants that heavily emphasized takeaway/delivery options in their advertisements (e.g. quick-service pizzerias), were thus classified in the fast food category.

Ethical approval

Ethical approval was not required as no human participants were involved in this study.

Analysis

Data was analysed using IBM SPSS version 18 for Windows. Non-parametric analyses were performed as the data was not normally distributed. Pearson $\chi 2$ tests were applied to determine significant differences in the proportion of food advertising. P-values of <0.05 were considered statistically significant (with Bonferroni adjustments for multiple comparisons). All data were analysed together as initial assessment showed that food advertising prevalence did not vary significantly by day of recording.

Results

A total of 735 television hours were recorded, within which 6,431 advertisements were shown at an average rate of 1.25 advertisements per channel per hour ($ch^{-1}hr^{-1}$).

Product types advertised

Across all channels, food was the most frequently advertised product category (n=1,730; 26.9%), broadcast at an average of 0.34 food-related advertisements per channel per hour. There was a significant difference in the proportion of the various product categories advertised ($\chi2(17) = 8248.6$, $p = <0.001$), with furniture (13.3%) and services (10%) being the next most frequently advertised categories. There was also significant variation in food advertising frequency between channels ($\chi2(6) = 1102.92$, $p = <0.001$).

Food types advertised

There was a significant difference in the proportion of food product categories advertised ($\chi^2(27) = 3687.05$, $p = <0.001$). The three most frequently advertised categories were for fast-food restaurants or meals (including "healthy" alternatives); non-fast food restaurants; and supermarket advertisements showing mostly non-core foods respectively (Table 6). The proportion of advertisements for non-fast food restaurants was significantly different from that of fast-food restaurants ($\chi^2(1) = 14.8$, $p = <0.001$) or HFSS spreads ($\chi^2(1) = 122.2$, $p=<0.001$). Vegetable and vegetable products without added sugar ranked 11th from the 29 food categori es, while fruit and fruit products ranked 26th. Breads and non-battered/crumbed meats were the 4th and 8th ranked food categories respectively.

Core, non-core and miscellaneous food advertisements by children's viewing times

Within our sample, non-core food advertisements were shown at a mean rate of 0.16 $ch^{-1}hr^{-1}$; core food advertisements were shown at a mean rate of 0.06 $ch^{-1}hr^{-1}$, and miscellaneous food advertisements at 0.12 $ch^{-1}hr^{-1}$. There was no significant difference between the rates at which food advertisements were broadcast during peak hours and non-peak hours ($p=0.171$). However, the proportion of core, non-core and miscellaneous advertisements within the food advertisement category differed significantly across peak and non-peak viewing times ($\chi^2(2) = 11.87$, $p = 0.003$). Table 6 suggests that a greater proportion of non-core food advertisements were broadcast during peak hours (52% or 0.19 $ch^{-1}hr^{-1}$) than during non-peak hours (44.6% or 0.14 $ch^{-1}hr^{-1}$); $\chi^2(2) = 41.9$, $p = <0.001$), while the opposite was true for core and miscellaneous food advertisements ($p=<0.001$).

Classification of food and beverages	Peak	Non-Peak	Overall	χ² test
	Freq. (%)	Freq. (%)	Freq. (%)	(p value)
Core foods	85 (14.00)	219 (19.48)	304 (17.56)	<0.001
Baby foods (excl. milk formulas)	1 (0.18)	2 (0.17)	3 (0.17)	0.564
Bottled water	1 (0.17)	18 (1.60)	19 (1.10)	<0.001
Breads, low-fat crackers, rice, pasta & noodles	33 (5.45)	79 (7.03)	112 (6.47)	<0.001
Fruit & fruit products without added sugar	0 (0.00)	5 (0.44)	5 (0.29)	/
Low-fat/reduced-fat dairy products	4 (0.66)	26 (2.31)	30 (1.73)	<0.001
Low-sugar & high-fibre breakfast cereals	3 (0.50)	3 (0.27)	6 (0.35)	1
Meat & alternatives (not crumbed/battered; incl. fish, legumes, eggs, nut products, peanut butter)	25 (4.13)	42 (3.74)	67 (3.87)	0.038
Soups (excl. dehydrated), salads & sandwiches, frozen meals, & low-fat savoury sauces	6 (0.99)	5 (0.44)	11 (0.64)	0.763
Vegetables & vegetable products without added sugar	12 (1.98)	34 (3.02)	46 (2.66)	0.01
Noncore foods	316 (52.06)	501 (44.57)	817 (47.20)	<0.001
Alcohol	1 (0.17)	24 (2.14)	25 (1.45)	<0.001
Cakes, muffins, cookies, pies, & pastries	19 (3.14)	42 (3.74)	61 (3.53)	0.003
Chocolate & confectionery (incl. chewing gum)	32 (5.28)	23 (2.05)	55 (3.18)	0.225
Crumbed/ battered meats & high-fat frozen meals	20 (3.30)	16 (1.42)	36 (2.08)	0.505
HFSS fast food or meals	153 (25.25)	258 (22.95)	411 (23.76)	<0.001
Frozen/fried potato products (excl. crisps)	9 (1.49)	8 (0.71)	17 (0.98)	0.808
Fruit juice & fruit drinks	1 (0.17)	14 (1.25)	15 (0.87)	0.001
Full-fat dairy products	26 (4.29)	44 (3.91)	70 (4.05)	0.031
HFSS spreads (excl. peanut butter), oils, high-fat savoury sauces, canned & dehydrated soups	40 (6.60)	48 (4.27)	88 (5.09)	0.394
High-sugar or low-fibre breakfast cereals	7 (1.16)	8 (0.71)	15 (0.87)	0.796
Ice cream & iced confections	0	5 (0.44)	5 (0.29)	/
Snack foods (incl. crisps, extruded snacks, popcorn, granola bars, sugar-sweetened fruit & vegetable products, sugared/salted nuts)	6 (0.99)	2 (0.18)	8 (0.46)	0.157
Sugar-sweetened drinks, incl. regular/diet soft drinks, cordials, sports drinks	2 (0.33)	14 (1.25)	16 (0.92)	0.003
Miscellaneous foods	206 (33.94)	404 (35.94)	610 (35.24)	<0.001
Baby & toddler milk formulas	4 (0.66)	3 (0.27)	7 (0.40)	0.705
Non-fast food restaurant/catering establishment	88 (14.52)	220 (19.57)	308 (17.80)	<0.001
Supermarkets advertising mostly core foods	5 (0.83)	30 (2.67)	35 (2.02)	<0.001
Supermarkets advertising mostly noncore foods	51 (8.42)	76 (6.76)	127 (7.34)	0.027
Supermarkets with non-specified foods (generic ads; unclear whether for core or noncore foods)	41 (6.77)	55 (4.89)	96 (5.55)	0.187
Tea & coffee	16 (2.64)	20 (1.78)	36 (2.08)	0.505
Vitamin & mineral supplements	0 (0.00)	5 (0.44)	5 (0.29)	/

Table 6. Contribution of food categories to overall food advertisements

While their respective proportions during peak and non-peak viewing hours on weekend days were not significantly different (p=0.234), Figure 13 indicates that non-core food advertisements were broadcast at a higher frequency during peak hours on weekdays, while core food advertisements were broadcast at higher frequencies during non-peak weekday hours ($\chi^2(2)$=10.2, p=0.006). There was also a significant difference in the proportion of food advertisements for core, non-core and miscellaneous food items ($\chi^2(2)$=230.9, p=<0.001) across all channels.

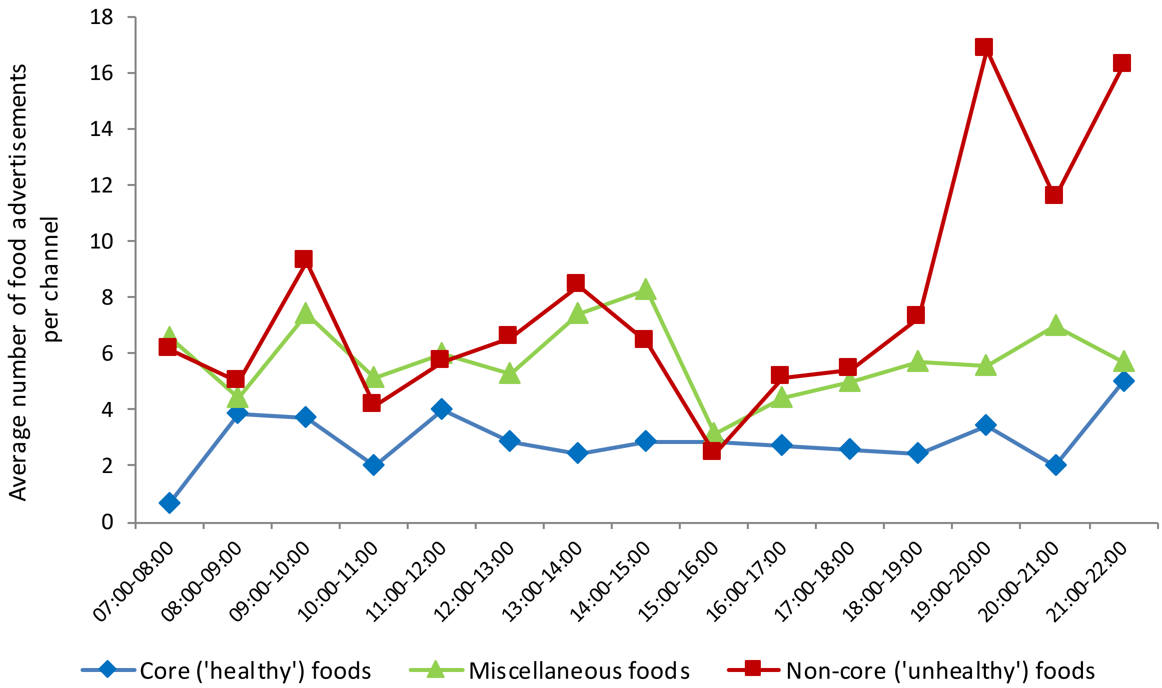

Figure 13. Volume of food advertisements per channel per hour

Food advertisements broadcast around different program types during peak viewing hours

There was a significant difference in the proportion of core/non-core food advertisements aired across the different programme types ($\chi^2(20)$=99.45; p=<0.001). During peak viewing hours, Entertainment/Gameshow programmes contained the highest proportion of food advertisements (43.2% of all advertisements in this category), followed by Magazine (variety) programmes (27%), Drama (26.7%) and Discussion/Current Affairs (25.4%). Within these four categories, only Drama and Discussion/Current Affairs had a significantly higher proportion of non-core compared to core food advertisements (p=<0.001). Children's programmes had among the least food advertisements overall, comprising 18.8% of all advertisements shown during such programmes. However the majority (71.4%) of these food advertisements were for non-core foods (p=<0.001).

Food advertisements aimed at children

Overall, 125 (7.2%) of all food advertisements were considered to be aimed primarily at minors (children or adolescents). 95% of these child-focused advertisements were for non-core foods (n=119; $\chi^2(2)=215.3$; p=<0.001). Chocolate and confectionery advertisements ranked first (40% of child-focused food advertisements), followed by full fat dairy products (21%) and cakes, muffins and pastries (18%). There was a significant difference with regards to the programme category within which these were aired ($\chi^2(8)=179.5$; p=<0.001). Only one child-focused advertisement (belonging to a large multinational fast food company) was broadcast during a children's programme. Instead, 38% of advertisements aimed at children were aired during Discussion/Current Affairs and 31% during Entertainment/Gameshow programmes. Child-focused advertisements were approximately equally distributed across days (p=0.37); between peak and non-peak viewing hours (p=0.93) and with regards to use of a persuasive technique (p=0.42). Political-commercial channels aired more child-focused advertisements than Public Service channels (76 vs 49; $\chi^2(1)=5.83$; p=0.016), whereas commercial channels did not broadcast any child-focused advertisements at all. Furthermore, a significant difference in the time at which child-focused advertisements were aired was identified ($\chi^2(14)=205.4$; p=<0.001), wherein 68% of all child-focused food advertisements were broadcast between 19:00 and 22:00.

Persuasive techniques used

Overall, 815 food advertisements incorporating a persuasive promotional technique were broadcast at an average rate of 0.16 $ch^{-1}hr^{-1}$. There was a significant difference between the use of persuasive techniques to promote core, non-core and miscellaneous foods ($\chi^2(2) = 207.3$; p = <0.001), with core foods unlikely to be linked to a persuasive technique. Few advertisements featured cartoon characters (n=38), however most of these (94.7%) were for non-core chocolate and confectionery or full fat dairy products. None were for core foods. Although no promotional toys were linked to specific adverts, 63 of these advertisements were regarded as being directly targeted at minors. Across all channels, a promotional character or celebrity endorsement featured on 47.3% of food advertisements. On the other hand, there was a significant difference between food category advertisements endorsed by local celebrities (χ^2 (2)=41.03; p = <0.001) with 47% showcasing miscellaneous foods and 34.6% showcasing core foods, while non-core foods were the category least frequently endorsed. 55% of adverts featuring a persuasive technique contained premium offers; of these, few were for core foods (7.1%), and there was no significant difference between the proportions of premium offer advertisements showcasing miscellaneous or non-core foods. Premium offers and celebrity endorsement techniques were primarily aimed at adults.

Persuasive appeals used

The proportions of all primary persuasive appeals used to advertise to adults except for 'weight loss' were significantly different from those used in advertisements aimed at minors (all p <0.001; Table 7). Overall, there was a significant difference between the proportions of different persuasive appeals used in child-focused advertisements ($\chi^2(5) = 87.3$; p = <0.001). 'Taste' was the most popular appeal to children, followed by 'fun' and 'peer status' (i.e. promoting consumption of a specific food as a means of social acceptance). 'Value for money' and 'General superiority' featured significantly more frequently in advertisements aimed at adults when compared to child-focused advertisements.

Primary Persuasive Appeal used	Primary Target of Advert (%)	
	Adults	Minors
Value for money	24.5	0
General superiority	22.9	5.6
Convenience	14.1	3.2
Health/nutrition	8.8	0
Taste	8.6	42.4
Premium/contest	7.6	0
Unique	6.5	0
Enjoyment/Satisfaction	5	21.6
Weight loss	1.7	0
Peer status	0.2	22.4
Energy	0.1	4.8

Table 7. Mean proportion of primary persuasive appeals used

Discussion

Malta is a signatory to the Vienna Declaration and the European Charter on Counteracting Obesity, which recommend considering child marketing restrictions as policy options for governments' obesity strategies [267,326]. However, although a number of national policy documents explicitly recommend reductions in promotion of unhealthy food to minors [80,110,227], this study suggests that

more can be done to protect Maltese children against exposure to HFSS food and drink on national television.
In some respects, television food advertising in Malta follows a pattern similar to that of other countries. Food was the most heavily advertised product category (26.9% of total advertisements), comparable to the high prevalence seen in Greece and Italy [538] and double that in the UK (12.8%) [542]. Most food advertisements on Maltese television channels are for energy-dense, HFSS food and beverages or restaurant advertisements, with less than a fifth of these representing 'core', nutrient-dense items. Non-core foods seem to be preferentially advertised during peak viewing hours at the expense of core food advertisements. From the core food types, unsweetened vegetable and fruit products accounted for less than 3% of all food advertisements. This strongly contrasts with dietary guidelines [110] and supports evidence from multiple international studies indicating that advertising for healthier foods such as fruits and vegetables is infrequent or absent [531].

Our results also highlight potential context-specific differences in comparison to findings from other countries that may be relevant to other small states, and which may reflect advertiser's familiarity with local television viewing habits. For example, reviews have indicated that children's advertising is typically dominated by pre-sugared breakfast cereals, soft drinks, confectionery, savoury snacks and fast foods [527,531]. In contrast, fast food restaurant and confectionery advertising were common in Malta (in line with findings from the island state of Singapore [551]), whereas breakfast cereals, soft drinks and savoury snacks advertisements were infrequent. In our sample, food advertisements were not frequently aired during children's programmes, unlike the trend in other countries [527,531,538]. Additionally, although the provision of free toys/gifts with purchase of items is a common marketing technique to promote food to children in many countries [551,552], this does not seem to be the case in Malta. The most common creative strategy employed to target children was the use of cartoon characters, and such advertisements were not typically aired during children's programmes. Instead, two thirds of all child-focused advertisements – of which the majority were for non-core foods – were broadcast during a three hour period that extends beyond the evening watershed. This corresponds to the 'prime time' hours when evening Entertainment/Gameshow programmes typically tail off in the early evening, followed by Drama and Discussion/Current Affairs programmes that start just before the 21:00 watershed. There is evidence to suggest that drama and entertainment programmes are very popular amongst Maltese children. In 2014 54.8% of 12-14 year old children named a drama production as their preferred programme, while 16.8% preferred to watch 'Entertainment' programmes [537]. Public Service broadcasters are the preferred channels of a third of 12-14 year old Maltese children, while 43.9% prefer to watch a cable TV channel aired internationally (typically the Disney Channel). This is understandable in light of the paucity of children's programmes on local television. Only eight instances of programmes aimed specifically at children were aired during the week of recording, constituting less than 2% of all programmes.

Core food advertisements were broadcast at higher frequencies during non-peak weekday hours, possibly targeting home makers who would typically be responsible for purchasing groceries for the family. On the other hand, non-core foods in general were more heavily advertised during peak viewing hours on weekdays, at times when children are likely to be watching television [537]. This difference was not seen on weekends, and merits further research. Our results suggest that most television advertising in Malta is targeted towards parents, not children. However, strategic broadcasting of adult-focused, non-core food advertisements during prime time might compensate for such advertisement's relative inability to directly engage the attention of children. Persuasive techniques employed in advertisements varied depending on the target audience. Unsurprisingly, advertisements in our study which featured promotional characters were often aimed at children and linked to non-core foods, echoing findings elsewhere [552]. Advertisements featuring premium offers and celebrity endorsement techniques were primarily aimed at adults, possibly indicating that advertisers on Maltese television do not perceive local celebrities as being effective in promoting their food products to children. On the other hand, a third of these advertisements featured core foods, possibly suggesting that adult purchasing of core foods is more likely to be influenced by celebrity endorsement. Associating a product with premium offers was also a common strategy and seemingly linked to non-core food promotion to children; cakes, muffins, fruit juices and full fat dairy products such as sugar-sweetened yogurt were typically advertised in this manner. Similar to findings in other countries [531,552], appeals to taste and fun were recurrent themes in our sample, highlighting the need for monitoring both content and timing of unhealthy food advertising to children.

There were some limitations to this research. Its cross-sectional, descriptive nature means that a link between advertising and potential behavioural outcomes in children cannot be explicitly made. Differences in categorization of health and unhealthy foods across countries may limit the comparability of results. For example, full fat dairy products and fruit juices are classified as non-core foods in our study, however these were considered to be healthy foods elsewhere [551]. Our adaptation of the definition of 'fast food' to include wedding catering and HFSS food advertisements offered by non-multinational 'quick service' restaurants may limit comparability of this category to existing research and policy applications. Methodological restrictions of TV audience reporting in Malta mean that data on children younger than 12 years of age is not routinely collected, hence conclusions on food promotion exposure in this age group should be interpreted with caution. Only national television stations were included in our survey as only these channels can be subject to statutory regulation by the BA. However, extrapolation of the viewing habits of 12-14 year olds [537] suggests that only a third of Maltese children aged 12-14 years watch local television stations, perhaps due to the increasing popularity of pay-TV subscriptions offering a variety of satellite channels: by end 2014 there were 147,880 pay-TV subscriptions in Malta, compared to the 152,980 private households assessed during the 2011 census [553]. This raises concern about inappropriate advertising to children on television channels (and other media platforms such as the internet) originating from outside the country's borders: such cross-border advertising is currently permissible, and requires concerted action at an international level for successful regulation [544].

Recommendations

Collection of seasonal TV advertising data would enable yearly advertising trends to be identified. Modification of the current broad age categories used in BA Malta's television audience reach surveys - and inclusion of children younger than 12 years – would contribute to a clearer understanding of the situation. The possibility of assessing promotions on popular foreign TV stations should also be considered as these are increasing in popularity, particularly among younger children. Additionally, the optimal INFORMAS approach to food promotion monitoring recommends collecting data from a number of media platforms [65]. Indeed, marketing food to children via electronic media is widespread even as the regulatory environment is weaker than that of other major platforms [554]. The Internet is known to be a popular platform amongst children aged 15 and older in Malta [555], and this may also apply to children younger than 12 years. The BA has made proposals aimed at amending existing legislation on "Protection of Minors"; these outline how promotion of HFSS food to children might be limited and recognizes *"...minors' immaturity or natural credulity..."*. This would be a welcome first step towards the development of a code of conduct for media service providers to follow [545], in line with national calls for development of a potentially legally binding code of practice in food advertising [110]. Such initiatives require careful phrasing in order to take into account children's frequent exposure to advertisements that are not specifically aimed at them. There has been a consensus amongst local broadcasters that the late-night watershed for HFSS food advertising should be set at 21:00. In reality, children's peak viewing hours overlap with adult's viewing hours, and most television stations tend to start broadcasting programmes which may include adult-oriented material any time after 8.30pm [546]. In order to effectively reduce children's exposure to HFSS food advertising and shift the balance towards healthier exposure for children, particular care should be taken so that regulation of HFSS food

advertisements encompasses all programmes (not just those aimed at children) aired during peak viewing hours, including family-oriented programmes that straddle the watershed. A shift in programme sponsorship trends could be encouraged, emulating 'child-friendly' policies such as those championed by the Disney Channel, which does not broadcast traditional food advertising, relying instead on television programme sponsorship [543]. However, we recognize that this might be a challenging option for small countries where local televised productions may be dependent on the food industry for a significant portion of their revenue.
The World Health Organization framework for implementing food marketing recommendations propose reducing children's exposure to marketing [522]. While recognizing the limitations of the current evidence base, restricting TV food advertising to children has been proposed as a cost-effective population-level intervention to reduce childhood obesity [556]. Currently, there is no statutory regulation of promotional techniques used in child-focused food advertising in Malta, and formal industry self-regulation in Malta has not taken place. In spite of broader initiatives such as the EU Pledge [557], findings indicate that industry self-regulation has not resulted in meaningful improvements in TV food advertising to youth [558–560] suggesting that voluntary industry-led action might not be the optimal way forward. Furthermore, any regulation – whether imposed or voluntary - would only apply to television broadcasts originating from Malta. In spite of these limitations, statutory regulation of television advertising on national stations during peak hours might shift the balance of advertising in favour of healthier food choices [561].

Conclusion

Malta's nascent legal-regulatory discourse around television advertising requires evidence to support and evaluate any policy measures introduced in the future. This cross-sectional study provides a useful starting point, addressing a gap in the knowledge base around children's exposure to unhealthy food and beverage promotion on television in Malta, and may help contribute to the international landscape of television food advertising. Improved data collection methods and sustained monitoring of television and other audiovisual media platforms including online media will be necessary to guide development of meaningful policy interventions, and provide evidence to support advocacy activity aiming to reduce children's exposure to unhealthy food promotions [65]. Further research exploring the link between advertising and outcomes such as consumption behaviour is warranted.

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End of Research Paper 3

Preamble to Research Papers 4 and 5

In Research Paper 3, I explore the advertising of food and beverages to children on Maltese television channels, highlighting how advertisements for energy-dense, low-nutrient food are aired at times when both adults and children are likely to be watching. However, other equally important dimensions of the Maltese food environment have received little attention by Maltese policymakers. According to the socio-ecological model, personal factors and the environment interact to influence behaviour. One aspect of this environment includes the settings where people procure food, such as grocery stores, restaurants, schools, workplaces and so on. These settings have been shown to independently predict food choice and dietary quality because they directly influence the types of food and beverages available to individuals [12,501,562]. Recognizing this, the 2012 national obesity strategy proposed that "variations in the availability of shops selling fast foods and vendors selling fresh fruit and vegetables" should be explored to generate baseline knowledge about the food environment [80]. In the following two articles, I partially fulfil this policy recommendation and elaborate upon objective 3 of this thesis.

4.2.1 Defining the food environment

The concept of the 'food environment' or 'nutrition environment' within the broader obesogenic environment was first described by Glanz et al. in 2005 [69]. It refers to the circumstances surrounding the procurement and consumption of food. Several food environment sub-types have been conceptualised, including the *informational* (i.e. media and advertising); *community* (i.e. number, type, location, and accessibility of food outlets in an area); *organizational* (referring to the type and availability of food in organizations such as the home, work or school); and *consumer* (i.e. conditions that individuals encounter within stores, including nutritional quality, price, promotion, and placement) food environments. These definitions are used throughout the remainder of this thesis.

4.2.2 Why measure the food environment?

As the debate around the contribution of the food environment to obesity intensifies, there is increasing concern regarding children's exposure to HFSS foods in grocery stores, supermarkets and other retail establishments. Although current evidence regarding associations between the community food environment and health outcomes – including obesity – is equivocal [191,563,564], marketing studies clearly show that the amount of shelf space, together with the location and number of displays allocated to food products within a store, are integral element of the consumer food environment which have a significant impact on sales [565–569]. The relationship between food availability, dietary habits, and weight status has not been clearly established, however availability and price of foods are likely to influence dietary behaviour and eventual risk of developing obesity [506,570,571]. Studies in the UK have shown that despite voluntary pledges to reduce in-store promotion of HFSS food by leading supermarket chains (i.e. the UK Government's 'Responsibility Deal') [204], the vast majority of products to which children are exposed at supermarket checkouts and queuing areas remain unhealthy [572–574]. These food products seem purposely positioned to be within children's reach and attract their attention, potentially encouraging children to 'pester' their parents to purchase such items [574,575].

Research Paper 4 explores the 'consumer food environment' in Malta. It investigates several aspects of the store food environment that may have an impact on purchasing behaviour, namely the quality, price and quality of food in grocery stores. Research Paper 5 delves into how a wide range of food and beverages are promoted in grocery stores. Since this research is not longitudinal, results are not indicative of any causal relationship between any characteristic of the food environment and childhood obesity. However, these aspects of the food environment are formally investigated and described for the first time, offering the most comprehensive overview of the Maltese food environment available to date.

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SECTION A – Student Details

Student	Daniel Cauchi
Principal Supervisor	Cécile Knai
Thesis Title	Childhood obesity in Malta: contributions of the obesogenic environment

SECTION B – Paper already published

Where was the work published?			
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If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
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Where is the work intended to be published?	Food Policy
Please list the paper's authors in the intended authorship order:	Daniel Cauchi, Triantafyllos Pliakas, Cécile Knai
Stage of publication	Submitted

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	See full details of author contributions on the next page.

Student Signature: D Cauchi **Date:** 29/07/2016

Supervisor Signature: Cécile Knai **Date:** 29/07/2016

Research Paper 4

Food environments in Malta: Associations with store size and area-level deprivation

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Status: Under review in: *Food Policy*

Author contribution: I formulated the research question and designed the study. I collected the data with assistance from independent fieldworkers, and analysed the data with input from Triantafyllos Pliakas. I drafted the manuscript and made revisions based on comments from Cécile Knai and Triantafyllos Pliakas.

Abstract

Food environments are potential targets for interventions to reduce obesity prevalence, particularly in island settings that are typically dependent on food imports. This observational study aimed to characterise the availability, quality and price of foods and beverages in a nationally representative sample of grocery stores in Malta using the Nutrition Environment Measures Survey for Stores (NEMS-S) instrument, and to examine the association between area-level density of different types of food stores and the likelihood of children living in these areas being overweight or obese. Fieldwork was carried out between March and May 2014. There was a strong positive correlation between store size and NEMS-S score ($p = <0.001$). Smaller grocery stores generally offered a smaller range of products and fewer options than larger supermarkets. Median prices of certain 'healthier' versions of foods were more expensive than their less healthy alternatives. A significant association between risk of childhood overweight and density of confectionery stores in children's locality of residence was found (OR 1.19; 95% CI: 1.04, 1.37). These baseline findings highlight opportunities to improve the food environment in Malta to support more healthful eating, and may be of particular interest to public health practitioners in island settings.

Introduction

Malta has one of the most obese populations worldwide [3]. Given the potential impact of the food environment on population weight [53,571], measuring the nature of local food environments is important to determine what is available for purchase and develop obesity prevention strategies [507,562,570]. Greater availability of grocery stores may improve overall dietary quality and lower obesity prevalence [576,577]. Conversely, a high density of outlets providing less healthy food including fast food restaurants and convenience stores has been associated with increased obesity [191]. Local food environments may also be related to neighbourhood socioeconomic level [578,579], as affluent areas may have better access and greater availability of healthy food compared to deprived neighbourhoods [580].

Objective documentation of potentially obesogenic food environments permits a more comprehensive understanding of dietary influences, consistent with an ecological approach [182]. In turn, environmental interventions aimed at facilitating healthier food choices through the creation of supportive food environments may achieve more effective results than behavioural interventions that require significant personal motivation [501,581].

This is the first study to systematically document the food environment in Malta, and one of few studies to review an 'island food environment'. Pacific island research indicates that islands may be disproportionately influenced by the global food system due to their reliance on imported foods [582]. Malta is similarly reliant on food imports [216], hence assessing the food environment may offer important insight into their effect on dietary behaviour. Research on the local food environment has been specifically recommended as part of a national obesity strategy [80]. We characterised the environment in grocery stores – the most common outlets for food purchases [200] – and tested for differences by area-level deprivation. We also examined associations between area-level density of different types of food stores and the likelihood of overweight or obesity in children living in these areas.

Method

The 'minimal' approach proposed by the International Network for Food and Obesity/non-communicable diseases Research, Monitoring and Action Support (INFORMAS) network was adopted [66,67]. Food environments refer to the circumstances surrounding the procurement and consumption of food. Two food environment sub-types, including the *community* (i.e. number, type, location, and accessibility of food outlets in an area) and *consumer* (i.e. conditions that individuals encounter within stores, including nutritional quality, price, promotion, and placement) food environments were assessed [69].

Area sampling

All localities in Malta were ranked by median socioeconomic (SE) deprivation and stratified into quintiles using probability proportional to size sampling [634]. A diverse representative sample of ten localities was randomly selected, with two localities in each quintile undergoing a field audit. Quintile one (Q1) represents the most affluent localities, whereas quintile five (Q5) refers to the most deprived localities. Google Earth™ was used to plan walking routes of around 0.5 km^2 (range: 0.3 km^2 – 0.7 km^2) in each area (Appendix 5A).

Community food environment

The location and frequency of all food stores within each audited area were recorded. Stores were categorized based on adapted, pre-existing food outlet classification criteria [547] (Appendix 5B). Additionally, a database of all food outlets licensed up to January 2014 was obtained from the Environmental Health Directorate (Malta) [583]. Density (per km^2) of different store types in the audited localities was calculated and categorised into low, medium or high density based on the observed distribution.

Consumer food environment

Between March and May 2014, one small (1 checkout), one medium (2-4 checkouts) and one large (≥5 checkouts) grocery store was randomly selected in each locality to undergo consumer food environment assessment (n = 30). The number of checkouts was used as a proxy for store size. For the purposes of this survey, the term 'grocery stores' referred to food outlets selling fresh fruit and vegetables (F&V) alone or in addition to other food products [584], including specialized green grocers, discount stores and supermarkets. Data were collected through in-person visits by DC, assisted by a fieldworker.

Screening instruments

The Nutrition environment Measures Survey for Stores (NEMS-S) instrument to measure the consumer environment in grocery stores was adapted for use in Malta (Appendix 5C) [57]. NEMS-S is a widely disseminated tool having high reliability and validity [57] that has been adapted for use in several countries [585,586]. It allows for comparisons between 'healthy' and 'regular' (i.e. 'less healthy') versions of foods to be made. Definitions of what is 'healthy' were based on existing literature, including considerations of fat and sugar levels per 100g of food [57,587]. One of the authors completed an online training course in the use of NEMS-S [588]. Following consultation with nutritionists at the Ministry for Health in Malta and taking into account local literature on affordable food baskets [589], elements of the EURO-PREVOB tool [62] and INFORMAS food pricing module [66] were added to the NEMS-S Malta instrument (Figure 14). This was pilot-tested and revised further to more accurately reflect the Maltese context.

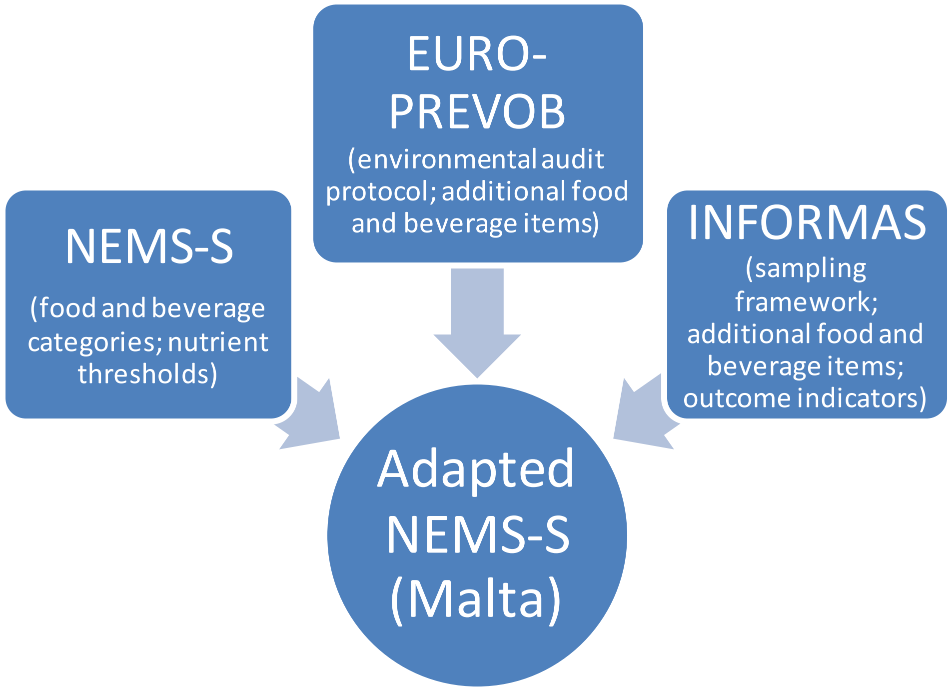

Figure 14. Adaptation of the NEMS-S instrument to the Maltese context

The final NEMS-S (Malta) instrument contains thirteen food and beverage categories. The most common brands were assessed whenever available. Quality of F&V was assessed based on appearance (i.e. bruising or over-ripeness), and the cheapest price for each category was collected as Euros (€) per kg/L. Shelf space allocated to milk was also assessed. NEMS-S composite scores were then calculated for food availability, quality and price. A lower price for a healthier item was scored positively, whereas a higher price subtracts a point from the price dimension. Higher scores denote greater availability of healthier options; better or equal price for healthy choices; and higher F&V quality.

Cohort BMI data

The Malta School Health Service provided objective anthropometric data for three national cohorts of primary schoolchildren aged around seven years of age, collected in 2008, 2010 and 2013

(Sant'Angelo, V., personal communication). Body mass index (BMI) percentile-for-age equivalents was calculated for 2,623 children residing in the ten audited localities using International Obesity Task Force (IOTF) cut-offs [92]. BMI > 25 kg/m^2 corresponds roughly to the 90th centile, whereas BMI > 30 kg/m^2 approximately corresponds to the 99th centile.

Data Analysis

Analysis was undertaken using SPSS v.23 and STATA™ 14.1. NEMS-S scores, ranges and mean standard deviations were calculated. Non-parametric analyses were performed as data were not normally distributed. Results were stratified by store size and locality-level SE deprivation. Spearman's coefficient and Chi-Square independence tests for association were used to explore associations between variables; Wilcoxon Rank-Sum tests were conducted to detect differences between two independent groups; and Kruskal-Wallis tests performed to detect differences across SE quintiles or store sizes. Post hoc pairwise comparisons were performed using Dunn's procedure with a Bonferroni correction. Adjusted p-values are presented; values of <0.05 are considered statistically significant. Logistic regression was applied to investigate whether area-level density of different food store types was associated with risk of being overweight or obese in children. Clustering of individuals within localities was taken into account using robust standard errors.

Results

Differences in store density, NEMS-S scores and food prices by SE quintile and store size

Table 8 shows descriptive statistics for density of all food store types and grocery store NEMS-S scores by SE quintile. There were no statistically significant differences between group means for density of any food store type. In addition, no significant differences in median NEMS scores, food prices, food quality, shelf space and variety of options available for specific food items were found between SE quintiles. Food variable data are presented in Appendix 5D. Differences in median NEMS-S scores by grocery store size emerged (Table 9), including statistically significant differences in median NEMS-S availability scores ($\chi2(2) = 17.542$, $p = <0.001$) and median NEMS-S total score ($\chi2(2) = 18.202$, $p = <0.001$). Post-hoc analysis revealed statistically significant differences in median NEMS-S total scores between the small and medium ($p = 0.032$), and small and large grocery stores ($p = <0.001$), but not between the medium and large stores. Additionally, there was a statistically significant difference in median NEMS-S availability score between the small and large stores ($p = <0.001$), but not between any other group combination.

	Q1	Q2	Q3	Q4	Q5	Difference (p value)
Store type						
Food stores	M: 27.50 ±27.1 R: 8.3 - 46.7	M: 21.33 ±7.5 R: 16.0 - 26.7	M: 44.57 ±10.5 R: 37.1 - 52.0	M: 35.33 ±16.0 R: 24.0 - 46.7	M: 45.67 ±24.9 R: 28.0 - 63.3	0.480
Supermarkets	M: 18.33 ±11.8 R: 10 - 26.7	M: 16.33 ±0.5 R: 16.0 - 16.7	M: 18.42 ±7.9 R: 12.9 - 24.0	M: 17.00 ±9. 9 R: 10.0 - 24.0	M: 22.33 ±6.1 R: 18.0 - 26.7	0.812
Takeaways	M: 4.17 ±3.5 R: 1.7 - 6.7	M: 15.33 ±1.9 R: 14.0 - 16.7	M: 12.85 ±10.1 R: 5.7 - 20.0	M: 12.33 ±8.0 R: 6.7 - 18.0	M: 12.33 ±6.1 R: 8.0 - 16.7	0.561
Bars	M: 4.17 ±5.5 R: 1.7 - 6.7	M: 16.00 ±5.7 R: 12.0 – 20.0	M: 14.42 ±2.2 R: 12.9 - 16.0	M: 6.33 ±0.57 R: 6.0 - 6.7	M: 35.66 ±3.3 R: 33.3 - 38.0	0.094
Restaurants or Cafeterias	M: 49.17 ±53.0 R: 11.7 - 86.7	M: 40.67 ±24.5 R: 23.3 - 58.0	M: 1.43 ±2.0 R: 0.0 - 2.9	M: 3.00 ±4.2 R:0.0 - 6.0	M: 29.66 ±19.3 R: 16.0 - 43.3	0.151
Mobile vendors	M: 2.50 ±1.2 R: 1.7 - 3.3	M: 9.67 ±5.2 R: 6.0 - 13.3	M: 7.71 ±8.9 R: 1.4 - 14.0	M: 9.67 ±8.9 R: 3.3 - 16.0	M: 5.33 ±19 R: 4.0- 6.7	0.626
NEMS-S scores						
Availability	M: 15.0 ±3.2 Md: 15.5 R: 10 - 19	M: 14.3 ±4.6 Md: 14.5 R: 8 - 19	M: 12.5 ±4.9 Md: 11.0 R: 7 - 19	M: 16.2 ±4.9 Md: 15.0 R: 10 - 23	M: 13.3 ±5.4 Md: 14.0 R: 6 - 19	0.730
Price	M: 1.8 ±3.1 Md: 3.5 R: -3 - 4	M: 1.0 ±1.3 Md: 0.5 R: 0 - 3	M: 1.7 ±1.9 Md: 2.0 R: -1 - 4	M: -0.5 ±2.6 Md: -1.5 R: -3 - 4	M: 0 ±2.1 Md: 0.5 R: -3 - 2	0.340
Quality	M:6.0 ±0 Md: 6.0 R: 6 - 6	M: 5.3 ±0.8 Md: 5.5 R: 4 - 6	M: 5.7 ±0.5 Md: 6.0 R: 5 - 6	M: 5.5 ±0.8 Md: 6.0 R: 4 - 6	M: 5.8 ±0.4 Md: 6.0 R: 5 - 6	0.210
Total NEMS score	M: 31.7±5.0 Md: 29.5 R: 27 - 39	M: 27.7 ±7.7 Md: 28.5 R: 17 - 36	M: 26.7 ±9.9 Md: 25.0 R: 13 - 39	M: 30.5 ±8.1 Md: 28.0 R: 22 - 41	M: 26.7 ±8.3 Md: 30.5 R: 13 - 33	0.810

Table 8. Food store density (in km^2) and NEMS-S scores by area-level SE quintile

(M = Mean ±SD; Md = Median; R = Range)

	Store size			
	Small	**Medium**	**Large**	**Diff. (p value)**
Availability	M: 10.0 ±3.3 R: 6 - 17	M: 14.3 ±2.6 R: 10 - 19	M: 18.5 ±2.9 R: 12 - 23	<0.001
Price	M: 0.9 ±2.3 R: -3 - 4	M: 1.0 ±2.3 R: -3 - 4	M: 0.5 ±2.6 R: -3 - 4	0.860
Quality	M: 5.7 ±0.7 R: 4 - 6	M: 5.6 ±0.7 R: 4 - 6	M: 5.7 ±0.5 R: 5 - 6	0.870
Total score	M: 21 ±5.5 R: 13 - 28	M: 29.7 ±4.2 R: 24 - 37	M: 35.2 ±5.4 R: 23 - 41	<0.001

Table 9. NEMS-S scores by grocery store size
M = Mean ±SD; R = Range

Differences in availability, number of options, and food quality by store size and SE quintile

No significant associations between the availability of any food item and SE quintile were observed. However, there was a strong positive correlation between store size and NEMS-S total ($r_s(28) = 0.778$; p=<0.001) and availability scores ($r_s(28) = 0.787$; p=<0.001). Larger store size was moderately to strongly associated with greater choice (i.e. more options available for a single product) of several foods including fresh vegetables (p=0.047); wholegrain rice (p=0.003); 'healthy' cereals (p=<0.001); canned vegetables (p=0.004); chocolate bars (p=<0.001) and packaged extruded snacks (p=0.004). Furthermore, there were moderate to strong associations between larger store size and availability of baked crisps (p=0.036); wholemeal pasta (p=0.010); brown rice (p=0.014); wholemeal bread (p=0.018); diet Cola (p=0.036); 'healthy' cereal (p=0.002); lean beef mince (p = <0.001); low fat baked goods (p=0.007); and low fat cheddar cheese (p=0.001). Baked crisps were consistently absent from small grocery stores. Fresh F&V quality was high overall, hence this variable was excluded from further analysis. While median shelf space allocated to whole or skimmed milk did not differ significantly across SE quintiles, larger stores offered significantly more shelf space to whole milk than smaller stores ($\chi2(2) = 13.363$; p=0.001). Differences in median shelf space allocated to skimmed milk ($\chi2(2) = 8.937$; p=0.011), were significant only between the small and large (p=0.010) stores.

Relationships between food prices, SE quintiles and store size

A moderately positive Spearman's correlation between SE quintile and the median unit price of grapes (p=0.007) and plums (p=0.018) was found. Increasing deprivation was also moderately associated with a reduction in the median price of cabbage (p=0.007); 1.5L diet (p=0.020) and regular (p=0.031) Cola drink bottles; and 100% orange juice (p=0.050). There were moderate to strong positive associations between store size and the price of watermelon (p=0.007); plums (p=0.035); peaches (p=0.043); apples (p=0.046) and broccoli (p=0.019); and negative correlations between store size and the unit prices of regular beef mince (p=0.001); regular cheddar cheese (p=0.001) and 1.5L bottles of regular Cola drink (p=0.012).

Differences in food prices by store size, and between 'healthy' and 'less healthy' food pairs

Table 10 shows food items exhibiting significant differences in unit price by store size, whereas Table 11 illustrates differences in median unit price between pairs of 'healthy' food items and their regular or 'less healthy' alternatives across all stores.

Food item (unit)	Chi-square test	Pairwise comparisons (median price in €)
Cheddar cheese, regular (kg)	χ2(2) = 9.320, p = 0.009	Difference between small and large stores only (p = 0.009)
Cola drink, regular (1.5L bottle)	χ2(2) = 6.722, p = 0.035	Difference between small and large stores only (p = 0.033)
Vegetable mix, frozen (kg)	χ2(2) = 7.666, p = 0.022	Difference between small and large stores only (p = 0.018)
Beef mince, regular (kg)	χ2(2) = 10.96, p = 0.004	Difference between the small and large (p = 0.034); and small and medium (p = 0.009) stores
Strawberries (kg)	χ2(2) = 6.795, p = 0.033	No significant pairwise comparisons observed
Watermelon (kg)	χ2(2) = 6.396, p = 0.041	Difference between small and large stores only (p = 0.035)

Table 10. Chi-Square independence tests for food items exhibiting a significant difference in unit price by store size

Item name (unit)	Healthy (€/unit)	Regular (€/unit)	Difference (€/unit)	P value
Cereal: unsweetened vs sweetened (kg)	7.74	8.85	-0.42	0.001
Pasta: wholemeal vs white (kg)	2.37	1.67	0.71	<0.001
Rice: brown vs white (kg)	3.85	3.64	-	0.146
Beef mince: lean vs regular (kg)	7.95	7.1	1	0.028
Cheese, cheddar: low-fat vs regular (kg)	10.9	7.23	4.1	0.004
Bread: brown vs white (400g loaf)	0.95	0.85	0.15	<0.001
Sausages: low fat vs regular (kg)	3.8	4.81	-	0.581
Yoghurt, plain: fat-free vs regular (kg)	1.73	2.2	-	0.257
Coca-Cola: diet vs regular (1.5 L bottle)	1.5	1.5	-	0.655
Juice: 100% juice vs juice drink (1L carton)	1.29	1.3	-0.01	0.016
Milk: skimmed vs whole (1L carton)	0.81	0.86	-0.05	<0.001

Table 11. Differences in median unit price of 'healthy' and 'less healthy' versions of select paired food products

Area-level food store density and risk of overweight or obesity

BMI percentile-for-age data for 2,623 children indicated that 34% (n=888) were overweight or obese according to IOTF criteria. Risk of overweight or obesity was modelled against area-level density of different food store types, after adjusting for SE quintile and clustering. Table 12 shows results for a selection of store types. Only confectionery store density was significantly associated with a higher risk of being overweight or obese (OR 1.19; 95% CI: 1.04, 1.37; p=0.013).

Area density	Unadjusted (95% C.I.) p-value	Adjusted (95% C.I.) p-value
All stores selling fast food*		
Low (reference)	1	1
Medium	0.85 (0.70, 1.04); 0.110	0.89 (0.68, 1.16); 0.372
High	0.94 (0.77, 1.14); 0.530	0.97 (0.73, 1.31); 0.861
All stores selling fruit and vegetables**		
Low (reference)	1	1
Medium	1.03 (0.86, 1.24); 0.734	1.04 (0.85, 1.29); 0.689
High	1.08 (0.81, 1.44); 0.614	0.94 (0.82, 1.09); 0.441
Small supermarket		
Low (reference)	1	1
Medium	0.99 (0.81, 1.22); 0.942	1.01 (0.8, 1.26); 0.948
High	1.19 (0.96, 1.46); 0.108	1.10 (0.95, 1.27); 0.190
Confectionery store		
Low (reference)	1	1
Medium	1.12 (0.89, 1.41); 0.328	1.05 (0.96, 1.14); 0.275
High	1.15 (0.97, 1.36); 0.112	1.19 (1.04, 1.37); 0.013
Convenience store		
Low (reference)	1	1
Medium	1.15 (0.91, 1.45); 0.230	1.17 (0.92, 1.48); 0.205
High	1.06 (0.84, 1.35); 0.601	1.09 (0.90, 1.31); 0.372

* Includes all stores offering takeaway including: takeaway outlets; bars where snack food is served (i.e. snack bars); fast food restaurants; mobile vendors selling fast food; and restaurants with takeaway option

** Includes green grocers; mobile vendors selling F&V; small discount stores and large supermarkets

Table 12. Unadjusted and adjusted (for area-level deprivation) odds ratios for being overweight or obese by area-level food store density

Discussion

This study aimed to explore intersections between the community and consumer food environments in Malta. Our findings support research suggesting that residents of deprived areas may not necessarily pay more for healthy food compared to residents of more affluent areas [590,591]. However, this should not negate the disproportionate impact of food expenditure on household budgets of less affluent consumers seeking diets of high nutritional quality [592]. Our results also support studies indicating that food product availability, price and variety may differ by grocery store size so that the size of stores where consumers shop has a greater impact on food prices than area-level deprivation [593,594]. Larger grocery stores provided a substantially more healthful overall consumer environment than smaller stores, having greater availability of healthier items at often cheaper prices. With the exception of some seasonal fruit, the price of most F&V did not differ significantly by store size or deprivation. Quality of fresh produce is an additional structural factor that might influence purchasing behaviour [595], however the quality of fresh F&V was high overall.

Substituting unhealthy food with healthier alternatives (e.g. replacing sugar-sweetened drinks with low-calorie alternatives) is frequently proposed as a way of improving dietary behaviour. There are conflicting results regarding the association of food prices with obesity [596,597], possibly due to the methodological challenges of testing for such associations. Overall, the evidence suggests that low energy-dense diets of high nutritional quality tend to cost more than less nutritious, energy-dense diets [598]; that healthy foods are perceived to be expensive [599]; and that price is more important than nutritional quality when making food choices [600]. People are more likely to buy healthy foods when they cost less [601]. Although no systematic research in this regard has yet been carried out in Malta, it is likely that the same principles apply to the Maltese consumer. Our study partially supports the belief that choosing the healthier option for certain frequently-consumed foods such as pasta, bread, beef and cheese [212] might prove to be a financial burden for consumers. Median prices of healthier versions of these products (i.e. wholegrain pasta, wholemeal bread, lean beef mince and low fat cheddar cheese) were significantly higher than the prices of their regular counterparts (i.e. white pasta, white bread, regular beef mince, regular cheddar cheese). This represents a potential disincentive to substitute regular versions of such foods for healthier alternatives.

On the other hand, regular breakfast cereal and whole milk - popular breakfast options among the Maltese [212] - were significantly more expensive than low-sugar, high-fibre cereal and skimmed milk. Thus, substitution in the case of cereal-based breakfasts could make financial sense. In addition, the median paired prices of plain yoghurt, juice products, rice and sausages did not differ significantly, suggesting that simple substitution of these items would not pose a disproportionate financial burden upon consumers. The median price of frozen F&V did not vary by store size or deprivation quintile, hence substituting fresh F&V with their generally cheaper frozen and packaged alternatives may be one way of minimizing price premiums without comprising the nutritional profile of one's diet. Such small changes could accumulate to have a potentially significant overall impact on diet, provided that substantial investment in health literacy and nutrition knowledge is made to empower consumers to make healthier choices [80]. Strategies to encourage owners of smaller stores to stock more healthful food options (e.g. assistance with purchasing freezers; improving links with farmers etc.) have also been shown to be successful [602,603]. With regards to soft drinks, diet and sugar-sweetened Coca-Cola were set at the same price point in each store, obviating any financial incentive to purchase the low calorie version. Taste preference and nutritional knowledge thus remain the primary reasons for selecting one option over the other. Our results also indicate that 1.5L bottles of diet and sugar-sweetened Cola drinks are cheaper in areas of greater deprivation and in larger stores: this finding warrants further investigation and might indicate that these items are positioned as 'loss leaders', being purposely under-priced in order to attract customers into stores [604].

A higher density of confectionery stores – which mainly sell sweets, pastries and chocolate – is associated with increased odds of being overweight or obese for children living in these localities. Interestingly, the density of other stores popularly thought to have protective (e.g. F&V stores) or harmful effects (e.g. fast food outlets or convenience stores), particularly within a local context that often blames fast food consumption for Malta's high obesity prevalence [110], did not show any association. The literature in this regard is inconsistent, as the relationship between food availability, dietary habits, and weight status has not been clearly established [506,570,571]. Yet, sales of unhealthy foods in supermarkets have been associated with greater overweight and obesity prevalence, particularly in areas of greater SE deprivation [605]. Despite these uncertainties, the limited effectiveness of interventions targeting individual activity and dietary behaviours has led to the recognition that broader environmental changes may be driving the obesity epidemic, and to calls for a multi-level environmental approach to obesity interventions [5]. Emerging research suggests that the *diversity* of food stores may be a more important predictor of weight outcomes than store *density*, hence policies may be more effective if the relative proportion of outlets serving healthy versus unhealthy foods is considered [606,607]. Recent efforts to establish farmers' markets across Malta to increase food retail diversity and access to fresh F&V [110] are laudable, however fiscal policies have been shown to be effective and should also be seriously considered [608].

Limitations

This study has a number of limitations. Although nationally representative, the relatively small sample size may have limited ability to detect significant associations. The foods assessed were not randomly selected and do not reflect the range of foods available to consumers. Moreover, the NEMS-S protocol requires use of branded products, possibly underestimating the true price differential between healthy and regular options since consumers on a limited budget might preferentially purchase cheaper, non-branded products that lack healthier alternatives. Only grocery stores were evaluated, hence results do not consider the full consumer food environment. This may be of importance: butcher stores in Malta, for example, typically offer packaged savoury snacks in addition to meat products. Seasonal changes in price, quality and availability of foods could not be determined due to the cross-sectional nature of the study. There is also uncertainty as to which is the most appropriate unit of analysis to characterise food store diversity [54], as neighbourhoods of differing affluence may be found within the same locality [609]. Furthermore, Malta's small size and the population's relative reliance on private transport [216] renders identification of the consumer food environment where food is actually purchased problematic. Although studies have hinted that socioeconomically disadvantaged individuals may shop frequently and in small amounts at 'traditional' food outlets close to their residences [610], selective purchasing behaviour from different locations and store types may be taking place (e.g. fresh F&V may be judiciously bought from vendors in the neighbourhood, whereas packaged foods are sourced from large supermarket conveniently located on the commute to the workplace) [610]. In addition, there is a dearth of quantitative research on individual food purchasing and food consumption behaviour of the Maltese [216], hence a definite relationship between the local food environments, individual dietary behaviour, and weight outcomes cannot be established. Lastly, our results regarding area-level food store density and risk of overweight or obesity should be interpreted with caution. It is possible that some stores listed in the database of licensed food outlets were inadvertently misclassified, and the lack of data on other relevant covariates such as actual location of children's residence; distance from stores in the neighbourhood; parental weight status and SES prevented adjusting for these variables in the analysis.

Conclusion

This is the first study to characterise the community and consumer food environment in Malta, providing baseline information for monitoring of food availability and prices. Findings may guide national policy efforts to improve the food environment in Malta, and may be of particular interest to public health professionals in other islands. The data presented here suggest that availability and price of most food items do not vary by area-level deprivation. However, small grocery stores often have lower availability of certain healthy food options and are more expensive compared to medium and large stores. Currently, a price premium for healthy versions of certain food categories exists in Malta, with only limited improvements in food choices possible without increasing overall food cost for the consumer. In turn, this would require that they be able to distinguish between healthier and less healthy foods within given categories, highlighting a need for further investment in public health interventions to foster such skills. Despite these findings, no firm conclusions can be made regarding the potential impact of price or structural modifications to the food environment upon dietary behaviour in Malta. Experimental or longitudinal research that accounts for neighbourhood self-selection and evaluates environmental influences on individual purchasing patterns is needed for causal inference to be determined [562,611]. Work to determine the most appropriate measures for socioeconomic status and units of analyses when characterising food environments is needed. Food environment studies set within a wider range of settings including schools and workplaces, and studies that assess individual travel patterns to determine food availability throughout the day rather than relying on residential address, are crucial [612].

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End of Research Paper 4

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SECTION A – Student Details

Student	Daniel Cauchi
Principal Supervisor	Cécile Knai
Thesis Title	Childhood obesity in Malta: contributions of the obesogenic environment

SECTION B – Paper already published

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SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	Journal of Nutrition Education and Behaviour
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SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	See full details of author contributions on the next page.

Student Signature: D Cauchi **Date:** 29/07/2016

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Research Paper 5

Product assortment in grocery stores: application of the GroPromo tool in Malta

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Author contribution: I formulated the research question and designed the study. I collected the data with assistance from independent fieldworkers, and analysed the data with input from Triantafyllos Pliakas. I drafted the manuscript and made revisions based on comments from Cécile Knai and Triantafyllos Pliakas.

Abstract

Objectives. To assess the promotional environment within grocery stores in Malta.

Design. The *GroPromo* instrument was used to collect data on the placement of seven products in nine key locations within each store, from a nationally representative, random sample of 28 grocery stores.

Results. Overall, unhealthy food and beverage items were placed in more prominent locations than fruit and vegetables, regardless of grocery store size. Larger stores promoted proportionally more unhealthy foods in more prominent locations than smaller stores. There were no significant differences by area-level deprivation in the promotional practices of grocery stores.

Discussion. Although grocery stores are often thought of as contributing to the healthfulness of the overall food environment, there is an obesogenic consumer food environment in grocery stores in Malta. This presents opportunities for interventions that aim to influence consumer food choices through product re-assortment.

Introduction

Malta's high prevalence of child and adult obesity [3,104], has generated interest in the food environment as a potential target for interventions to address the growing obesity burden [80]. Supermarkets and grocery stores are particularly important components of the overall food environment since they are the primary outlets for food and beverages purchases in Malta [200,584]. There is extensive literature exploring the impact of geographic accessibility of grocery stores and supermarkets on dietary behaviour [53,562,571,613]. However, the consumer food environment (i.e. the conditions that individuals encounter within food stores, including nutritional quality, price, promotion, and placement of foods) [69] within these outlets has been relatively understudied [216,565].

Marketing literature suggests that the 'marketing mix' [614] of products within stores influences consumer purchasing behaviour [565–569]. The placement of products is a key strategic element of the mix, comprising price, product, promotion, and place, that is gaining attention among public health researchers interested in the impact of in-store marketing on choice [615]. Product assortment – traditionally defined as the number of products offered within a single product category [616] – also influences sales [565,567]. For example, offering an increased variety of products has been shown to increase customer visits to a store [567], although excessive choice may overwhelm consumers [617]. The amount of shelf-space allocated to a product, the presence and variety of food items and the prominence of their location (such as at the end of an aisle; at a checkout); or their visibility at eye-level may influence purchasing decisions [565,618]. This is particularly true for energy dense snack foods and sugar-sweetened beverages, which are considered to be impulse items whose purchase is more subject to in-store decision-making than staple products such as bread and milk [566,619].

Placement strategies that increase the visibility of healthier foods have been shown to significantly enhance the sales of healthier items in grocery stores and supermarkets, leading to potential improvements in dietary choices [620,621]. The presence of additional display stands has also been shown to significantly increase sales [566,569,622]. Altering product placement within grocery stores to increase the accessibility of healthy food items whilst conversely reducing the visibility and promotion of less healthy products is consistent with a social ecological approach [501]. Interventions may have even greater impact if aimed specifically at altering the placement and reducing promotion of less healthy foods, rather than simply increasing access to healthier options [566,623]. For example, results of a UK supermarket intervention in relation to the alcohol environment indicate that the removal of alcohol from prominent end-of-aisle displays is likely to encourage healthier purchasing behaviour amongst consumers, without affecting availability or cost of products [624]. Checkout areas – typically the most accessible to children and the most likely to be stocked with confectionery and other unhealthy foods and beverages [625] – have also been highlighted as potential targets for manipulation of consumer behaviour: interventions such as the introduction of 'healthy checkout aisles' have been shown to be moderately effective at reducing impulse purchases of unhealthy food and facilitating healthier dietary choices in Norway and the Netherlands [626,627].

Studies have also hinted at an association between weight status and cumulative availability of food within neighbourhood stores. For example, a US study has suggested that availability of energy-dense food was positively associated with body mass index of neighbourhood residents [628], although this was not the case for shelf space allocated to fruit and vegetables. However, causality has not yet been clearly established: interventions aiming at increasing the availability of healthy foods items in US corner stores found that the initiatives significantly improved healthy food availability, sales, and consumption [603,629] but no significant impact on weight was identified [629].

Research on the food environment has been specifically recommended as part of a national strategy to address the obesity epidemic, however to the best of our knowledge this is the first attempt to objectively characterise the promotional environment in grocery stores in Malta [80]. The purpose of this study was to assess the placement of key food and beverage categories in different locations within grocery stores in a representative, random sample of localities in Malta. The minimal approach advocated by the International Network for Food and Obesity/non-communicable diseases

Research, Monitoring and Action Support (INFORMAS) network was adopted [630]. It was hypothesized that larger stores, and stores in more deprived localities, would place unhealthy foods in more prominent locations than would smaller stores or stores in affluent neighbourhoods [631,632]. Such systematic, objective observation is a useful first step towards understanding the potentially obesogenic environment within grocery stores. Findings from this study may also contribute to the development of store-based environmental interventions aimed at improving dietary choices through manipulation of the consumer food environment [5,69,633].

Method

Area sampling

All 68 localities in Malta were ranked by median socioeconomic (SE) deprivation using a proxy score derived from the proportion of residents in each locality receiving means-tested social assistance and unemployment benefits [609]. Localities were categorised into SE tertiles, and a diverse representative sample of ten localities was selected at random using probability proportional to size sampling [634]. At least three localities in each tertile underwent a field audit. Each audit encompassed an area of around 0.5 km^2. Grocery stores in audited localities were identified and the number of checkouts recorded.

Assessment of promotional environment in grocery stores

Between March and April 2014, the in-store environment of a sample of grocery stores located in audited localities was assessed. One small (1 checkout), one medium (2-4 checkouts) and one large (≥5 checkouts) grocery store was selected at random in each locality. For the purposes of this research, the term 'grocery stores' referred to food outlets selling fresh fruit and vegetables alone or in addition to other food products in fresh, prepared or packaged form [584]. This included specialized green grocers, discount stores, and supermarkets. Data were collected through in-person visits by the same fieldworker to each store. Small and medium grocery stores were selected from within the audited areas, however larger grocery stores or supermarkets (≥5 checkouts) were not always present as these tend to be located on the outskirts of urban village cores in Malta. In such cases, the nearest eligible supermarket was selected for assessment.

Screening instrument

The validated GroPromo instrument (Appendix *6*) was applied to measure aspects of the grocery store environment that may influence food purchasing [72]. The tool was designed to assess promotional strategies employed within grocery stores, particularly the placement and promotion of product categories in key locations of varying prominence within the store. It contains seven food and beverage categories having documented positive or negative associations with obesity [635]. These were: cereal; sweets and chocolate *(candy)*; crisps *(chips)*; soda drinks; biscuits *(cookies)*; juice drinks (with added sweetener); and fruits and vegetables (F&V) [636]. The latter category represents a healthy 'control' variable. Cereals were included in GroPromo due to the availability of 'healthy' (low sugar, high fibre) and 'less healthy' (high added sugar, low fibre) options and the fact that they are frequently marketed to children [72]. The GroPromo instrument also includes nine types of in-store locations, each of which is weighted as having high, medium or low prominence based on customers' average exposure to these locations as derived from the literature (Table 13) [72]. The fieldworker identified the key product categories and noted their location. The placement of items at child height (up to 1.2 metres' height) and any promotions focused at children were also examined. Each store was assessed in a systematic manner to ensure that all locations were recorded.

Categories	Description	Promotional Prominence
Locations		
Outside	Area immediately outside of store entrance	Low
Entrance	Area within 10 feet (3 metres) of store entrance	Medium
End Cap A	End of aisles facing checkouts	High
End Cap B	End of aisles not facing checkouts	Medium
Aisle	Main aisles where food is displayed	Medium
Edge	Inside perimeter of store	Low
Checkout side	Displays lining checkout lanes	High
Checkout edge	End cap of the checkout lanes (facing end cap A)	High
Island	Temporary, moveable display in isolation or standing out significantly from other areas	Medium
Promotional features		
Size	Promotional displays that are larger than the norm for that store	Not applicable
Theme	Promotions based on holidays, seasons, etc.	Not applicable
Display	Branded container for holding food items	Not applicable
> 5 products	> 5 types of 1 product (e.g. different flavours)	Not applicable
Child height	Items up to 4 feet (1.2 metres) in height	Not applicable
Child focus	Presence of cartoons, caricatures, animals, pictures of children, child-focused prizes or movies, etc.	Not applicable

***Source:** Kerr et al. (2012) *Assessing Reliability and Validity of the GroPromo Audit Tool for Evaluation of Grocery Store Marketing and Promotional Environments*

Table 13. Descriptions of locations and promotions as coded in the GroPromo instrument

Covariates

The following variables were analyzed: 9 location counts; 7 product category counts; F&V count in 9 possible locations; and unhealthy food item counts (sum of crisps, soft drinks, sweets and chocolates, biscuits, cereal and juice drinks) in 9 possible locations. Child focused cereal (CFC) placement at child height (i.e. less than 1.2 metres' height from the ground, equivalent to placement upon the bottom three shelves of a typical aisle) and the percentage of these shelves occupied by CFCs were analyzed as individual variables. Other data including the presence of diet, low fat or low sugar options; the number of items within the product category; and the presence of any additional promotional displays, such as oversized displays and seasonal themes, were recorded, but not analyzed. Each individual location where one of the seven product categories was identified contributed to the count of locations for each store. For example, if F&V were observed in three separate locations within a store, the F&V count for that store would be three. If any of the seven product categories were identified in any five separate islands, the count for islands in that store would be five. Locations which did not contain any of the 7 product categories were not considered.

Data Analysis

Data were analysed using IBM SPSS version 23 for Windows. GroPromo data from 28 out of 30 grocery stores was available for analysis. Non-parametric analyses were performed as the data was not normally distributed. Spearman's correlation was conducted to detect associations between product categories and product location, whereas Kruskal-Wallis H (KW-H) tests were run to detect significant differences in product promotional placement between stores of different size and between SE tertile. Pairwise comparisons were performed using Dunn's procedure with a Bonferroni correction for multiple comparisons. Rank analyses of covariance for non-parametric data [637,638] with post hoc tests were also performed to compare unhealthy and healthy food placement in areas of low, medium and high promotional prominence across SE tertiles, after controlling for store size. Analyses of covariance were adjusted (using RANK ANOVA method) for the number of checkouts as a proxy for store size [57,72] since larger stores have more aisles and opportunities for endcaps and other promotional strategies. Adjusted p-values are presented, with values of <0.05 considered statistically significant for all tests.

Results

Descriptive analysis

Store size ranged between one to eleven checkouts (mean = 3.1; SD: 2.9). Means and ranges for locations and product categories are presented in Table 14. All grocery stores displayed F&V in at least one location. Not every grocery store had displays of sweets and chocolates (specialized green grocers sold F&V exclusively), however this category was the most frequently displayed category, across the widest variety of locations, in all other stores. Foods and beverages were rarely displayed outside or at store entrances. The most popular locations were edges, aisles, end caps facing the entrance, and islands.

	Mean (SD)	Range
Locations		
Outside	0.46 (0.69)	0 - 2
Entrance	0.25 (0.59)	0 - 2
Edge	5.86 (3.18)	2 - 17
Aisle	2.64 (2.51)	0 - 9
Island	3.00 (3.29)	0 - 11
End Cap Front	2.67 (3.97)	0 - 20
End Cap Back	2.03 (2.41)	0 - 9
Checkout Side	1.35 (2.06)	0 - 8
Checkout End	2.28 (2.64)	0 - 9
Food and beverage categories		
Fruit and Vegetable	1.50 (0.64)	1 - 3
Crisps	2.78 (2.23)	0 - 8
Biscuit	2.00 (2.14)	0 - 7
Juice	1.21 (0.68)	0 - 3
Soda	2.46 (1.84)	0 - 8
Sweets or Chocolates	6.96 (6.56)	0 - 27
Cereal	1.79 (1.48)	0 - 7

Table 14. Mean number of displays by location and food category, across stores (n = 28)

Tables 15 and 16 illustrate the mean number of observations for all unhealthy foods and F&V by specific display location and by category of promotional prominence respectively. There were very few locations where F&V were found other than in the designated produce section, usually at the edge. No F&V displays were observed at any location of high promotional prominence. Unhealthy products were found across a wider range of locations, appearing more often in areas of medium or high promotional prominence.

Location	Unhealthy foods	F&V
Outside	0.11 (0.32)	0.36 (0.49)
Entrance	0.22 (0.51)	0.36 (0.19)
Edge	4.89 (3.27)	0.71 (0.59)
Aisle	2.43 (2.53)	0.21 (0.42)
Island	2.82 (3.12)	0.18 (0.39)
End Cap Front	2.29 (2.57)	0
End Cap Back	1.89 (2.02)	0
Checkout Side	1.32 (2.04)	0
Checkout End	2.29 (2.64)	0

Table 15. Mean (SD) observations per store of food and beverage displays, by location

Promotional prominence	Unhealthy foods	F&V
High	5.89 (5.57) [0 - 19]	0 (0) [0 - 0]
Medium	7.41 (7.13) [0 - 22]	0.43 (0.57) [0 - 2]
Low	5.04 (3.35) [0 - 16]	1.07 (0.66) [0 - 3]

Table 16. Distribution of product categories by promotional prominence, mean (SD) [Range]

Store Size and Promotional Practices

Spearman's correlation showed that number of checkouts in each grocery store was significantly positively correlated with number of unhealthy items observed in areas of high and medium promotional prominence ($r_s(28) = 0.737$; p = <0.01 and $r_s(27) = 0.882$; p = <0.01 respectively), but not with number of unhealthy items observed in areas of low promotional prominence ($r_s(27) = 0.187$; p = 0.35). The number of grocery store checkouts was strongly, negatively correlated with outdoor F&V displays specifically ($r_s(28) = -0.69$; p = <0.01), but there was no significant correlation with F&V observations in the broader categories (i.e. high, medium, or low) of promotional prominence (Table 18). There was a moderate to strong positive correlation between number of checkouts and number of locations containing crisps ($r_s(28) = 0.51$; p = 0.006); biscuits ($r_s(28) = 0.72$; p = <0.01); juice drinks ($r_s(28) = 0.61$; p = 0.001), sweets or chocolates ($r_s(28) = 0.83$; p = <0.01) and cereal ($r_s(28) = 0.78$; p = <0.01), but not with F&V ($r_s(28) = -0.04$; p = 0.83) or soda ($r_s(28) = 0.27$; p = 0.16). Additionally, increasing number of checkouts was moderately, positively associated with the presence of child-accessible shelves that contained a higher proportion (> 75%) of CFC ($r_s(28) = 0.45$; p = 0.017). However, KW-H testing did not detect differences in proportions of CFC placement between small ($\chi^2(2) = 0.03$; p = 0.99), medium ($\chi^2(2) = 3.83$; p = 0.15) or large ($\chi^2(2) = 2.47$; p = 0.29) stores.

Associations of product categories with display locations were also investigated (Table 17). End cap displays and checkout end displays were strongly positively correlated with observations of sweets/chocolates and cereals (all combinations p = <0.01). With the exception of F&V and soda, there was also a strong correlation of food categories with aisle displays (p = <0.01). Results of the post-hoc analysis showed significant differences between store sizes in the display of F&V in locations of low prominence (p = 0.023), as well as displays of unhealthy foods in locations of high (p = 0.002) and medium (p = <0.01) prominence, but not in the display of unhealthy foods in areas of low prominence (p = 0.56).

	Spearman's correlation (p value)						
	F&V	**Crisps**	**Biscuits**	**Juice drinks**	**Soda**	**Sweets / chocolates**	**Cereals**
Outside	0.16 (0.43)	-0.66 (<0.01)	-0.51 (0.006)	-0.23 (0.25)	-0.14 (0.47)	-6.54 (<0.01)	-0.47 (0.011)
Entrance	-0.12 (0.55)	0.18 (0.37)	0.22 (0.25)	0.22 (0.27)	0.02 (0.91)	0.11 (0.56)	0.03 (0.89)
Edge	0.02 (0.92)	0.14 (0.49)	0.52 (0.005)	0.32 (0.10)	0.37 (0.05)	0.32 (0.09)	0.49 (0.007)
Aisle	-0.18 (0.36)	0.70 (<0.01)	0.76 (<0.01)	0.66 (<0.01)	0.40 (0.035)	0.74 (<0.01)	0.73 (<0.01)
Island	-0.02 (0.91)	0.69 (<0.01)	0.56 (0.002)	0.34 (0.08)	0.52 (0.004)	0.73 (<0.01)	0.58 (0.001)
End Cap front	-0.19 (0.33)	0.59 (0.001)	0.50 (0.006)	0.51 (0.005)	0.19 (0.31)	0.77 (<0.01)	0.71 (<0.01)
End Cap Back	-0.184 (0.35)	0.76 (<0.01)	0.55 (0.002)	0.44 (0.02)	0.28 (0.15)	0.74 (<0.01)	0.68 (<0.01)
Checkout Side	-0.26 (0.18)	0.07 (0.71)	0.22 (0.27)	0.13 (0.52)	0.11 (0.57)	0.24 (0.22)	0.27 (0.17)
Checkout End	-0.22 (0.25)	0.63 (<0.01)	0.64 (<0.01)	0.54 (0.003)	0.21 (0.29)	0.76 (<0.01)	0.72 (<0.01)

Table 17. Spearman's correlation between food and beverage categories and in-store locations

	Spearman's correlation (rho)	P value
Fruit and vegetable displays		
Outside	-0.69	**<0.01**
Entrance	0.20	0.29
Edge	0.32	0.98
Aisle	-0.14	0.46
Island	0.43	**0.022**
End Cap Front	/	/
End Cap Back	/	/
Checkout Side	/	/
Checkout End	/	/
All locations of high prominence	/	/
All locations of medium prominence	0.24	0.22
All locations of low prominence	-0.24	0.22
Unhealthy foods displays		
Outside	-0.34	0.85
Entrance	0.23	0.26
Edge	0.23	0.24
Aisle	0.85	**<0.01**
Island	0.75	**<0.01**
End Cap Front	0.67	**<0.01**
End Cap Back	0.66	**<0.01**
Checkout Side	0.27	0.16
Checkout End	0.62	**<0.01**
All locations of high prominence	0.74	**<0.01**
All locations of medium prominence	0.88	**<0.01**
All locations of low prominence	0.19	0.35
Shelf space allocated to CFCs		
Shelves with under 50% CFC	0.14	0.47
Shelves with 50-75% CFC	0.38	**0.046**
Shelves with >75% CFC	0.45	**0.017**
Food and beverage categories		
F&V	-0.04	0.83
Crisps	0.51	**0.006**
Biscuits	0.72	**<0.01**
Juice drinks	0.61	**0.001**
Soft drinks	0.27	0.16
Sweets or Chocolates	0.83	**<0.01**
Cereal	0.78	**<0.01**
All unhealthy	0.87	**<0.01**

Table 18. Spearman's correlation of store variables with number of checkouts

Differences by SE tertile

A KW-H test was run to determine if there were significant differences in the frequency of foods displayed in different store locations across SE tertiles. Distributions were similar for all locations except for a significant difference in the frequency of display of unhealthy foods at checkout sides ($\chi^2(2) = 7.948$, $p = 0.019$). Post hoc analysis revealed statistically significant differences for this variable between medium (8.0) and high (19.18) SES stores ($p = 0.023$), but not between any other group combination. Further KW-H testing showed no significant differences by SE tertile in the distribution of foods in locations of low, medium or high promotional prominence, or in the proportion of CFC in shelves that are accessible to children. No statistically significant differences were found.

Discussion

A thorough understanding of the impact of the overall food environment on food choice and dietary behaviour requires characterization of the foods and beverages marketed in food stores. Although grocery stores and supermarkets are often thought of as contributing to the overall healthfulness of the food environment [454,576,639], this benchmark study illustrates the imbalance between healthy and less healthy food and beverage product assortment in grocery stores, regardless of size. Frequent displays of unhealthy foods in grocery stores, particularly displays of sweets and chocolates, provide ample opportunities for consumers to purchase highly visible foods or beverages high in fat, sugar or salt, whereas healthier foods appear to be less prominently displayed. If the number of in-store promotions were to be merely an effect of store size, such associations would be expected to be consistent across all product categories (including F&V).Thus, our hypothesis that larger stores would place proportionally more unhealthy products in prominent locations than smaller stores was substantiated by our findings. One possible explanation for this pattern is that larger grocery stores are more likely to be franchises with sites in multiple locations, and typically adhering to standardized, uniform store designs informed by marketing principles to maximize sales [640]. However, while there were expectations that there would be more strategic placement of unhealthy foods in visible locations in deprived areas compared to affluent areas, this was not borne out by our results, possibly due to Malta's small size and mix of neighbourhood deprivation within localities, or due to limited variation within grocery store chains.

Analysis of customer receipts in the original GroPromo study suggested that the type of location, but not necessarily number of locations, in grocery stores was an important factor influencing food purchasing [72]. Food purchases were related to the number of food placements in areas of high promotional prominence. Marketers are aware that maximal food visibility, or salience, needs to be achieved at the point of purchase (i.e. allocating more shelf space to a food product or placing items at eye-level) in order to generate sales [641]. Salience serves as a continuous reminder of potential consumption, hence the sight of food may increase hunger and has been correlated with greater consumption [642]. Most large chain supermarkets, recognizing that the purchase of snack and energy-dense foods is more likely to be dependent on visual cues within stores that subtly encourage impulsive, unplanned purchase and consumption [566,628], strategically place sweets, chocolates and other impulse-driven food items near checkouts [575,643]. By understanding the impact of food placement, actions can be taken to use these locations in ways that encourage healthier choices [584].

The results of this study provide some evidence for the existence of an obesogenic consumer food environment in grocery stores in Malta. The collection of quantitative data characterising this situation may raise awareness about in-store aspects of the food environment and serve as a benchmark against which future progress may be monitored. To date, nutrition and obesity policy in Malta has focused on improving access to fresh fruit and vegetables (e.g. through farmers' markets); nutrition education; reducing the availability of foods high in fat, sugar and salt within the school environment, and conducting surveillance research on population dietary habits [80,110]. Although a number of regulatory and fiscal policy approaches to reducing the consumption of unhealthy foods are under consideration [80], these tend to generate considerable resistance by food industry. Modification of the in-store environment to restrict access to or visibility of unhealthy foods may be an acceptable alternative [619], rather than focusing on increasing access to healthier options [565]. However there are currently no programs or policies aimed at directly modifying the environment in food stores in Malta. Such store-based strategies might consist of interventions to improve the quality and healthfulness of checkouts, whereby confectionery is replaced by snack-sized fruit or vegetables [627,644]; establishment of a voluntary scheme amongst retailers to promote characteristics of healthy store designs [645]; or encouraging store owners to change their stocking practices, improving the healthfulness of their mix of stocked products. Incentives may be required for store owners to enact such health-promoting policies in order to compensate for potential loss of income due reduced sales of profitable, unhealthy items, or to counter 'slotting fees' paid by manufacturers for prominent product placement in stores [646]. Although small, the sample of grocery stores was nationally representative. However, this study has a number of limitations. A validated protocol was used for this study, however the sample of food items explored was not selected at random and cannot be said to represent the range of healthy or unhealthy foods available to consumers. Only grocery stores were evaluated; other store types such as convenience stores were not evaluated. Data on stocking frequency or other factors that influence product assortment and space allocation were not collected. In addition, information on consumer purchases (e.g. receipts) was not collected, hence a direct link between the in-store promotional environment and actual individual cannot be established.

Conclusions

This study provides a baseline characterization of the in-store marketing environment of key food and beverage categories within grocery stores in Malta. Although they are often thought of as contributing to the healthfulness of the overall food environment, the majority of grocery stores allocated more space to unhealthy foods in areas of high promotional prominence than to fruit and vegetables. This presents opportunities for interventions that aim to influence consumer food choices through product re-assortment. Studies assessing the promotional environment in other store types, including online supermarkets, are required. Further research is also needed to examine the relationship between the in-store environment and actual purchasing behaviour, to gain a deeper understanding of how promotions in prominent locations are perceived by individuals and on which promotion locations are encountered most often by customers.

Acknowledgements

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End of Research Paper 5

CHAPTER 5. KEY INFORMANT INTERVIEWS & FOCUS GROUPS

In the previous chapter I presented objectively measured data on several aspects of the obesogenic environment which may be contributing to the high rates of childhood obesity in Malta, and which may be of use to policymakers who are interested in addressing the issue from a soci o-ecological perspective. Such information provides a useful baseline against which the feasibility and potential impact of future obesity prevention interventions may be assessed. However, the factors underlying the high prevalence of childhood obesity in Malta are clearly more numerous and complex than any single facet of the observed environment. Furthermore, objective measurements cannot offer insight into the relation between individuals and their environment which influences risk of obesity. In order to explore these links, I conducted a qualitative study of key informants whose actions may directly or indirectly influence the various dimensions of the obesogenic environment in Malta. The measures proposed in the national obesity strategy (Appendix 1) were used to explore their views on what should be done to address childhood obesity. Having been involved in public health policy making in Malta for a number of years, I was particularly interested in the perspectives of public health professionals, academics, and food industry representatives. I also conducted focus groups with children and parents, in order to gain an understanding of their lived experiences around how their environment influences dietary and physical activity behaviours (objective 4).

Preamble to Research Papers 6 and 7

According to the social-ecological model, interactions between individuals and their surrounding social and physical environment directly influence health-related behaviours and beliefs, promoting or hindering overall health [29,354,365]. Accordingly, various factors operating at multiple levels of the socioecological model of health behaviour may contribute to childhood obesity [33,182], and there is evidence to support the notion that the apparent spread of obesity within social networks is in fact due to the shared environment in which related individuals live [647]. Although Research Papers 3 to 5 provide objective information on this shared environment, there are innumerable ways in which it may be experienced by, and exert its influence upon, individuals.

Childhood and adolescence represent pivotal periods of development which may impact behaviours during the remainder of the life trajectory [488,648]. Thus far there has been limited formative research to identify specific environmental factors that may be undermining efforts to improve dietary or PA behaviour among children in Malta. Thus, I was motivated to ask: *'What is the lived experience of individuals living in this environment?'.* In my research, I chose to focus on secondary school-aged children because these were likely to have sufficient ability to vocalize their experiences in a way that illustrates their interactions with their environment. The research papers presented in the previous chapters suggest that there is a need for environmental interventions to promote healthy food habits and PA patterns among adolescents and younger children in Malta. This in turn requires insight into the context which shape such behaviours. This chapter explores the potential causes and manifestations of the obesogenic environment in Malta, and reports on contextual findings that illustrate how this environment may influence individual behaviours and thus contributes to childhood obesity.

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Student	Daniel Cauchi
Principal Supervisor	Cécile Knai
Thesis Title	Childhood obesity in Malta: contributions of the obesogenic environment

SECTION B – Paper already published

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Student Signature: D Cauchi **Date:** 29/07/2016

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Research Paper 6

Barriers to children's healthy food habits: a qualitative study of the Maltese food environment

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Author contribution: I formulated the research question and designed the study. I collected and analysed the data with input from Cécile Knai. I drafted the manuscript and made revisions based on comments from Cécile Knai.

Abstract

Malta has a high prevalence of childhood obesity, and understanding the factors influencing healthy eating behaviour has become critical. Drawing on in-depth semi-structured interviews and focus groups conducted in Malta, we explored child, parent and community stakeholder perspectives on environmental drivers of Maltese children's dietary behaviour. Between June and July 2014 we conducted 10 focus groups with secondary schoolchildren (n = 77), one focus group with parents (n = 10) and 69 interviews with 73 key stakeholders, including health professionals, academics, government and food industry representatives. Data were analysed thematically, using the ANGELO framework to structure emergent themes. Our results indicate that a sociocultural milieu that encourages overconsumption of convenience food may be compounding the problem of childhood obesity in Malta. In addition, an obesogenic food environment characterised by easy access to foods high in fat, sugar and salt exists in communities, secondary schools and in their immediate surroundings. Food environments are key targets for interventions to reduce obesity prevalence. This study widens our understanding of the broader environmental context within which children's eating habits develop, highlighting opportunities to support more healthful eating.

Introduction

The environments within which children live and operate shape children and adolescents' dietary behaviour and nutrition-related ill-health [5,13]. Childhood obesity is recognised as a serious public health issue in Malta [2,10,104] and is likely related to high daily intake of soft drinks [96,99,100] and a preference for HFSS foods [52]. Understanding the reasons for poor dietary behaviour among Maltese children and adolescents is thus critical, especially given the tendency of eating patterns to persist into adulthood [648,649]. Food environments are likely to be particularly important mediators of dietary behaviour and hence, eventual risk of obesity [53,376,571,576,613]. Children in Malta are exposed to frequent advertising of HFSS food on local television channels which may influence their dietary behaviour [352]. At the community level, greater availability of stores selling fruit and vegetables may improve overall dietary quality and potentially reduce odds of obesity [576,577], whereas a high density of fast food restaurants and convenience stores has been associated with increased odds of obesity [191,650].

In addition, two key settings for children are the school and the home. The home food environment, family rules around eating, parental eating behaviour and parenting practices have been shown to mediate children's dietary behaviour and familial patterns of overweight [154]. The food environment within and around schools, where children spend a substantial portion of their weekdays, has also been identified as a key setting for obesity prevention interventions [651–653]. School meals are not typically on offer at most Maltese schools, hence the majority of students consume a packed lunch from home. These tend to consist of bread with ham, cheese and/or butter fillings; or of food high in fat, sugar and salt (HFSS foods), typically bought by schoolchildren (particularly boys) from tuck shops [208]. HFSS foods are sold in school tuck shops and canteens in spite of contractual obligations to sell healthy items that adhere to nutritional criteria [230]. Until recently, there was also a lack of formal monitoring of tuck shop sales, whereas street hawkers and other vendors selling HFSS foods are often located in the immediate vicinity of schools [269].

The recently updated 'Healthy Eating and Physical Activity Policy' (HEPA) – a school-based policy which is mandatory for state schools but voluntary for independent and church schools – acknowledges the importance of providing a supportive school environment to encourage a healthy lifestyle and promote healthy choices early on in life [230,332]. It provides strict nutrition criteria aimed at enhancing the provision of food with high nutritional value and prohibiting HFSS food and drink from being sold in tuck shops, school canteens, vending machines and catering provided during special events in order to support healthier dietary habits. Since September 2015, formal, independent monitoring of school adherence to these standards has been carried out on a regular basis. Such nutrient and food-based standards have been shown to be effective and may play an important role in promoting dietary health [325].

Qualitative research methods were employed to explore the range of stakeholder, parent and children's views on barriers to, and enablers for, healthy nutrition and environmental factors that influence children's dietary behaviour. Understanding such factors provides rich, credible data to inform approaches to childhood obesity prevention in Malta.

Methods

Semi-structured interviews

Semi-structured interviews were carried out with key stakeholder groups. A balance of sectors was sought by purposely sampling individuals with health or nutrition expertise, food industry representatives and academics (Table 19), drawing from an established professional network of contacts. These were supplemented through 'snowball' sampling to ensure a diverse range of stakeholders. Potential interviewees were invited by email and provided with background information on the study (Appendix 8). We anticipated that interviewees may access their email accounts infrequently so we subsequently telephoned those who had not responded. Two versions of a topic guide were developed as appropriate for industry and non-industry stakeholders to enable key questions to be asked whilst allowing free expression and flexibility to probe deeper into responses (Appendix 7). These mirrored one another to ensure core topics were investigated. DC also familiarised himself with the portfolio of food or beverage products, and any published corporate social responsibility policies, for each company in order to tailor questions within the interview topic guides. Interviews were carried out on a one-to-one basis (except for three combined interviews where more than one stakeholder participated) by the lead author between May and July 2014. DC adopted a neutral stance during interviewing to avoid creating a situation that may have inhibited or coloured interviewee's accounts. Interviews lasted around 60 minutes and were held in Maltese or English. Interviewees were assured of anonymity and confidentiality, and signed a consent form prior to interview (Appendix 8). With permission of respondents, interviews were recorded. Two respondents declined to be recorded, with notes being taken instead. Interviewing paralleled the analysis and continued until theoretical saturation had been reached.

Focus groups

Focus groups (FGs) were carried out in ten state secondary schools across Malta. Data were collected during a one-day visit to each school between May and June 2014. While not intended to be a representative sample, groups were balanced for gender, level of independence, and socioeconomic level of their locality of residence. Children who had just started (i.e. 10-11 years), or who were about to finish (i.e. 14-15 years) their secondary school education were included in order to obtain a spectrum of experiences and ability to vocalize opinions and views. Each focus group lasted approximately 90 minutes and was conducted during school hours in a classroom. Group size ranged from six to ten participants (Table 20). The focus group topic guide mirrored the interview topic guide and explored interactions between participants and their environment in relation to food behaviour and physical activity (Appendix 7). However, this article focuses only on the emerging interactions between food and the environment. The following themes were broadly covered: participants' perceptions of the home, school, and neighbourhood or community food environment; dietary behaviour; and barriers or enablers of healthier eating habits. One focus group with ten parents of secondary school children attending a church school was also organised. Recruiting parents from state schools proved difficult, in spite of the authors' flexibility with regards to location, date and time of the focus group. Although not representative, this group of parents provided important information that adds value to the study, and their views have been included.

Data processing and analysis

Recordings were anonymised and transcribed verbatim by the lead author to ensure consistency. Data were analysed using principles of the 'constant comparative method' within the framework approach [81], following the systematic framework method outlined by Gale et al [82]. DC led the analysis, reading a random sample of transcripts several times before developing open codes. CK also read multiple transcripts, compared interpretations of the data with DC, and reviewed the ongoing analysis. Recurrent themes were coded and organised under individual headings derived from the ANGELO framework, and analysed thematically. Newly emerging themes were continually compared to the coding framework and amended to ensure that they reflected the data, and the framework itself was refined to accommodate new themes. The organisation of data, including illustrative quotes, under these emerging themes helped to describe and elucidate the data, interconnections between the data, and the generation of explanatory patterns. Extract codes adjacent to quotes indicate key informant group (sector) or gender and age in the case of children. The London School of Hygiene & Tropical Medicine Ethics Committee and the University of Malta Research Ethics Committee granted ethical approval for the study.

Results

Participant characteristics

A total of 69 interviews were conducted with 73 key informants (Table 19). Perspectives from government or regulatory agencies; food industry representatives; academics, health professionals, non-governmental organizations (NGOs) and representatives of professional and grassroots advocacy associations were sought.

Sectors	Interviewees
Academia/Education (research institutions, faculty directors, heads of schools)	13
Government (ministries*, public health regulator, government agencies)	21
Health Professionals (paediatricians, GPs, physiotherapist, dietician)	5
Industry (food or beverage importers/manufacturers, fast food store managers, restaurant owners)	17
NGOs (patients and consumer organizations, union representatives, urban planners, Curia, alternative transport advocacy groups, journalist organizations)	13
Other (World Health Organization, independent consultants)	4

*including Ministry for Energy and Health, Ministry for Education and Employment, Ministry for Finance, Ministry for the Family and Social Solidarity, Office of the Prime Minister, Ministry for Sustainable Development, the Environment and Climate Change, Ministry for Social Dialogue, Consumer Affairs and Civil Liberties

Table 19. Sectors represented by key informants

Seventy-seven children and ten parents participated in eleven focus groups. There were approximately equal numbers of boys and girls in each age group (Table 20).

Age group (years)	Male	Female
10-12	18	17
14-15	21	21
18+ (parents)	4	6

Table 20. Focus group participants

Emergent themes regarding physical, sociocultural, economic and political barriers to healthy eating are illustrated in the sections below using representative quotes.

Socio-cultural barriers

Socio-cultural factors refer to the broader cultural context within which individuals live. Historical influences and societal norms about nutrition may be responsible for shaping food preferences. In particular, Maltese cuisine was heavily influenced by the food preferences of the British, leading to the adoption of a diet high in refined carbohydrates, meat, fats and salt [216]. This was further reinforced by the economic need to cater for mostly British tourists following independence. As explained by a cultural expert:

> *"[It] was a disaster. [We] were introduced to items with more fat and oils…this was strengthened particularly at the start of the budding tourism industry in the 60's [which] was mostly British… they introduced a sub-culture which is undoubtedly not Mediterranean… Go to any supermarkets and you'd be horrified by the variety and choice of butter and margarines…that, to me, is a red flag…. They introduced canned fruit, when we have fresh fruit that doesn't need to be canned. They introduced sugar instead of honey. They introduced soft wheat bread instead of grano-duro bread... We scrapped goat's milk – which has very low cholesterol – because they didn't like goat's milk but preferred cow's milk. Beef, which we did not usually eat…we used to eat pork and goat and poultry... After the war a culture of canned foods started spreading… [and] we changed our culinary values completely. So obviously we paid the price." [Academia]*

This nutrition transition was abetted by the subsidizing of certain food products high in fat and sugar by the British colonial administration:

> *"If you look back to a hundred years ago we had a very healthy diet, based a lot on the Arab diet, funnily enough, with pulses and so on. It's changed completely. We were, in my opinion, partly ruined by the British… [who] pushed us to subsidise heavily: sugar, beef, tinned milk, cheese, and tea. I mean…it was a classical British diet. And these were bulk-bought and subsidised. So you paid less for your sugar, you paid less for your tinned milk than you would for fresh milk. So you had no chance." [Academia]*

In addition, the Maltese population's experience of hunger and starvation, and memories of food insecurity, during World War II have shaped attitudes to food and body shape in Malta, where it is still preferable for a child to be 'chubby' than to risk being perceived as under-nourished due to thinness:

> *"I think it's very cultural…there is still impact from World War II. That generation… suffered extreme hunger and starvation during the war, or right afterwards. When suddenly things started picking up in the late 50's and 60's, people went overboard... Certainly there was food around, a greater variety of food started to be imported…so people wanted to have big portions on their plate. It gave them a sense of security…of satisfaction…even the sense of self-actualization [and] their offspring grew up with that attitude of [having] big portions on the plate. Now this is still trickling over… grandparents in particular are very scared. They tend to want to give the young children a lot of food to show their love…" [Academia]*

Several other cultural traits around food intake emerged during this research, including a preference for quantity over quality; an emphasis on the social aspects of eating over nutritional value of food; and pleasure taken in demonstrating one's hospitality and affection through providing food. Indeed, these traits are so ingrained into popular culture that not offering food to guests would be considered to be a breach of etiquette. Such values may lead to over-consumption in order not to waste food or show disrespect to one's hosts:

> *"…in Malta it's the portion that matters, rather than the quality… it's a question of culture, a matter of making your money last…I think the Maltese like to eat. It's a priority for us. Food is important, the Maltese lives to eat, rather than eating to live." [NGO]*

Changing lifestyles were proposed as determinants of dietary behaviour, with the rapid pace of modern lifestyles and maternal employment highlighted as key barriers to healthy eating. A majority of respondents perceived that the search for convenience drives modern food choices, resulting in a growing reliance on processed or packaged food:

"Unfortunately I think that today's lifestyle is so rushed, so stressful, that many people take the easy way out…if both parents work they might not have time to cook at home, so what's the easiest thing to do? Purchase fast food on the way back home... So yes, unfortunately the environment does not help people to make healthy choices…" [Health Professional]

Eating out was portrayed as a family treat on weekends, special occasions and as a reward for children's good behaviour. Although industry stakeholders acknowledged the negative impact of HFSS foods and drinks on health, they described that the supply of such options in restaurants was a response to customers' taste preferences:

"…we reward children with fast food. We take them out to a fast food outlet. For many families, that's the weekend treat." [Government]

"I think eating out is quite a treat. That's the feeling that I get from my customers. And they won't want to think about nutrition when it's a treat… And when you go out to eat, wherever you go, you're going to want full flavour." [Industry]

"…we also have a soft drink culture… When you go to a restaurant, you'd see soft drinks on the table…Unfortunately if you go to any child's birthday party, it's cake and soft drink [on offer]. And if you offer children water instead they will always opt for soft drink... Yes, for kids it's just [about] taste." [Industry]

Industry stakeholders commented about the difficulty of establishing a financially sustainable business offering healthier food, blaming the Maltese population's preference for sweet and carbohydrate-rich products for the lack of commercial success:

"People want sugar, with a vengeance, with a vengeance! I have been in the business for 20 years, and I have never seen people with such a craving, such a craving [sic]! …they absolutely showed that government attempts at education have failed. So you see obese people with a huge bag of sweets – rather than saying that they should stay away from sweets, they seem to want more…first a milkshake, then pancake with ice cream and doughnuts, then take away…" [Industry]

At the micro-level, family, peer and school authority' perceptions and attitudes towards food may influence children's dietary behaviour. Grandparents may have a role in both encouraging overconsumption of food, and in promoting healthy eating by increasing availability and access to fruit and vegetables:

> *"Nowadays… grandparents spoil [children] to show them their love. So parents try to be careful and encourage healthy eating, while grandparents do the opposite…" [Industry]*

> *"She [grandmother] always puts too much on my plate. She'd ask me how much food I want on my plate, and then double the portion. Sometimes I'd be angry with [her] because I'd have just eaten, my stomach would be full, and she'd try to give me more food…that sometimes annoys me…I would be stuffed and she'd still insist that I eat everything on the plate…" [Student, M, 11]*

Physical barriers

Several aspects of the overall physical environment were identified as barriers to healthy dietary behaviour. Stakeholders described an unsupportive food environment that limits visibility of and children's access to healthy food while simultaneously enhancing exposure to unhealthy food. For example, advertising techniques employed by fast food corporations to shape food preferences and encourage consumption of HFSS food by children - such as offering free promotional toys, portion size upgrades (Figure 15) or use of cartoon characters in adverts - were criticised by stakeholders:

> *"…you may think we are buying things of our own free will but we're being seriously nudged into buying …and marketing has a lot to do with it. Case in point: go and look at bill boards associated with the World Cup at the moment. Not only do you get a Big Mac, you get a Grand Mac... encouraging people to eat more of stuff which might not be that good for them." [Academia]*

Quick-service restaurants have become an integral feature of the Maltese landscape:

> *"I enjoy seeing my child eat, but I tell my child to eat healthy food and whatever. But sometimes…once a week she wants to eat at McDonalds. When we were young, for example, we didn't have all these fast food outlets, it was easier [to avoid fast food]." [Parent]*

Figure 15. Roadside Coca-Cola billboard: World Cup promotions/gifts
Credits: author

One food item which was repeatedly mentioned during focus groups and interviews was the 'pastizz'. This popular traditional savoury pastry, consisting of filo pastry with a ricotta or mushy pea filling, is typically sold in confectionery stores and fast food take-away outlets ('pastizzerias'). Throughout this study, the term 'pastizzerias' was used as an umbrella term referring to food outlets selling cheap, take-away unhealthy food. The number of pastizzerias and confectionery stores in Malta has increased rapidly over the past decade [216], reflecting high demand for the cheap, convenient food products sold at such outlets:

"…sometimes you'd find two or three pastizzerias next to each other. I imagine that if they're still ongoing, they must be successful." [Government]

In addition to fast food stores and restaurants, mobile vendors emerged as another aspect of the community food environment in Malta. Two types of vendors that typically follow fixed routes with temporary stops in different neighbourhoods were frequently discussed: the fruit and vegetable (F&V) hawker and the doughnut hawker. F&V vendors represent positive features of the overall community food environment, as they enhance access to fresh produce (Figure 16).

Figure 16. Fruit and vegetable hawker
Credits: author

Children did not report any personal interaction with F&V hawkers. On the other hand, several children reported being directly targeted by doughnut vendors who often included stops at sites popular amongst children – including schools – along their routes, establishing personal relationships with young consumers:

> *"In my experience it's these vans [hawkers] which are influencing us. I mean, you don't find doughnuts in many shops… so these vans sort of oblige you [to buy]… otherwise you wouldn't go out of your way to buy doughnuts…" [Student, F, 11]*
>
> *"Yes they [doughnut hawkers] used to come next to the wall and sell to us... during break. He used to stop by the gate, we'd tell him what we'd like, and he'd throw us the stuff over the gate ... You'd see almost the entire school eating doughnuts." [Student, M, 14]*

Doughnut hawkers and ice cream trucks featured particularly prominently in stakeholders' descriptions of the food environment outside of schools. Parents commented on the apparent inconsistency of healthy food policies within school walls that are undermined by vendors selling unhealthy foods just outside the school gates:

> *"Well, for example for a while, the doughnut hawker used to come around [the school]. And it was tempting...my daughter would go out of school to buy a doughnut, before coming fo r lunch. That's not good." [Parent]*

Stakeholders observed that offerings on children's menus tend to be fried foods high in fat, partly in response to demand from young customers who do not like vegetables:

> *"I would go so far to say that we take it for granted that children do not like vegetables – look at children's menus in restaurants, and you'll see what rubbish there is." [Industry]*

Unsurprisingly, food manufacturers, food importers and restaurateurs stated that their ability to generate sales primarily determines their decision-making around whether to stock a particular product. Even as they acknowledged that what is beneficial for business is not necessarily good for individual health, they commented on the difficulty of importing or offering a wider choice of healthier products, in part due to Malta's small size and limited demand for such foods. Malta's dependence on food imports was highlighted as yet another negative factor influencing the consumer food environment since the local food industry is constrained to a great extent by external, corporate decisions made elsewhere:

> *"The truth is that what is bad for you tastes good and what is good for you tastes bad...I cannot eliminate my fried [meals] and offer just grilled [meals] because I'd have to close down the business. So even if you're importing, you have a shelf-life...if a product doesn't sell, you don't [import] it... as a business strategy on its own, you won't survive [by importing healthy products only]." [Industry]*

All stakeholders highlighted the importance of having a supportive food environment within the school to complement nutrition education and health promotion efforts. One positive finding across schools was that vending machines did not dispense soft drinks or other sugar-sweetened beverages (SSBs), with only water, flavoured water or juices being available for sale. However, students reported that despite nutrition education, tuck shops and canteens in most secondary state schools – some of which are operated on contract independently of the school, or which are a source of income for the school – offer a wide variety of unhealthy food and beverages. They speculated that healthier food items are not popular amongst students, and that tuck shop or canteen managers are unwilling to stock food items with low turnover. Students expressed confusion at being exposed to a food environment inside and around their school which contrasts starkly with the messages being passed on by nutrition educators:

Student: We do have people telling us what is good for you, but then when you go to the tuck shop – this is what I don't understand – and then find all these doughnuts, ice creams…
Student: It's like the school is trying to set one up to be tempted. [Students, M, 14]

"I used to eat much more healthily in primary school. Now, because of junk food in the [secondary] school, I don't eat as healthily as I used to. There's no consistency…if there's something in school telling you to eat vegetables, there's another telling you 'No, don't eat vegetables, eat something fattening instead.'" [Student, F, 11]

"What I don't like… is that we'd be talking about healthy eating at school…then as soon as we go out of school we'd see the doughnut guy, the pastizzi guy…right outside the school gates. So on one hand you're talking about and emphasising the importance of healthy eating, on the other hand you'll see pastizzi, or the ice cream van right outside. Or you'd see teachers with pastizzi in their hands…" [Student, F, 11]

The impact of the home food environment on diet was also explored. Parents were generally aware of the principles of 'healthy eating', yet they reported adopting a pragmatic approach to feeding their children in order to balance the often conflicting demands of lifestyle, children's requests for unhealthy food, and good nutrition:

"[My daughter] has to have one Cadbury a day after lunch. If I don't buy her this Cadbury….!!!! Such a fuss. She wants it. And if she finds the place where I hide them, they'd disappear. She loves them…" [Parent]

Political barriers

This refers to national or regional policies and regulations around food provision and media advertising at the macro-level, as well as informal family rules around eating or school food policies at the micro-level. At a national level, Maltese authorities have little control over the nutritional value of imported foods. Malta's lack of autonomy in this regard was presented as a potential barrier to a healthy population diet, since popular demand for HFSS foods is likely to influence the type and quantity of such food imported to Malta. Similarly, legally binding regulations to minimise children's exposure to advertising of unhealthy food to children on television or online are lacking in Malta. This was identified as a lacuna that may need to be addressed:

"Today with cable and satellite television and internet, kids are being bombarded by all types of messages… guidelines will always remain guidelines. If you do not respect guidelines there is very little we can do… there needs to be a definite framework which guides broadcasters into what can be done and what shouldn't be done, especially in children's programs… There is the Audio-Visual Media Services Directive [EU directive] which hints at this, and encourages

– that's the word – encourages stations not to broadcast these types of advertising or commercial communications, but I think we're still a long way off from having a harmonised framework across the EU for these kinds of adverts." [NGO]

Views on the political dimension of the school food environment and the implementation of the Healthy Eating Lifestyle Plan (HELP) policy document, which outlines guidelines for creating a supportive environment conducive to healthy eating and physical activity in schools were mixed. Students in particular claimed that its implementation and enforcement in secondary school was lax compared to primary school, representing a barrier to healthy eating at school:

"There was supposed to be a healthy food policy at school, but they never implemented it…because they wouldn't have managed to keep the business going, there aren't any students here who like eating that type of food." [Student, M, 14]

Multiple respondents suggested that the non-binding nature of the HELP guidelines was a barrier to the creation of a healthy school food environment, since token efforts were being made to appear to adhere to guidelines in certain schools whilst simultaneously providing HFSS food in tuck shops and canteens. Representatives of academia in particular expressed frustration at the seeming dissonance between what is taught in school curricula and actual practices, suggesting that the income from sales of HFSS foods is prioritized over health considerations. Additionally, unexpected adverse effects of implementing HELP policy were highlighted, such as the emergence of a black market within the student body to cater for demand that could no longer be satisfied through official school food sources:

"We don't have any control over what is provided at home, but if you provide unhealthy food at school...it goes against all that we teach. Who monitors tuck shops? Tuck shop owners are bound by contract to provide healthy food. Strictly speaking they can be fined…Enforcement is all. And there's not enough of it...There are even tuck shops selling unhealthy food 'under the counter' [illicitly], with nothing unhealthy on display. Don't forget that the tuck shop is very good income for the school... And the more junk is sold, the higher the profits. The problem is that in schools which adhered strictly to the HELP guidelines, a black market was created. Students buying three large bottles of Coca Cola, placing them in their lockers, and selling disposable cups of Coke for €1 a cup. And if you're really the kind of person who can't do without your daily dose of Coca Cola…you'd buy it." [Government]

Ultimately, the Head of School was described as having a key role in the implementation of HELP guidelines and overall school food environment. Head teachers have the potential to influence the entire school community including students, parents and staff, hence their attitude towards school food policies may hinder or improve the overall school food environment:

> *"A lot depends on the Head of School – a lot! – and whether he or she takes [the HELP guidelines] on board or not. And then the Head influences teachers, the teachers influence parents, but the Head influences parents directly as well." [Academia]*

A separate initiative frequently mentioned by students was the School Fruit Scheme, introduced in Maltese primary schools in 2009/2010. This was described in positive terms by secondary school students, particularly by younger children who would have become used to receiving pots of fresh fruit or vegetables on a weekly basis throughout their years attending primary school. The scheme was credited with shaping their food preferences through repeated exposure, with several children stating that they would look favourably upon its extension into secondary school:

> *"In primary school they used to give us containers with fruit or vegetables. Now, since we've grown up a bit, they don't anymore. I wish they could continue giving us bowls now, in secondary school." [Student, F, 11]*

Older children who might have only heard about the scheme also expressed an interest, indicating disappointment at the fact that it is only implemented in primary schools:

> *"These things shouldn't be just for young children! They should be available even to children our age." [Student, M, 14]*

Rules and regulations enforced within the home are also crucial for the development of young children's dietary behaviours, which are subsequently carried on into adolescence and adulthood. They also impact the perceptions of adolescents regarding healthy and unhealthy foods. As one stakeholder pointed out:

> *"Once a child has got into the habit of bad eating and over-eating, the child will grow with this attitude, and it's…it's very difficult to get a person to reverse bad habits. Bad habits die hard. So I think it's mostly about habits: parents' habits and children's habits." [Government]*

Children also described eating patterns and practices outside of the school environment that seem to augment their food intake. One particularly recurrent emergent theme was the commonly observed practice of parents who insist that all food on a plate should be eaten, even if portions were large. This adds credence to grandparents' attitudes towards food described earlier. Stakeholders proposed that such attitudes have been passed on from post-war generations (i.e. grandparents) who had experienced hunger:

> *"…we have grown up in a culture where parents almost try to stuff food down your throat. In fact, I think it's common that children are warned not to leave the table unless they have eaten everything. That came from our past, from the poverty we came from… [People] want to be replete at every meal." [Industry]*

This was confirmed by several children who related personal experiences of being encouraged to eat until no food remained on their plate in spite of expressing reluctance to continue eating, occasionally with the implicit threat of being disciplined if they did not do so. They expressed mixed feelings about such rules imposed by their caregivers, linking them to a greater risk of becoming overweight:

> *"My mother wants me to eat the entire plate, even if it's really big. And I often tell her that I don't want my stomach to grow bigger, because I don't want to grow fatter." [Student, F, 11]*

> *Student: My mother insists that I eat everything even if I have a big plate. So I'd eat it even if I already feel full. She'd force me to eat it. My father would punish me [if I don't].*
> *Focus group leader: How do you feel about that?*
> *Student: I don't like it, I feel unwell. I'd be full and I'd have to keep on eating and eating…and even if I tell her I can't eat any more she'd insist "One last bite!", over and over again. [Student, M, 11]*

> *"…I feel full quickly, and my mother gives me quite a big portion of food … usually [she] tells me to eat everything that is on my plate, even if I don't like it." [Student, M, 11]*

Older children revealed more freedom regarding the amount of food they are obliged to eat during meals, but young children described not being allowed to drink liquids during a meal due to a parental belief that this would adversely impact their child's food intake, which in turn may contribute to overconsumption of food by children:

> *"My mother tells me not to drink during a meal – I have to drink after eating. Because otherwise I'd get bloated with water. And she would punish me [for not eating everything on the plate]." [Student, M, 11]*

Economic barriers

The economic dimension encompasses factors such as income and socioeconomic status at the micro level, and the broader economic climate at the macro-level. The Maltese were depicted as being sensitive to food prices, suggesting that levels of fish, fruit and vegetable consumption in particular remain low in part due to a perception that fresh produce is expensive. In spite of growing awareness of the link between food and long-term health, people may not be able to afford the healthier versions of certain food products:

> *"Unfortunately, healthy food is apparently more expensive than unhealthy food, so whoever is not doing well financially will not see the point of purchasing healthy food when his or her finances are limited. Health to them is not a priority, especially long-term health." [Health Professional]*

Potential reasons why fruit and vegetables (F&V) are perceived to be expensive were proposed by agricultural experts. These included the inherent nature of fresh products which expire more quickly than processed foods, as well as complex international and local agreements and policies between suppliers and distributors that favour higher F&V prices:

> *"I find it easy to believe that F&V are more expensive, because these are fresh. That means that there's an added cost, which is the cold chain…and perishability... The Common Agricultural Policy is definitely the main tool that can determine [supply and prices]. Not the only one, because unfortunately there are also downstream contractual relationships between supermarkets and Farmer's Cooperatives [that determine prices]. Experience shows that in every country… the bulk of the contractual strength lies in the supermarkets' hands… In the case of fruit and vegetables in general, overall negotiations between Europe and the World Trade Organization have more impact on prices than individual subsidies… It's certainly difficult for prices to decrease without having a significant impact on the income and survival of farmers in Europe, and a reliance on third countries with the accompanying issues of food security." [Government]*

Economic considerations also operate within the school setting. Some students highlighted how access to excessive amounts of money may lead to needless purchase of food that they would not otherwise have bought from tuck shops at school:

> *"...their parents give them too much money, and the children wouldn't know what to do with it so they go to the tuck shop to buy things. I only take 50 cents with me to school in case I need to buy a bottle of water. Not more, or else I'd spend it on other things." [Student, M, 11]*

Discussion

This qualitative study investigated environmental barriers to children's and adolescents' healthy dietary behaviour in Malta using a wide range of stakeholder perspectives. Participants highlighted numerous environmental contextual factors at multiple levels may encourage poor dietary behaviour, set within a broad sociocultural milieu that promotes over-consumption of food. Overall, the themes emerging from this study were similar to those found in urban areas in similar studies [654,655]. Our findings contribute to a socio-ecological model of the food environment in Malta, illustrating the need for multi-level obesity prevention interventions across several dimensions of the environment [501].

Mothers and grandparents emerged as key food gatekeepers in Malta. There is extensive evidence of the impact of caregivers on children's food choices and long-term dietary behaviours. Caregivers set rules, provide information and modelling behaviours, and determine the accessibility and type of foods and beverages (F&B) available in the home [656–658]. Children's physiological satiety cues may be systematically overridden by expectations that all food on the plate should be eaten and food waste avoided. Several studies have shown that having fruits and vegetables in visible locations within easy reach at home is positively associated with their consumption [488,659]. Parents also have some influence over what is eaten outside the home, particularly in Malta where school lunches are typically prepared by parents. In addition, the amount of pocket money given to older children and adolescents may also impact their food purchasing behaviour outside of the home. Grandparents also play a key role in bringing up young children in Malta, yet few studies have explored their contribution to children's dietary behaviour [660,661]. Our findings suggest that grandparents have an important role in mediating both positive and negative food behaviours of their grandchildren in Malta. Grandparents' views that the overweight child is a healthy child, and that their affection can best be demonstrated by providing abundant food, may be contributing to obesity in Malta. Thus, educational courses aimed at both grandparents and parents to correct inappropriate feeding practices may be important components of multi-strategy interventions to prevent obesity.

Stakeholders overwhelmingly indicated that schools should be settings where healthful eating behaviour is the norm, and hence targeted for intervention [488,501]. Currently, the reported easy access to and high availability of unhealthy food within and outside of schools and in residential neighbourhoods directly conflicts with the goals of nutrition education, and is a cause for concern [488]. Regrettably, our findings suggest that Maltese secondary schoolchildren have easy access to HFSS snack foods within and around most state secondary schools, echoing findings of a 2011 report by the National Audit Office [269]. Research has shown that close proximity to fast-food outlets and high density of stores selling fast-food in home or school neighbourhoods increase the likelihood of food purchasing from such outlets by adolescents [190]. The perishability of healthy food items is likely to be a key barrier to stocking and selling such foods by tuck shops and school canteens [662]. Issues such as low perceived demand, inadequate equipment or infrastructure for storage and reluctance to risk financial losses on unsold items may be just a few of the reasons why most adolescents typically reported that salads and wraps become progressively less available as the school year progressed. Incentives to encourage tuck shop and school canteen owners to invest in appropriate storage equipment may be important drivers of change. Furthermore, the school tuck shop or canteen may be an important source of additional income for certain schools. This may lead to a lack of enforcement of school nutrition standards that may negatively impact income. However, some progress was noted. Formal monitoring of food and beverage items sold through school tuck shops was established and the HELP guidelines made mandatory in all state schools, starting from September 2014. Although no direct observations of the school food environment were carried out in this study, participating students described their beverage choices at school as being limited to bottled water, flavoured water and juices sold in vending machines or school food outlets. Soft drinks and other SSBs were not available within school premises. Additionally, a new compulsory subject (Physical Health Education) comprising elements of Physical Education and Home Economics was introduced to all primary- and secondary-school students on a compulsory basis in 2015 [229]. This is expected to improve nutritional knowledge among all students across all schools. Despite these positive developments, more remains to be done. The provision of free drinking water to students has been associated with a reduction in the risk of developing overweight [484,663], yet currently drinking water availability appears to be limited to bottles in vending machines. None of the children participating in focus groups reported having water fountains at their school. Furthermore, action to prevent the emergence of 'black markets' within schools should be considered.

Efforts to improve the food environment at the home neighbourhood level and around schools are also required. Children are being directly targeted by mobile vendors selling doughnuts, ice cream and packaged snacks outside the school gate. Thus there remains a need to address the fiscal priorities of food vendors around schools and the inherently divergent goals of business owners and public health professionals when designing community interventions [664]. The rapid proliferation of fast food outlets in recent decades [216] and the increasing popularity of eating out [52] have augmented children's daily exposure to HFSS foods and beverages. Urban planning measures such as zoning laws to prevent construction of new fast food outlets around schools, or changing the function of existing food outlets in such zones, may reduce their density in the long term. Additionally, observations of food prices in grocery stores in Malta suggest that the price of certain healthy versions of food items are indeed more expensive than their regular, less nutritious alternatives (e.g. wholemeal bread compared to white bread), confirming the existence of economic barriers to healthy eating [see Research Paper 4]. The same study also identified a positive significant association between the density of confectionery stores in a locality and the prevalence of overweight among children in that locality. There is a growing body of literature that store-based interventions combining multiple strategies (e.g. point-of-purchase information, pricing modification, changes to advertising, placement and promotion) may increase both the supply and demand for healthy food and positively impact childhood obesity and dietary behaviours [603,665]. Work can also be carried out with restaurant chefs to reduce the fat, sugar and salt content of restaurant meals; remove HFSS food from children's menus; and reduce portion sizes where possible. The creation of a 'healthy restaurant' scheme approved by public health authorities and actively promoted during health promotion efforts may be one such avenue for exploration.

Public health efforts should be targeted at working with the food industry to discourage imports of unhealthy foods, particularly when healthier options are available. This in turn may require fiscal mechanisms to increase the price of unhealthy food and subsidise healthy products, as well as public health engagement in international trade negotiations in order to push for healthier global food systems. There is a nascent debate around the feasibility of introducing taxation of HFSS F&B in Malta [80], in part fuelled by encouraging preliminary reports of reductions in the sale of taxed beverages following the imposition of an excise tax on SSBs in Mexico [666]. Malta's high rate of soft drink consumption by children warrants further serious consideration of such fiscal measures. Additionally, the media exert great influence over children's and adolescents' food decisions [488,501]. Studies have consistently shown a positive association between television viewing and childhood obesity [463]. Research on television advertising on local channels indicated a high proportion of adverts promoting HFSS food throughout the day, including family-oriented programmes popular with children that extend beyond the 9pm watershed [352].

Stakeholders were asked about potential facilitators of healthy eating. Almost all health professional, academic and non-governmental organization representatives expressed support for systemic, environmental interventions to improve dietary outcomes. Some suggestions are already being implemented, including elevating HELP guidelines to the level of legislation, enforcement of existing school food policies and precluding mobile vendors from the immediate vicinity of schools. Others, such as revising urban planning rules to restrict licensing of new food outlets in the vicinity of schools; introducing colour-coded food labels; and restriction of HFSS food advertising to children on television during watershed hours, are actively being considered. They also emphasised the need for more effective targeting of nutrition education efforts at parents and greater focus on nutrition in the school curriculum. Government stakeholders were less articulate about the likely need for more stringent legislation to support a healthy food environment, citing the complex multi-factorial aetiology of obesity and the difficulties of reaching a balance between industry needs and public health interventions as limiting factors. With few exceptions, food industry stakeholders disagreed with any regulation, recommending that obesity prevention initiatives should focus solely on enhancing delivery of nutrition-related knowledge to parents and children. However, they distinguished between the intra-school environment and the food environment outside of school, suggesting that implementation of strict school food policies may be warranted and that mobile food vendors should not be allowed near schools. All adult stakeholders looked favourably upon increasing monitoring and surveillance of tuck shops and school canteens and enforcement of contracts that specify the provision of nutritious foods and the elimination of HFSS food. Ensuring adequate school income would also minimise the risk of budget-starved head teachers turning a blind eye to the sale of lucrative HFSS foods within school premises [77,667,668]. Children demonstrated enthusiasm about receiving more nutrition education, but looked less favourably upon implementation of strict school food policies unless these were applied in all schools, creating a 'level playing field'. Several students recommended introducing greater variety of healthy food options such as fruit, vegetables, salads and yogurts to school canteens and tuck shops, with HFSS being sold on an infrequent, occasional basis as a treat. They also suggested enhancing the quality and taste of perishable healthy products currently sold in schools (e.g. salads and wraps), claiming that they had limited appeal to children as they do not taste good. Lastly, some students suggested expanding the School Fruit Scheme [270] to secondary schools as a way of maintaining exposure to fruit and vegetables beyond primary school.

Strengths and Limitations

There are some limitations to this study. Our sample of parents was small (n = 10), and the views of children younger than ten years of age were not examined. Information on participant health or weight status was not collected, although this may have an impact on attitudes towards food and dietary behaviour in general. No direct observation of children's actual eating behaviours or of the school food environment were made. However, adolescents having a wide range socioeconomic backgrounds participated in focus groups, and a large number of experts from different sectors contributed to the study. Interviews and focus groups were conducted in familiar locations that potentially improved the comfort of participants; adolescents were encouraged to contribute to the focus group discussion in a non-dominant manner, allowing everybody a chance to speak. Interactions between students enhanced engagement and encouraged sharing of their experiences of their neighbourhood and school food environments. The frequency and consistency of recurring themes from multiple independent sources suggests that theoretical saturation was achieved and that the barriers identified are important.

Conclusions

Recognition of barriers to healthy eating and understanding the ways in which interactions between multiple levels of the food environment may influence food behaviours are essential to improving population diet. By applying a socio-ecological approach, this study contributes to the development of obesity-prevention strategies aimed at promoting healthy eating and reducing obesity among children in Malta.

End of Research Paper 6

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SECTION A – Student Details

Student	Daniel Cauchi
Principal Supervisor	Cécile Knai
Thesis Title	Childhood obesity in Malta: contributions of the obesogenic environment

SECTION B – Paper already published

Where was the work published?			
When was the work published?			
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
Have you retained the copyright for the work?*		Was the work subject to academic peer review?	

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SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	Social Science and Medicine
Please list the paper's authors in the intended authorship order:	Daniel Cauchi, Cécile Knai
Stage of publication	Not yet submitted

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	See full details of author contributions on the next page.

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Research Paper 7

Barriers to Maltese children's physical activity: a qualitative study

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Author contribution: I formulated the research question and designed the study. I collected and analysed the data with input from Cécile Knai. I drafted the manuscript and made revisions based on comments from Cécile Knai.

Abstract

Malta has a high prevalence of childhood obesity and physical inactivity. It is likely that environmental factors influence physical activity behaviour within a local context. Drawing on in-depth semi-structured interviews and focus group, we explored child, parent and key informant perspectives on environmental influences on Maltese children's physical activity levels. Between May and July 2014 we conducted 10 focus groups with children (n = 77), 1 focus group with parents (n = 10) and 69 interviews (n = 73) with key actors who are active in sectors and areas that may influence the environment in Malta. Data was analysed thematically, using the ANGELO framework to structure emergent themes. Our results suggest that stakeholders perceive Malta to be excessively urbanized, characterised by excessive traffic and inadequate access to public open spaces where children can play unsupervised. A socio-cultural context that discourages active transport also limits physical activity among children. This study widens our understanding of the broader environmental context within which children's physical activity takes place, a crucial first step towards developing interventions aimed at addressing the multiple environments within which children live and play.

Introduction

Childhood obesity [10,104,105] and physically inactivity in Malta [215] are of critical concern. The physical and mental health benefits of engaging in regular physical activity (PA), especially in childhood, are unequivocal [669–673]. However, levels of PA among Maltese children are generally low. Pre-school and primary school children engage in minimal PA [674,675], and only 39% and 10% of ten to eleven year-old boys and girls respectively meet the World Health Organization's (WHO) daily PA recommendations [210,211]. Adolescence is a particularly influential period of human development where PA typically declines [676,677]; this is also the case for Malta, where the proportion of physically active children decreased substantially from 21% and 28% of 11 year-old girls and boys respectively, to just 9% and 16% of 15 year-old girls and boys [100]. Instead, children – particularly obese children - report engaging in increasingly sedentary behaviour [96,97,100,210].

Evidence suggests that the environments within which children live and play impact their behaviour, including personal intention to engage in PA [13,678]. Children are not fully independent and are influenced by their environmental constraints to a greater extent than adults [193]. The socio-ecological model proposes that such behaviour arises from complex interactions between individuals and the sum of their physical, social, political and economic environments [29,679]. Altering human behaviour within an environment that does not support healthy choices is difficult to achieve and sustain [38]. Although the Maltese government has made political commitments to improve physical activity among children [228,328,680 80 332], a recent study of the 'obesogenic' environment [25] in Malta concluded that many environment factors, such as an overwhelming reliance on vehicular transport and limited infrastructure for PA, favour a sedentary, physically inactive lifestyle [216]. Furthermore, local research has identified excessive homework, lack of transport options, lack of space at home and excessive use of technology as barriers to PA among children [681].

The aim of this study was to qualitatively examine stakeholders' perceptions of environmental barriers to children's PA. Understanding barriers to, and enablers of, structured and unstructured PA could inform relevant policy and aid in the development and implementation of environmental strategies to promote PA throughout life.

Methods

Semi-structured interviews

Semi-structured interviews were carried out with key stakeholder groups. A balance of sectors was sought by purposely sampling individuals with health or nutrition expertise, urban environment and/or transport expertise, food industry representatives and academics (*Table 21*), drawing from an established professional network of contacts. These were supplemented through 'snowball' sampling to ensure a diverse range of stakeholders. Potential interviewees were invited by email and provided with background information on the study (Appendix 8). We anticipated that interviewees may access their email accounts infrequently so we subsequently telephoned those who had not responded. A topic guide was developed to enable key questions to be asked whilst allowing free expression and flexibility to probe deeper into responses (Appendix 7). Interviews were carried out on a one-to-one basis (except for three combined interviews where more than one stakeholder participated) by the lead author between May and July 2014. DC adopted a neutral stance during interviewing to avoid creating a situation that may have inhibited or coloured interviewee's accounts. Interviews lasted around 60 minutes and were held in Maltese or English. Interviewees were assured of anonymity and confidentiality, and signed a consent form prior to interview (Appendix 8). With permission of respondents, interviews were recorded. Two respondents declined to be recorded, with notes being taken instead. Interviewing paralleled the analysis and continued until theoretical saturation had been reached.

Focus groups

Focus groups (FGs) were carried out in ten state secondary schools across Malta. Data were collected during a one-day visit to each school between May and June 2014. While not intended to be a representative sample, groups were balanced for gender, age, and socioeconomic level of their locality of residence. Children who had just started (i.e. 10-11 years), or who were about to finish (i.e. 14-15 years) their secondary school education were included in order to obtain a spectrum of experiences and ability to vocalize opinions and views. Each focus group lasted approximately 90 minutes and was conducted during school hours in a classroom. Group size ranged from six to ten participants (*Table 22*). The focus group topic guide mirrored the interview topic guide and explored interactions between participants and their environment in relation to food behaviour and physical activity (Appendix 7). However, this article focuses only on the emerging interactions between PA behaviour and the environment. The following themes were broadly covered: participants' perceptions of the home, school, and neighbourhood or community food environment in relation to PA; transport and mobility; safety concerns; and barriers or enablers of PA. One focus group with ten parents of secondary school children attending a church school was also organised. Recruiting parents from state schools proved difficult, in spite of the authors' flexibility with regards to location, date and time of the focus group. Although not representative, this group of parents provided important information that adds value to the study, and their views have been included.

Data processing and analysis

Recordings were anonymised and transcribed verbatim by the lead author to ensure consistency. Data were analysed using principles of the 'constant comparative method' within the framework approach [81], following the systematic framework method outlined by Gale et al [82]. DC led the analysis, reading a random sample of transcripts several times before developing open codes. CK also read multiple transcripts, compared interpretations of the data with DC, and reviewed the ongoing analysis. Recurrent themes were coded and organised under individual headings derived from the ANGELO framework [25], and analysed thematically. Newly emerging themes were continually compared to the coding framework and amended to ensure that they reflected the data, and the framework itself was refined to accommodate new themes. The organisation of data, including illustrative quotes, under these emerging themes helped to describe and elucidate the data, interconnections between the data, and the generation of explanatory patterns. Extract codes adjacent to quotes indicate key informant group (sector) or gender and age in the case of children.

The London School of Hygiene & Tropical Medicine Ethics Committee and the University of Malta Research Ethics Committee granted ethical approval for the study.

Results

Participant characteristics

A total of 69 interviews were conducted with 73 key informants (*Table 21*). Perspectives from government or regulatory agencies; food industry representatives; academics, health professionals, non-governmental organizations (NGOs) and representatives of professional and grassroots advocacy associations were sought.

Sectors	Interviewees
Academia/Education (research institutions, faculty directors, heads of schools)	13
Government (ministries*, public health regulator, government agencies)	21
Health Professionals (paediatricians, GPs, physiotherapist, dietician)	5
Industry (food or beverage importers/manufacturers, fast food store managers, restaurant owners)	17
NGOs (patients and consumer organizations, union representatives, urban planners, Curia, alternative transport advocacy groups, journalist organizations)	13
Other (World Health Organization, independent consultants)	4

*including Ministry for Energy and Health, Ministry for Education and Employment, Ministry for Finance, Ministry for the Family and Social Solidarity, Office of the Prime Minister, Ministry for Sustainable Development, the Environment and Climate Change, Ministry for Social Dialogue, Consumer Affairs and Civil Liberties

Table 21. Sectors represented by key informants

Moreover, 77 children and ten parents participated in 11 focus groups. There were approximately equal numbers of boys and girls in each age group (*Table 22*).

Age group (years)	Male	Female
10-12	18	17
14-15	21	21
18+ (parents)	4	6

Table 22. Focus group participants

Emergent themes regarding physical, sociocultural, economic and political barriers to healthy eating are illustrated in the sections below using representative quotes.

Physical environment

Neighbourhood

Several aspects of the built or physical environment were identified as barriers to children's PA. The changing urban landscape, urbanization and increasing vehicular traffic were the most frequently mentioned obstacles. Although fears over road safety emerged as the primary cause for this parental behaviour among younger children, children of all ages also commented on a general lack of space where to play:

> *"My mother doesn't let me play in the road because it's not safe. She doesn't like it. She… doesn't let me walk around on my own…because I'm still young. I think it's a bit silly – [but] there are many cars around, and streets with no pavements." [Student, M, 11]*

In densely populated, land-scarce Malta, space is at a premium, as highlighted by stakeholders who reported that relatively few children have access to gardens or backyards where they can play safely. In addition, the redevelopment of localities' open spaces into private enclosures (e.g. football pitches, *Figure 17*) owned by for-profit enterprises that charge a fee for access has further reduced opportunities to be active:

> *"Any open space…is being closed off, revamped as a five-aside [football pitch], and rented out to earn some money. So children have nowhere to play ball in. It's an obscenity…Where can one play, it's so full of traffic? Children can't afford to rent out a ground. We need to give children the opportunity to play." [NGO]*

Figure 17. Small enclosed football pitch within a public open space
Credits: author

Children were asked to comment more specifically about physical environmental barriers to being active within their neighbourhoods or localities. Traffic, the absence of adequate facilities, and neglected or vandalized playgrounds were identified as major deterrents to PA. Without any prompting, students linked these restrictions to sedentary behaviour and childhood obesity:

> *"We don't meet often anymore, because that's where we used to meet. Now I spend more time at home playing on the computer… Since we can't play in the [football] ground, the only thing we have to do at home is homework, so what else can we can do [other than play computer games] once we finish that?" [Student, M, 11]*

Given the circumstances outlined above, several key informants pointed out that national policies which propose behavioural interventions to reduce obesity and improve PA among children are inappropriate:

> *"If, in the [national obesity] strategy, exercise is mentioned so frequently, while at the same time we keep destroying the natural environment to build on it, not leaving space for children to play in... If we allow so many cars on the road which restrict the outdoor space where children can go…it has become a major limitation." [NGO]*

Schools

A common concern across stakeholders was that insufficient time was allocated to physical education (PE), and that there are inadequate facilities for PA in schools. Students in certain schools also expressed frustration about school policies, implemented in response to damage caused to school property during play, that prevent them from using existing spaces in schools:

> *"PA at school is non-existent. [My daughters] have a maximum of two lessons a week of PE, with no facilities except for a small yard… and during break time they can't do anything, can't run or play with balls. So we're actually instilling a sedentary culture…schools, and other extra-curricular activities, are not really helping to change the mentality." [NGO]*

> *"The problem is that previously we used to have some football, but now they've stopped it, because somebody kicked the ball and broke a window, so we only have football during a league game or during PE." [Student, M, 11]*

Sociocultural environment

The sociocultural environment was recognised as a dimension of the environment affecting children's PA that is particularly challenging to address. Several traits that may be contributing to the population's current disinclination to be active were identified, including lack of knowledge on what constitutes sufficient exercise; safety concerns; parental overprotection and lack of parental example; excessive emphasis on academic performance; and the impact of electronic devices on children's social interactions. An experienced public health professional suggested that at a macro-level, there has been insufficient public health focus on educating the general population on the importance of being active (possibly due to an institutional emphasis on nutrition education). This might have limited the impact of behavioural interventions to promote PA and active transport at a population level:

> *"If you ask people how much sugar or cholesterol this or that food has, they'll tell you down to milligrams…But if you ask people how many calories you'll burn if you run from here to the church, nobody knows. What amount, what kind of exercise should you be doing every day? Few will know. …possibly we are trying to change behaviour without there being a knowledge base. [Government]*

Other stakeholders attributed the Maltese population's sedentariness to laziness, lack of positive parental example, or to a misperception that PA is to be performed outside of one's daily activity:

> *"My daughters… are lazy. Really lazy. I have no problem saying that. You take them to the beach, they want to laze around on the deckchair. You take them out to the countryside, they want to lie down and enjoy the view. Possibly because they are not brought up active, and I have to admit I am not a very active person myself." [NGO]*

> *"…we Maltese, culturally, think of exercise as something separate, as something to be done outside of your daily living…the Maltese population's bias towards not doing exercise is very evident, and continues to be a strong policy challenge" [Government]*

This cultural tendency to equate PA with sports, rather than integrating activity in everyday life, was highlighted as a problem by health and sports professional stakeholders. These decried the shift away from unstructured PA in favour of organised sports activities, partly due to the limited opportunities for play available to children:

> *"Children need both unstructured and structured PA, but what we're doing is trying to increase structured PA to compensate for the lack of unstructured PA, when it should be the other way round. Children need both." [Health Professional]*

The prevalence of technological devices and associated sedentary behaviours emerged as key factors that negatively influence PA. All adult stakeholders commented on the increasing proportion of time children spent in front of a screen; children themselves (older boys in particular) indicated that they preferred to engage in sedentary behaviour such as playing games or socializing with peers online instead of playing outdoors. Such online interactions and relationships were reported to be increasingly replacing face-to-face interactions:

> *"[My child] also does a lot of sports, three times a week…But in between, the activity that one might have on a daily basis is very low…because she prefers to stay on her iPad chatting to friends. She enjoys socialising on the computer more… because her friends are online." [Parent]*

Participants also described a national mindset that favours the use of cars over alternative means of transport, providing historical and sociocultural reasons for this mentality. In part, this is likely to be due to economic improvements and transport policies that have facilitated car ownership; the perception of cars as status symbols; as well as the 'social trap' whereby, through their chauffeuring of children to school and other venues, parents aim to protect their children from the traffic hazard to which they are contributing [682]. The irony of driving children to places where they can perform structured or unstructured PA was not lost on parents and other adult stakeholders. Inappropriate use of the car to travel short distances was a common theme to emerge from interviews and focus groups:

> *"We are challenged by the concept of the "Sunday Drive". Or if people are going to go for a walk, they're going to drive half across the island to go for a walk, which to me is an oxymoron. Why wouldn't you walk from your house onwards?" [Government]*

> *"This mentality that to swim in the sea, if possible one should drive a car and dip one's toes in the water from the car… this mentality of wanting to be comfortable…it is now embedded in our population – the idea that a car is a status symbol." [Government]*

Both parents and children seemed to regard driving to their destination (as opposed to using alternative means of transport) as unremarkable, suggesting normalisation of this behaviour. Parents also contrasted their independent mobility during their own childhood with current expectations, using examples to illustrate the inconvenience caused by the need to transport children by car:

"Why can't they [children] use public transport? …I did everything on my own. Going by bus everywhere. Nowadays, we take our children everywhere by car. When I suggest that my daughter catches the bus to go to school, she'd make a fuss and claim that she won't arrive on time. And I'm talking about my eldest who goes to university! We spoil our children. So I wasted time in the car waiting for her to start, then waited some more before this meeting because I arrived early…now I'll wait a bit more in the car because she won't have finished…as if I have nothing better to do!" [Parent]

Yet another important emerging theme common across all stakeholder categories was that children were under intense pressure to perform well academically. This emphasis on achieving academic success impinges on children's opportunities to perform PA both during and after school. It was suggested that the school syllabus is too demanding for children, and that PE lessons are not considered to be a priority, often being replaced by revision lessons as exams approach during the school term. Outside of school, many children are encouraged to attend private (tutoring) lessons throughout the year, taking up substantial time from their day. In fact, cultural pressure to perform well academically was a key theme reported by numerous stakeholders:

"*We have this thing about academia, academia, the grades, the grades. Everybody goes to private lessons, this or that. Ok there are quite a lot of sports outlets and football clubs, which have increased and improved facilities and so on. But still, the priority, to average Maltese family, is the academic side…they're too focused on the academic importance of schooling. Something which challenges me a lot is that 4 year olds are already sitting behind a desk all day long" [Academia]*

Political environment

The political dimension refers to organizational or national planning policies and regulations that govern how and when spaces may be used for PA. A broader political context which has failed to address physical inactivity emerged as a recurrent theme. Politicians were criticised by non-governmental respondents for succumbing to the interests of an allegedly powerful motorist lobby instead of taking steps to improve cycling infrastructure; and for not being proactive in designing and implementing initiatives that would show positive outcomes in the long term, beyond the five-year electoral cycle:

"[Politicians] haven't got the guts… much of what is being done is cosmetic. There's nothing radical being done…there's a kind of resignation really. Government is not providing an environment which encourages children to safely be active." [Other]

"As soon as you start touching where people drive, it's political suicide, and this is perhaps what is driving TM's unwillingness to take cycling on board." [NGO]

At a more local level, inter-organizational politics and lack of collaboration with relevant stakeholders were also highlighted as barriers to development of interventions to tackle physical inactivity. For example, a number of respondents referred to the development of a new umbrella subject that integrates Health Economics with Physical Education [216], and indicated disappointment at the relative lack of consultation:

"That's another challenge in Malta. Why shouldn't we work together? ... It frustrates me. I'm not saying I or my colleagues are experts, but sorry, you need to bring all the stakeholders on board…. in Malta I see a lot of parochialism: 'Don't come into my space please. This is my space'." [Academia]

At the same time, civil servants and academics suggested that there may be excessive political interference by external parties that limit effective interventions to address public health issues or influence local planning policies that influence the amount of outdoor space or quality of environment where children can be active:

"Partly the problem is culture, but the other big problem is politics and management. And here, politics and management are one thing – and it's the politics which count. At the end of the day, if politicians wanted to, we could change the environment and make it a healthy environment, but no-one wants to, because at the end of the day money counts most here… political will is driven by money and industry, and the industry at the moment as you know is much more in favour of, you know, obesogenic [activities?] than anything else." [Academia]

Stakeholders were asked about regulations that might limit PA at home, within schools or in neighbourhoods. Children did not report any parental rules or regulations around being active at home unless prompted. This suggests that the home was not considered to be a location where PA is typically performed. However, regulations that influence PA at school or in their neighbourhood often emerged. Policies that restrict the type of PA that can be performed in public spaces were criticised by participants, particularly younger boys whose idea of 'play' included most of the prohibited activities (*Figure 18*). For example, the current school curriculum and short school day were criticized, as informants queried the possibility of reducing the academic load or lengthening the school day to permit more PE lessons:

"…schools are definitely not doing enough, because they don't have the time to fit in a PE lesson. It's difficult enough fitting in the curriculum. We're in a situation where some schools actually finish at 1 pm. So how…can you have a break and run around a bit? On top of that, they actually shrink their hours further in summer. I'm talking about certain church schools. I mean, how can you do PE when your scholastic year is so crammed, simply because your school days are so short? [Health Professional]

Figure 18. Signage prohibiting certain forms of physical activity in a public garden
Credits: author

"There are huge barriers. Large classes; equipment limitations …The lack of facilities… and the [school] ground being out of bounds at certain times, because it belongs to the Malta Sports Council (KMS), not to the school. There are many such conflicts... So there are limits imposed… children cannot play there during break unless supervised for a league match." [Academia]

The overall school ethos around PA also emerged as a crucial determinant of the frequency, type and amount of PA performed in schools. In turn, this appears to be heavily influenced by the Head of School (HoS), who has the ability to foster or constrain additional activities beyond the compulsory PE lesson:

"…in schools, PA depends too much on the Head of School… [PA] should be a policy, not left to the individual Head or College Principal. There are certain teachers who are afraid of asking their Heads for permission to take children out to play. It's an abuse of the power of the Head. We need to review the school structure. [NGO]

Economic environment

The economic aspect of children's PA environment was infrequently mentioned by stakeholders, however a lack of financial resources is likely to represent an additional obstacle to participation in sports-related PA. There was some criticism of the extent and type of financial support provided by the government to increase PA levels:

> *"Another issue is the price of PA. Cheap options do exist, and the service is good. But still it can be improved, or subsidised further. PA for children is being pushed… [but] the payment offered [to instructors] by the government for free PA sessions is ridiculous, so instructors don't accept. The value that government gives to health in terms of the money it is willing to spend leaves much to be desired." [NGO]*

Stakeholders also implied that the conversion of open public spaces into privately owned sports grounds accessed at a fee was forcing children to pay for any structured PA that they would like to do, and reduced their options for performing unstructured PA. In addition, maintenance costs and the potential cost of repairing damage to open spaces and sports grounds following vandalism were highlighted by adults as economic barriers to PA:

> *"Almost every village has a football ground, but only football is played there. Now, I don't blame the managing authorities for each ground for not opening them to the public, even though most of them were built using public funds. Because if there is no supervision, there would be chaos... they would have been vandalised. But vandalism will continue to happen, so where damages occur, one must repair, and quickly, so that it opens again and is used again. But again, it costs money." [NGO]*

Discussion

This research provides insight into the environmental influences on children's PA, pinpointing barriers and facilitators that could aid in designing enabling interventions and strategies to promote PA. The major obstacles to children's PA identified in this study – including traffic safety concerns; the absence of sports facilities or open spaces where children can safely play; the lack of bicycle lanes or other infrastructural features that may encourage active transport (e.g. sufficiently wide pavements or aesthetically pleasant surroundings); the proliferation of technological devices; and cultural attitudes that facilitates sedentary behaviour – are not limited to Malta [683–685]. However, it is possible that the rapid urbanization that has occurred over the past few decades [216] has exacerbated these environmental barriers to the point where the inactivity of Maltese children needs to be urgently addressed by policymakers. This study is coherent with other research which has shown that availability of nearby open space, walkability of neighbourhoods, positive perceptions of neighbourhood safety and low traffic have been associated with increases in the amount of time children spend being physically active outdoors [686,687].

Recommendations to address these barriers are proposed below. First, understanding patterns in the use of playgrounds and open spaces by children (e.g. semi-participatory ethnographic studies in combination with GIS mapping of routes taken to such venues) may help to identify opportunities for increasing their accessibility and overall frequency of unstructured PA. Second, the introduction of low speed limits or modification of roads to improve safety (e.g. installation of passive, traffic-calming measures in residential streets) are necessary to address road traffic hazard fears and improve overall safety [688]. Environmental modification has been shown to be effective in promoting modal shift among UK residents [689–691]. Targeted efforts to instil a change in population perceptions and behaviour around transportation may also be crucial [692]. These may involve action to build parental confidence through educational campaigns that emphasise the benefits of PA, as well as approaches to managing parental concerns combined with strategies to enhance child self-efficacy [693]. In turn, these actions need to be supported by local planning policy changes to preserve and expand the accessibility of public open spaces where children can play. Third, physical environmental interventions need to be supported by social interventions to promote active transport to school, such as designated days on which walking to school is actively encouraged [688]. The provision of adequate infrastructure is also likely to be crucial. For example, a California study found that the frequency of children's active transport increased following the construction and maintenance of pavements together with installation of traffic lights on the way to school [694]. Fourth, regular auditing of actual time spent being physically active should be carried out in all schools on a regular basis, and ideally more time allocated for PE. The quality and duration of PE lessons should also be improved. Fifth, PA during break should be promoted through a combination of measures that address physical, social and organizational aspects of the school environment. These may include implementation of school policies which support PA in all weather conditions (including indoor PA when inclement weather restricts outdoor activity); enhanced teacher presence during break to resolve conflicts and to organize engaging activities; actively encouraging children to be active during break time; lengthening duration of break times to permit play; introduction of new equipment (possibly outdoor gym equipment which were repeatedly mentioned in a positive light by older children); and re-negotiation with sports bodies such as KMS to allow use of currently out-of-bounds sports grounds during beak time. These actions may require a high degree of commitment and motivation from school management and teachers to be successful. Funding constraints may also need to be addressed.

Provided that sufficient care is taken to overcome cultural resistance to change, “walking school buses”, exercise breaks during lessons, and the organization of novel, fun activities during break times are just a few examples of low-cost interventions that find traction among children and which may contribute to an increase in children’s PA levels.

Besides intervening at policy level in communities and in schools, educational and behavioural interventions to change existing cultural attitudes should also be considered. Ensuring that new drivers are taught to be aware of cyclists and pedestrians at all times should be a perquisite for obtaining a car license. In addition to reducing curricular load, schools may need to engage in dialogue with parents to reduce academic pressure at home. Incentives to promote alternative types of recreation should also be considered. For example, children indicated that they were very active on beaches during summer. As an island surrounded by water, this represents a potentially untapped opportunity for encouraging unstructured PA, in the form of swimming, at minimal expense. Furthermore, the importance of neighbourhood social networks emerged as an interesting factor that merits further investigation: is children’s need for socialising being sufficiently met online? As identified in studies elsewhere, parents perceived that absence of neighbours or nearby friends to play with seemed to influence levels of outdoor PA [695], whereas greater social interaction may enhance independent mobility in children [696]. Certainly, the proliferation and adoption by children of technological devices that facilitate online social interaction or provide alternative, sedentary avenues for having fun (e.g. gaming) have exacerbated this trend. Perhaps local initiatives to attract groups of children living in the same neighbourhood – similar to the regular catechism lessons organised by the Society for Christian Doctrine (M.U.S.E.U.M) [697], some of which also organise PA activities – may be effective means of supporting PA among children. In addition, behavioural or environmental interventions to limit screen time are likely to be key elements of any successful obesity prevention strategy [663].

Strengths and limitations

A limitation of this study was the non-random sample of participants, and the lack of objectively measured behavioural data that would enable comparison of children’s actual PA with the themes emerging from this research. The parents in this study were self-selected, and are unlikely to have been truly socio-demographically representative. However, participants included individuals with a wide range of contrasting interests and perspectives across a range of sectors as well as children themselves. Many interviewees were also parents themselves, and often used their parental experiences to illustrate or fortify their arguments. Another strength of this study was the participation of children, which enabled contextually relevant information to be elicited. The consistency of findings from these independent sources suggests that the environmental influences identified in this study reflect reality and should remain important considerations for the development of obesity prevention interventions.

Conclusion

The physical and cognitive benefits of PA have been clearly elucidated [698–700], yet Maltese children are severely restricted in their PA choices. In particular, children's options to be active within their neighbourhood while unsupervised are severely limited. Addressing Malta's 'obesogenic' environment [25], requires system-wide, contextually appropriate environmental interventions that complement educational measures and create supportive environments that make healthier choices the easiest choices [216]. There is a clear need to act on multiple levels and dimensions of the environment, including family, school, neighbourhood and country level. This study has potentially important implications for urban planning. Strategies to reduce motorized traffic, improve infrastructure for active transport, and enhance availability of, and access to, open spaces where children can play are likely to be key to creating an environment that supports children's PA.

End of Research Paper 7

Preamble to Research Paper 8

Negative societal attitudes toward obese individuals persist [126,127] and have been described as being damaging to public health efforts to counteract obesity [128]. Obese individuals face widespread stereotyping, often being perceived as lazy, unmotivated, incompetent and lacking self-control [701–704]. Discrimination and stigmatization of obesity in adults have been extensively documented, showing that overweight and obese individuals face prejudice and social inequities across multiple settings including employment, education, legal institutions, healthcare, and interpersonal relationships [122,128,702,703,705]. Research papers 3 through to 7 seek to provide context to the problem of obesity – particularly childhood obesity – in Malta. They present the case that successful efforts to reduce childhood obesity are likely to require policies that target both individual behaviours, and more importantly, external environmental factors including socio-economic conditions, the physical environment and social norms. Numerous actors and sectors have the potential to influence environments, and hence affect individual energy balance and childhood obesity levels. Relevant actors in Malta include parents; grandparents; heads of schools; retailers and food manufacturers or importers (i.e. the food industry); government agencies; transport and urban planners, among others. Each of these actors has the potential to facilitate or hinder obesity-related policy development, implementation and eventual success, and different actors have different perceptions of obesity. Thus it is possible – even likely – that policy changes targeted at modifying the broader environment may encounter resistance from the general public and from groups whose interests might be adversely affected by the enactment of such policies The food and soft drink industries in particular are increasingly seen to be powerful players with substantial direct or indirect input into policy related to nutrition and health [706–708]. Strategic liaisons with policymakers and other such tactics are typically used by industry to undermine public health efforts to address obesity [706–708]. For example, the soft drink industry strongly opposed the introduction of a SSB tax in Mexico [709], and numerous attempts to introduce SSB taxes in several US states or cities failed in part due to strong industry lobbying against their introduction [604,710]. Such resistance also occurs locally. During the research process, some interviewees described corporate strategies to influence policymaking around obesity in Malta in order to protect the soft drink industry's commercial interests. The following example narrated by a public health policymaker clearly illustrates the power of corporate lobbying:

> *"Industry is very strong. The food industry is probably stronger than the tobacco industry… bigger, equally rich, and deals with essential beneficial stuff, not killing stuff... These are the issues that put you back. So the industry is very clever, it knows how to tackle [policymakers], it goes on to sensitive areas. For example when we issued the [national] obesity strategy, it was*

mentioned in the strategy that we will carry out – this is all it says, that 'we will carry out' - a feasibility study on the introduction of taxes and subsidies on healthy and unhealthy foods. Within a week, Coca-Cola [representative] came to Malta asking about these taxes, saying that they have a [charitable] foundation, that they do a lot of good, etc etc. They tried to blind us with science that 'No, the sugar in Coca-Cola does not cause that much harm, you can burn it off with exercise.' And we listened them out. They offered to support, they offered us money for our [health promotion] campaigns – we would join forces to campaign against obesity…as long as we don't say anything against Coca-Cola. And we said 'Thank you very much', and left things there. Then weeks pass – and this happens, I can quote a number of examples even in the past – and this week we find that the Coca-Cola Foundation is subsidising an initiative by the Ministry of Gozo to the tune of $800,000. So now you can be sure that if we come to cabinet at some stage to say that we want to introduce a 1 cent tax on a bottle of Coke, the Gozo Ministry will be reluctant because they [Coca-Cola] will stop their funding…" [Ministry for Health]

In addition to direct involvement in policymaking, the food industry also seeks to shape public opinion in its favour by reinforcing a narrative of obesity that protects its commercial interests [706–708]. Distinct narratives or frames of obesity are created by a range of competing stakeholder entities who have vested interests in framing the debate to suit their agenda [499,711,712]. Positioning obesity as an individual health problem equates excessive weight gain with a lack of restraint and discipline, blames individuals for their excess weight, and results in policies that promote changes in individual lifestyle as the main solution to the obesity epidemic [711]. This contrasts starkly with the ecological approach that acknowledges the complex, multi-factorial aetiology of obesity and recognizes a broad range of physical, socio-cultural, economic and political contexts within which individuals are embedded, suggesting that they are not personally to blame for their obesity [5,33,182]. Indeed, any recommendations to tackle childhood obesity may be inappropriate if these prevailing contexts are not taken into account [233]. In the following article, I focus on the contrasting narratives of public health and food (including soft drink) industry representatives in Malta. Thus far, no qualitative research has been carried out on causal attributions of obesity, obesity narratives and perceptions of obesity policy in Malta. Although qualitative research on the opinion of the Maltese public around obesity could not be carried out within this research, there is substantial value to describing obesity frames among two of the key stakeholder groups in Malta. Identifying and documenting these frames enables greater understanding of the broader context and policy debate around childhood obesity in Malta, potentially providing useful information to pre-empt personal responsibility arguments put forward by the food industry and guide future public health advocacy efforts.

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SECTION A – Student Details

Student	Daniel Cauchi
Principal Supervisor	Cécile Knai
Thesis Title	Childhood obesity in Malta: contributions of the obesogenic environment

SECTION B – Paper already published

Where was the work published?			
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Research Paper 8

Framing Childhood Obesity in Malta: Narratives, Attributions and Support for Current Approaches

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Author contribution: I formulated the research question and designed the study. I collected and analysed the data with input from Cécile Knai and Mark Petticrew. I drafted the manuscript and made revisions based on comments from Cécile Knai and Mark Petticrew.

Abstract

Introduction. This articles outlines how the food industry and public health sectors frame the issue of childhood obesity in Malta. Framing analysis may be key to understanding how competing interests may influence the policymaking process around obesity.

Methods. We conducted 38 qualitative interviews with food industry and public health actors in Malta between May and July 2014. A semi-structured interview guide was used to solicit views on the causal explanations of obesity, stated beliefs around attributions of blame and responsibility for addressing childhood obesity, and opinions regarding potential solutions.

Results. A range of framings that generally corresponded with stakeholders' underlying interests was revealed. Food industry representatives predominantly framed obesity as a consequence of unhealthy individual lifestyle choices, limited to a minority of the population and largely attributed to knowledge deficits. Regulatory approaches were rejected outright, whereas targeted educational interventions were advocated as the primary solution to obesity. In contrast, public health actors framed obesity as a population-wide issue originating from wider determinants of health, including the presence of an obesogenic environment. Society was presented as having a collective responsibility to address obesity by creating supportive environments that facilitate healthier dietary and physical activity choices, primarily using a legislative or regulatory approach. Both groups shared a narrative that parents have a key role in preventing childhood obesity.

Conclusion. Identifying and documenting these frames enables greater understanding of the broader context and policy debate around childhood obesity, providing useful information to pre-empt arguments put forward by industry and guide future public health advocacy efforts.

Keywords: Childhood obesity, framing, industry, parental responsibility

Introduction

Obesity has become a critical public health challenge globally as prevalence continues to rise [1–3,7]. The health and economic implications of obesity are significant [226], largely driven by tracking of obesity into adulthood [87,88] and associated incidence of non-communicable diseases [107,112–114]. Malta is no exception, having experienced high levels of childhood and adult obesity over the past decades [10,216] which are likely to burden the future healthcare system [226]. Reaching consensus regarding the causes, implications, and potential solutions for the obesity epidemic is difficult [499,713,714]. Highlighting personal responsibility for obesity has been a consistent characteristic of the global discourse for decades, and individuals are often blamed for their overweight status [502,715,716]. However, a growing body of literature suggests that the environments within which people live and operate may shape their risk of becoming obese [5,13]. The environment in Malta, as in many other countries, has been described as 'obesogenic', characterised by a food environment that promotes consumption of highly palatable, energy-dense foods and beverages and a built environment that offers limited opportunities for physical activity [216]. Changing human behaviour within an environment that does not support healthy choices is difficult to achieve and sustain [5,38].

'Framing' refers to the way in which a particular issue is defined or presented, including its origins, impact, responsibility for resolving the problem and moral judgements about which solutions are appropriate [716–718]. In turn, the specific framing of an issue influences whether it is identified as a political problem and the range of policy responses under consideration [719]. Often, conflicting narratives are proposed by competing stakeholder groups which may have a vested interest in promoting a particular narrative to suit their agenda [313,711,718,720–722]. Several sectors have significant potential to influence policy related to obesity. For example, literature suggests that while health professionals and policy makers may view obesity as a socio-ecological problem having environmental and socio-cultural determinants, industry prefers to frame obesity as a consequence of poor lifestyle choices [711,718]. The food industry relies on sale of foods to generate profit, and thus exerts an influence upon population dietary patterns through marketing, advertising and other promotional practices [706]. Conversely, the public health sector has a vested interest in shaping obesity-related policy since its primary aim is to protect and improve population health [718].

Knowledge of the different interests, narratives and frames around obesity is essential for public health policy because it offers important insights into the dynamics of the policymaking process [723,724]. The food industry in particular may affect population dietary patterns by shaping the debate around nutrition and obesity, and by exerting an influence on the government's policy response to these issues [724,725]. In addition, frames are likely to influence public opinion and political support for obesity prevention policy [312,313,721]. For example, stated beliefs around causes of obesity, such as associating obesity with pejorative concepts like 'sloth' or 'gluttony', can be strong predictors of public support for obesity policies [312]. Public support is a key ingredient of successful lobbying for - and eventual implementation of – effective population-level interventions to prevent overweight and obesity, hence awareness of existing frames is useful for public health actors and policy-makers [726].

Relatively little is known about the ways in which obesity is framed by the industry and public health sectors. The aim of this study is to address this gap in knowledge and reflect informant views from these two groups in Malta against existing literature. Documenting the food industry and public health frames of obesity will contribute to a deeper understanding of the broader policy context around childhood obesity, both in Malta and elsewhere, and may guide future obesity policy development.

Methods

Semi-structured interviews

Semi-structured interviews were carried out with a diverse sample of public health and food industry representatives. Potential interviewees were invited by email and provided with background information on the study (Appendix 8). We anticipated that interviewees may access their email accounts infrequently so we subsequently telephoned those who had not responded. A topic guide was developed to enable key questions to be asked whilst allowing free expression and flexibility to probe deeper into responses (Appendix 7). Proposed solutions for childhood obesity derived from the 2012 national obesity strategy [80] were used to stimulate discussion and explore participants' views on how obesity should be addressed in Malta. These included proposals such as the introduction of zoning laws to restrict licensing of fast food outlets in the immediate vicinity of schools; fiscal measures including taxes and subsidies of unspecified foods or beverages; and behavioural interventions. Interviews were carried out on a one-to-one basis (except for three industry interviews where more than one stakeholder participated) by the lead author between May and July 2014. DC adopted a neutral stance during interviewing to avoid creating a situation that may have inhibited or coloured interviewee's accounts. Interviews lasted around 60 minutes and were held in Maltese or English. Anonymity and confidentiality were ensured, and a consent form signed prior to interview. With permission of respondents, interviews were recorded. Two respondents declined to be recorded, with notes being taken instead.

Sampling

We sought to represent both perspectives by having a diverse sample of individuals with public health or nutrition expertise, as well as food industry representatives (Table 23), drawing from an established professional network of contacts. These were supplemented through 'snowball' sampling. A total of 38 interviews with 20 public health informants and 21 industry representatives were conducted. Food industry representatives included food manufacturers; importers/exporters; and industry associations. A relatively broad definition of public health was employed to include perspectives from: (i) government or regulatory agencies having a direct or indirect impact on population health and public policy; (ii) academics with health, nutrition or physical activity expertise; (iii) health professionals; and (iv) non-governmental organizations (NGOs) concerned with health.

Category	Representative(s)
Public Health and Policy	Department for Policy in Health, Ministry for Health
	Department of Food Studies and Environmental Health, Faculty of Health Sciences, UoM
	Department of Health, Physical Education and Consumer Studies, Faculty of Health Sciences, UoM
	Department of Public Health, Faculty of Medicine and Surgery, UoM
	Dieticians
	Foundation for Social Welfare Services, Ministry for the Family and Social Solidarity
	Health Promotion and Disease Prevention Directorate, Ministry for Health
	Malta Association of Physiotherapists
	Malta Association of Public Health Medicine
	Malta College of Family Doctors
	Malta Diabetes Association
	Malta Health Network
	Malta Paediatric Association
	Ministry for Education and Employment
	Ministry for Health
	Ministry for Sustainable Development, the Environment and Climate Change
	Office of the Superintendence of Public Health
	The Today Public Policy Institute
Industry	Bottled water manufacturer
	Dairy products manufacturer
	Food caterers
	Food import/export
	Food manufacturing: including manufacturers of biscuits, packaged snacks, other processed food; meat products; fruit and vegetable producers; canned foods
	General Retailers and Traders' Union
	Malta Chamber of Commerce
	Malta Hotel and Restaurants Association
	Restaurateurs: including quick service/regular restaurants
	Smoothie manufacturer
	Soft drink manufacturers
	Winery/fruit juice manufacturer

Table 23. Key informants

Data processing and analysis

Recordings were anonymised and transcribed verbatim by the lead author to ensure consistency. Data were analysed using principles of the 'constant comparative method' within the framework approach [81], following the systematic framework method outlined by Gale et al [82]. Data were coded and analysed by the first author, while CK cross-checked excerpts and any disagreements were discussed until consensus was achieved. A matrix used previously to frame obesity was applied to ensure systematic identification and recording of the main components of the frames [711,718]. The matrix consists of two devices or components: (i) the signature 'rhetorical' devices which comprise the overall position; attributed causality; core underlying values; and policy responses considered to be appropriate; and (ii) the signature 'framing' devices, which consist of metaphors; use of examples to illustrate key points; catchphrases; characterizations; and visual images. Devices are not mutually exclusive within and across frames [711]. Table 24 depicts the framing matrix used to code the data for the 'rhetorical' devices, which was adapted from work by Jenkin et al. (2011) [718]. Few signature 'framing' devices emerged in this study, and these were therefore excluded from the analysis. Populating the matrix, including allocating illustrative quotes to each key aspect outlined, helped to highlight differences and interconnections between the data. The London School of Hygiene & Tropical Medicine Ethics Committee (ref. 6485) and the University of Malta Research Ethics Committee granted ethical approval for the study.

Rhetorical devices	Key aspects	Prompts (to identify and code data)*
Position	Overall description	How is the issue described? What is the emphasis? Why is the issue a problem?
	Type of problem	What type of problem (health, social, economic, moral) is it? Who the issue is a problem for? Is it an individual, specific community or whole population problem?
	Affected groups (depiction of subjects)	Are age, gender, ethnicity & socioeconomic dimensions mentioned? Who is excluded from or not affected by the problem? How are subjects (those with the problem) described?
Causal roots	Main cause	What is identified as the main cause? Is the cause environmental or individual? Is there any additional focus or emphasis in the discussion of causes?
	Non-causes	What are dismissed or explicitly identified as non-causes?
Main responsibility	Responsibility for obesity	Who/what is to blame for the problem?
Solutions	Existing policy and interventions	What are the views on current policy and interventions?
	Proposals	What solutions are proposed/emphasized? What issues are included & excluded? Are the solutions targeted or universal? Who is responsible?
	Non-solutions	What solutions are opposed?
Core values	Appeals to principle	What values or principles are evident in the problem representation?

*Source: Jenkin et al. Framing obesity: The framing contest between industry and public health at the New Zealand inquiry into obesity. *Obes Rev* 2011; **12**: 1022–1030 [718]

Table 24. Framing matrix used to code the data

Results

There were substantial differences but also some convergences between the rhetorical devices of the two main stakeholder groups (Table 25). These findings are discussed in more detail below. Appendix 9 contains illustrative quotes that highlight typical responses by stakeholders.

Problem representation

There was general agreement among both groups that obesity in Malta needs to be urgently addressed. All stakeholders expressed knowledge and awareness of Malta's high obesity prevalence when compared to other countries. However, public health stakeholders emphasised the scale and severity of obesity in Malta by framing it as an intractable 'epidemic', pointing to Malta's top ranking in the international obesity prevalence charts as a cause for concern. In contrast, industry stakeholders framed obesity as a 'complex issue', commenting that Malta is not exceptional in having high obesity prevalence (Appendix 9).

Stakeholders in both groups agreed that obesity represents an economic concern for Malta due to its associated healthcare costs, but only public health informants argued that the government has a moral, as well as an economic, obligation to address obesity. Public health presented obesity as a 'massive', public health issue that affects the whole population across generations, whereas industry framed obesity as a medical problem affecting a minority group that is not inherently comparable to the rest of the population. When defining those affected by obesity, some industry representatives commented on the association between underlying socioeconomic factors and risk of developing obesity, suggesting that one's level of education is a key mediator of risk. Public health interviewees adopted a stronger position in this regard, stating that obesity may be both a cause of, and a result of, cumulative social and health inequalities. While recognizing that low socioeconomic groups are more likely to be affected, they presented obesity as an issue that cuts across socioeconomic strata. Many expressed concern at society's 'normalization' of obesity, where being overweight is considered to be normal.

Causal roots

All representatives agreed that obesity has a multifactorial aetiology. Industry cited genetics; unhealthy lifestyle choices; and lack of knowledge about appropriate dietary and physical activity behaviour as the main culprits behind current obesity trends. In particular, individual lifestyles characterised by overconsumption of food, insufficient physical activity and increasingly sedentary behaviour were presented as the primary underlying factor. Furthermore, they suggested that the proliferation of technological devices and a general lack of opportunities for physical activity are key reasons for inactivity and sedentary behaviour. However, industry emphasised that no single food or beverage product category can be blamed for causing obesity, and that public health arguments to restrict or regulate products such as soft drinks, chocolates and other energy-dense foods are too 'simplistic'. They alleged that such products are only harmful when eaten in excess, but can be beneficial when ingested 'in moderation'. Excessive consumption of these food and drink items was attributed to a lack of dietary knowledge on the part of the individual, to familial dietary patterns that encourage large portion sizes, or to a lack of motivation on the part of the individual to control their diet and weight. 'Moderation' during food consumption was a recurrent theme among industry representatives, who proposed that this should be the responsibility of individual consumers, not of food suppliers: responsibility for one's weight should not be 'imposed on others'.

Some public health representatives also highlighted a potential role for genetics, overconsumption of food and individual lifestyles, however these were considered to be minor contributors to development of obesity when compared to broader, multi-sectoral societal influences. In contrast to industry, they emphasised that knowledge deficits were not responsible for increases in obesity, and criticised industry's focus on education as the solution to this public health issue. According to public health respondents, the main reason underlying obesity in Malta is the 'obesogenic environment', defined by Swinburn et al. (1999) as "the sum of the influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations" [25]. Obesity was perceived to be a problem whose origins primarily lie outside of the health sector, having strong sociocultural, physical, political and economic influences. Heavy marketing of, easy access to, and increased availability of energy-dense, nutrient-poor foods; price premiums on healthy food; cultural attitudes promoting large portion sizes and lack of infrastructure to promote active travel were just a few of the factors outlined by public health respondents to illustrate how the obesogenic environment in Malta does not support healthy dietary or physical activity choices. Generally, the emphasis was on features of the environment that promote excessive food intake as opposed to features that limit energy expenditure. Soft drinks and 'pastizzi' (a savoury snack with high fat and salt content) were repeatedly put forward as examples of popular but highly obesogenic foods.

Public health disagreed that there is insufficient knowledge about food at population level. Some proposed that there has been too much public health emphasis on nutrition education, and insufficient promotion of culinary skills, budgeting and other individual competences conducive to healthy dietary behaviour. Respondents across both groups also suggested that more ambitious personal aspirations and changes to the social fabric such as increased uptake of part-time employment in addition to full time work to make ends meet; more women in employment; and the shift away from the traditional nuclear family structure may have contributed to obesity in Malta. Allegedly, these factors have collectively resulted in in parents spending less time with children, limited ability to act as positive role models, fewer opportunities to be active or to cook nutritious food at home, and a preference for highly-processed convenience foods. While this seemed to reinforce the common perception position that parents are partially to blame for childhood obesity, some fast food representatives suggested that offering convenience foods to busy parents would actually increase the amount of time actually spent with their children.

Responsibility for obesity

Industry stated that individuals are personally liable for their own overweight status. Self-discipline was perceived as the ideal way to control food intake. One food manufacturer commented that government is primarily responsible for providing nutrition education and knowledge to the general public, and that any consideration of more regulatory approaches (e.g. fiscal mechanisms, restriction of advertising) directly reflects governmental failure to provide adequate education. Only one industry representative acknowledged that the food industry has contributed to the obesity burden, arguing that this places them in a position to search for solutions in collaboration with government. Interviewees across both stakeholder groups expressed clear views that responsibility for children's healthy weight lies primarily with parents. Industry representatives in particular commented on the importance of 'leading by example' pointing out how parental dietary or physical activity 'misbehaviour' leads to propagation of that inappropriate behaviour amongst their children. Public health representatives expressed a more nuanced view of parental responsibility for childhood obesity. Several nutrition academics and educators commented that parents should share responsibility for instilling healthy dietary and physical activity behaviour with school staff, rather than abdicating responsibility and undermining nutrition behaviours instilled during school hours. In general, public health respondents rejected the view that individuals are entirely to blame for their own excess weight, stating that all of society is responsible for an obesogenic environment that does not support healthy choices. Public health policy makers in particular cited the need for joint responsibility among parents, government, schools, and the food industry if obesity is to be effectively tackled. Several stakeholders in this group expressed concern at what they perceived to be political inertia and short-term approaches that characterise current obesity policy in Malta. They acknowledged that any health or economic gains resulting from investment in health promotion are likely to take longer than the five-year electoral cycle to appear, hence long-term strategies are likely to be unattractive to politicians. In addition, they hinted at excessive industry influence on policymaking that is compounded by excessive 'politicization' of health in Malta, where there is 'no clear divide…between the political and the technical'. This has negative repercussions on health and obesity policy development.

Solutions

Current approaches

Few industry stakeholders were familiar with the 2012 national obesity strategy. Two informants who had collaborated with the Ministry for Health during the strategy's consultation stage seemed satisfied with the measures outlined in the document. Other industry representatives including soft drink manufacturers and quick service restaurant franchise owners stated that they would have welcomed being consulted during drafting, but were not familiar with its contents at the time of interview. Public health representatives were both supportive and critical of the national obesity strategy. Several informants suggested that it was unrealistically ambitious in its targets; vaguely worded; and criticized its focus on behavioural measures rather than on altering the environment or the wider determinants of public health. Concern was expressed regarding the strength of the evidence base underlying the proposed measures, and regarding the strategy's implementation and future evaluation. However, many public health actors and policymakers praised its cross-sectoral, whole-of-society' and inter-governmental approach.

Public health practitioners were generally critical of government's health promotion efforts thus far, suggesting that there has been excessive emphasis on health education and treatment instead of addressing the root causes of obesity. Inadequate obesity treatment services and the lack of appropriate referral services were also criticised by health professionals including paediatricians, dieticians and physiotherapists. On the other hand, there was substantial support for financial incentives (tax rebates) and subsidies offered to parents by government in order to encourage children's participation in sports. Malta's Food and Nutrition Policy and Action Plan (2015) [110] and the revised school nutrition and physical activity policy (2015) [332] were also specifically highlighted as positive, progressive responses to childhood obesity in Malta, particularly if the latter is adequately enforced in schools.

Policy prescriptions

Various solutions to obesity in Malta were presented. Industry emphasised that more targeted, government-led nutrition education and greater promotion of active lifestyles were the main solutions to obesity. There was support for increased physical education in schools and the establishment of strict nutritional standards for food and drinks sold within schools and public institutions (e.g. hospitals). In line with overall industry emphasis on the importance of energy expenditure as a solution to obesity, some industry representatives also commented on the need for better urban planning that incorporates cycling or walking infrastructure and more open spaces in order to facilitate active transport (and hence, energy expenditure) at the community level. However, industry was adamant that it should be allowed to voluntarily regulate its advertising and marketing practices "rather than have to conform to legislation in the absence of self-regulation". Industry respondents were unanimously in favour of front-of-pack nutritional labels, yet strongly opposed traffic light labelling, claiming that the latter is overly simplistic (yet at the same time confusing to consumers), and would pose a threat to sales of certain food items. They also opposed food or beverage taxes, suggesting that these are regressive, that they may actually increase sugar or fat consumption due to substitution effects, or that implementation of such taxes in other countries has generated unsatisfactory results leading to their withdrawal. Zoning laws (e.g. restriction of new fast food outlets near schools) were also perceived to be too prohibitive by industry, which expressed concerns around the risk of progressive governmental erosion of personal liberties. Some food and drink manufacturers highlighted their own contributions and efforts to address obesity as part of their corporate social responsibility strategy, citing examples such as sponsorship of sports events, sponsorship of sports equipment in schools, and product reformulation. Industry also argued in favour of broader industry involvement in public policy-making around nutrition.

Public health prescribed a greater variety and wider range of approaches that reflected their concern with the wider determinants of health. Most interviewees emphasised the importance of adopting a multi-sectoral, health in all policies, whole-of-society approach that includes collaboration with industry (e.g. to promote product reformulation) and working with entities at the grassroots level. The legislative, and fiscal measures strongly opposed by industry (e.g. traffic light labelling; restrictions on marketing and television advertising of unhealthy food; fat and sugar sweetened beverage taxes; zoning laws etc.) were broadly welcomed by public health. Other regulatory measures such as fruit and vegetable subsidies or fiscal mechanisms to reduce the price differential between healthy and unhealthy food; improved traffic management and infrastructure; urban planning; public transport reforms and curricular revision to increase time spent in physical education in schools were supported by industry and public health alike. Public health representatives perceived such initiatives as being more effective than education alone, since they create supportive environments in schools and communities that facilitate healthy choices. It is pertinent to note that not all public health representatives were in agreement upon this point: two NGO representatives echoed industry concerns regarding taxation and 'excessive' legislation outside of schools, commenting that these might prove unpopular with the general public. Public health advocated for more consistent nutritional education that is targeted towards certain vulnerable population groups, rather than a 'one size fits all' approach. Conversely, solitary nutrition education campaigns that are not sustained and reinforced over time, or undue focus on obesity treatment instead of prevention, were perceived to be a non-sustainable means of addressing obesity. Lastly, several interviewees within this group highlighted a need for public health to adopt a strong, independent yet collaborative stance with industry in order to mitigate the effects of industry lobbying within the political sphere. An experienced public health representative also observed that public health advocacy should highlight the short-term gains and 'low hanging fruit' of investing in childhood obesity in order to overcome the political inertia described earlier.

Core values

Industry representatives frequently emphasised the importance of consumers' right to choose, stating that it is up to individuals to be disciplined and moderate their intake of unhealthy foods. Some also commented on their duty to generate a profit for their shareholders and reflected upon their moral obligation to 'respond to demand' by offering choice to consumers. One food manufacturer lamented that past efforts to reformulate food products were met with little uptake by consumers, forcing the manufacturer to discontinue these healthier versions in order to remain competitive and responsive to demand. On several occasions industry deflected arguments promoting legislation by commenting on the need for a 'level playing field' across industry, citing potential discrimination due to their small market share if legislation were to be introduced. The threat of legislation was perceived by some industry representatives as a powerful argument for collaborative self-regulation by the industry sector. Core public health values included the need for 'evidence-based' solutions to address obesity, despite potential resistance to potentially controversial approaches such as legislation; concern around adequate enforcement of any regulation introduced; and consideration of both the beneficial health as well as economic impact of reducing population obesity rates.

		Public health	Industry
Position	Overall	An 'epidemic' Malta ranks highly compared to other countries	A 'complex' issue Worldwide problem, Malta not an exception
	Type of problem	Economic and moral concern; a multi-generational public health (population) problem	Economic concern; a medical problem (limited to certain groups)
	Affected groups	Whole population (normalization of overweight and obesity); all social groups, esp. the socioeconomically deprived	Socioeconomically deprived
Causal roots	Main cause	Obesogenic environment Sociocultural influences: historical positive attitudes towards overweight; changing family lifestyles and familial dietary behaviour; price sensitivity Individual lifestyle characterised by overconsumption Genetic factors Socio-economic inequalities Skill deficits	Individual lifestyle characterised by overconsumption Genetic factors Changing employment and social patterns Knowledge deficits
	Non-causes	Knowledge deficits	Any single food product category
Main responsibility	Responsibility	Whole of society; parents; government	Individuals; parents; government; industry (limited)
Solutions	Existing policy and interventions	Criticism: lack of overall policy direction; absence of referral services; focus on obesity treatment Support: for fiscal incentives; school nutrition and physical activity policy Balanced criticism of and support for national obesity strategy	Support for continued voluntary self-regulation; little knowledge of national obesity strategy among industry representatives not directly involved during the consultation stage
	Prescriptions	Regulatory and legislative measures: including fiscal mechanisms, traffic light labelling, regulate marketing and advertising Supportive environments in communities and schools: mandatory school nutrition standards; more physical education in schools; improved active transport infrastructure Multi-sectoral approach: including collaborating with industry Appropriate referral (treatment) services Long term strategy focusing on improved better public health advocacy; consistent, targeted nutritional education and skill-based training/empowerment	Education: lifestyle education for parents & children (portion control; food preparation skills etc.) Supportive environments in communities and schools: mandatory school and hospital nutrition standards (but not in the community); more physical education in schools; improved active transport infrastructure Collaboration with industry during policy development Voluntary, self-regulated initiatives: Front-of-Pack GDA labelling; product reformulation; Corporate Social responsibility
	Non-solutions	Education/ excessive legislation in isolation/ treatment focus Short-term strategy	Legislation: taxation; zoning laws; traffic-light labelling
Core values	Appeals to principle	Evidence-based solutions Economic considerations Enforcement of existing regulations	Individual choice: self-discipline/moderation Moral obligation to make a profit and to respond to consumer demand Level playing field

Table 25. Obesity frames

Discussion

This study aimed to identify and describe how two key interest groups with the potential to influence government policy in this area in Malta frame obesity: public health and the food industry. Despite a few similarities across frames, there were also stark contrasts between the signature rhetorical devices used by the two sectors. The food industry in Malta were aware of, but played down the significance of, Malta's alarmingly high ranking in terms of obesity prevalence. Although cognizant of the potential economic impact of obesity upon the healthcare system as a whole, obesity was presented as an issue affecting few individuals that is best addressed through targeted interventions. Significantly, food industry actors framed obesity as an individual lifestyle problem, in line with industry framings of obesity reported elsewhere [502,712,727]. In contrast, public health actors described obesity as an epidemic affecting the whole population, proposing that government has a moral as well as an economic obligation to address the issue. There was some agreement between sectors that genetic factors contribute to obesity. However, industry generally framed excess weight as a consequence of poor lifestyle choices due to knowledge or personality deficits, and emphasised physical inactivity as a key contributing factor. In contrast, the public health frame presents obesity as a societal problem arising from continued exposure to an obesogenic environment and prioritised addressing upstream structural and socio-economic determinants of obesity.

Industry representatives argued in favour of education as a key strategy to address obesity. They vociferously resisted many of the upstream (legislative and regulatory) policy solutions outlined in the Healthy Weight for Life (obesity) strategy [80] intended to create food environments that support healthier dietary choices. More specifically, these included zoning laws to restrict fast food and confectionery outlets around schools; subsidies and taxes on specific food and beverages; and the introduction of colour coded nutritional labelling schemes [80]. Measures intended to create supportive physical environments that would not directly affect their commercial interests, such as the provision of more public open spaces, were not opposed. Although they were not entirely averse to applying stricter nutritional standards in schools and public institutions, industry claimed that government regulation outside of these settings would detrimentally impact consumers' right to choose. Key arguments included claims that no product is intrinsically harmful to health if ingested in moderate quantities as part of a 'balanced diet'; that individual foods or beverages such as biscuits and soft drinks are unfairly demonised by public health since even innocuous items like apples and water can be dangerous if ingested in excessive quantities; and that government-imposed restrictions or taxes would ultimately result in blanket bans on all sweetened products (Appendix 1), thus restricting individual choice. In contrast, public health representatives were supportive of the proposed government regulation, highlighting the need for implementation of evidence-based solutions and the enforcement of existing legislation to control obesity. Although policy proposals within the 2012 national obesity strategy generally met with approval within this group, underscoring this support was an evident feeling of frustration at the lack of progress achieved thus far through educational campaigns alone. Some representatives also expressed skepticism about the possibility of introducing significant environmental change, citing political inertia at government level as a key factor or hinting at industry ties with policy makers that impede effective obesity policy development.

Most industry representatives expressed a desire to be consulted during obesity or nutrition-related policy-making in the future. Industry actors are able to influence the policy process and shape the policy debate in several ways, including direct lobbying of government policymakers; the formation of trade associations, scientific organizations and civil society groups [708]; and funding of political campaigns [728]. For example, the 'Global Energy Balance Network' – a US-based public-private organization which was criticised for actively promoting physical activity while downplaying the role of energy intake – was disbanded shortly after being established following revelations that Coca-Cola executives not only funded, but were also directly involved in shaping the network's strategy and development [729]. Research on the tobacco industry has also highlighted how corporate actors deliberately sought to influence public and policymaker perceptions of and scientific debate around the detrimental health effects caused by their products [730,731]. Involving food and drink corporations in obesity policy development would represent an inherent conflict of interest because they have a legal obligation to maximise profit for shareholders through increasing sales of food and beverage products. Arguments favouring self-regulation are coherent with the 'personal responsibility' argument promoted by food industry since they deflect responsibility for altering individual dietary behaviour onto the consumer, rather than the food provider. Thus, self-regulation is perceived to be preferable to any government-imposed legislative framework. However, the effectiveness of voluntary industry self-regulation is highly debatable. In the UK a 'Public Health Responsibility Deal' outlining voluntary industry action aimed at improving population health was espoused by the food industry and government in 2011 [353]. Since then, research has shown that the actions proposed in the Responsibility Deal were mainly downstream, informational or educational interventions, which the evidence shows are less likely to be effective or to have a positive impact on population health [204,206].

The role of parents

Repeated assertions by key informants across both sectors regarding parents' key role in fostering healthy food and physical activity behaviour indicate a pervasive belief that parents hold some responsibility for their children's lifestyle behaviours and weight status. The role of parents in the development of childhood obesity is controversial [715,732,733] and often placed under intense scrutiny [734,735]. Poor eating habits and exercise patterns are often established during childhood, as parents and other primary caregivers profoundly influence and guide their children's weight-related behaviour [732,736] through the promotion of specific values and attitudes, reinforcement of specific behaviours, determining the availability of food eaten in the home, provision of health-related information, and by serving as role models [733,737–739]. Studies showing associations between maternal weight status prenatally, maternal diet and child taste preferences (that start to develop in utero), and risk of the child developing obesity later on in life, have also reinforced such beliefs [735]. Whilst parental support of health promoting behaviours can impact positively on child overweight and obesity [740], parents may not recognize their children's overweight status [741] or childhood obesity's detrimental health consequences [742,743]. Studies indicate that the news media often blame parents – particularly mothers – for their children's weight-related health problems [735,744].

However, the argument of parental responsibility is employed in different ways by industry and public health actors. It was frequently used and emerged most clearly amongst industry stakeholders in Malta, suggesting that industry finds parental blame to be a convenient way of deflecting attention away from the influence of marketing and advertising while simultaneously reducing risk of being held responsible for childhood obesity. Similarly, arguments about industry regulation and legislation were deflected by shifting discussion towards 'irresponsible' parents who fail to act as positive role models to their children and create unsupportive, unhealthy environments at home. This reinforced industry's framing of obesity as an 'individual' problem deriving from lack of personal self-discipline or self-efficacy. Yet, the food industry's strong influence on parental (particularly maternal) food preferences and its potential to shape the home food environment through marketing techniques that promote consumption of food high in fat, sugar and salt was not discussed by industry representatives. The implication was clear: it is up to parents to teach these skills to children, and it is up to government to educate parents. The theme of parental responsibility was also echoed by several public health informants, who expressed frustration at alleged parental 'abdication of responsibility' to act as role models to their children. However, unlike industry, public health actors acknowledged that upstream environmental influences directly or indirectly affect parental behaviour and play a role in the development of children's food and physical activity preferences, hence parents are not solely to blame for not being ideal role models to their children.

Although a diverse sample of key informants within the sectors of industry and public health in Malta were interviewed, our results might not represent the entire range of opinions and stated beliefs of actors within each sector. However, clear parallels were drawn between the contrasting frames of industry and public sectors in Malta, and those of equivalent sectors in countries such as New Zealand [718], the USA [711], and Mexico [745]. The international food industry's response to increasing public health calls for more regulation by government in order to address obesity has been well-described elsewhere [706,707]. Similarities with the apparently organized strategies employed by the alcohol and tobacco industries to prevent legislation that might impact their profits have been observed [746,747], raising questions on whether industry should have a role in policy-making at all [748]. This 'playbook' includes features such as promotion of narratives that shift responsibility away from food manufacturers and advertisers and onto consumers; a focus on personal responsibility; raising fears around alleged threats to personal freedoms and civil liberties; criticism of scientific studies that hurt the industry's image; placing emphasis on physical activity and energy expenditure over diet and energy intake; pledging to self-regulate; emphasising moderation; and statements purporting that there are no food or bad foods, only excessive intake of food (hence no single food category should be targeted) [502,746]. Almost all of these features emerged during this study. Furthermore, the importance and power of framing problems such as obesity using personalized examples and causal stories to shape public opinion and broader societal discourse should not be underestimated [312,721]. Different framings may significantly influence obesity-related behaviours: in a recent study, framing obesity as a consequence of wider structural determinants raised awareness of obesity as a societal issue and increased acceptability of upstream, environmental responses to obesity [749]. In the USA, where the concept of personal responsibility has long been a centrepiece of food industry arguments against government action [502], studies suggest that the general public views obesity as primarily a personal responsibility [314,750] with parents being the second-most blameworthy entity responsible for the rise in obesity [715]. Several studies in multiple countries have found that a majority of overweight and obese individuals hold themselves responsible for their own dietary choices [314,715,727,751,752], possibly due to an internalisation of messages focusing on personal responsibility [738]. Consolidation of these framings at the individual level is likely to increase their potency and make them difficult to change [738]. The belief that obesity is subject to internal control is likely to result in less support for policies promoting healthier social, economic and physical environments [312,314].

Differences between the public health and industry frames highlight how each sector adopts a narrative that reinforces their arguments and matches their interest [718,725]. Understanding these frames provides useful information on how public health advocacy should best respond to industry framing, underscoring the importance of developing messages that acknowledge the impact of individual choices in the development of obesity while emphasising external mediating factors and societal determinants [502]. Reframing obesity as a multi-sectoral, whole-of-society issue that requires contextual social, economic, physical and political determinants to be addressed, but which also requires parental investment in their children's health, should be a deliberate strategy endorsed by public health actors in Malta [753]. This approach has been successfully employed elsewhere, such as in the field of alcohol policy to introduce minimum unit pricing for alcohol in Scotland [754]. Future work in this area might include a media analysis and assessment of the frames used by other key interest groups around obesity in Malta, including those of children, parents, non-governmental organizations and the general public. This would be helpful to aid in the contextually relevant reframing of obesity by public health in a way that pre-empts counterarguments and addresses concerns. In addition, research might also analyse the timing and consistency of specific messages and frames across industries in Malta and internationally to gain insight into how specific narratives are developed and disseminated over time. Research on how different frames may influence public support for obesity policy should also be carried out [312,726,749].

Conclusions

Competing conceptualizations of causes of and solutions to obesity may influence policy discourse and policy development by precluding certain policy responses and favouring others. Specific framings may also influence the direction of public support for obesity policy. Analysis of the contrasting frames of two key sectors which have significant potential to influence obesity policy in Malta clearly illustrated the 'framing contest' currently underway between these groups. Industry actors predominantly framed obesity in ways which were consistent with their underlying commercial interests, whereas public health offered a competing frame which highlighted the need for whole-population approaches to address obesity. This has significant implications for policy, since the narrative promulgated by industry essentially misrepresents the evidence around the causes of obesity. Ineffective solutions that are less threatening to industry's commercial interest (i.e. education) are promoted over more effective solutions such as taxes and subsidies [500,755]. Furthermore, each sector's frames of obesity showed clear convergence with those of equivalent sectors in other countries, suggesting that the food industry in Malta has adopted frames from the international 'playbook'. The tension between the food industry and public health frames is likely to be present worldwide.

End of Research Paper 8

CHAPTER 6. FORECASTING THE FUTURE OF OBESITY IN MALTA

Preamble to Research Paper 9

The contextual analysis revealed mounting concern about the spiralling costs of obesity [216]. An increasing number of national policy documents mirror international calls for addressing the problem of obesity at multiple levels of the environment, including the introduction of fiscal instruments to encourage healthy nutrition [38]. Malta is also a signatory to the European Charter on Counteracting Obesity [267], which emphasised the importance of subsidies, reformulation and marketing restrictions to address structural drivers or obesity. However, translation of policy into action is not a straightforward process. The cost of implementing interventions, and the likely return on investment, are typically of concern to policymakers. Public health professionals might find it difficult to convince budget-conscious policymakers to implement interventions which have been shown to be successful outside of Malta but which have not yet been attempted locally. As outlined in Research Paper 2 (Overview of systematic reviews), the majority of childhood obesity prevention interventions have produced equivocal results in different settings, and if positive the effect size is usually modest. Despite these limitations, modest benefits multiplied many times over might well prove to be cost effective at a population level [756]. Implementing such interventions, however, is often a challenge [706,709]. The dominant 'personal responsibility' frame of obesity adopted by industry and the food industry's pivot towards positioning itself as part of the solution to obesity [757] - as shown in Research Paper 8 – may hinder the implementation of politically controversial environmental interventions that may impact industry profits, such as regulation of television advertising to children and taxation of SSBs. The use of quantitative evidence that highlights the economic consequences of unchecked obesity and the potential financial savings resulting from reductions in population BMI may be key to changing policymakers' attitudes in this regard [38]. Although mostly derived from a reductionist view of a complex system, modelling can potentially support the argument for an socio-ecological or environmental approach to tackling obesity, bridging the gap between evidence generation and policy implementation. Thus I felt that there was scope for the application of innovative instruments that can inform and support decision-making in childhood obesity nationally, allowing forecasts about the effectiveness of environmental, population-level interventions to be made [758]. One such instrument is microsimulation modelling, which has been extensively used to test the impact of different scenarios in diverse spheres such as HIV treatment [759], tobacco control [760], and long-term care expenditure [761].

Microsimulation modelling has also been used to project the financial and health impact of reductions in population BMI, and to forecast the effect of interventions and policies on future obesity prevalence and obesity-related disease burden [231,762]. It is highly likely that such projections played a key role in the political debate leading to the successful excise tax on SSBs in Mexico [666] and the recent introduction of a levy on SSBs in the UK [763]. Limited projections related to the future health and cost burden of obesity in Malta have been made [226,764], however these did not take childhood obesity prevalence data into consideration, relying instead on relatively inaccurate self-reported BMI data for adults [108]. Given existing links with public health colleagues in Malta, I determined that I might be granted access to data that would not be easily accessible to international researchers. It is hoped that more robust outputs will be welcomed by policymakers who face an uphill challenge in attempting to apply socio-ecological principles to obesity prevention in Malta.

Models that have been used to simulate obesity include the UK Health Forum's (UKHF) Obesity Microsimulation Model [758]; HIA-DYNAMO [765,766]; and the OECD/WHO's Chronic Disease Prevention (CDP) model [232]. The UKHF microsimulation model was created for the 2007 Foresight report `Tackling Obesities' [767] to predict and analyse future trends in disease and societal costs attributable to the rise in obesity in the UK. It was ultimately preferentially selected due to the convenience of being able to run the model from the UKHF offices in London, and because the data required for input was relatively readily available. In contrast, the CDP Model – which I also considered - required data such as nutrient intake at population level which is not yet available for Malta. I initially planned to extract environmental interventions mentioned in the national obesity strategy [80] (e.g. introduction of fiscal measures to influence food consumption; ban on TV advertising of HFSS food before the 9pm watershed) and model their impact on population obesity level, offering a quantitative perspective on their potential impact to policymakers. However, modelling constraints and limited data meant that this could only be done for a possible SSB tax. Results, responding to objective 5 of my thesis, are presented in the following research paper. Lastly, it is relevant to note that microsimulation modelling typically assumes linear cause-effect relationships that may not reflect the reality of obesity, which has been described as a complex adaptive system that does not fit neatly within narrowly defined cause-and-effect boundaries [768]. Thus the scope of the model is to highlight the potential benefits of reducing overall population BMI, rather than to identify and hierarchically classify 'best practice' interventions for Malta.

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SECTION A – Student Details

Student	Daniel Cauchi
Principal Supervisor	Cécile Knai
Thesis Title	Childhood obesity in Malta: contributions of the obesogenic environment

SECTION B – Paper already published

Where was the work published?			
When was the work published?			
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
Have you retained the copyright for the work?*		Was the work subject to academic peer review?	

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SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	Public Health Nutrition
Please list the paper's authors in the intended authorship order:	Daniel Cauchi, Laura Webber, Cécile Knai, Dorothy Gauci, Zaid Chalabi, Neville Calleja
Stage of publication	Submitted

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	See full details of author contributions on the next page.

Student Signature: D Cauchi **Date:** 29/07/2016

Supervisor Signature: Cécile Knai **Date:** 29/07/2016

Research Paper 9

Health and Economic Consequences of Projected Obesity Trends in Malta

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Status: Under review in: *Public Health Nutrition*

Author contribution: I formulated the research question and designed the study. I collected and analysed the data with input from Laura Webber, Dorothy Gauci, Zaid Chalabi and Neville Calleja. I drafted the manuscript and made revisions based on comments from all co-authors.

Abstract

Given the scale of the obesity epidemic, there is increasing concern about the potential health and economic consequences of current obesity trends. The aim of this study was to assess the impact of unchecked obesity and the benefits of reducing population weight in Malta. We projected disease burden and direct healthcare costs for stroke, coronary heart disease, diabetes, hypertension and several types of cancer in Malta to 2035 using a microsimulation model. This utilizes a two-stage modelling process to predict future body mass index rates, disease prevalence and costs, and to determine the impact of public health interventions upon future disease incidence. Our results indicate that uncontrolled overweight and obesity are projected to result in a 62% increase in stroke prevalence; a 16% increase in prevalence of hypertension, and a 27% increase in obesity-related cancers by 2035. The prevalence of coronary heart disease is expected to double within the next two decades. Associated cumulative direct healthcare costs will amount to around €814 million by 2035. However, a 5% reduction in average population body mass index by 2035 is projected to result in €141 million less being spent on obesity-related conditions over twenty years. These findings have significant implications for obesity policy in Malta and other European nations with similar health systems and levels of population obesity, highlighting the need for, and benefits of, effective population-level strategies to address this avoidable condition.

Introduction

Obesity has become a critical public health issue globally as overall prevalence continues to rise [1,2]. Malta is no exception, leading the overweight and obesity rankings in Europe [2,3]. Around 35% of Maltese 10-11 year-olds and 40% of nine year olds are overweight or obese [104,105], whereas self-reported data indicates that older Maltese children are also amongst the most obese worldwide [100]. Obesity is a major risk factor for non-communicable diseases (NCDs) including diabetes, hypertension, coronary heart disease (CHD), stroke, and certain cancers [113], and there is a well-established link between obesity, poor health outcomes and all-cause mortality [114]. The direct and indirect economic implications of overweight and obesity are also significant, largely driven by increased incidence of related NCDs [769]. Health services in Malta are mainly provided by the state and are free at point of use, with a private sector acting as a parallel, complementary system for health-care coverage and service delivery [770]. Health expenditure has increased steadily in recent years, exceeding the rise in GDP [770]. Annual direct costs attributable to the consequences of overweight and obesity in the Maltese adult population have been conservatively estimated to be around €20 million, or 5.7% of total health expenditure [226]. This included medical expenses such as in-patient stays, day-patient stays, and general practice or specialist consultations, but excluded costs related to medication, surgery and ancillary services.

Concern about tracking of childhood obesity into adulthood [89] and its potential to substantially burden the health care system [764] has led to the publication of a national policy aimed at obesity prevention [80]. Increasingly, an ecological approach to addressing obesity that acknowledges its complex, multi-factorial aetiology and which recognizes policy and environmental factors influencing individual obesity-related behaviour is being advocated [38]. Simulation models are useful tools that aid in the understanding of the complex interaction of drivers of obesity and health outcomes [762]. The UK Foresight microsimulation model [771] has been applied to obesity in several countries. The aim of this study was to model the potential trajectory of unchecked overweight and obesity trends in Malta, the economic and health consequences of such trends, and the potential benefits of any mitigating action taken. Our results may help to guide resource allocation at a national level and emphasise the positive health and economic outcomes of implementing preventive measures to curb obesity levels, in Malta as well as in other nations with similar levels of population overweight.

Methods

Data sources for the model are shown in Table 26.

BMI data

Databases were included if body mass index (BMI) data were nationally representative. Adult data was categorised by WHO cut-offs for normal weight (<25kg/m^2), pre-obesity (25-29.99 kg/m^2), and obesity (≥30kg/m^2), whereas child height and weight data were converted into BMI equivalents using International Obesity Task Force cut-offs [92]. Currently, the availability of nationally representative BMI data for Maltese adults is limited to two national rounds of the European Health Interview Survey (EHIS) conducted in 2002 and 2008 [108,213]. Both measured and self-reported data for several cohorts of Maltese children were used as the microsimulation model inputs. Additionally, the School Health Service within the Ministry for Health provided anthropometric data for three national cohorts of schoolchildren born in 2001, 2003 and 2005, measured when they were approximately 7 years old. Anthropometric measurement of the 2001 cohort was repeated in 2009 and 2010, when children had a median age of 9 and 10 years respectively. In addition, self-reported BMI data from four rounds of the 'Health Behaviour in School-aged Children: WHO Collaborative Cross-National Survey' (HBSC) conducted in Malta during 2002, 2006, 2010 and 2014 were provided for 11, 13 and 15 year-old children [96,97,99,100]. Outliers were removed where data fell outside of 95% confidence limits.

Disease data

A review of epidemiological studies and nationally available data sets was undertaken to identify incidence and prevalence for the following obesity-related diseases by age and gender: type 2 diabetes, CHD, stroke, hypertension and obesity-related cancers (breast, colorectal, oesophageal, endometrial, liver, kidney and pancreas). Diabetes, CHD, and hypertension incidence was derived from prevalence data [214] using WHO's Dismod model [772]. The Clinical Performance Unit (CPU) provided prevalence, incidence and survival data for stroke, whereas the Directorate for Health Information and Research (DHIR) provided prevalence and incidence data for cancers [773]. Mortality and survival data were also collected for fatal diseases: CHD, stroke, and cancers [136,773,774]. The relative comorbidity risks related to being overweight or obese for each of these diseases were obtained from the International Association for the Study of Obesity [775].

Cost data

Direct costs of non-cancerous disease include the cost of in-patient stays, day patient stays, and GP and specialist consultations. Estimated attributable costs for 2013 were calculated by DHIR, based on 2008 disease prevalence estimates [226]. It was assumed that disease prevalence had not changed since 2008, and that any increase in cost was due to inflation (2% yearly) and demographic change. Expenses related to medication, surgery, and ancillary services were unavailable. Approximate direct healthcare cost of breast cancer and colorectal cancer for 2009 were obtained from an EU cost analysis study informed by a mix of national and proxy data [776]; cost data on other individual obesity-related cancers were unavailable. Indirect costs such as those associated with premature mortality, productivity losses or loss of income due to absenteeism from work were also omitted from this study due to a lack of national data on these factors.

Sugar-Sweetened Beverage Tax

Growing evidence for deleterious health effects of sugar-sweetened beverages (SSBs) and their association with obesity and other NCDs has led to global calls for action to limit consumption [523,777]. Studies suggest that preventive "upstream" policy interventions are likely to be the most cost-effective options [608]. For example, fiscal measures aimed at raising the price of SSBs to modify purchasing behaviours may potentially reduce obesity rates [778], and have been proposed as viable tools for policymakers [347,523,779]. Recently, the United Kingdom (UK) announced the introduction of a levy on sugar-sweetened fizzy drinks to help tackle childhood obesity [763]. Given Malta's reportedly high consumption of SSBs [96,97,99], the Maltese government has recognised the potential of – and has indicated a willingness to explore – such approaches [80,110]. Modelled estimates of the health effects of taxing SSBs vary significantly depending on, among other factors, the type and level of tax imposed; SSB price elasticity; and purchasing and consumption estimates in the country of interest. For example, a 20% SSB tax in the United States has been predicted to reduce obesity by up to three percentage points [780,781], whereas markedly different levels of consumption of SSBs in the United Kingdom (UK) suggest a lower impact when implementing the same tax [782]. Currently, reliable information on SSB price elasticity and population-level consumption of SSB in Malta is lacking, hence it is not possible to accurately model the impact of a sweetened drink tax intervention. However, the use of proxy data from the UK – which has a broadly similar adult obesity rate [3] – to estimate health and economic effects of a 20% SSB tax in Malta was deemed to be a valid first step towards conservatively illustrating the potential of such fiscal policy approaches. We have adopted the BMI outcome from a 2013 UK study which estimated that introducing the tax would result in a reduction in average population BMI of 0.07 (confidence interval: 0.05 to 0.09), with the same patterning by income and age as the predicted changes to prevalence of obesity [782]. Forecasting models suggest that most of the effect would occur within two years, with maximal effect achieved after five to 10 years [781]. Tax revenue and administrative expenditure estimates were outside the scope of this study and were not calculated.

Category	Source (data year)
Population characteristics	
BMI distribution	EHIS (2002, 2008) [108,213] School Health Services, Malta (2007; 2008; 2009; 2010; 2013) [Sant'Angelo, V., personal communication] HBSC (2002, 2006, 2010, 2014) [97–99]
Population size	National Statistics Office (2012) [17]
Incidence/Prevalence	
CHD, Diabetes, Hypertension	EHIS (2008) [108]
Stroke	DHIR & CPU (2013) [England, K.; Distefano, S., personal communication]
Cancer	National Cancer Registry (2013) [773]
Relative risks of obesity on disease risks	
Relative risk	International Association for the Study of Obesity (2010) [775]
Survival	
CHD	DHIR & CPU (2013) [England, K.; Distefano, S., personal communication]
Stroke	DHIR & CPU (2013) [England, K.; Distefano, S., personal communication]
Cancers	EUROCARE-5 (2007) [774]
Costs (direct)	
CHD, Diabetes, Hypertension, Stroke	DHIR (2013) [co-author calculation]
Cancer*	Economic burden of cancer across the European Union: a population-based cost analysis (2009) [776]
Disease-specific mortality	
CHD, Diabetes, Stroke	National Mortality Register (2013) [136]
Cancer	National Cancer Register (2013) [773]

* Breast and colorectal cancer only

Table 26. Data sources for the microsimulation model

Microsimulation model

A two-stage modelling process developed by the UK Foresight working group and described in more detail elsewhere [767] was used to project future obesity-related disease burden in Malta. Assuming that an individual's BMI status in the same-age cohort is consistent over time, cross-sectional data were used to simulate longitudinal BMI trajectories to 2035, starting from 2015. Briefly, the first module fits multivariate, categorical regression models to the cross-sectional BMI data. A BMI value is probabilistically and stochastically assigned to simulated individuals as a function of age, sex and calendar year, and the predicted proportions of the population in each BMI category is constrained, resulting in a longitudinal growth model of the population (Appendix 10A). Size and age distributions were based on medium variant projections from the UN population database [783]. Disease data enabled the consequences of these BMI trends to be determined, so that each virtual individual's chance of contracting, surviving or dying from these set of conditions was simulated. Subsequent healthcare costs associated with these trends could then be calculated. The effects of constraints on future BMI growth were also modelled, allowing insight into how levels of obesity-related chronic disease prevalence, mortality, and healthcare costs might change following one of four distinct trend scenarios, one of which involved the implementation of a population-based public health intervention:

- Scenario 0: obesity trends continue unchecked
- Scenario 1: mean population BMI decreases by 1%
- Scenario 2: mean population BMI decreases by 5%
- Scenario 3: reduction in mean adult population BMI by -0.07 points as a consequence of the introduction of a 20% sugar-sweetened beverage (SSB) tax in 2015

Twenty million Monte Carlo [784] simulation trials were performed for each scenario.

Results

BMI distribution

The projected prevalence of overweight and obesity (≥25kg/m^2) in the Maltese population by 2035 is illustrated in Figure 19. Prevalence in males is projected to increase over the coming decades to reach 79%, while prevalence in the adult female population - currently around 50% - is predicted to decrease slightly to approximately 48% by 2035. The proportion of adults in the overweight category is generally predicted to increase at the expense of the normal weight and obese categories, with the exception of young (25-34 years) and elderly (70+ years) adults who are predicted to have a high obesity prevalence. Results also suggest an increase in the burden of overweight and obesity in children up to 14 years of age, with prevalence increasing by around 17% and 3% in girls and boys respectively by 2035. Table S1 in Appendix 10B presents the proportion of the population in each BMI group by sex and age group projected to 2035. Figures S1 – S6 in Appendix 10E illustrate a sample of the projections with confidence limits.

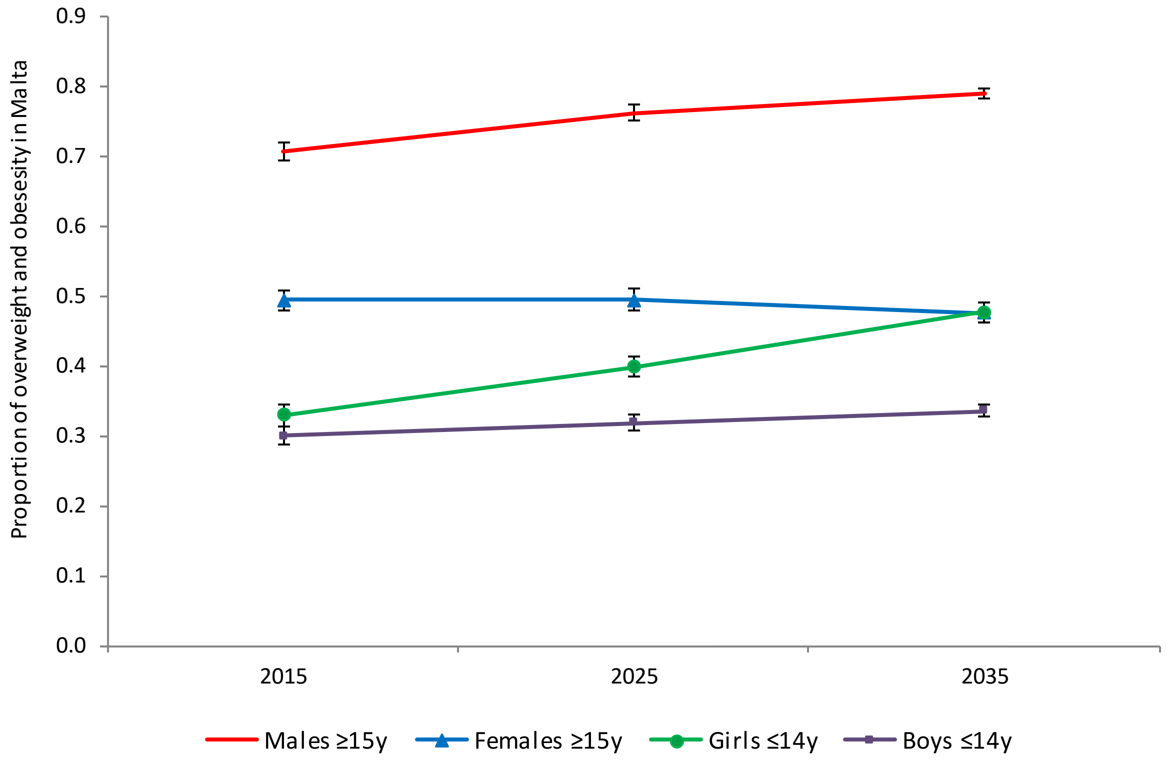

Figure 19. Projected prevalence of overweight and obesity in the Maltese population by 2035

Disease prevalence and projected outcomes

Should current obesity trends continue unabated, the prevalence of almost all related diseases is expected to increase. The exception is type 2 diabetes, the prevalence of which is projected to continue increasing up to around 2025, followed by a prolonged slow decline (Table S10, Appendix 10F). Any reduction in population BMI would substantially influence disease prevalence and incidence. Figure 20 illustrates projected obesity-related disease incident cases avoided by 2035 if a 1% (scenario 1) and 5% (scenario 2) decrease in average population BMI were to be achieved, when compared to no intervention (scenario 0).

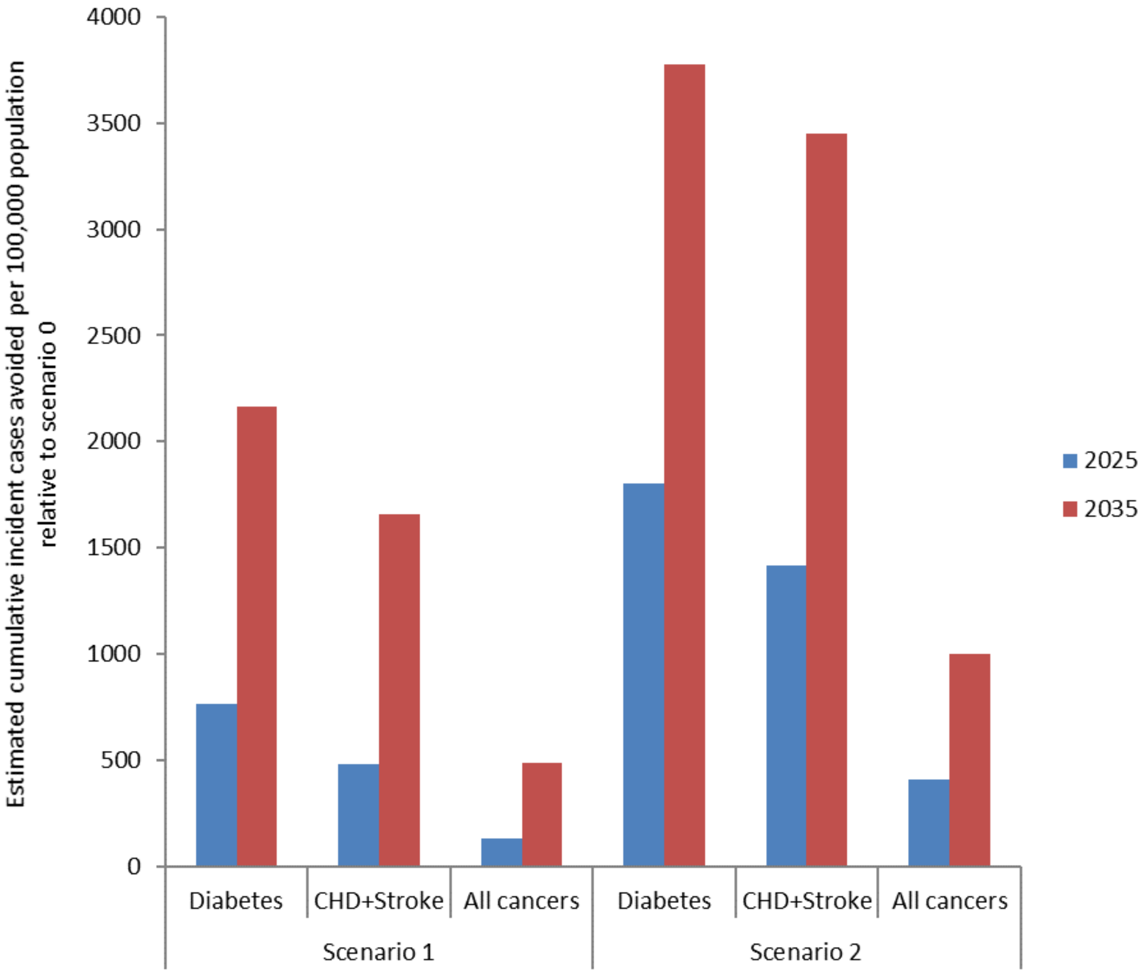

Figure 20. Estimation of cumulative incident disease cases avoided per 100,000 population in scenarios 1 and 2, relative to scenario 0 (hypertension not shown)

Using UN total population projections for Malta, by 2025 scenario 1 is projected to decrease prevalence of CHD and stroke by 2037 cases; diabetes by 3264 cases; and all cancers by 554 cases. Scenario 2 has a more significant impact, reducing occurrence of CHD and stroke by 6025 cases; diabetes by 7674 cases; and all cancers by 1743 cases by 2025. There would also be a projected reduction in hypertension by 3566 and 9847 cases for scenarios 1 and 2 respectively (Table S14, Appendix 10F). Scenario 3 shows more modest reductions of 149 cases of diabetes, 98 cases of CHD and stroke, 13 cancer cases and 158 cases of hypertension by 2025, which accumulate over time to result in 278 fewer cases of diabetes, 192 cases of CHD and stroke, 56 cases of cancer and 307 cases of hypertension by 2035. Appendix 10F provides further information on estimated prevalence; prevalent cases avoided through intervention; cumulative incidence avoided and incident cases avoided through intervention.

Economics

Conservative estimates suggest a direct healthcare cost for diseases associated with obesity (including breast and colorectal cancer, but excluding endometrial, kidney, liver, oesophageal and pancreatic cancers for which cost data were unavailable) of around €32 million in 2015. Hypertension comprises 34% of these costs in 2015, followed by diabetes (28% of the costs). Stroke and CHD together comprise a further 25% of the total obesity-associated healthcare costs. The projected increase in obesity-related diseases has a substantial impact on healthcare expenditure: assuming current trends remain unchanged; by 2035 associated direct healthcare costs are conservatively projected to reach €43.6 million yearly. The proportion of direct healthcare costs attributable to CHD and stroke will increase to 35%; cost attributable to breast and colorectal cancers and arthritis will increase slightly; whereas the proportion attributable to hypertension and diabetes is expected to decrease by 5% and 8% respectively. This reflects findings in modelling studies for other European countries which indicate that increases in CHD and stroke prevalence will be disproportionately responsible for rising expenditure [764,785–787]. Table 27 shows that a 1% decrease in population BMI is estimated to result in €2.9 million less being spent each year on obesity-related morbidity by 2025, and €7.1 million less per year by 2035. This translates into cumulative savings of €65.5 million by 2035. A 5% decrease in population BMI will clearly have a greater impact, resulting in cumulative savings of €141 million by 2035 due to direct annual healthcare costs that are €7.8 million and €12.2 million less by 2025 and 2035 respectively. Projections for scenario 3 suggest that the introduction of a 20% SSB tax might result in a modest cumulative saving of €2.3 million by 2035 (Appendix 10D).

	Scenario 0			Scenario 1				Scenario 2				Scenario 3			
	2015	2025	2035	2025 (*)		2035 (*)		2025 (*)		2035 (*)		2025 (*)		2035 (*)	
Hypertension	11.0	12.2	13.0	11.7	(0.5)	11.6	(1.4)	10.9	(1.3)	10.4	(2.6)	12.1	(0.0)	12.9	(0.0)
Diabetes	9.0	9.2	8.8	8.1	(1.0)	6.4	(2.5)	6.8	(2.3)	5.0	(3.9)	9.1	(0.0)	8.8	(0.1)
Breast + Colorectal Ca	4.0	5.8	6.6	5.5	(0.3)	5.9	(0.7)	5.0	(0.9)	5.5	(1.1)	5.8	(0.0)	6.5	(0.1)
CHD + Stroke	8.0	12.1	15.2	11.0	(1.0)	12.7	(2.5)	10.3	(1.8)	12.8	(2.4)	12.0	(0.0)	15.1	(0.1)
Total	32.0	39.2	43.6	36.3	(2.9)	36.5	(7.1)	31.4	(7.8)	31.4	(12.2)	39.0	(0.2)	43.3	(0.3)

(*) Estimated annual healthcare cost savings for in € million, relative to scenario 0

Table 27. Direct annual healthcare costs in € million, by year and disease

Discussion

This study used the most recent Maltese data to model the impact of potential reductions in average population BMI on future obesity-related disease burden. Projections of the future obesity burden in Malta have been previously published [226], however this is the first to report on direct health care costs of five key obesity-related conditions for Malta. Results are consistent with those found elsewhere in Europe and the Americas [758,785–789]. In all cases, the projected rise in overweight and obesity levels is expected to lead to a substantial increased burden of NCDs and associated healthcare spending. Given the organization of the health system in Malta, a large proportion of this burden is likely to be shouldered by the state: public expenditure comprised almost two thirds of total health expenditure in 2010, with the remainder derived from out-of-pocket payments and voluntary health insurance [770]. In 2013, total health expenditure for Malta was 9% of GDP [790], equivalent to around €678 million (GDP at market prices). Our results suggest that obesity-related diseases currently account for at least 4.7% of this expenditure (i.e. 0.43% of GDP). Furthermore, this financial burden is likely to be substantially higher if more accurate direct and indirect costs were to be included in these calculations.

The model indicates that increased CHD and stroke incidence will have the most significant impact on the healthcare system, as risk of developing cardiovascular disease increases with age. Surprisingly, modelled incidence and prevalence of diabetes plateaued and gradually declined over two decades, possibly due to the death of individuals with diabetes at the same time as fewer people are born to contract the disease. Alternatively, this finding could be an artefact arising from the limitations of the data that informed the model. Projections of accurate, measured anthropometric data recorded over the past decade showed substantial increases in childhood obesity rates, particularly in girls. However, this was inconsistent with the projected modest increase in adult male overweight and obesity rates, and the reduction in adult female rates. This is most likely due to the paucity of Maltese adult BMI data (only two data points were available) or to the inherent inaccuracy of self-reported BMI data used for adult projections [791], hence no firm conclusions can be derived from these results.

This study expands on the results for Malta published in a recent World Health Organization (WHO) cross-European microsimulation study [764]. We set out to add value to the findings by utilising the most up-to-date data available and deriving disease cost estimates, avoiding the use of proxy data when possible. A comparison of our results with those of the WHO modelling study show substantially higher cumulative incident cases avoided across all diseases in our study. Additionally, while the cumulative incident cases per 100,000 for diabetes and all cancers across the two studies were broadly similar, our study found a lower cumulative incidence over time for CHD and stroke, as well as hypertension. There were also differences in estimated prevalence cases: our study indicated a slightly lower overall projected prevalence of cancer and a substantially lower prevalence of CHD, stroke and diabetes than WHO calculations. Prevalence estimates of hypertension in both studies were broadly similar. Projections for arthritis utilising UK proxy data were included in the WHO estimates, however the self-reported prevalence data available to authors from the EHIS 2008 survey were deemed to be insufficiently accurate to warrant inclusion of this established risk factor. Thus, actual cost of obesity-related disease is likely to be higher than that outlined in our study.

Quantification of the burden of NCDs is important to patients and public health professionals because of the long-term consequences to patients' function and demand for healthcare. Such data are vital if national policies to control NCDs are to be appraised objectively. Although the Maltese government has developed a national strategic plan to improve population diet and physical activity patterns, the translation of policy into tangible action is unlikely to be a straightforward process. Public health professionals may find it difficult to persuade budget-conscious policymakers to consider interventions shown to be cost effective and successful outside of Malta but which have not yet been attempted locally. We chose to include a fiscal intervention in view of increasing public health interest and debate around this topic, as well as interest expressed by the Maltese government in exploring the feasibility of such an intervention. Significantly, although the majority of childhood obesity prevention interventions have produced equivocal results [284], and if positive the effect size is usually small, modest benefits multiplied many times over might well prove to be cost effective at a population level [756]. In particular, environmental interventions are designed to alter the context in which people live, creating conditions that are more supportive of healthy behavioural choices and which influence individual-level behaviours among a large group of people, making them more efficient [756]. Taxation schemes that produce relatively large changes in price can alter purchasing habits and are likely to improve health to a greater extent than small price changes [780,792]. In 2013, Mexico launched a tax regime on soft drinks and junk food; preliminary results suggest a substantial reduction in soft drink sales [793]. A levy on sugar sweetened soft drinks was announced in the 2016 UK budget, suggesting increased interest in such population-level approaches to address obesity among policymakers [763]. Our results suggest a small but positive effect of a 20% tax on SSBs can result in significant cost savings over time. However, food and beverage industry resistance often makes implementation of such regulatory policies difficult to implement sustainably in the long term [706,707].

Limitations

As with all models, the quality of microsimulation modelling output is dependent on the accuracy of surveillance data and the underpinning assumptions of the model. Limitations of the model have been described elsewhere [758,767]. For example, obesity cannot be considered to be the sole causal factor contributing to the projected rise in NCDs, and it was not possible to incorporate the impact of economic growth or future increases in the cost of healthcare into the analysis. BMI projections for adults should be interpreted with caution as only two data points were available. In addition, although the utilization of cross-sectional data to construct BMI trajectories may not be applicable to upcoming generations, the model assumes that any BMI changes occurring as a result of interventions are fixed over time. Furthermore, high quality healthcare data was difficult to locate, limiting the accuracy of our findings. Direct costs for kidney, liver, pancreatic, endometrial and oesophageal cancers were not included due to lack of accessible data, hence study estimates are likely to be gross underestimations of the true cost. Finally, no indirect cost data was available hence indirect costs of obesity for Malta could not be determined.

Conclusion

This research provides evidence of avoidable direct health care costs for five major obesity - related illnesses using a recognised forecasting model, thereby providing an impetus for policymakers to take action by bridging the gap between evidence generation and policy implementation. It is clear that any reduction in population overweight and obesity levels will have a substantial cost saving effect in the longer term. Multi-component, population-level interventions addressing drivers of obesity at multiple levels are the most likely to be effective. Collection of disaggregated surveillance data related to disease costs and indirect costs of obesity would enhance the accuracy of future modelling efforts.

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End of Research Paper 9

CHAPTER 7. DISCUSSION

7.1 Summary

This research set out from the premise that there is a discrepancy between the alarming scale of childhood obesity prevalence in Malta, and a policy agenda to address the issue which is not proportionate in complexity and scope and that fails to adequately consider environmental contributions to obesity. The aim of this PhD was to answer the research question "*Is there an obesogenic environment contributing to the high rate of childhood obesity observed in Malta, and what opportunities exist to address this public health problem using an ecological approach?*" The specific objectives of my research were to:

obesity

1. describe the upstream and downstream drivers of childhood obesity in Malta
2. review the evidence on effective environmental interventions to address childhood obesity
3. describe and assess the obesogenic elements characterising select local communities
4. understand the views of main stakeholders around childhood obesity in Malta, the way the issues is framed, and explore barriers to physical activity and healthy dietary behaviour among children
5. assess the long-term health and economic burden of childhood obesity in Malta and evaluate the impact of preventive interventions to reduce childhood obesity
6. develop recommendations for adopting an environmental approach to address childhood obesity in Malta

Findings generated by the application of a mixed-methods approach to achieve these objectives have been presented in the form of research papers, each of which includes a discussion specific to that paper. This final thesis chapter will synthesise these results, outline their implications for national obesity policy and suggest directions for future research (objective 6).

7.2 Quality assurance

This mixed-methods thesis combined observational studies with qualitative research. These disparate yet interconnected components were subject to conceptual and methodological shortcomings which are discussed in the respective research papers. As outlined in Chapter 2, the use of study protocols to guide the quantitative aspects of data collection aided scientific rigor and led to the collection of reliable and valid data that were presented in Chapters 3, 4 and 6. However, at this point it is also useful to outline the quality criteria to which I adhered when conducting the qualitative research outlined in Chapter 5. In particular, Lincoln and Guba argue that the 'trustworthiness' of research is important to determine its value, and proposed an alternative framework to the concepts of 'reliability' and 'validity' (typical of quantitative research) in order to ensure rigor in qualitative studies [794]. Trustworthiness involves satisfying the following four criteria:

1. *Credibility*: researcher's confidence that the study findings represent a true picture of reality
2. *Transferability:* the provision of sufficient detail so that the study findings can be applied to other, similar contexts
3. *Dependability:* ensuring that the research findings are consistent and can be repeated
4. *Confirmability:* taking steps to demonstrate that findings truly emerge from the data, rather than researcher bias, motivation, or interest (i.e. demonstrate researcher neutrality)

7.2.1 Credibility

Credibility corresponds to the concept of validity, whereby researchers seek to ensure that a study measures what it is actually intended to measure [795]. I endeavoured to meet this criterion through adopting well-established research methods, including transcribing my interviews verbatim and keeping comprehensive and detailed records of my findings. Interviews were carried out in either Maltese, English, or in a mixture of both. I am fluent in both languages, and paid substantial attention to the careful translation of Maltese into English in order to remain as faithful as possible to what was said during interviews. Where possible, I questioned informants iteratively, referring to issues previously raised by other interviewees and rephrasing questions during the interview to ensure that the data collected reflected the informants' opinions. Triangulation was a key consideration during this research, reflected in my interviews with a wide range of informants to enable verification of indivudal viewpoints and experiences against others, and to reduce the impact of local factors peculiar to one institution. I attempted to gain familiarity with the structure and culture of all organizations represented by key informants prior to each interview, and with the policies of schools where focus groups were carried out. This was not always possible, beyond gleaning information from official websites and brochures. Lastly, I engaged in a reflective commentary to record my initial impressions of, and any emerging patterns from, each interview or focus group session. In addition, the use of distinct but complementary data collection methods was designed to result in a comprehensive snapshot of the range of environmental influences on obesity, highlighting challenges and opportunities for applying an environmental approach to reversing the obesity crisis in Malta.

7.2.2 Transferability

Transferability corresponds to external validity, or the extent to which the research can be transferred to other contexts. However, this is difficult to achieve within qualitative research since the results of a qualitative study must be understood within the specific contextual characteristics of the area in which fieldwork was carried out. Shenton states that providing a highly detailed description of the methods used to conduct research is essential, hence I have attempted to do so throughout this thesis [795].

7.2.3 Dependability

Dependability corresponds with reliability, or whether the research process is methodologically consistent and correct, whether the research questions are clear and logically connected to the research purpose and design, and whether findings are consistent and repeatable. In order to do so, I followed an interview guide to ensure that all issues were covered, and transcribed interviews as soon as possible after the interview. Furthermore, I have reported upon each research method in detail to enable an external researcher to potentially repeat the study and achieve similar results.

7.2.4 Confirmability

Confirmability refers to whether researcher objectivity was maintained throughout the research process. It is impossible to be entirely objective when conducting qualitative research. Instead, it is suggested that the researcher should adopt an attitude of 'evenly suspended attention' [26] in order to minimize research bias. *Reflexivity* refers to the process whereby the researcher's subjective impressions, pre-formed theoretical assumptions and political values are explicitly acknowledged, and the researcher's role in generating and analysing the data is critically reflected upon [75]. Such reflexivity promotes understanding of the issue under study and improves data reliability [796]. In this section I will reflect upon my role in conducting this research, and how my background might have influenced interpretation of the data generated.

Background

As a medical professional specialising in public health within the Ministry for Health in Malta, I am aware that my training and professional interactions with public health colleagues may have shaped my thoughts and beliefs regarding the drivers of childhood obesity in Malta. Additionally, I entered into this research having been informed and influenced by the literature on 'obesogenic environments', which resonated with my experience and observations as a public health professional. Thus, I am aware of having had pre-conceived ideas regarding the possible existence of an obesogenic environment and its likely contribution to childhood obesity in Malta.

Research experience

Prior to commencing this research, my experience had been strictly limited to quantitative methods. While this proved beneficial in the sense that I was aware of the need to rigorously follow protocol during the quantitative aspects of data collection, it also meant that I was a newcomer to qualitative research. I received welcome guidance on qualitative methods from my supervisor and qualitative research experts, whereas the iterative development, piloting and revising of the topic guide enabled my understanding of the qualitative method to evolve. During fieldwork, I learnt to adopt a more open-ended, participant-led approach to interviews and focus groups in order to allow participants' perspectives to come through in the data. I was careful to adopt a neutral stance when discussing obesity policy and responsibility for obesity, particularly when interviewing industry stakeholders, where awareness of my professional background might have influenced responses.

Despite these precautions, my relative inexperience is likely to have influenced this research, and may explain any missed opportunities for generating data that could have altered the findings or provided a more comprehensive understanding of the topic. However, this does not negate the overall integrity of the study. I consciously acknowledged these pre-existing beliefs and potential bias at all times during the research and declared my background upfront prior to stakeholder interviews. I am confident that, by reflecting on the possible influence of my professional background and discussing possible interpretations of the data with colleagues outside of the study, I was able to minimize the effect of my inexperience on the research process.

7.3 Findings of the thesis

Findings of the research papers presented in Chapters 4 to 6 are briefly summarized below.

7.3.1 Contextual Analysis

The contextual analysis identified numerous factors that may contribute to obesity in Malta. A nutrition transition towards a 'Western' diet high in fat sugar and salt that commenced during colonial times has been thoroughly consolidated in recent decades. Furthermore, aspects of the food environment such as the uniquitous pastizzeria and confectionery establishments strongly hints at the commercial success of these outlets, possibly due to strong demand. From a policy perspective (see also section 3.4 Policy response to obesity in Malta), there are encouraging signs that more importance is being given to improving the overall school food environment, and to the quality of nutrition and physical education in schools. However, the contextual analysis indicated that little is being done to create supportive food or built environments in communities. In summary, the contextual analysis indicated that an obesogenic environment characterised by limited infrastructure for active living combined with an energy-dense food supply exists in Malta, and highlighted the relative absence of published research on this topic.

7.3.2 Overview of Systematic Reviews

The overview indicated that environmental approaches to addressing childhood obesity show promise, yet most of the evidence is currently limited to the school setting and review results are often equivocal. Disentangling the contribution of environmental components within multi-level interventions (that also incorporate behavioural components) to overall intervention effectiveness presents additional difficulties to policymakers. Most systematic reviews did not provide clear recommendations regarding which environmental components were effective. Furthermore, few systematic reviews of relevance were of high quality, and the lack of standardisation of reporting was identified as a potential barrier to the extraction of relevant review implications and recommendations by policymakers. In order to add value to the overview and be able to respond to objective 2 of this thesis, primary studies reviewed in eligible systematic reviews were also assessed to identify specific environmental interventions that may be of interest to policymakers in Malta. Notably, the overview suggests that creating a healthier school food and physical activity environment may be modestly effective in improving weight outcomes among school-aged children. However, the overview also revealed a dearth of successful home or community-based interventions with environmental components. Only two such components were identified: substitution of sugar sweetened beverages with zero-calorie alternatives, and use of a time manager device to limit television watching. The need for further research to identify effective environmental interventions outside of the school setting was highlighted.

7.3.3 Environmental Audit

Research Paper 1 (Contextual analysis) highlighted a lack of objective data that characterizes the obesogenic environment in Malta. In order to respond to this gap in knowledge and to objective 3 of this thesis, I audited the built and food environment in a representative sample of localities across Malta and assessed children's exposure to HFSS food advertising on local television channels. Study findings establish a baseline against which future progress towards creating more supportive food and built environments may be measured. With regards to the built environment, statistically significant differences in pavement quality and bus stop density between the most and least deprived localities were observed. However, these findings do not necessarily indicate that socio-economic forces are at play. In the absence of longitudinal trends, and given the lack of physical activity behaviour data of individuals using the audited built environment, it is difficult to meaningfully interpret these cross-sectional findings. However, the dearth of cycle lanes observed in audited areas highlights a gap in Malta's active transport infrastructure and underscores concerns about road safety expressed by cycling advocates in the qualitative part of this thesis (Research Paper 7).

Research Paper 3 (Television advertising) showed heavy promotion of unhealthy food and beverages not only during children's programmes, but also throughout the weekday. Indeed, the intensity of HFSS advertising increases during prime time, at times when children are known to watch popular family dramas [537]. Research Papers 4 (Environmental audit: NEMS-S) and 5 (Environmental audit: GroPromo) describe key features of the food environment in the community and in grocery stores, adding rich detail to the overall picture depicted in Research Paper 1 (Contextual analysis). Given the increasing number of confectionery stores granted a license in recent years, it is interesting that this food store type was the only store category positively associated with increased risk of overweight and obesity in children living in the audited localities. Although this association does not imply a causal link, it provides support for regulatory measures currently being considered by the Maltese government, including proposals to investigate the feasibility of '*increasing the availability of healthy food outlets and restricting outlets selling fast foods*' [80]. The data also indicate that an obesogenic environment is present within grocery stores (the consumer food environment). More specifically, Research Paper 4 (Environmental audit: NEMS-S) illustrates that median price of certain 'healthier' versions of foods was more expensive than their less healthy alternatives, potentially disincentivizing purchase of healthy versions by customers. Research Paper 5 (Environmental audit: GroPromo) further suggests that children are exposed to HFSS food items displayed in prominent locations within grocery stores, possibly intentionally in order to increase sales of these items. On the other hand, with few exceptions, the absence of significant SES differences in food availability, price, quality and promotion was an unexpected finding. One possible explanation for this is that Malta's small size and relative ease of transportation enable consumers to judiciously shop around for food. In turn, this promotes competition among major supermarket chains, where the Maltese purchase the bulk of their food [200]. Thus, grocery store size was a better predictor of food pricing than area-level deprivation, since less affluent customers may still find reasonably priced food items at their nearest large grocery store.

7.3.4 Barriers to children's healthy dietary and physical activity behaviour

Research Papers 6 and 7 offer rich insight into children's and key informants' views regarding the impact of Malta's food and built environment upon children's dietary and PA behaviour respectively. Findings suggest that Maltese children have limited opportunity to be active within their neighbourhood while unsupervised, and that this situation is compunded by parental concern regarding traffic hazards and general safety. Strategies to reduce motorized traffic, improve infrastructure for active transport, and enhance availability of, and access to, open spaces where children can play are likely to be key to creating an environment that supports children's PA. With regards to the food environment, there is clearly more to be done at policy level in order to make healthy food choices the default choices for children. Numerous strategies can be employed to establish a more supportive, healthier food environment. These include environmental interventions such as regulation of HFSS food advertising on television during peak hours; introduction of fiscal measures to make healthier food options cheaper; more regulation and stricter enforcement of laws or policies that support healthier food choices within and around schools; and educational and behavioural interventions aimed at parents and grandparents in order to avoid the establishment of inappropriate dietary habits at home. The data presented in these articles support the quantitative findings outlined in Research Papers 3-5, and complement the conclusions reported in the contextual analysis. This suggests that triangulation of data was achieved in this research.

7.3.5 Obesity frames

Research Paper 8 provides insight into the framings of obesity by two key stakeholder groups in Malta. Findings indicate that the food industry in Malta has adopted the 'industry playbook' utilised by the industry sector in many other countries. This script promotes a narrative of obesity that revolves around the concept of personal responsibility for one's dietary and physical activity choices. Obesity is presented as a problem affecting a minority of the population that is best addressed through education and an emphasis on energy expenditure. Such a narrative deflects attention away from any industry responsibility for actively promoting unhealthy dietary behaviour among consumers. In contrast, public health actors highlighted the existence of an obesogenic environment (partly described in Chapters 4 and 5 of this thesis), and proposed an obesity frame that shifts attribution of responsibility away from the individual. According to public health, there is a collective societal responsibility to tackle the underlying cause of obesity, that is, obesogenic environmental factors that make healthy behaviour difficult to pursue. While the frames espoused by each sector matched with those reported in the international literature, there was unexpected agreement between sectors regarding the key role of parents in addressing childhood obesity.

7.3.6 Microsimulation modelling

The results of the microsimulation model (Research Paper 9) offer a useful contribution to the policy debate around childhood obesity. They provide modelling evidence of the tangible financial and population health benefits that may be achieved if bold action to address obesity is undertaken. Despite the lack of data on indirect costs of obesity, it became clear that any reduction in population overweight and obesity levels in Malta – even a relatively small decrease of 1% of population BMI – would substantially reduce the health burden of obesity-related disease and healthcare costs over the coming two decades. In particular, the financial savings that can be achieved are ‘low-hanging fruits’ that are likely to be attractive to budget-conscious policymakers in the short term. Future microsimulations will benefit from the inclusion of adult BMI data that is currently being collected within the framework of a third European Health Interview Survey, which will offer a clearer picture of future population obesity trends in Malta.

7.4 Strengths and limitations of this research

7.4.1 Strengths

This research has a number of strengths. It made extensive use of complementary methods to generate new knowledge and strengthen the overall validity of findings. Triangulation of qualitative and quantitative data was sought and achieved, with substantial convergence of findings demonstrated across research papers. All quantitative approaches made use of validated instruments for data collection. Although microsimulation modelling on the health and economic impact of obesity in Malta has previously been carried out [764], model inputs for this thesis were the most up to date data

available, reflecting my access to data sources (through professional contacts) that are not in the published literature and which would not have been easily accessible to other researchers.
The qualitative aspect of my research brought together the perceptions of a wide range of stakeholders from diverse backgrounds, including representatives of the food industry and other sectors in Malta whose views regarding childhood obesity have not previously been investigated. Additionally, the socio-cultural dimension of the obesogenic environment could only be explored and verified through qualitative work, which helped to unpack how environmental factors identified in the contextual analysis actually influence children's behaviour and, hence, risk of developing obesity.

7.4.2 Limitations

Several conceptual and methodological challenges encountered while conducting research also merit discussion. Ultimately, the quantitative data collected during this research was cross-sectional in nature and can only represent the state of the environment as measured over a short period of time. Furthermore, time and resource limitations meant that only a few key aspects of the overall environment that potentially contribute to obesity could be assessed. For example, the broader food environment consists of more than just grocery stores; other establishments such as restaurants and convenience stores also play a role in moderating dietary behaviour. In addition, as mentioned in research Paper 4 (Environmental audit: NEMS-S), when investigating associations between area level deprivation, density of food stores and risk of overweight or obesity among children living in those areas, I was unable to control for other confounders that may mediate this relationship including residential address, socioeconomic background, parental educational level etc. Thus, no causal relationship can be implied from the data, particularly because no longitudinal behavioural or weight outcome data was collected. Additionally, the use of 'locality' to characterise the food and built environment may not have been the most appropriate unit of analysis, as it presumes that children living in these localities are exposed to all potential destinations within that locality. It does not acknowledge children's limited mobility (e.g. due to imposed parental restrictions or distance from origin) or the absence of areas of interest to the child in a particular neighbourhood within that locality. Lastly, one should also keep in mind that due to the relatively small sample size which may have limited study power, all quantitative findings must be interpreted with caution.

ALthough the EURO-PREVOB community questionnaire was shown to be applicable to Malta, those aspects of the built environment that emerged as being important moderators of PA behaviour during interviews and focus groups were not explored in sufficient depth during the environmental audit. For example, traffic count and pavement quality were objectively measured at random locations in each locality, in accordance with the audit protocol. In hindsight, it would have been more useful to assess stakeholders' concerns regarding traffic hazard (a key barrier to unstructured PA identified in this research) in specific neighbourhoods, and then randomly measure traffic count or traffic volume in the streets described as being the most dangerous due to traffic. This might have allowed some insight into what volume of traffic is considered to be 'safe' by children, parents or informants (i.e. a volume of traffic that does not prohibit unsupervised, unstructured PA by children living in these neighbourhoods). Alternatively, a more targeted assessment of the built environment along typical routes used by children, starting from the origin (e.g. home, school) to the final destination (e.g. food store, leisure area) might have been more informative than the broad field audit. More recently, innovative research methods to collect information on children's perceptions of urban risk have been described. One such approach that could be applied to Malta involves participatory mapping, where children identify and mapt out real risk situations – such as streets with heavy traffic – onto geographic information system tools (e.g. Google Earth) [797].

With regards to the qualitative aspect of this research, resource and time limits meant that I could only conduct focus groups with secondary school-aged children attending ten state schools. While recognizing that this might limit the generalizability of the study findings to younger schoolchildren and to those who do not attend state schools, I believe that participants represented a mix of educational and socioeconomic backgrounds, and that findings arising from these focus groups reflect the experienced reality of the environment in audited localities irrespective of age or school.

7.5 Overall contribution of the thesis

This research represents an important step towards addressing the gap in knowledge around potential environmental drivers of childhood obesity in Malta. More specifically, this thesis has made the following contributions to knowledge:

1. This thesis includes the first contextual analysis of environmental factors associated with childhood overweight in Malta. This revealed a dearth of local research on environmental factors that might be associated with childhood obesity

2. It also includes the first objective investigation of the food and built environment carried out in Malta, and the first to explore socioeconomic differences at the locality level. In doing so, it

has highlighted some limitations of the instruments used to collect data, but also opportunities for future research on obesogenic features of the environment

3. Systematically assessed and characterised the extent of children's exposure to HFSS food advertising on Maltese television channels for the first time. This has generated a body of evidence that is currently being used to inform upcoming legislation to implement the EU's Audio-visual Media Services Directive (AVMSD) in Malta

4. This thesis includes the first qualitative analysis of socio-ecological barriers to physical activity and healthy dietary behaviour among secondary school-aged children in Malta. It also illustrates features of an obesogenic food and built environment from the perspective of several stakeholder, including the often neglected perspective of children. Themes emerging from interviews and focus groups support the hypothesis that an obesogenic environment exists in Malta, offering an added layer of depth to the quantitative results outlined above

5. For the first time, framings of childhood obesity by the food industry and public health sectors in Malta are explored, highlighting differences and similarities between the narratives espoused by these two key stakeholders groups and outlining parallels with frames reported in the international literature

6. Contributed to the international evidence base through a comprehensive overview of systematic reviews of environmental interventions to prevent childhood obesity. This also investigated primary studies included within reviews to provide information on the effectiveness of these interventions to policymakers. Findings are presented to policymakers in Malta and elsewhere as an easily accessible, comprehensive manuscript

7. Provided policy-relevant data on the future health and economic burden of unchecked childhood obesity, and offered robust information regarding the cost savings and reductions in disease incidence that might be achieved should mean population BMI decrease. Additionally, the model evaluated the potential impact of an SSB tax - a current 'hot' topic with significant policy relevance – on the prevalence of obesity, representing the first such application of microsimulation modelling to Malta

These results have numerous policy and research implications, and these are outlined in more detail below.

7.5.1 Implications for policy

Tackling childhood obesity is a tempting objective for policymakers, partly due to its long term health and economic consequences, but also because children are perceived to be vulnerable individuals who lack the ability to make autonomous behavioural decisions [268]. There is substantial literature supporting the need for broad systemic change to address obesity [38,501]. Addressing the obesity epidemic is likely to require bold action to transform the current obesogenic landscape into one which facilitates healthy choices, and many of these measures involve changes in physical environments, public policies, or organizational practices [798]. Yet, despite our evolving understanding of the causes of obesity, the traditional bio-medical perspective is still the norm in Malta. In section 3.4 Policy response to obesity in Malta I describe how health education, health promotion and clinical treatment remain the mainstay of current anti-obesity policy in Malta thus far [80,799]. Just 14% (3 out of 21) of current initiatives related to food and nutrition in Malta ('Annex 3: Current Initiatives for Food and Nutrition in Malta' in the FNAP [110]) can be classified as being environmental in nature. These are the EU School Fruit Scheme, the EU School Milk scheme, and the introduction of Farmers' Markets in certain localities. The remainder (n = 21) are either treatment programmes (e.g. weight management programmes) or educational/behavioural public health interventions (e.g. national campaigns aimed at raising awareness on healthy eating; parent-craft classes; breastfeeding walk-in clinics; community outreach campaigns to teach cooking skills etc.). Such efforts primarily aim to modify behaviour to restore energy balance, despite evidence showing that education alone is not very effective at altering individual behaviour.

Sustained advocacy by public health practitioners is likely to be required to promote a socio-ecological perspective of obesity among policymakers and politicians across all political parties, since even well-intentioned policymakers face considerable challenges to implementing a more ecological approach to tackling obesity. [800] These include lack of communication across different governmental sectors (political 'silos'), unpredictable funding allocation, vacillating public opinion about what environmental interventions are deemed to be acceptable, and ideological fears regarding what may be perceived as governmental overreach to influence people's behaviour or restrict choices [725,800]. Yet there are also opportunities to be grasped. Policymakers should aim to become 'policy entrepreneurs' and take advantage of the upcoming 'policy window' (see section 2.1.2.2 Multiple Streams Approach) in order to catalyse efforts to address childhood obesity. Policy windows define the context within which policy is made, and it is possible that the next two to three years will provide a unique opportunity for public health professionals in Malta to push for policy that focuses on distal, upstream environmental interventions to tackle population obesity. Crucially, childhood obesity will be a key theme of Malta's six-month presidency of the EU, due to start on January 2017. There is more awareness of and debate around Malta's burden of obesity than ever before, and more accurate data on food consumption and childhood obesity prevalence is due by 2018. Governmental entities such as the Ministry of Education and the Ministry for Health are demonstrating increased cooperation in the implementation of initiatives to tackle obesity [301,332]. Potential actions have already been tentatively identified in the national obesity strategy and Food and Nutrition Policy and Action Plans [80,110]. These include assessment of the feasibility of introducing fiscal measures to tackle obesity which have already been implemented – or are about to be implemented – elsewhere (e.g. tax on sugar-sweetened beverages in Mexico [778,793] and in the United Kingdom (UK) [763]). In addition, a recent bill to counteract obesity proposed by a member of the Opposition which was enacted into law on 15th January 2016 [337] suggests that political cross-party consensus is possible on policy direction is achievable. Unfortunately, there is no formal coalition of interest groups advocating for policy change around obesity in Malta (such as the 'Action on Sugar' interest group in the UK) as yet. However, the empowerment of local grass-root coalition groups in recent years and their vociferous contribution to the debate around issues as diverse as spring hunting and urban planning offers encouraging prospects for a similar process to happen around obesity [801]. Crucially, the next Maltese general election must be held by not later than June 2018, representing another feature of the political stream that may be manipulated by public health officials. As an experienced Maltese policymaker stated during an interview:

> *"… [One should not] take drastic measures on the eve of the elections. You have to time your interventions. You would not go to a politician with something critical or major - that will cause a fuss…2 weeks before an election. You'd be crazy to do it. But if you have [a policy] which is really tough, you'd push for it soon after an election, when the government will have the guts to do it. But the more time passes [the less chance of being successful]….politicians have a five-year term, so to them long-term means five years."*

7.5.1.1 Evidence Based Policy Making: the challenges of translation

The implications are clear: there is no time like the present. Efforts should be made to take advantage of the converging 'streams' [48] within the policy process in Malta to translate knowledge into effective action. However, translating evidence into policy is often a challenging process. As indicated in Research Paper 2 (Overview of systematic reviews), the hypothetical policymaker intent on applying a socio-ecological approach to address obesity will require evidence to explain why such action is needed, to help determine what actions to implement and evaluate, and possibly to counter criticism from opposing stakeholders. Ideally, relevant evidence would be readily available to respond to these needs, yet this is not always the case. An interview with a prominent health policymaker in Malta conducted during this study illustrated the thinking that currently characterises policy making within the health sector. I had asked this individual about what I perceived to be shortcomings in the national obesity strategy [80], namely, the absence of stringent evaluation criteria for measures outlined in the strategy and the sparsity of concrete 'upstream' environmental interventions (including fiscal or legislative approaches, some of which are likely to be politically controversial) to tackle obesity. The reply I received reflected international calls for more evidence to inform decision-making [802,803] and indicated a need for more high-quality evidence that would lay the groundwork for unspecified targeted action in the future:

> "*We try to be evidence-based in everything we do...We are waiting for the evidence to show us what is really happening. At the end of the day, we will do what we have to do. But this is a step-wise approach: first we should have the evidence, then we'll talk about it…These are the steps that need to be taken to make our solid case…not based on conjecture or hearsay. Let us see what is really going on and why. When we can zero in on three or four culprits, then we can speak to industry, once we have evidence*." *[Ministry for Health]*

Initially, I perceived this comment as a convenient way of deflecting the question, perhaps a symptom of political unwillingness to act in ways that may be unpopular with the voting public, or a reluctance to assume responsibility for implementing environmental interventions that have been shown to be effective. However, upon further reflection, I came to the conclusion that it is more likely to be an expression of the evidence-based policymaking (EBPM) movement. EBPM traces its origins in the field of clinical medicine towards the end of the last century, and is based on the concept that medical decision-making benefits from being underpinned by the best available research evidence, rather than unsubstantiated anecdotal observations or beliefs [804,805]. The movement arose following a realisation that clinicians resisted the adoption of treatments that were proven to be superior to past practices, and amidst calls for increased accountability and transparency in clinical practice [806]. Evidence-based medicine has gradually become the dominant paradigm for healthcare, characterised by the establishment of a hierarchy of evidence where randomised controlled trials (RCTs) and systematic reviews are considered to be the gold standard of scientific research [807]. Gradually, the evidence-based medicine approach expanded beyond medicine into other areas, including public health [808,809]. However, within the sphere of public health, multi-component interventions carried out on large populations contrast with the relatively narrow focus of clinical medicine, where short-term clinical interventions are carried out on specific populations. Thus, RCTs and traditional systematic reviews may not be the appropriate methods to determine the best way to address public health issues that are usually embedded within broader policy contexts [810].

While there have been repeated calls promoting rigorous, relevant science as a necessary component of effective health decision-making [811–813], these have not necessarily been translated into practice [364]. Furthermore, research in the UK has suggested that government may make highly selective use of the public health evidence presented to it [814,815]. Reasons for this research-policy gap – and ways in which they can be overcome – have been the focus of some research in recent years [816–818]. EBPM has been described as a vague, aspirational term that can be interpreted in multiple ways, rather than as a policy process in and of itself [819]. Indeed, rather than there being a direct link between evidence and policy outcomes, policy (including public health policy) is known to be profoundly influenced by the context within which the decision-making process occurs [820], hence the lack of contextual information in reports of intervention evaluations and systematic reviews is lamentable [810,821]. Crucially, failure to produce and provide access to relevant, reliable and clear research findings have been shown to limit policymakers' use of research [364,822]. On the other hand, research is likely to have more impact on policy if strong links and ongoing collaborative relationships are forged between researchers, advocates and policymakers; when knowledge exchange is incentivised; and if efforts are made to ensure that relevant, clear research is disseminated and easily accessible to policymakers [813,823]. This may be an advantage for small countries like Malta, where the demarcation between public health policymakers and researchers may be blurred as experts take on roles in both spheres. Thus the Maltese policymaker's call for more EBPM around obesity may be justifiable from a political perspective, since effective environmental measures to tackle obesity are likely to be politically sensitive or controversial. However it also means that there is a dire need for more research on the obesogenic environment that exists in Malta in order to provide contextually relevant data upon which to base policy. It is my hope that the data arising from this research responds to this need, and that policymakers will take advantage of the upcoming 'policy window' described earlier to make judicious use of this evidence and take bold, innovative steps to address childhood obesity using an ecological approach. I decided to publish my findings in 'paper-style thesis' format partly following consideration of the recommendations for increasing the use of research in policy and practice outlined above [823], including the provision of relevant, timely and actionable research that is easily accessible to policymakers (i.e. in the form of peer-reviewed articles rather than in typical dissertation format).

In spite of these challenges, it is encouraging to see that some of the effective interventions identified in the overview of systematic reviews reflect those proposed within the national obesity strategy [80] (*Appendix 1*) and the Food and Nutrition Action Plan [110], and are currently in the process of being implemented nationally. These include the introduction and enforcement of school nutrition policies [332]; banning of HFSS food in school canteens [332]; provision of free water in schools [110]; increases in opportunities for PA during the school day through increased number of PE lessons; and organization of formal PA sessions after school [680]. Outside of the school arena, environmental interventions to reduce screen time and sedentary behaviour (such as through the installation of TV time managing devices) and replace SSB consumption with zero-calorie alternatives were identified as being among the most effective interventions in the overview of reviews. The national obesity strategy briefly touches upon behavioural (as opposed to environmental) strategies to reduce screen time (Appendix 1), and recommends embarking upon feasibility studies to assess the potential impact of fiscal measures on foods and drinks. However, little information on who is responsible for conducting these studies, scale, timelines etc. is available in the document. Nor are the food and beverage products under consideration explicitly identified, suggesting that such interventions are not being seriously considered at this stage.

7.5.2 Implications for research

In the previous section I point out that Maltese policymakers' call for more evidence prior to implementing a soft drink tax suggests a need to generate more knowledge about the environmental drivers of childhood obesity in Malta, in order to provide contextually relevant data upon which to base such policy. Policy recommendations to tackle childhood obesity may not be appropriate if prevailing cultural, political, economic and physical contexts are not taken into account. Thus, relevant research around these areas is important in order to develop an appropriate policy response to obesity in Malta [233]. In addition, research needs to be aligned with the needs of public health policymakers [798]. Gaps in the research that need to be addressed in order to improve our understanding of the links between the environment and obesity in Malta have been highlighted throughout this thesis. Below are some of the areas that I believe would particularly benefit from further study:

1. Assessment of the extent of policy implementation on food environments by the Maltese government in comparison with international best practice using the "Food Environment Performance Index" (FOOD-EPI) developed by INFORMAS [824]. The index aims to systematically

score country actions to support and encourage healthy food choices, and comprises a policy component with seven domains on specific aspects of food environments (food composition, labelling, marketing, provision, retail, prices and trade), as well as an infrastructure support component with six domains (leadership, governance, funding and resources, monitoring and intelligence, platforms for interaction and health-in-all-policies). This assessment has already been carried out in New Zealand [824] and in the UK (data under analysis)

2. Analysis of obesity-related (e.g. nutrition, PA) policy documents using systems-oriented [825] or socio-ecological [826] frameworks to assess the direction of obesity policy in Malta, together with a review of the quality of evidence underlying current policy recommendations as has been done for the UK [814]. This exercise would identify areas where obesity policy can be improved.

3. Media analysis to explore the framings of obesity in Maltese newspaper and online articles using established approaches [827]. This may contribute to a broader understanding of the wider public debate around obesity, and provide useful information on the current state of obesity perceptions among the public.

4. Public opinion surveys to gauge the level of support for current obesity policy, and to increase public support for environmental obesity prevention policy [312,313].

5. Research on the obesogenicity of the school environment (e.g. tuck shops, canteens) in all secondary schools in Malta, using an instrument that has already been successfully applied in New Zealand [828]. This will be supplemented by observational data on food availability obtained during visits to schools, and by purchasing data provided by tuck shop owners.

6. Behavioural PA research: the use of accelerometer and GPS data that objectively assesses children's PA in their neighbourhood could be linked to 'virtual' audit data that assesses obesogenic characteristics of the built environment [61]. This in turn would allow researchers to clarify the links between neighbourhood features and PA patterns, identifying which built environment characteristics promote or inhibit PA in children. If conducted in neighbourhoods that have pedestrianised streets, roads with a low speed limit, or cycling lanes, such research would provide invaluable data on the impact of low traffic and walking/cycling-friendly infrastructure on children's PA behaviour, potentially supporting built environment interventions to reduce the dominance of motorized transport and facilitate active transport.

7. Continued involvement in INFORMAS and participation in modules such as those intended to monitor the food and beverages sold in public and private institutions, and the monitoring of health-related labelling of food and non-alcoholic beverages sold in retail settings [68,235,829].

7.6 Reflections on the use of the socio-ecological model, and the next step: opportunities for using a systems approach

Socio-ecological models of obesity consider economic, cultural, physical and political dimensions of the environment and examines the influence these exert upon individual energy balance [182]. They advocate that solutions to the obesity epidemic should combine individual approaches with shaping the environment to support healthy choices [13,28]. Applying a socio-ecological model proved to be a useful framework within which to identify and describe factors contributing to childhood obesity in Malta. However, the model has some limitations. Despite presenting obesity as being inherently complicated, obesity is still framed within a relatively reductionist, linear framework. Environmental dimensions and levels are identified and examined in relative isolation, without addressing h ow the different levels influence each other and whether this interaction influences overall obesity outcomes. Thus, despite a growing awareness of the importance of examining the interactions between these environmental factors, the socio-ecological model offers a relatively 'siloed' way of looking at obesity. It also does not provide information on what can be done to address childhood obesity (i.e. what is the optimal combination and sequence of interventions to bring about sustained impact at population level?).

As our understanding of obesity matures, systems thinking has emerged as a promising complementary approach to obesity prevention [830]. Here, obesity is presented as a 'complex adaptive system' that that does not fit neatly within narrowly defined cause-and-effect boundaries [768], and which requires a paradigm shift in thinking if it is to be effectively tackled [799,825,831,832]. It is only when a complex system perspective is applied that connections and relationships between the environmental factors, actors and sectors contributing to childhood obesity start to become clear. A system approach builds upon the acknowledgement of contextual and cultural influences stipulated by the socio-ecological model, but goes beyond simply describing factors and interventions that may influence obesity. It promotes an understanding of how interventions interact with their context and with each other [825,833]. In the following section I will briefly discuss the application of 'systems science' thinking to Malta's childhood obesity problem as a promising avenue for exploration. The diversity and range of interconnections between factors related to obesity in Malta are outlined, using data from this research to help frame and reflect the heterogeneity of this complex system.

7.6.1 Systems Science

Systems science suggests that a complex system is composed of an intricate network of heterogeneous elements. These interact and combine at multiple levels to produce overall behaviour that cannot be broken down into merely the actions of its individual components [46]. Elements include individual agents, larger organizational entities such as corporations and governments, smaller biological units such as cells and genes, as well as structural elements such as the urban design and infrastructure [834]. The diverse constituent elements are autonomous and operate individually at the local level, yet they are also interdependent within and across levels, so that small changes to a single component may produce profound unintended changes in other areas or systems which are difficult or impossible to predict (emergence) [835]. Complex adaptive systems are characterized by feedback and non-linear dynamics resulting from positive or negative feedback loops in the system, where small actions may be amplified to result in large effects, whereas large actions may be dampened to have smaller effects than expected. Thus, a system may remain relatively stable for long periods of time, only to shift to another stable yet distinct state following a disturbance that pushes it beyond a particular threshold [834]. This is true for both individual weight gain as well as population weight gain or loss, and is further complicated by the inherent time lag between applying any intervention and obtaining results [835]. In 2007 the Foresight group developed an Obesity System Map (Figure 21) that visualised characteristics of the complex system related to obesity [836]. The Map highlights how multiple interconnections between system characteristics, including those lying outside of the energy balance equation, may indirectly influence obesity prevalence. It encompasses a large number of diverse components ranging from genetic factors and individual psychology to food pricing and availability. It illustrates interdependencies as well as numerous feedback loops between component variables, and highlights how modifying one part of a system may have unintended consequences in other areas of the system [799]. For example, food choices are influenced by food prices, availability, labelling, cultural values around food and by biological responses to food [837]. Evidence suggests that treating obesity in a reductionist manner as a simple biomedical problem of energy imbalance has met with limited success [799] because external contextual forces often place eating and exercise behaviour beyond an individual's rational control [837,838].

Systems-oriented approaches provide an organized conceptual framework whereby the complexity of obesity drivers at multiple levels and domains can be addressed and integrated dynamically to understand the functioning of the obesity systems as a whole [833]. Systems thinking has important implications for policymakers because it permits the identification of new leverage points to tip the obesity system into a more favourable configuration. It also highlights the fact that the solution to the obesity epidemic lies in policies and interventions that alter the context around obesity [38,768,837]. These contextual factors, in turn, are likely to be environmental in nature and scope.

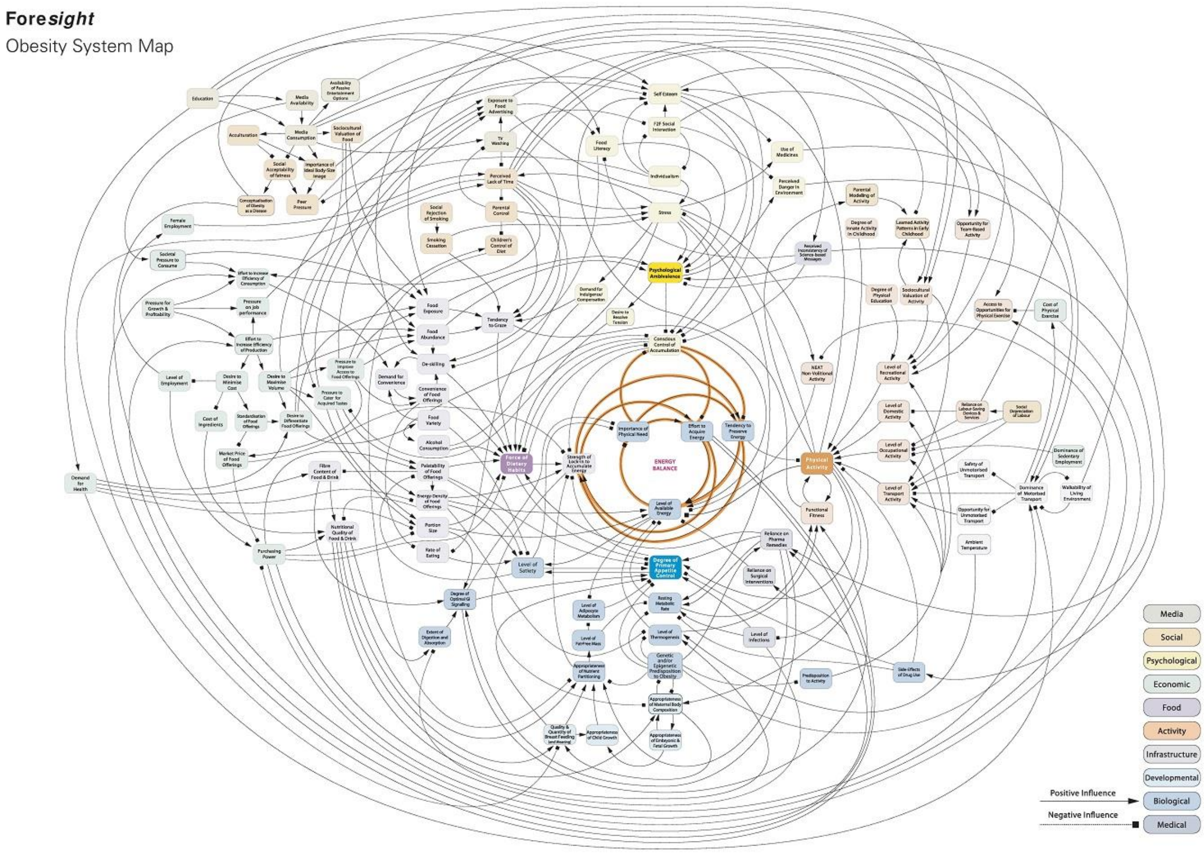

Figure 21. Foresight Obesity System map

7.6.2 Systems approach to addressing childhood obesity in Malta

I became aware of the literature around application of systems science to obesity relatively late into this research, but it was immediately clear that complex systems thinking and the socio-ecological model are complementary, mutually supportive approaches to conceptualising and addressing childhood obesity. As discussed in the previous section, the systems approach focuses on the interconnections across actors, factors and sectors that contribute to childhood obesity [832]. A number of frameworks that help to structure systems exist. Among these, the Intervention Level Framework (ILF) proposed by Johnston et al. [825] presents five points of intervention whereby a system can be influenced (Table 28). Based upon earlier work by Donella Meadows [839], it collapses Meadows' original 12 points of intervention into more mutually exclusive levels to facilitate analysis.

Level	Description
Paradigm	System's deepest held beliefs Source of system's goals, rules, and structures Difficult to intervene at this level but can be very effective
Goals	Targets that conform to the system's paradigm and need to be achieved for paradigm to shift Actions at this level can change aim of the system
System structure	Interconnections between system elements and subsystems Actions at this level will shift the system structure by changing system linkages or incorporating novel elements
Feedback and delays	Allows the system to regulate itself by providing information about the outcome of different actions back to the source of the actions Actions at this level can create new feedback or increase gain around existing loops
Structural elements	Subsystems, actors, and physical elements of the system Easiest level at which to intervene Many actions at this level are usually required to create system-wide change

Source: Meadows D 2008, adapted by Johnston et al 2014 [825]

Table 28. The Intervention Level Framework

Adopting a systems approach (possibly using the ILF) to describing and addressing childhood obesity in Malta would not just identify the policy, cultural, economic and physical environmental factors that contribute to this public health problem. It would also provide a structural framework for the integration of childhood obesity prevention and management by revealing the underlying inter-relationships between system variables and outcomes, representing the next logical step towards effectively tackling obesity. A systems approach takes into considerations the role of different sectors on obesity, and considers influences at many levels including the global, national, community, household and individual levels. For example, excess sugar intake has been linked to the growing obesity epidemic [523]. Research Paper 1 (Contextual analysis) shows that Malta's per capita supply of sugar is the highest in the EU (Figure 8) and among the highest in the world (FAOSTAT 2013 [253]). This suggests that sugar could be a major source of calories in the Maltese diet [238]. Among other factors, the amount of sugar in population diet is influenced by agricultural policies such as the EU Common Agricultural Policy (CAP), which to a large extent determines the price and availability of sugar produced in Europe. Until recently this has been a highly protected sector under CAP, keeping sugar prices relatively high. In 2013, CAP reform liberalised the EU sugar market, leading to the abolition of sugar quotas in 2017 [840]. This is expected to drastically reduce sugar prices and increase production, giving the food industry a financial incentive to incorporate more sugars into a broader range of processed products [841]. Thus, while international institutions and national public health bodies such as the WHO such and UK's Public Health England adovate for drastic reductions in levels of sugar consumption and product reformulation to lower food sugar content [523,842] , these reforms will lower the cost of sugar to the food industry in Malta and the rest of the EU. From a systems perspective, this represents a clear misalignment of food system policies with public health objectives that is likely to have a negative impact on population nutrition and obesity prevalence in Malta.

At a national level, the regulation of HFSS food advertising to children on local television channels is being actively discussed (see Research Paper 3). From a system perspective, exposure to food advertising in the '*Social Psychology*' sector of the Foresight Obesity Map [836] may negatively influence '*food literacy*' and result in '*psychological ambivalence*' towards food (in the *'Individual Psychology'* sector). This may lead to a dampening of '*conscious control of accumulation',* potentially resulting in over-consumption of food and disturbing energy balance. At the micro-level, other interactions between system variables may be elucidated. For example, within the *'Activity Environment'* sector, two variables have a positive impact on an individual's level of recreational activity and overall PA levels (i.e. on the *'level of recreational activity'* variable within the *'Individual Physical Activity'* sector). These are *'opportunity for team-based activity'* and *'access to opportunities for physical exercise'.* Conversely, the variable *'dominance of motorised transport'* negatively influences safety of, and limits opportunities for, non-motorised transport. It also reduces the walkability of the living environment. These interactions in turn reduce level of transport activity and overall PA levels (*'level of transport activity'* variable in the *'Individual Physical Activity'* sector).

Sociocultural elements may also play a role in the obesity system. A number of informants interviewed during this research expressed concern at the 'normalization' of childhood obesity in Malta, suggesting that changing social norms have made overweight and obesity in children more socially acceptable. There may be just cause for this concern, as studies have shown that obesity may spread through social networks in a pattern that is dependent on an individual's social ties, independent of environmental factors [843]. Agent-based modelling carried out in the US has also indicated that high BMI in children may lead to increased greater social acceptability of elevated child BMI. In turn, this feeds back into the system, creating a situation where a continuously increasing population BMI becomes more likely [844] whereas societal discrimination against the obese may decrease.

Linkages and feedback between variables (and between sectors) are important determinants of dynamics in the obesity complex system. This was clearly illustrated during an interaction with children during a particular focus group session. During auditing of the locality where these children resided, I had recorded the presence of a gated, publicly accessible five-a-side football pitch set in the middle of a large sandy beach. Both the beach and the football pitch seemed to be ideal settings for PA, and I assumed that children in the area made regular use of the ground for sports. I had also noted several other playing fields and public open spaces in this particular locality. However, while discussing resident children's perceptions of barriers to PA in this locality, numerous challenges faced by children seeking to be active emerged. In this particular instance, the fence around the five-a-side football pitch had apparently been vandalized, and the enclosure was consequently locked up by the local council (refer to Research Paper 7 – Barriers to PA). Children who had previously made extensive use of the pitch to play football reported that they were unable to find alternative sites where they could play. Upon asking what appeared to be the obvious alternative - *Why not play football on the sandy beach?* - I was presented with numerous reasons about why this was not a suitable option:

> *Focus group leader: How about playing on the sand?*
> *Student: [express disgust] No! It's silly! Sometimes the goalposts are not the same size, and the ball doesn't bounce properly. It's not fun. And it's difficult to run too…sometimes sand can get in your eye, and the ball can get kicked into the sea.*
> *Student: And sometimes there would be syringes in the sand.*

This last statement was unexpected. It demonstrated how a researcher with little or no knowledge of the specific context around a particular behaviour (in this case, a reluctance to engage in PA outside of the football pitch) might remain unaware of environmental interactions leading to such behaviour unless active effort is made to understand these contextual factors. Clearly, the mere presence of spaces where PA can potentially be performed does not necessarily imply that such spaces can be used for this purpose. Furthermore, before actually speaking to children with first-hand experience of the context around this particular football pitch, I had assumed that children living in this neighbourhood were privileged in that they had access to ample opportunities for PA.
Further discussion about the ramifications of the football pitch closure was also illuminating:

> *"Since we can't play in the ground, the only thing we have to do at home is homework, so what else can we can do [besides playing video games] once we finish it?"*

Not only did the local council's decision to close the football pitch – an environmental policy factor lying outside the children's direct control – reduce their opportunity to perform team sport and engage it PA; it also led to '*Psychological ambivalence*' (a variable in *'Individual Psychology'* sector of the Foresight Obesity Map) about performing PA and resulted in increased sedentary behaviour. Other interactions emerged clearly from this research. Heavy traffic on roads in Malta is possibly due to an absence of policies or regulations that limit car use, together with socio-cultural drivers promoting car ownership and motor transport as described in Research Papers 1 (Contextual analysis) and 7 (Barriers to PA). This negatively influences safety of, and limits opportunities for, non-motorised transport such as cycling and walking. As illustrated in the Foresight Map, the variable '*Dominance of motorised transport*' also has a detrimental effect on the '*Walkability of living environment*', which in turn is likely to influence *'Sociocultural valuation of activity'*. Potential interactions between the food environment and individual dietary habits were also explored in this research (Research Paper 6). For example, many of the variables in the '*Food consumption*' and *'Social Psychology'* sectors of the Foresight map emerged as themes in this thesis, including a positive '*sociocultural valuation of food*'; common *'availability of passive entertainment options'* such as playing video games; *'social acceptability of fatness'* among parents of young children; and significant '*exposure to food advertising*' on television (Research Paper 3 – Television advertising). These factors impact energy balance and contribute to a child's risk of developing obesity.

The complexity of obesity has important implications for obesity policy and the design of effective interventions to reverse current trends [834]. Multiple determinants of obesity that exert their influence across myriad sectors and domains need to be addressed simultaneously, using an approach that takes into consideration the broader obesogenic environment within which individual decision-making occurs [7,182,825]. Recognizing and characterising the diverse elements that contribute to the obesity system is crucial [832]. The heterogeneity of the system's actors and subsystems, actors' goals and motivations, and the non-linear nature of interactions within the system make it difficult to shift overall system balance at population level in the desired direction [832]. Simple solutions targeting individual behaviour address only a minute fraction of the variables involved, and thus are unlikely to have much effect on the system as a whole [799]. On the other hand, this very non-linearity and the presence of feedback loops mean that small, focused changes at micro-or macro-level may have large impacts on the system which 'tip' it into a more desirable state [832]. Thus, childhood obesity solutions for Malta should include a combination of behavioural interventions to influence energy balance among individuals, structural environmental actions to support this approach at population level, and measures to shift social norms [38]. Encouragingly, there are signs that the obesity system in Malta may have reached a critical state of readiness for change. In part, this may be due to increasing concern about the projected health and economic burden of childhood obesity which threatens the economic viability of the national health care system (Research Paper 9 – Microsimulation modelling). To a certain extent, the areas for action presented in the 2012 national obesity strategy [80] indicate that a gradual shift in the overall governmental approach to tackling obesity is taking place. Several macro and micro-level policies, regulations and other ecological interventions are outlined in the strategy although most of these measures have not yet been implemented (see Appendix 1).

Systems thinking needs to be promoted at policy level in order to emphasise the need for environmental measures that 'tip' the obesity complex system towards a less obesogenic state. Broad, systemic changes to address and prevent obesity should be urgently examined and implemented. Policymakers are encouraged to make judicious use of empirical evidence arising from this thesis and from other sources to adopt a systems approach that complements the socio-ecological model of obesity prevention [825].

7.7 Conclusion

This research study has illuminated some of the myriad environmental factors which may influence children's dietary, sedentary and physical activity behaviour in Malta, demonstrating the existence of an obesogenic environment. Across several research papers, I have illustrated a need to urgently address obesity using a microsimulation modelling approach (Research Paper 9); highlighted opportunities for modifying the obesogenic environment in Malta by characterising certain key features (Research Papers 1 and 3 through 5); explored how the obesogenic environment influences children's dietary and physical activity behaviours (Research Papers 6 and 7 respectively); identified framings of obesity that may have policy relevance (Research Paper 8); and comprehensively reviewed environmental interventions that have been shown to be effective at improving weight outcomes among children (Research Paper 2). Lastly, this thesis has also highlighted the value of applying a socio-ecological approach to understanding and addressing obesity and led to the identification of areas for future research, including the application of systems thinking to obesity.

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Appendix 1 – Healthy Weight for Life Strategy: Areas for Action

Research actions	Type of study	Category	Aim	D/PA/SB
Explore variations in the availability of shops selling fast foods and vendors selling fresh fruit and vegetables	Observational	Evidence generation	Prevention	D
Feasibility and analysis of the potential impacts of subsidies/taxes on specific foods and drinks (impact on behaviour and income redistribution)	Feasibility	Environmental	Prevention	D
Feasibility of incentives to increase the availability of healthy food outlets (eg. smoothie bars, fresh fruit and vegetable salad bars), and restrictions related to outlets selling fast foods	Feasibility	Environmental	Prevention	D
Feasibility of providing a regular healthy breakfast to all kindergarten children	Feasibility	Environmental	Prevention	D
Feasibility of regulatory measures to restrict children's access to nutritionally inappropriate meals/snack foods from retail outlets located in the vicinity of schools	Feasibility	Environmental	Prevention	D
Measure primary and secondary students yearly and ensure monitoring and appropriate referral for overweight and obese children, and regular communication and lifestyle advice and help for the family	Surveillance	Evidence generation	Prevention	N/A
Carry out a health technology assessment and assess the feasibility of including bariatric surgery on the list of services available from the public health care sector	Feasibility	Treatment	Treatment	N/A
Non-research actions	**Env. dimension**	**Category**	**Aim**	**D/PA/SB**
Set up a Task Force to develop action plans on the introduction of agreed mechanisms to reduce salt and sugar, limit saturated fat and eliminate trans-fat content in local food products	Policy	Environmental	Prevention	D
Complete the revision of the Malta Food and Nutrition Policy	Policy	Behavioural, Environmental	Prevention	D
Establish Mater Dei Hospital as a recognised baby-friendly hospital which promotes exclusive breast feeding	Policy	Behavioural, Environmental	Prevention	D
Adopt the HELP document as national policy and ensure its implementation and monitoring within all schools	Policy	Behavioural, Environmental	Prevention	D/PA/SB
Set up a Healthy Food Scheme using colour coding so that healthy food is easily identifiable to the population	Policy	Environmental	Prevention	D
Work towards the clarity of labelling on food and drink products such that the content of products is clear and easily understood by consumers	Policy	Environmental	Prevention	D

To tighten legislation on alcohol advertising and improve the enforcement of restrictions on the sale of alcohol to children and adolescents	Policy	Environmental	Prevention	D
Introduce national guidelines on food provision within canteen/cafeteria facilities at workplaces which will promote less high-energy dense foods and more healthy options that are low in fat, sugar and salt	Policy	Behavioural	Prevention	D
Introduce regulations to ensure that all canteens and cafeterias within institutions, hospitals and homes for older people are in line with healthy dietary guidelines	Policy	Environmental	Prevention	D
Enhance Physical Activity through national policies that target changes in a number of sectors thereby promoting physical activity both for relaxation as well as for everyday activities	Policy	Unclear	Prevention	PA
Develop a National Physical Activity Action Plan	Policy	Behavioural, Environmental	Prevention	PA
Revise the national curriculum to include at least 30 minutes of daily Physical Activity during official school hours to be increased to 3 hours per week by 2015	Policy	Environmental	Prevention	PA
To transform school yards and recreational areas to facilitate the uptake of physical activity during breaks	Physical	Environmental	Prevention	PA
Update and monitor the implementation of healthy dietary guidelines for use in homes for older people to ensure a good range of products and food portion sizes that provide an adequate balance of nutrients	Policy	Environmental	Prevention	D
To issue guidelines on messages to be delivered in weight management courses carried out in both the private as well as the public sector	Policy	Behavioural	Prevention	D/PA/SB
To ensure that only persons certified as having received the relevant training in their field of activity provide such a service to the people	Policy	Environmental	Prevention	D/PA/SB
Promote healthy meals/snacks during extracurricular school activities such as fund-raising activities, school bazaars, sports days, etc	Socio-cultural	Behavioural	Prevention	D
Encourage media service providers to develop codes of conduct regarding inappropriate audiovisual communications on foods and beverages, accompanying or included in children's programmes	Policy	Behavioural	Prevention	D
Educational/Promotion	**Env. dimension**	**Category**	**Aim**	**D/PA/SB**
Promote exclusive breastfeeding for at least six months and continued breastfeeding in the first years of life together with appropriate complementary foods	Socio-cultural	Behavioural	Prevention	D

Provide educational programmes on maternal and infant nutrition (including breastfeeding) for health professionals	Socio-cultural	Behavioural	Prevention	D
Provide more education and support to pregnant women through augmented parentcraft courses on breastfeeding techniques, infant weaning and healthier lifestyles for themselves and their families	Socio-cultural	Behavioural	Prevention	D
Develop clear guidelines for parents and carers on the age-appropriate content of lunchboxes for school-aged children	Policy	Behavioural	Prevention	D
Include more emphasis on the food chain in the PSD, Physical Education and Home Economics curriculum with particular attention to the importance of a healthy balanced diet	Policy	Behavioural	Prevention	D
Use social marketing techniques to promote moderation in food consumption and to work with stakeholders to establish protocols to standardise portion sizes in ready meals and snacks and in food outlets	Socio-cultural	Behavioural, Environmental	Prevention	D
Work with the hospitality industry to enhance the preparation and increase the availability of nutrient-dense healthy meals as attractive and tasty options within their outlets, and increase the options available on children's menus	Socio-cultural	Behavioural, Environmental	Prevention	D
Increase knowledge of children, parents, carers and teachers on the benefits of Health Enhancing Physical Activity (HEPA)	Socio-cultural	Behavioural	Prevention	D/PA/SB
Encourage children and parents to use a screen time log, reduce the number of hours of watching TV, use of computer/video games to not more than 2 hours per day and to encourage sit down meals as family time as opposed to TV Dinners	Socio-cultural	Behavioural	Prevention	SB
Enhance awareness of shared spaces on roads to allow safe use by cars, bicycle users and pedestrians	Socio-cultural	Behavioural	Prevention	PA
Ensure the inclusion of persons living with disability in physical activity opportunities	Socio-cultural	Unclear	Prevention	PA
To raise awareness on the importance of physical activity on the health status of the individual among health professionals	Socio-cultural	Behavioural	Prevention	PA
To establish partnerships with sport organisations to increase awareness on the role of nutrition and physical activity on healthy lifestyles and provide sessions of enjoyable physical activity which are available to the general population	Socio-cultural	Behavioural	Prevention	PA
To increase the inclusion of knowledge on healthy choices and behaviour change strategies in the initial training and continuing education for all health professionals	Policy	Behavioural	Treatment	D/PA/SB

To strengthen and diversify the provision of up to date advice by the HP&DPD in order to ensure that it is a reputable and easily available resource for the population	Socio-cultural	Behavioural	Prevention	D/PA/SB
To work with stakeholders to encourage active transport action groups e.g. walking bus, cycle to work	Socio-cultural	Behavioural	Prevention	PA
Community/School initiatives				
To set up a healthy lifestyle programme targeting students by the provision of keep fit sessions, talks on healthy foods and weigh in sessions so that students are monitored and provided with support within the school environment	Policy, Socio-cultural	Behavioural	Prevention	D/PA
To roll out the World Health Organisation Nutrition Friendly School Initiative with all state, church and private schools being eligible to participate	Policy, Socio-cultural	Behavioural	Prevention	D
To establish a competition and award on an annual basis rewarding schools for helping children to adopt healthy lifestyles on school premises	Policy, Socio-cultural	Behavioural	Prevention	D/PA/SB
To establish partnerships with the wider community and in association with local councils and NGOs for the provision of more nutrient-dense food and beverage options in the community	Socio-cultural	Environmental	Prevention	D
To set up a Healthy Workplace Scheme, which provides support and incentives for employers to promote healthy eating in the workplace and support weight management programmes	Policy, Socio-cultural	Behavioural	Prevention, Treatment	D
To plan and implement training programmes on healthy eating and physical activity amongst care professionals, thus re-enforcing and supporting patients and residents towards adopting healthier eating habits	Policy, Socio-cultural	Behavioural	Prevention, Treatment	D
To provide opportunities and incentives to encourage NGOs, local councils, schools, workplaces, sports clubs, gyms and the private sector to provide physical activity classes, active play and sports which are both accessible and affordable to the general population	Economic	Behavioural	Prevention	PA
To work towards the improvement of the existing cycle lanes and creation of further networks wherever possible and providing the necessary regulatory structures to ensure their safety	Physical	Environmental	Prevention	PA
To strengthen and expand workplace health promotion initiatives which specially target both nutrition and physical activity	Socio-cultural	Behavioural	Prevention	D/PA
To increase the provision by the HP&DPD of regular and accessible weight management programmes for adults with BMI > 25 in different	Socio-cultural	Behavioural	Treatment	PA

settings, with a particular emphasis on communities with a higher risk				
To enhance HP&DPD – organise regular and accessible physical activity programmes and walking schemes especially for adults with BMI >25 for all ages and in different settings	Socio-cultural	Behavioural	Treatment	PA
To set up cookery clubs at community level and in schools education to provide practical advice on nutrition and healthy eating	Socio-cultural	Behavioural	Prevention	D
To set up specialised multidisciplinary Obesity Clinics in the Primary Health Care sector	Policy, Socio-cultural	Behavioural	Treatment	D/PA/SB
To set up a multidisciplinary paediatric weight clinics	Policy, Socio-cultural	Behavioural	Treatment	D/PA/SB
To support Local Councils and other stakeholders in developing opportunities to complement the national infrastructure for physical activity by providing better walkways built to proper standards, parks, more pedestrianised areas and creatively utilising spaces for physical activity within their locality	Physical	Environmental	Prevention	PA
Widen the existent opportunities of afterschool sports and dance programmes	Physical	Environmental	Prevention	PA
Employer tax incentives to motivate employees to adopt healthier choices	Economic	Environmental	Prevention	D/PA/SB
Use of public spaces so that they can be utilised to maximise the encouragement of physical activity uptake	Physical	Environmental	Prevention	PA
Incentives to promote the uptake of physical activity	Economic	Behavioural	Prevention	PA
Provision of Training				
Support the proposed National Physical Activity Guidelines for school children and young people through initial and in-service teacher training	Policy	Environmental	Prevention	PA
Include health promotion and prevention in undergraduate curricula for all health professionals	Policy	Behavioural	Prevention	D/PA/SB
Provide continuing professional development training in effective health promotion to all health professionals; including regular CPD events specifically dealing with overweight and obesity prevention and management issues, specific training on diet and nutrition, physical activity and health behaviour change	Policy	Behavioural	Prevention	D/PA/SB
Supply health care workers with the necessary resources to encourage weight loss and healthy living; and health professionals to advise people on healthy choices	Policy	Behavioural	Prevention, Treatment	D/PA/SB
Set up post-secondary training courses for care professionals in order to increase the human resource pool in the sector	Policy	Behavioural	Prevention, Treatment	D/PA/SB

Develop a national curriculum and certification for training professionals, facilitators and advisors in the field of nutrition, weight management, and physical activity	Policy	Behavioural	Prevention, Treatment	D/PA/SB
Provide health professionals with guidelines on healthy choices i.e. nutrition, exercise and alcohol, so that a uniform and coherent message is communicated	Policy	Behavioural	Prevention, Treatment	D/PA/SB
To ensure that health professionals proactively screen for and manage risk factors associated with overweight and obesity	Socio-cultural	Behavioural	Prevention, Treatment	D/PA/SB
To increase the complement of registered nutritionists and dieticians and recruit food community workers	Policy	Behavioural	Prevention, Treatment	D/PA/SB

* HP&DP = HP&DPD

Appendix 2 - EUROPREVOB

EURO-PREVOB Policy Analysis Tool

The EURO-PREVOB policy analysis tool consists of:

Part A. Glossary of terms

Part B. Policy checklist made of four thematic sections:

1. Food environment
2. Natural and built environment
3. Maternal and young child health services
4. Schools

Part C. Community questionnaire

1. Food environment
   - **a. Community survey** (CURRENT DOCUMENT)
   - **b.** McDonalds
   - **c.** Television advertising
2. Built environment

This questionnaire will be filled in by EURO-PREVOB local project coordinators (and their research teams), in Bosnia and Herzegovina, Czech Republic, France, Latvia and Turkey using direct observation.

Note:

Fieldwork manuals provide details of the methods that should be used to organise and conduct the pilot process of the policy analysis tool, and to gather information using the EURO-PREVOB policy analysis tool.

Date data collected : _____/_____/200__ (dd/mm/yy) **Fieldworker1: |__|__|** **Fieldworker 2: |__|__|** **Area code |__|__|__|__|__|**

COMMUNITY QUESTIONNAIRE ON THE FOOD ENVIRONMENT

Food environment of the neighbourhood

Detailed list of shops selling foods

Before setting out to do this portion of the survey, please ensure that you have with you:

- ❑ One clipboard each
- ❑ The map of the area being surveyed and the planned walking route
- ❑ The fieldworker manual (you should have reviewed the definitions and methods before starting the survey).
- ❑ Your official badge clearly pinned onto your clothes
- ❑ The letters and information sheet for shopkeepers in a plastic envelope.
- ❑ A mobile phone (for safety).
- ❑ A blue ink pen each
- ❑ An extra layer of clothing [supermarkets are air-conditioned / refrigerated]

Go to the start point and proceed as follows:

1. One fieldworker should fill in the questionnaire while the other one should locate the shops on the map.
2. You should come to an agreement when filling in all parts of the questionnaires. If an agreement is difficult to reach, this should be included as a comment on the data collection forms, and as a comment on the process evaluation form.
3. Enter the **address/description of the start point** and the **start time** below.
4. Following the planned walking route, identify all shops selling any type of foods or beverages (you may need to enter in the shop to verity).
5. Using a BLUE ink pen, locate each shop selling food on the map and indicate its number.
6. Select what type of shop it is (see "EURO-PREVOB Glossary").

7. If the shop is a FOOD STORE and not a restaurant, assess whether the shop sells any fresh fruit, fresh vegetables, sweet snacks and salty snacks. Do not treat ice-creams, fresh pastries, croissants and 'viennoiseries' as sweet snacks, and pizzas, sandwiches, and quiches as salty snacks.
8. If the shop is a GROCERY STORE, indicate the number of checkouts. All checkouts should be counted, even if a staff member is not there at the time of the visit and even if it is a self-service checkout.
9. Once all information has been collected, check that you have not missed some items or sub-questions.
10. Enter below the **end time** (time you finished collecting data)
11. Take note in the extra space provided at the end of the questionnaire of any other **information related to the borders of the area** covered that can help analyse the food environment of the area (e.g. nearby market or large supermarket, etc – in that case, indicate the approximate walking distance between these facilities and the nearest border of the area). Use extra pages if needed.
12. Also include at the end of the questionnaire any comments (e.g. related to problems during fieldwork) you may have.

Address/description of start point (please include your planned walking route when handing in the forms to the local coordinator):

____

Start time _____:______ (hour:min)

End time _____:______ (hour:min)

Date data collected : _____/_____/200__ (dd/mm/yy) Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|

Provide below details for each shop selling foods. Indicate each shop on the map (with its number).

1 Name of shop: ____

Circle ONE:

FOOD STORE
1. Convenience store
2. Grocery store
3. Specialised food store *(specify)* ____________________
4. Temporary stand e.g. market *(specify incl. frequency)* ____________________
5. Permanent stand e.g. daily market *(specify)* ____________________
6. Other food store *(specify)* ____________________

RESTAURANT
7. Fast-food restaurant *(specify)* ____________________
8. Café/fast casual restaurant *(specify)* ____________________
9. Sit-down restaurant *(specify)* ____________________
10. Other restaurant *(specify)* ____________________

If this is a FOOD STORE (1-6 above):

Are fresh fruit available? *(circle number)*	1 Yes	2 No
Are fresh vegetables available? *(circle number)*	1 Yes	2 No
Are sweet snacks available (e.g. chocolate bars, candies, biscuits, etc)? *(circle number)*	1 Yes	2 No
Are salty snacks available (e.g. crisps, salty biscuits, etc)? *(circle number)*	1 Yes	2 No

If this is a GROCERY STORE (answer 2 above): Number of checkouts *(include details e.g. number of self-checkouts)*: ____________________

2 Name of shop: ____

Circle ONE:

FOOD STORE
1. Convenience store
2. Grocery store
3. Specialised food store *(specify)* ____________________
4. Temporary stand e.g. market *(specify incl. frequency)* ____________________
5. Permanent stand e.g. daily market *(specify)* ____________________
6. Other food store *(specify)* ____________________

RESTAURANT
7. Fast-food restaurant *(specify)* ____________________
8. Café/fast casual restaurant *(specify)* ____________________
9. Sit-down restaurant *(specify)* ____________________
10. Other restaurant *(specify)* ____________________

If this is a FOOD STORE (1-6 above):

Are fresh fruit available? *(circle number)*	1 Yes	2 No
Are fresh vegetables available? *(circle number)*	1 Yes	2 No
Are sweet snacks available (e.g. chocolate bars, candies, biscuits, etc)? *(circle number)*	1 Yes	2 No
Are salty snacks available (e.g. crisps, salty biscuits, etc)? *(circle number)*	1 Yes	2 No

If this is a GROCERY STORE (answer 2 above): Number of checkouts *(include details e.g. number of self-checkouts)*: ____________________

Date data collected : _____/_____/200__ (dd/mm/yy) Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|__|

3 Name of shop: ____

Circle ONE:

FOOD STORE
1. Convenience store
2. Grocery store
3. Specialised food store *(specify)* ______________________
4. Temporary stand e.g. market *(specify incl. frequency)* ______________
5. Permanent stand e.g. daily market *(specify)* ________________
6. Other food store *(specify)* ______________________

RESTAURANT
7. Fast-food restaurant *(specify)* ______________________
8. Café/fast casual restaurant *(specify)* ______________________
9. Sit-down restaurant *(specify)* ______________________
10. Other restaurant *(specify)* ______________________

If this is a FOOD STORE (1-6 above):

Are fresh fruit available? *(circle number)*	1 Yes	2 No
Are fresh vegetables available? *(circle number)*	1 Yes	2 No
Are sweet snacks available (e.g. chocolate bars, candies, biscuits, etc)? *(circle number)*	1 Yes	2 No
Are salty snacks available (e.g. crisps, salty biscuits, etc)? *(circle number)*	1 Yes	2 No

If this is a GROCERY STORE (answer 2 above): Number of checkouts *(include details e.g. number of self-checkouts)*: ______________________

4 Name of shop: ____

Circle ONE:

FOOD STORE
1. Convenience store
2. Grocery store
3. Specialised food store *(specify)* ______________________
4. Temporary stand e.g. market *(specify incl. frequency)* ______________
5. Permanent stand e.g. daily market *(specify)* ________________
6. Other food store *(specify)* ______________________

RESTAURANT
7. Fast-food restaurant *(specify)* ______________________
8. Café/fast casual restaurant *(specify)* ______________________
9. Sit-down restaurant *(specify)* ______________________
10. Other restaurant *(specify)* ______________________

If this is a FOOD STORE (1-6 above):

Are fresh fruit available? *(circle number)*	1 Yes	2 No
Are fresh vegetables available? *(circle number)*	1 Yes	2 No
Are sweet snacks available (e.g. chocolate bars, candies, biscuits, etc)? *(circle number)*	1 Yes	2 No
Are salty snacks available (e.g. crisps, salty biscuits, etc)? *(circle number)*	1 Yes	2 No

If this is a GROCERY STORE (answer 2 above): Number of checkouts *(include details e.g. number of self-checkouts)*: ______________________

Date data collected : _____/_____/200__ (dd/mm/yy) **Fieldworker1: |__|__|** **Fieldworker 2: |__|__|** **Area code |__|__|__|__|__|**

(add more pages if necessary)

COMMUNITY QUESTIONNAIRE ON THE FOOD ENVIRONMENT

Food environment of the neighbourhood

Detailed list of shops selling foods

You will now examine the food environment in three grocery stores, one small, one medium and one large grocery store. You should have one copy of the questionnaire for each store.

Before setting out to do this portion of the survey, please ensure that you have with you:

- One clipboard each
- The map of the area and the address of the grocery stores to be surveyed
- The fieldworker manual (you should have reviewed the definitions and methods before starting the survey)
- Your official badge clearly pinned onto your clothes
- The letters and information sheet for shopkeepers in a plastic envelope.
- A mobile phone (for safety)
- A blue ink pen each
- A digital camera which indicates the same time as your watch and which is formatted to show the date on the photo.
- An extra layer of clothing [supermarkets are air-conditioned / refrigerated]

Go to the closest store and proceed as follows:

1. You should come to an agreement when filling in all parts of the questionnaires. If an agreement is difficult to reach, this should be included as a comment on the data collection forms, and as a comment on the process evaluation form.
2. Go in the store and find the store manager (or equivalent). Introduce yourself and show him/her the explanatory letter. ***You need to obtain approval before starting to collect data***.

3. Start by collecting information **inside the store:**
   a. Enter **start time**.
   b. Walk around the store to familiarise yourself with the store and to identify where the food and beverage items included in the questionnaire are placed (they can be spread in different places, e.g. soft drinks).
   c. Follow the questionnaire to gather details of the selected food and drink items.
      - Look at all information on individual packages or boxes (e.g. for fruit/ vegetables) to obtain a good description of each item.
      - Record the <u>quality</u> of the selected fresh fruit and vegetables by marking **"A"** for acceptable and **"UA"** for unacceptable.
        - o Acceptable = peak condition, top quality, good colour, fresh, firm and clean
        - o Unacceptable = bruised, old looking, mushy, dry, overripe, dark sunken spots in irregular patches or cracked or broken surfaces, signs of shriveling, mould or excessive softening
        - o The rating should be based on the majority (>50%) of fruit/vegetables. If it seems difficult to decide whether to mark "A" or "UA", mark "UA" and describe in comments.
      - <u>Price</u>: If the price of the selected items is not available, you should ask an employee at the checkout or at customer service. However, you should wait until all of the measures have been completed before asking the price of the items that are needed. There may be exceptions to this (i.e., you are in the produce section and there is no price shown but an employee is working there), so you should use your judgment. You should not use a "sale/promotion" price unless it is the only price posted – this should then be indicated as "Price based on a promotion" in the questionnaire.
      - <u>Number of types of fresh fruit, fresh vegetables, chocolate bars, potato chips, colas:</u> When counting these items, different varieties count as different items, e.g. 3 varieties of apples (Granny Smith, Gala and Brayburn) will count as 3 separate types of fruit. Enter the number of types of foods you counted.
   d. Finish by examining whether salty snacks/sweets are available at the checkouts, and whether any health information messages on visible signs and posters in the shops, or health promotion leaflets are available.
4. **Outside the store**: Follow the questionnaire to assess advertising outside the store, taking photos when appropriate. See fieldworker manual.
5. Once all information has been collected, check that you have not missed some items or sub-questions.
6. Enter **end time**.
7. Enter any comments (e.g. related to problems during fieldwork) you may have at the end of the questionnaire.
8. Go to the next store.

Date data collected : _____/_____/200__ (dd/mm/yy) **Fieldworker1: |__|__|** **Fieldworker 2: |__|__|** **Area code |__|__|__|__|__|**

FOOD ENVIRONMENT IN SELECTED GROCERY STORES – Questionnaire [3 copies needed]

COMPLETE THIS BOX BEFORE FIELDWORK

Shop number from general list of shops selling foods |____|

Name of shop:____

Size of shop *(circle correct answer)*: 1 Small 2 Medium 3 Large

Start time _____:______ (hour:min)

INSIDE THE GROCERY STORE

Number of checkouts:__________

Food item *(If a food item is not available, write NA)*		Cheapest	Most expensive
1 litre orange juice (100% pure juice) – [box or bottle not fresh juice]	Description:		
	Brand:		
	Format (weight or volume):		
	Calories/100g or 100 ml if packaged:		
	Overall cost and cost for 1 litre if available (specify)		
	Price based on a promotion (Yes/No)?		
1 litre orange drink – [box or bottle– either with or without gas]	Description (include % juice if any):		
	Brand:		
	Format (weight or volume):		
	Calories/100g or 100 ml if packaged:		
	Overall cost and cost for 1 litre if available (specify)		
	Price based on a promotion (Yes/No)?		

Date data collected : _____/_____/200__ (dd/mm/yy)   Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|

Food item (*If a food item is not available, write NA)*		Cheapest	Most expensive
1 kg fresh orange [not for juice]	Description:		
	Brand:		
	Format (weight or volume):		
	Overall cost and cost for 1kg if available (specify)		
	Price based on a promotion (Yes/No)?		
	Quality (A / UA)		
Types and quality of fresh fruit	Approximately how many types of fresh fruit are available (do not count nuts)? _______________ *(Enter number)*		
	Do any (more than 3) of the fruits in the store appear to be damaged (bruised, rotten, or of poor quality)?	1 Yes	2 No
	Have some (more than 3 kinds) of the fruits in this store been specially packaged, wrapped or boxed for sale?	1 Yes	2 No
1 kg fresh carrots	Description:		
	Brand:		
	Format (weight or volume):		
	Overall cost and cost for 1kg if available (specify)		
	Price based on a promotion (Yes/No)?		
	Quality (A / UA)		
1 kg fresh potatoes	Description :		
	Brand:		
	Format (weight or volume):		
	Overall cost and cost for 1 kg if available (specify)		
	Price based on a promotion (Yes/No)?		
	Quality (A / UA)		
Types and quality of fresh vegetables	Approximately how many types of fresh vegetables are available (do not count potatoes and fresh herbs)? _______________ *(Enter number)*		
	Do any (more than 3) of the vegetables in the store appear to be damaged (bruised, rotten, or of poor quality)?	1 Yes	2 No
	Have some (more than 3 kinds) of the vegetables in this store been specially packaged, wrapped or boxed for sale?	1 Yes	2 No

Date data collected : _____/_____/200__ (dd/mm/yy)   Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|__|

Food item (*If a food item is not available, write NA)*		Cheapest	Most expensive
1 loaf of whole grain bread	Description:		
	Brand:		
	Format (weight or volume):		
	Calories/100g if packaged:		
	Overall cost and cost for 1kg if available (specify)		
	Price based on a promotion (Yes/No)?		
1 loaf of white bread	Description:		
	Brand:		
	Format (weight or volume):		
	Calories/100g if packaged:		
	Overall cost and cost for 1kg if available (specify)		
	Price based on a promotion (Yes/No)?		
1 regular size box of plain cornflakes (not sugar coated)	Description:		
	Brand:		
	Format (weight or volume):		
	Calories/100g if packaged:		
	Overall cost and cost for 1kg if available (specify)		
	Price based on a promotion (Yes/No)?		
Availability of low-fat milk products	Is there any type of yoghurt labelled as low fat? 1 Yes 2 No If yes, describe		
	Is there any type of cheese labelled as low fat? 1 Yes 2 No If yes, describe		

Date data collected : _____/_____/200__ (dd/mm/yy) **Fieldworker1: |__|__|** **Fieldworker 2: |__|__|** **Area code |__|__|__|__|__|**

Food item (*If a food item is not available, write NA)*		Cheapest	Most expensive
1 litre of semi skimmed or low fat milk	Description (include % fat):		
	Brand:		
	Format (weight or volume):		
	Calories/100g or 100 ml if packaged:		
	Overall cost and cost for 1 litre if available (specify)		
	Price based on a promotion (Yes/No)?		
1 litre of full fat milk	Description (include % fat):		
	Brand:		
	Format (weight or volume):		
	Calories/100g or 100 ml if packaged:		
	Overall cost and cost for 1 litre if available (specify)		
	Price based on a promotion (Yes/No)?		
1 kg lean minced beef (5% fat or lowest percentage fat available)	Description (include % fat; fresh/frozen):		
	Brand:		
	Format (weight or volume):		
	Calories/100g if packaged:		
	Overall cost and cost for 1kg if available (specify)		
	Price based on a promotion (Yes/No)?		
1 kg regular minced beef (15% fat or highest percentage fat available)	Description (include % fat; fresh or frozen):		
	Brand:		
	Format (weight or volume):		
	Calories/100g if packaged:		
	Overall cost and cost for 1kg if available (specify)		
	Price based on a promotion (Yes/No)?		

Date data collected : _____/_____/200__ (dd/mm/yy)   Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|

Food item (*If a food item is not available, write NA*)		Cheapest	Most expensive
100 g milk chocolate bar	Description:		
	Brand:		
	Format (weight or volume):		
	Calories/100g if packaged:		
	Overall cost and cost for 1kg if available (specify)		
	Price based on a promotion (Yes/No)?		
Types of chocolate bars	How many types of chocolate bars are available? (do not count bars without chocolate but include Mars bars and similar types) _________ *(Enter number)*		
	How many types of chocolate bars labelled as low fat or low sugar are available (do not count bars without chocolate but include Mars bars and similar types)?___________ *(Enter number)*		
100 g regular potato crisps	Description:		
	Brand:		
	Format (weight or volume):		
	Calories/100g if packaged:		
	Overall cost and cost for 1kg if available (specify)		
	Price based on a promotion (Yes/No)?		
Types of potato crisps	How many types of potato chips are available? (do not count tortilla or other kinds of crisps/chips) _______________ *(Enter number)*		
	How many types of potato chips labelled as low fat are available? ________________ *(Enter number)*		
1.5 litre of regular (non diet) cola	Description:		
	Brand:		
	Format (weight or volume):		
	Calories/ 100 ml if packaged:		
	Overall cost and cost for 1 litre if available (specify)		
	Price based on a promotion (Yes/No)?		
Types of colas	How many types of regular colas are available? _______________ *(Enter number)*		
	How many types of diet colas are available? _______________ *(Enter number)*		

EURO-PREVOB Policy Analysis Tool

The EURO-PREVOB policy analysis tool consists of:

Part A. Glossary of terms

Part B. Policy checklist made of four thematic sections:

1. Food environment
2. Natural and built environment
3. Maternal and young child health services
4. Schools

Part C. Community questionnaire:

1. Food environment
   a. Community survey
   b. McDonalds
   c. Television advertising

2. Built environment (CURRENT DOCUMENT):

This questionnaire will be filled in by EURO-PREVOB local project coordinators (and their research teams), in Bosnia and Herzegovina, Czech Republic, France, Latvia and Turkey using direct observation.

Note:

Fieldwork manuals provide details of the methods that should be used to organise and conduct the pilot process of the policy analysis tool, and to gather information using the EURO-PREVOB policy analysis tool.

Date data collected : _____/_____/200__ (dd/mm/yy) **Fieldworker1: |__|__|** **Fieldworker 2: |__|__|** **Area code |__|__|__|__|__|**

EURO-PREVOB

COMMUNITY QUESTIONNAIRE ON THE BUILT ENVIRONMENT

SIXTH FRAMEWORK PROGRAMME

Before setting out to do the survey, please ensure that you have with you:

- ❑ A clipboard each
- ❑ The map of the area being surveyed and the planned walking route.
- ❑ The 7 maps to be used to enter data on each aspect covered by the questionnaire.
- ❑ The fieldworker manual (you should have reviewed the definitions and methods before starting the survey).
- ❑ Extra pages for the questionnaire.
- ❑ The letter of explanation about the study in a plastic envelope (in case someone asks you what you are doing)
- ❑ Your official badge
- ❑ A mobile phone (for safety)
- ❑ The following pen: 1) Blue ink pen; and 2) highlighter.
- ❑ A digital camera which indicates the same time as your watch and which is formatted to show the date on the photo.
- ❑ A watch that indicates seconds.

Go to the start point and proceed as follows (further details are given in the fieldworker manual):

1. Enter the start time below.
2. You should come to an agreement when filling in all parts of the questionnaires. If an agreement is difficult to reach, this should be included as a comment on the data collection forms, and as a comment on the process evaluation form.

3. Follow the planned walking route to familiarise yourself with the area. Do not answer the questionnaire yet but indicate in the table below whether ou have seen any of the following items:

Items in the built environment questionnaire	**Comments**
Cycle lanes	
Public open spaces	
Public transport stops	
Traffic volume	
Marked Road crossing	
Pavements	
Level of neighbourhood attractiveness/unattractiveness	

4. Go back to the start point. While following the planned walking route for a second time, answer all parts of the questionnaire.
5. Once all information has been collected, check that you have not missed some items or sub-questions.
6. Enter the time you finished collecting data (end time below).
7. Take note in the space provided at the end of the questionnaire of any other information related to the borders of the area covered (buffer) that can help analyse the built environment of the area (e.g. nearby large park, pool, etc – in such case indicate the approximate walking distance between these facilities and the nearest border of the area).
8. Also include at the end of the questionnaire any comments (e.g. related to problems during fieldwork) you may have.

Address/description of start point (please attach your planned walking route when handing it the forms to the local coordinator):

____

Start time _____:______ (hour:min)

End time _____:______ (hour:min)

Date data collected : _____/_____/200__ (dd/mm/yy) **Fieldworker1: |__|__|** **Fieldworker 2: |__|__|** **Area code |__|__|__|__|__|**

CYCLE LANES

1. Are there cycle lanes present in the area? 1 Yes |___| 2 No |___|

2. If yes, identify and number ALL cycle lanes with a BLUE INK PEN on the 'map for data on cycle lanes'. Also HIGHLIGHT THE CYCLE LANES with a HIGHLIGHTER PEN on the map.

3. For each separate cycle lane identified, insert ONE PHOTO (more only if required), noting the exact time that the photo was taken and describe the quality based on the criteria below. The photograph should give an overall view of the lane if possible.

Cycle lane number	# photos taken	Time photo(s) taken hh:min	Quality (enter code)	Continued? Y/N	Cyclist(s) visible? Y/N	Obstructions (e.g. cars) on lane? Y/N	Comments (e.g. users of the lane, types of obstructions, etc)
C1							
C2							
C3							
C4							
C5							
C6							
C7							
C8							
C9							

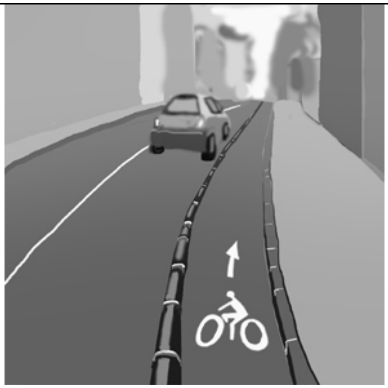
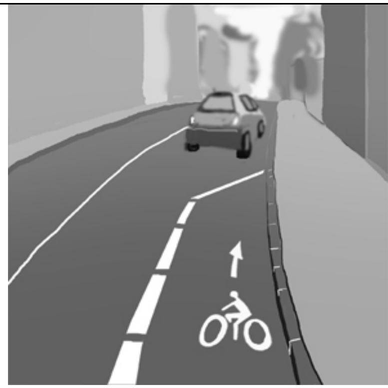
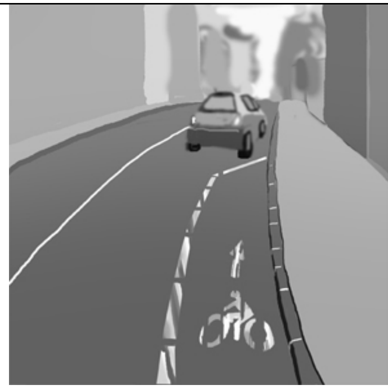
Date data collected : _____/_____/200__ (dd/mm/yy)   Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|

C10							

(use extra pages if required)

QUALITY CRITERIA & EXAMPLES

1 = Continuous cycle lane segregated from traffic by a physical barrier – e.g. raised kerbs	**2 =** Continuous cycle lane marked on the road but not separated from traffic by any barriers.	**3 =** Cycle lane marked on road but not continuous	**4 =** Cycle lane marked on road but difficult to see

Date data collected : _____/_____/200__ (dd/mm/yy) **Fieldworker1: |__|__|** **Fieldworker 2: |__|__|** **Area code |__|__|__|__|__|**

PUBLIC OPEN SPACES

4. **Are there public open spaces (POS) present in the area?** 1 Yes |___| 2 No |___|

5. **If yes, identify and number ALL separate public open spaces with a BLUE INK PEN on the ‘map for data on POS’. Also HIGHLIGHT THE PUBLIC OPEN SPACES with a HIGHLIGHTER PEN.**

6. **For each separate POS identified, note whether it includes a playground or not, insert ONE PHOTO (more only if required) of the POS and of the playground, and describe the quality based on the criteria below. The photographs should give an overall view of the POS and of the playground if possible. Include in the comments whether the public open space includes any special physical activity equipment (e.g. pool, tennis courts, etc).**

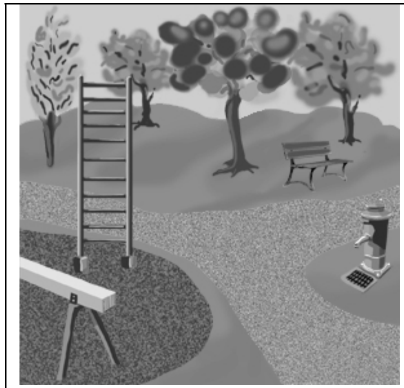
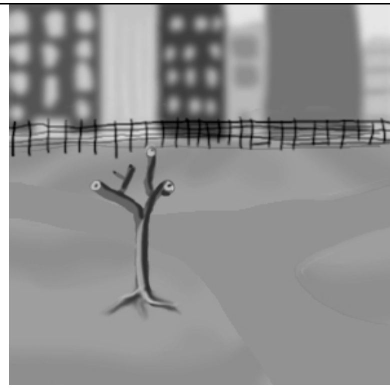
POS number	Playground present? Y/N	POS		Playground		Quality POS (enter code)	Quality playground (enter code)	Comments
		# photos	Time hh:min	# photos	Time hh:min			
POS1								
POS2								
POS3								
POS4								
POS5								
POS6								
POS7								
POS8								
POS9								
POS10								

Date data collected : _____/_____/200__ (dd/mm/yy)   Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|

(use extra pages if required)

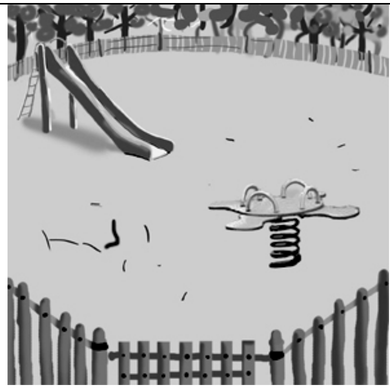
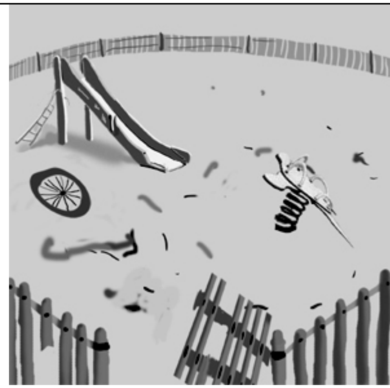
QUALITY CRITERIA & EXAMPLES

a) Public open space

1 = Public open space of good general fabric, e.g. well maintained, tidy, benches available. Big green area (2+ football pitches). Would take you 10+ min to walk around.	**2 =** Public open space of relatively good fabric but not as good as '1'. Some trees or green area(s). Smaller than 2 football pitches. Would take you 5-10 min to walk around.	**3 =** Public open space of limited size or of relatively poor general fabric e.g. badly maintained, dirty, litter, graffiti, dog poo. OR restricted access (i.e. membership). Few or no grass or trees. Approximately tennis court size or smaller.	**4 =** Very small public open space or of poor quality e.g. badly maintained, dirty, litter, graffiti, dog poo. OR restricted access (i.e. membership). Few or no grass or trees, mainly concrete. Smaller than tennis court size. Limited possibilities for physical activity.
			

Date data collected : _____/_____/200__ (dd/mm/yy) Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|

b) Playground

1 = Decent facilies, i.e. sports pitch, well maintained, tidy, etc.	**2 =** Decent facilities but missing one or more of the criteria in the definition of 'High quality' but better than 'Low quality'.	**3 =** Limited or relatively poor quality facilities, e.g. badly maintained, dirty, litter, graffiti, dog poo. OR restricted access (i.e. membership). Tiny urban playground.	**4 =** Limited and very poor quality facilities, e.g. badly maintained, dirty, litter, graffiti, dog poo.
			

Date data collected : _____/_____/200__ (dd/mm/yy)   Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|

PUBLIC TRANSPORT STOPS

7. Are there public transport stops (bus, tram or metro/underground train) in the area?   1 Yes |__| 2 No |__|

8. If yes, identify and number ALL separate public transport stops with a BLUE INK PEN on the 'map for data on public transport stops'.

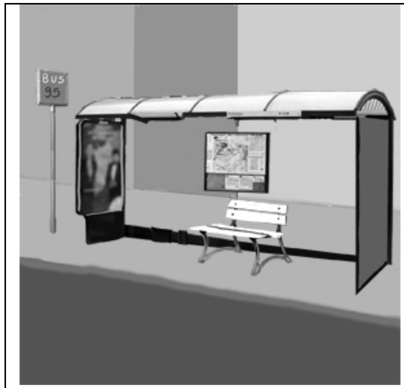
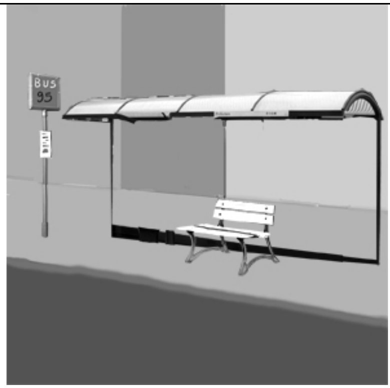
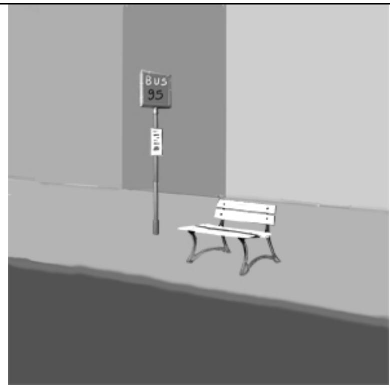
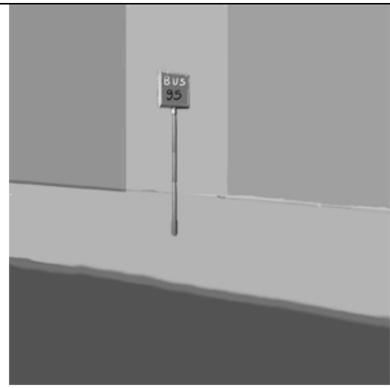
9. For each separate public transport stop identified, insert ONE PHOTO (more only if required) and describe the quality based on the criteria below. Include details of frequency of service (use 'Comments' column if needed). The photographs should give an overall view of the public transport stops.

Public transport stop number	# photo(s) taken	Time photo(s) taken hh:min	Quality (enter code)	Frequ. at peak time	Frequ. at other times	Schedule (time start, time end)	Comments
S1							
S2							
S3							
S4							
S5							
S6							
S7							
S8							
S9							
S10							

(use extra pages if required)

Date data collected : _____/_____/200__ (dd/mm/yy)   Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|

QUALITY CRITERIA & EXAMPLES

1 = With seat, covered, lit (i.e. nearby street lighting, appealing, travel information)	**2 =** With seat, partly covered and with some travel information.	**3 =** Stick with bus sign, some travel information with a place to sit. Not covered.	**4 =** Stick with bus sign only.
			

Date data collected : _____/_____/200__ (dd/mm/yy)   Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|

TRAFFIC VOLUME

10. Is there traffic present in the area? 1 Yes |__| 2 No |__| If no, explain why (e.g. pedestrian area):_____________________________

11. If yes, you will assess the traffic flow TWICE on THREE SELECTED MAIN ROADS (see fieldworker manual for the selection of roads). Mark on the 'map for data on traffic volume' WITH A BLUE INK PEN the location where you stood to assess traffic flow, and give details of the type of road and number of lanes.

Then assess the traffic flow TWICE: Count the number of motorised vehicules (cars, trucks, buses, motorcycles, etc) passing by in both directions during a 5 minute period – indicate the time at which you started counting. Wait for a few minutes and start again.
Observations should be taken on a weekday during a peak period.

Road/ location number	Type of road (one vs 2 ways)	Total # lanes	Traffic flow 1		Traffic flow 2		Comments (e.g. traffic jams, etc)
			Time started	Total # vehicules	Time started	Total# vehicules	
V1							
V2							
V3							

Date data collected : _____/_____/200__ (dd/mm/yy) Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|

MARKED ROAD CROSSINGS

12. **Are there marked road crossing points in the area?** 1 Yes |__| 2 No |__| If no, explain why (e.g. pedestrian area)_______________________

13. If yes, identify and number ALL MARKED CROSSING POINTS with a BLUE INK PEN on the 'map for data on road crossing'.

14. For each MARKED CROSSING POINT identified, take ONE PHOTO (more only if required) and describe the quality based on the criteria below.

Crossing point number	# photo(s) taken	Time photo(s) taken hh:min	Quality (enter code)	Comments
R1				
R2				
R3				
R4				
R5				
R6				
R7				
R8				
R9				
R10				

(use extra pages if required)

Date data collected : _____/_____/200__ (dd/mm/yy)   Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|

QUALITY CRITERIA & EXAMPLES

1 = Crossing point marked on road, with traffic light or special pedestrian crossing light.	**2 =** Crossing point marked on road, accompanied with a sign (but no light)	**3 =** Crossing point marked on road (no light or sign).	**4 =** Crossing point marked on road but difficult to see.

Date data collected : _____/_____/200__ (dd/mm/yy) **Fieldworker1: |__|__|** **Fieldworker 2: |__|__|** **Area code |__|__|__|__|__|**

PAVEMENTS/SIDEWALKS

15. Are there pavements in the area? 1 Yes |__| 2 No |__| If no, explain why: ____

16. If yes, you will assess the quality of 100m SEGMENTS OF PAVEMENTS on SIX ROADS SELECTED AT RANDOM (see fieldworker manual for the selection of roads). Highlight on the ‘map for data on pavements’ the location of the roads with a HIGHLIGHTER PEN.

17. For each selected road, take ONE PHOTO (more only if required) of representative pavements, and describe the general quality based on the criteria below. The photograph should give an overall view of the pavement. Number these examples and mark their location on the map using a BLUE INK PEN.

Pavement number	# photo(s) taken	Time photo(s) taken hh:min	Quality (enter code)	Comments
P1				
P2				
P3				
P4				
P5				
P6				

(use extra pages if required)

Date data collected : _____/_____/200__ (dd/mm/yy)   Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|

QUALITY CRITERIA & EXAMPLES

1 = Good quality pavements: no or few heaves, cracks, broken sections, sufficiently large, etc.	**2 =** Good quality pavements but narrower and possibly some cracks	**3 =** Relatively good quality pavements but narrow and possibly some obstructions, possibly a few heaves, cracks and broken sections.	**4 =** Relatively poor quality pavements with heaves, cracks or broken sections, obstructions, litter, etc that make it harder to walk

Date data collected : _____/_____/200__ (dd/mm/yy)   Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|

LEVEL OF NEIGHBOURHOOD ATTRACTIVENESS / UNATTRACTIVENESS

18. **Is there evidence of unattractiveness in the area?**   1 Yes |__| 2 No |__|

19. If yes, identify and number ALL EVIDENCE OF UNATTRACTIVENESS with a BLUE INK PEN on the ‘map for data on unattractiveness’ (see fieldworker manual).

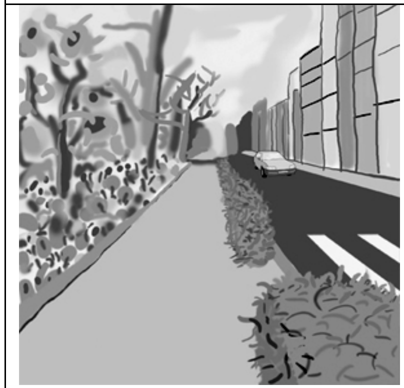
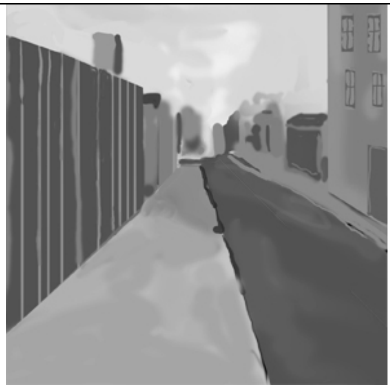
20. For each EVIDENCE OF UNATTRACTIVENESS identified, take ONE PHOTO (more only if required) and describe the quality based on the criteria below. The photograph should give an overall view of the evidences of attractiveness / unattractiveness

Unatract. number	**# photo(s) taken**	**Time photo(s) taken hh:min**	**Quality (enter code)**	**Comments**
U1				
U2				
U3				
U4				
U5				
U6				
U7				
U8				
U9				
U10				

(use extra pages if required)

Date data collected : _____/_____/200__ (dd/mm/yy)   Fieldworker1: |__|__| Fieldworker 2: |__|__| Area code |__|__|__|__|__|

QUALITY CRITERIA & EXAMPLES

1 =. Good neighbourhood conditions, well maintained area, well-maintained houses, aesthetic/pleasant/attractive for walking, appears to be safe for walking	**2 =** Less attractive and less aesthetic than no. 1 (e.g. some but relatively few graffitis/tagging, litter, etc).	**3 =** Some graffitis/tagging, some evidence of crime and vandalism (e.g. litter, overgrown grass, deteriorating buildings), could be unsafe for walking.	**4 =**. Many graffitis/tagging, clear evidence of crime and vandalism (e.g. burnt cars, drug taking equipment (needles), litter, overgrown grass, deteriorating buildings, appears to be dangerous for walking.
			

Appendix 3 - Environmental components of childhood obesity prevention interventions: an overview of systematic reviews

Appendix 3A: Ovid MEDLINE(R) Search Strategy

#	Searches	Results
1	obesity/ or obesity, abdominal/ or obesity, morbid/ or pediatric obesity/ or body mass index/ or skinfold thickness/ or waist-hip ratio/ or Waist Circumference/	216561
2	(obesity or overweight or body mass index or BMI or adiposity or body fat or skin fold thickness or waist-hip ratio or waist circumference or BMI Z score).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	335529
3	1 or 2	337833
4	environment/ or city planning/ or environment design/ or exercise/ or recreation/	132778
5	(environment* or obesogenic* or built environment or physical environment or social environment or political environment or path* or playground* or playing field or park* or school* or community or neighbo?rhood* or food outlet* or food store* or grocer* or supermarket* or restaurant* or urban design or urban planning or land-mix or public transport).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	3358684
6	4 or 5	3422735
7	adolescent/ or young adult/ or child/	2592789
8	(children or child or adoles* or student* or boy* or girl* or teenag* or school-children or schoolchildren).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	2962488
9	7 or 8	3155219
10	3 and 6 and 9	28166
11	((review or meta-analysis) not (comment or letter or editorial)).pt.	2023058
12	10 and 11	2748
13	limit 12 to yr="1995 -Current"	2581

Appendix 3B: List of excluded SRs with reason for exclusion

First author name	Reason for exclusion
Ajie 2014 [1]	No eligible intervention(s) with extractable anthropometric outcome data
Ayliffe 2010 [2]	No eligible intervention(s) with extractable anthropometric outcome data
Baranowski 2002 [3]	No eligible intervention(s) with extractable anthropometric outcome data
Barr-Anderson 2011 [4]	No eligible intervention(s) with extractable anthropometric outcome data
Bautista-Castaño 2004 [5]	Not a primary systematic review
Branscum 2012 [6]	No eligible intervention(s) with extractable anthropometric outcome data
Campbell 2001 [7]	More recent update available (Campbell 2002)
Cesa 2014 [8]	No eligible intervention(s) with extractable anthropometric outcome data
Cleland 2012 [9]	No eligible intervention(s) with extractable anthropometric outcome data
Clemmens 2004 [10]	No eligible intervention(s) with extractable anthropometric outcome data
Connelly 2007 [11]	No eligible intervention(s) with extractable anthropometric outcome data
Daley 2009 [12]	Not a primary systematic review
Dangour 2013 [13]	No eligible intervention(s) with extractable anthropometric outcome data
de La Hunty 2013 [14]	No eligible intervention(s) with extractable anthropometric outcome data
de Meester 2009 [15]	No eligible intervention(s) with extractable anthropometric outcome data
de Souza 2011 [16]	No eligible intervention(s) with extractable anthropometric outcome data
DeMattia 2007 [17]	No eligible intervention(s) with extractable anthropometric outcome data
Ding 2012 [18]	No intervention outcome data
Ding 2011 [19]	No intervention outcome data
Doak 2006 [20]	Not a primary systematic review
Faith 2007 [21]	No eligible intervention(s) with extractable anthropometric outcome data
Fogelholm 2002 [22]	Not a primary systematic review
Friedrich 2012 [23]	No eligible intervention(s) with extractable anthropometric outcome data
Gao 2008 [24]	Focus on obese children
Gerards 2011 [25]	No eligible intervention(s) with extractable anthropometric outcome data
Gonzalez-Suarez 2009 [26]	No eligible intervention(s) with extractable anthropometric outcome data
Guerra 2014 [27]	No eligible intervention(s) with extractable anthropometric outcome data
Harris 2009 [28]	No eligible intervention(s) with extractable anthropometric outcome data
Hingle 2010 [29]	No eligible intervention(s) with extractable anthropometric outcome data
Hoelscher 2013 [30]	Not a primary systematic review
Katz 2009 [31]	Not a primary systematic review
Kellou 2014 [32]	No eligible intervention(s) with extractable anthropometric outcome data
Lopez 2010 [33]	No eligible intervention(s) with extractable anthropometric outcome data
Luckner 2011 [34]	No eligible intervention(s) with extractable anthropometric outcome data
Malik 2006 [35]	More recent update available
Matson-Koffman 2005 [36]	No eligible intervention(s) with extractable anthropometric outcome data
Mayne 2015 [37]	No eligible intervention(s) with extractable anthropometric outcome data
Meininger 2000 [38]	No eligible intervention(s) with extractable anthropometric outcome data
Mozaffarian 2012 [39]	Not a primary systematic review
Mueller 2005 [40]	Not a primary systematic review
Nelson 2011 [41]	No intervention outcome data

First author name	Reason for exclusion
Osei-Assibey 2012 [42]	No eligible intervention(s) with extractable anthropometric outcome data
Penney 2014 [43]	Not a primary systematic review
Perez-Morales 2009 [44]	No eligible intervention(s) with extractable anthropometric outcome data
Powell 2013 [45]	No intervention outcome data
Robbins 2011 [46]	No eligible intervention(s) with extractable anthropometric outcome data
Robinson 2014 [47]	No eligible intervention(s) with extractable anthropometric outcome data
Schwartz 2012 [48]	No eligible intervention(s) with extractable anthropometric outcome data
Sharma 2011 [49]	No eligible intervention(s) with extractable anthropometric outcome data
Shaya 2008 [50]	No eligible intervention(s) with extractable anthropometric outcome data
Soler 2010 [51]	No eligible intervention(s) with extractable anthropometric outcome data
Staniford- Brown 2009 [52]	No eligible intervention(s) with extractable anthropometric outcome data
Story 1999 [53]	Focus on obese children
Summerbell 2005 [54]	More recent update available
Sun 2013 [55]	No eligible intervention(s) with extractable anthropometric outcome data
Szajewska 2010 [56]	No intervention outcome data
Thomas 2006 [57]	No eligible intervention(s) with extractable anthropometric outcome data
Upton 2014 [58]	Focus on obese children
Van Cauwenberghe 2010 [59]	No eligible intervention(s) with extractable anthropometric outcome data
van der Kruk 2013 [60]	No eligible intervention(s) with extractable anthropometric outcome data
Van Lippevelde 2012 [61]	No eligible intervention(s) with extractable anthropometric outcome data
Van Sluijs 2007 [62]	No eligible intervention(s) with extractable anthropometric outcome data
Verrotti 2014 [63]	Not a primary systematic review
Vine 2013 [64]	Focus on clinical settings
Wahi 2011 [65]	No eligible intervention(s) with extractable anthropometric outcome data
Wall 2006 [66]	Focus on adults
Wang 2015 [67]	No eligible intervention(s) with extractable anthropometric outcome data
Whittemore 2013 [68]	No eligible intervention(s) with extractable anthropometric outcome data
Whitt-Glover 2009 [69]	No eligible intervention(s) with extractable anthropometric outcome data
Wilson 2003 [70]	Not a primary systematic review
Williams 2014 [71]	No eligible intervention(s) with extractable anthropometric outcome data

Appendix 3C - Characteristics of SRs (Part 1)

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review**	AMSTAR score
Avery *et al.* 2015 [72]	Clarify which interventions aimed at children help to reduce the consumption of SSBs and whether these interventions lead to subsequent changes in body fatness.	Date range: Jan 2000 - Aug 2013 Databases: Embase, Medline, WoS Language: English	Study design: RCT Setting: Any Participants: 2-18 years Primary outcome focus: SSB consumption leading to changes in body fatness Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (Jadad Scale) Funding Sources: British Dietetic Association	3
Baker *et al.* 2011 [73]	Evaluate the effects of community wide, multi-strategic interventions upon population levels of physical activity.	Date range: Jan 1995 - Nov 2009 Databases: Cochrane Public Health Group Specialised Register, The Cochrane Library, Medline, Embase, CINAHL, LILACS, PsycINFO, ASSIA, The British Nursing Index, Chinese CNKI databases, EPPI-Centre, DoPHER, TRoPHI, ERIC, HMIC, Sociological Abstracts, SPORTDiscus, Transport Database, WoS (SCI, SSCI, CPCI), reference lists, experts contacted, websites searched Language: No restrictions	Study design: CRCT, RCT, Q-RCT, ITS, PCCS Setting: Community Participants: whole population Primary outcome focus: PA Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (Cochrane risk of bias tool) Funding Sources: Health Practitioner Research Scheme, Queensland Health, Australia; NIHR	11
Barr-Anderson *et al.* 2014 [74]	Identify weight-related behavioural interventions for African American children aged between 5 and 18 years that took place during Outside-of-School Time (OST) and identify key intervention components that are relevant when focusing on specific OST periods.	Date range: up to Sep 2013 Databases: AGRICOLA, CINAHL, Cochrane Library, ERIC, NIH RePORTER, PsycINFO, PubMed, reference lists Language: English	Study design: Not reported Setting: Not in school Participants: African American children and adolescents aged 5-18 years Primary outcome focus: Weight/related behaviour Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (author-derived aggregate score) Funding Sources: Robert Wood Johnson Foundation	7
Beauchamp *et al.* 2014 [75]	Summarize the effectiveness of interventions for the primary prevention of obesity that report their effect on anthropometric outcomes by socioeconomic strata, and to identify common attributes of interventions that may be most likely to benefit all SEP groups.	Date range: up to Sep 2012 Databases: Medline, Embase, CINAHL, EBM reviews, SCOPUS, Cochrane collaboration, Cochrane Public Health Group, EPPI-Centre, SIGLE, the Virtual Library for Public Health Language: English	Study design: RCT, Q-nRCT, Cohort, repeated XS Setting: Any Participants: whole population Primary outcome focus: Obesity-related (by SES) Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (Effective Public Health Practice Project Quality Assessment Tool) Funding Sources: Australian National Preventive Health Agency Grant (188PEE2011); Australian Research Council grant (ARC	6

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review **	AMSTAR score
			LP12010041), National Health and Medical Research Council Career Development Award; National Heart Foundation (PH 12 M6824)	
Bleich *et al.* 2013 [76]	Review the evidence on community-based childhood obesity-prevention programs in high-income countries.	Date range: up to Aug 2012 Databases: Medline, Embase, PsychInfo, CINAHL, Cochrane Library Language: English	Study design: RCT, QE, NE Setting: Community Participants: 2-18 years Primary outcome focus: Any Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (Down and Black) Funding Sources: AHRQ contract 290-2007- 10061-I; NHLBI grant 1K01HL096409	6
Brandt *et al.* 2010 [77]	Compare results of school-based prevention programs and to identify effective methods.	Date range: Jan 1990 - Apr 2009 Databases: PubMed, reference lists Language: Not reported	Study design: RCT, CCT Setting: School Participants: 4-18 years Primary outcome focus: Any Intervention type: Any Synthesis: Narrative Assessed study quality: No Funding Sources: Not reported	1
Branscum and Sharma 2011 [78]	Systematically analyze and summarize findings for health education and promotion interventions aimed at the prevention of childhood overweight and obesity among primarily Hispanic children.	Date range: Jan 2000 - May 2010 Databases: CINAHL, ERIC, PubMed Language: English	Study design: Not reported Setting: Any Participants: Hispanic, Latino or Mexican American children Primary outcome focus: Any Intervention type: Health education and promotion Synthesis: Narrative Assessed study quality: No Funding Sources: Not reported	2
Brown and Summerbell 2009 [79]	Determine effectiveness of school-based interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity.	Date range: Jan 2006 - Sep 2007 Databases: Embase, Medline, reference lists Language: No restrictions	Study design: RCT, CCT Setting: School Participants: 5-18 years Primary outcome focus: Obesity-related Intervention type: Any Synthesis: Narrative Assessed study quality: No Funding Sources: Not reported	3
Brown *et al.* 2015 [80]	Assess the effectiveness of diet and physical activity interventions to prevent or treat obesity in South Asian children and adults and to	Date range: 2006 – 2014 Databases: ASSIA, CCTR, Embase, Medline, SSCI, Google, reference lists, experts contacted Language: English	Study design: RCT, CCT, CBA Setting: Any Participants: South Asian ethnicity (whole population)	10

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review **	AMSTAR score
	describe the characteristics of effective interventions.		Primary outcome focus: Obesity-related Intervention type: Any Synthesis: Meta-analysis Assessed study quality: Yes (Six Item Checklist Of Quality Of Execution (adapted from the Effective Public Health Practice Project Quality Assessment Tool) Funding Sources: NIHR, Project ID: RP-PG-0407-10044	
Budd and Volpe 2006 [81]	Review the school-based RCTs aimed at reducing body weight or preventing weight gain.	Date range: 1985 - 2004 Databases: Medline, CINAHL, PsycINFO, CDSR reference lists, websites of professional organizations and governmental agencies (unspecified) Language: Not reported	Study design: RCT Setting: School Participants: elementary, middle, or high school students Primary outcome focus: Obesity-related Intervention type: Any Synthesis: Narrative Assessed study quality: No Funding Sources: NINR grant 2-T32 NR 007100-06	3
Calancie *et al.* 2015 [82]	Synthesize available evidence on the adaptation, implementation, and effectiveness of policy and environmental obesity-prevention strategies in rural settings.	Date range: Jan 2002 - Jun 2013 Databases: PubMed, CINAHL, PAIS, Cochrane databases, reference lists, experts contacted Language: English	Study design: Not reported Setting: Community Participants: whole population Primary outcome focus: Any Intervention type: Nutrition-related policy/environmental Synthesis: Narrative Assessed study quality: No Funding Sources: NOPREN Rural Food Access Working Group (grant no. 5-37850); University of North Carolina (no. U48/DP000059); NINR grants T32NR007091 & 5T32NR008856	5
Campbell *et al.* 2002 [83]	Assess the effectiveness of educational, health promotion and/or psychological/ family/behavioural /counselling/management interventions that focussed on diet, physical activity and/or lifestyle and social support, and were designed to prevent obesity in childhood.	Date range: 1985 - July 2001 Databases: Medline, Psyclit, Embase, SCI, SSCI, CINAHL, CCTR and the Cochrane Heart Group's specialised register Language: No restrictions	Study design: RCT, nRCT Setting: Any Participants: 0-18 years Primary outcome focus: anthropometric Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (Jadad Scale) Funding Sources: Collaborating Institutes acknowledged but main source of funding unclear; external sources of support were the Department of Human Services, Victoria, Australia; NHS Centre for Reviews and Dissemination, University of York, UK	9
Chen and	Evaluate the literature reporting on the effectiveness of technology-based interventions in preventing obesity in	Date range: Jan 1990 - Jan 2014 Databases: CINAHL, Embase, PubMed, PsycINFO, the Cochrane Library, reference lists	Study design: RCT, QE Setting: Any	6

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review **	AMSTAR score
Wilkosz 2014 [84]	adolescents and to explore components of these interventions that are associated with significant BMI outcomes.	Language: English	Participants: 2-18 years Primary outcome focus: Obesity-related/behavioural Intervention type: internet/active video game Synthesis: Narrative Assessed study quality: Yes (Cochrane Effective Practice and Organization of Care Review Group's methodological rigor assessment) Funding Sources: Not reported	
Chriqui 2013 [85]	Examine the influence of state laws and local policies on changes to school and other environments, individual activity and nutrition-related behaviours, and obesity and weight outcomes.	Date range: Jan 2012 - March 2013 Databases: PubMed, PAIS, EconLit Language: Not reported	Study design: quantitative, review, and qualitative studies Setting: Any Participants: whole population Primary outcome focus: Any Intervention type: Policy Synthesis: Narrative Assessed study quality: No Funding Sources: Robert Wood Johnson Foundation; NIDDKD grant R01DK089096; NCI grant R01CA158035	2
Chriqui *et al.* 2014 [86]	Examine the influence of specific state laws and district level competitive food policies on changes to student BMI and weight outcomes; student consumption, purchasing, and dietary intake; or in-school competitive food availability and access.	Date range: Jan 2005 - March 2013 Databases: PubMed, CINAHL, EconLit, ERIC, PAIS, "Childhood Obesity" journal archives Language: English	Study design: NE Setting: Any Participants: pre-school to grade 12 Primary outcome focus: Obesity-related /SSB consumption or availability Intervention type: Policy Synthesis: Narrative Assessed study quality: No Funding Sources: Robert Wood Johnson Foundation	4
Cole *et al.* 2006 [87]	Describe the theoretical and methodological characteristics of effective school-based interventions that used healthy lifestyle education, dietary habits, and/or physical activity interventions.	Date range: up to Feb 2005 Databases: PubMed, CINAHL, reference lists Language: Not reported	Study design: RCT, nRCT Setting: School Participants: 4-14 years Primary outcome focus: Obesity-related Intervention type: Any Synthesis: Narrative Assessed study quality: No Funding Sources: Not reported	1
Cook-Cottone *et al.* 2009 [88]	Examine study factors and effect sizes in school-based obesity prevention studies.	Date range: Jan 1997 – July 2008 Databases: Medline, PsycINFO, CINAHL, Academic Search Premier, CDSR, reference lists Language: English	Study design: RCT, nRCT Setting: School Participants: Pre-school to Grade 12 Primary outcome focus: Obesity-related	6

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review **	AMSTAR score
			Intervention type: Any Synthesis: Meta-analysis Assessed study quality: No Funding Sources: Not reported	
De Bourdeaudhuij *et al.* 2010 [89]	Systematically review the evidence of school-based interventions targeting dietary and physical activity behaviour in primary (6–12 years old) and secondary school (12–18 years old) children in Europe.	Date range: 1990 to Dec 2007; rerun Jan and Jun 2008 Databases: PubMed, WoS, CINAHL, The Cochrane Library and MDConsult, reference lists, websites of groups conducting systematic reviews (unspecified), SIGLE, Social Care Online and British National Bibliography for Report Literature, supplements of: 'International Journal of Obesity' and 'Acta Paediatrica' Language: English	Study design: No restrictions Setting: School Participants: 6-18 years Primary outcome focus: Any Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (Effective Public Health Practice Project Quality Assessment Tool) Funding Sources: European Commission's Sixth Framework Programme	27
de Sa and Lock 2008 [90]	Systematically synthesize worldwide evidence from published and unpublished literature on interventions to promote fruit and/or vegetable consumption in children in school settings.	Date range: up to Aug 2007 Databases: PubMed, CABDirect, Cochrane Library, WoK, IBSS, PsycINFO, Embase, Biomed Central, reference lists, experts contacted Language: English abstract but no language restrictions	Study design: RCT, CRCT, nRCT Setting: School Participants: 5-18 years Primary outcome focus: F&V consumption/knowledge Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (using a published tool utilised previously in a similar review. No details provided) Funding Sources: No external funding sources	5
Dobbins *et al.* 2013 [91]	Summarize the evidence of the effectiveness of school-based interventions in promoting physical activity and fitness in children and adolescents.	Date range: 1985 to Jul 2007 Databases: Medline, BIOSIS, CINAHL, Embase, SPORTDiscus, PsycINFO, Sociological Abstracts, CENTRAL, reference lists, experts contacted Language: No restrictions	Study design: RCT Setting: School Participants: 6-18 years Primary outcome focus: PA Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (Effective Public Health Practice Project Quality Assessment Tool) Funding Sources: Cochrane Health Promotion and Public Health Field, Australia and the City of Hamilton Public Health Services, Canada.	10
Flodmark *et al.* 2006 [92]	Update the findings of a 2002 report by the Swedish Council on Technology Assessment in Health Care (SBU) on preventive	Date range: 2001 – 2004 Databases: PubMed, NHS - Economic Evaluation Database, Cochrane Library Language: Swedish, Norwegian, Danish, English, German, French	Study design: RCT, CCT Setting: Any Participants: Children and adolescents (age unspecified) Primary outcome focus: Obesity-related	5

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review **	AMSTAR score
	interventions against obesity in children and adolescents.		Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (author- proposed quality criteria) Funding Sources: Not reported	
Gao and Chen 2014 [93]	Synthesize the exergame-related research carried out in less controlled field-based settings including homes, schools and communities, and discuss the effectiveness of exergames on children's obesity-related outcomes.	Date range: 1985 – 2013 Databases: Academic Search Complete, ERIC, Medline, PubMed, PsycINFO, SPORTDiscus, reference lists Language: English	Study design: RCT, CCT Setting: Any Participants: Children and adolescents (age unspecified) Primary outcome focus: Obesity-related /fitness Intervention type: Exergaming Synthesis: Narrative Assessed study quality: No Funding Sources: Not reported	6
Haynos and O'Donohue 2012 [94]	Review RCTs of universal prevention of obesity in children.	Date range: Not reported Databases: Medline, PsycINFO, reference lists Language: Not reported	Study design: RCT Setting: Any Participants: 0-18 years Primary outcome focus: Obesity-related Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (No specific tool; quality assessment criteria included: description of participant sample, interventionist variables, and intervention settings, intervention components, study design, and criterion measures) Funding Sources: Not reported	1
Holub *et al.* 2014 [95]	Examine the effects of obesity-related interventions on Latino children in U.S. schools and identify specific strategies that can be used to combat childhood obesity, specifically in Latino youth.	Date range: 1965 – 2010 Databases: PsycINFO, Medline, CINAHL, Cochrane Library, Current Controlled Trials, LILACS, Global Health, Global Index Medicus, WoS Language: English, Spanish, Portuguese	Study design: Not reported Setting: School Participants: children and adolescents (age unspecified) Primary outcome focus: Obesity-related Intervention type: multi-component, obesity related Synthesis: Narrative Assessed study quality: Yes (CDC's Community Guide) Funding Sources: CDC grant 1U48 DP001917	6
Ickes *et al.* 2014 [96]	Compare and contrast U.S. and international school-based obesity prevention interventions and highlight efficacious strategies.	Date range: Jan 2002 - Dec 2013 Databases: Academic Search Premier, CINAHL, Medline, ERIC, Psychology and Behavioral Sciences Collection Language: English	Study design: Not reported Setting: School Participants: children and adolescents (age unspecified) Primary outcome focus: Any Intervention type: Any Synthesis: Narrative Assessed study quality: No	4

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review**	AMSTAR score
			Funding Sources: Not reported	
Jaime and Lock 2009 [97]	Systematically review the evidence on the effectiveness of school-based nutrition policy on the food environment, and student's dietary intake and BMI	Databases: PubMed, CAB abstracts, WoK (including WoS and ISI databases), The Cochrane Library, and LILACS, Google, reference lists, experts contacted Language: Not reported	Study design: RCT, nRCT, NRNCT, XS Setting: School Participants: children and adolescents (age unspecified) Primary outcome focus: menu composition; availability/sales of school food and beverages; dietary intake; BMI Intervention type: Food/Nutrition policies Synthesis: Narrative Assessed study quality: No Funding Sources: International Nutrition Foundation; Ellison Medical Foundation	6
Kaiser *et al.* 2013 [98]	Assess whether: (i) an increase in SSB intake increases body weight or BMI in humans; (ii) a reduction of SSB intake reduces body weight or BMI in humans.	Date range: Jan 2010 - Oct 2012 Databases: PubMed, PsycINFO, the Cochrane Collaborative Website, SCOPUS, PROQUEST Language: No restrictions	Study design: RCT Setting: Any Participants: whole population Primary outcome focus: Obesity-related Intervention type: SSB consumption Synthesis: Narrative Assessed study quality: Yes (Cochrane risk of bias tool) Funding Sources: NIH grant P30DK056336	9
Kamath *et al.* 2008 [99]	Assess the effectiveness of behavioural interventions to prevent childhood obesity.	Date range: up to Feb 2006 Databases: Medline, ERIC, Embase, CINAHL, PsycINFO, Dissertation Abstracts, SCI, SSCI, CENTRAL, reference lists, experts contacted Language: Not reported	Study design: RCT Setting: Any Participants: 2-18 years Primary outcome focus: Nutrition/PA/BMI Intervention type: Behavioural Synthesis: Meta-analysis Assessed study quality: Yes (No specific tool; quality assessment criteria included: allocation concealment; blinding of participants (to allocation and to study hypothesis), health care providers and/or data collectors; use of intention to treat analysis; and extent of losses to follow up.) Funding Sources: The Endocrine Society	8
Kanekar and Sharma 2008 [100]	Assess the effect of school-based interventions to prevent childhood obesity, and conduct a meta-analysis focusing on the outcome indicator of BMI.	Date range: 2000 – 2007 Databases: Medline, CINAHL, reference lists Language: English	Study design: Not reported Setting: School Participants: 0-18 years Primary outcome focus: BMI Intervention type: Curricular Synthesis: Meta-analysis Assessed study quality: Yes (Author- proposed quality criteria)	4

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review **	AMSTAR score
			Funding Sources: Not reported	
Katz *et al.* 2008 [101]	Evaluate the effectiveness of school-based strategies to control or prevent obesity.	Date range: up to Oct 2004 Databases: Medline, HealthSTAR, PsycINFO, Embase searched up to Feb 2000. Update searches performed on Medline, CINAHL and PsycINFO from Feb 2000 to Oct 2004. Language: English	Study design: RCT, nRCT Setting: School Participants: 3-18 years Primary outcome focus: Obesity-related Intervention type: Any Synthesis: Meta-analysis Assessed study quality: Yes (CDC's Community Guide) Funding Sources: Not reported	5
Kesten *et al.* 2011 [102]	Evaluate the effectiveness of interventions to prevent overweight and obesity in pre-adolescent girls.	Date range: 1990 - Feb 2010 Databases: Medline, SPORTDiscus, PsycINFO, WoS, Biological Sciences, PEI Language: English	Study design: RCTs, CBA, Non-controlled studies Setting: Any Participants: Pre-adolescent girls (7-11 years) Primary outcome focus: Any Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (Effective Public Health Practice Project Quality Assessment Tool) Funding Sources: Not reported	6
Knowlden and Sharma 2013 [103]	Examine the usefulness of school-based obesity-prevention interventions targeting African American and Hispanic children, and develop a set of recommendations to enhance their effectivness.	Date range: Jan 2001 - May 2012 Databases: CINAHL, ERIC , Medline, Psychology and Behavioral Sciences Collection, CENTRAL Language: Not reported	Study design: Experimental, QE Setting: School Participants: African American or Hispanic children Primary outcome focus: Anthropometric Intervention type: Any Synthesis: Narrative Assessed study quality: No Funding Sources: Not reported	1
Kropski *et al.* 2008 [104]	Examine the effectiveness of and provide a focused evaluation of the quality and results of long-term school-based obesity prevention programs, and to offer guidance for future investigations.	Date range: Jan 1990 - Dec 2005 Databases: PubMed, Biological Abstracts, Education Abstracts, reference lists, experts contacted Language: Not reported	Study design: Experimental, QE Setting: School Participants: children and adolescents (age unspecified) Primary outcome focus: Obesity-related Intervention type: Curricular/environmental Synthesis: Narrative Assessed study quality: Yes (GRADE) Funding Sources: Not reported	6
Lamboglia *et al.* 2013 [105]	Evaluate the use of exergaming as a strategic tool for the promotion of healthy behaviours.	Date range: Jan 2008 - Apr 2012 Databases: SciELO, LILACS, PubMed, EBSCO, Science Direct Language: Portuguese, English	Study design: XS, Experimental Setting: Any Participants: 6-15 years Primary outcome focus: PA; body composition; fitness levels	3

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review **	AMSTAR score
			Intervention type: Exergaming Synthesis: Narrative Assessed study quality: No Funding Sources: CAPES; FUNCAP	
Lavelle *et al.* 2012 [106]	Determine the efficacy of school-based interventions on reducing BMI in children.	Date range: up to Feb 2011 Databases: Medline, Embase, reference lists Language: English	Study design: RCT, C-RCT, efficacy trail, QE, PCS Setting: School Participants: 0-18 years Primary outcome focus: BMI Intervention type: Any Synthesis: Meta-analysis Assessed study quality: No Funding Sources: Not erported	6
LeBlanc *et al.* 2013 [107]	Explore the relationship between active video games and several health and behavioural indicators in young people aged 0 to 17 years.	Date range: Not reported Databases: Medline, Embase, PsycINFO, SPORTDiscus, CENTRAL Language: English, French	Study design: RCT, CS, CR, CC Setting: Any Participants: 0-17 years Primary outcome focus: Health or behavioural indicator Intervention type: Active video game Synthesis: Narrative Assessed study quality: Yes (GRADE) Funding Sources: Active Healthy Kids, Canada	7
Leung et al. 2012 [108]	Assess the effectiveness of interventions that focus on reducing sedentary behaviour among school-age youth and to identify elements associated with interventions' potential for translation into practice settings.	Date range: 1980 - Apr 2011 Databases: Medline, PubMed, PsycINFO, Cochrane Library Language: English	Study design: RCT Setting: Any Participants: 6-19 years Primary outcome focus: Sedentary behaviour Intervention type: educational, health promotion or behavioural strategies at the individual and family levels Synthesis: Narrative Assessed study quality: No Funding Sources: Not reported	1
Li *et al.* 2008 [109]	Systematically review intervention studies aimed at the prevention or control of excess weight among children and adolescents in China.	Date range: 1990 – 2006 Databases: China Journal Full Text Database, Wanfang Database, Medline, Meditext Language: Chinese, English	Study design: RCT, nRCT Setting: School Participants: Children and adolescents (age unspecified) Primary outcome focus: Obesity-related, knowledge Intervention type: Behavioural Synthesis: Narrative Assessed study quality: Yes (Effective Public Health Practice Project Quality Assessment Tool)	6

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review **	AMSTAR score
			Funding Sources: National Health and Medical Research Council of Australia	
Liao *et al.* 2014 [110]	Assess the effects of sedentary behaviour interventions on BMI in children, and to compare whether multi-component interventions have a higher mean effect size than interventions with single component.	Date range: up to July 2012 Databases: Medline, PsycINFO, WoS, Google Scholar, reference lists Language: English	Study design: RCT Setting: Any Participants: 0-18 years Primary outcome focus: BMI Intervention type: Behavioural Synthesis: Meta-analysis Assessed study quality: Yes (Effective Public Health Practice Project Quality Assessment Tool) Funding Sources: NIH grant R25 CA57712; American Cancer Society grant 118283-MRSGT-10-012-01-CPPB	8
Lissau 2007 [111]	Identify studies on the prevention of paediatric obesity within the school arena.	Date range: 2001 – Aug 2005 Databases: PubMed, Embase, PsycINFO, NHS – Economic Evaluation Database, ERIC, experts contacted Language: Not reported	Study design: RCT, CCT Setting: School Participants: Children and adolescents (age unspecified) Primary outcome focus: Obesity-related Intervention type: Any Synthesis: Narrative Assessed study quality: No Funding Sources: Not reported	3
Lobelo *et al.* 2013 [112]	Examine the effectiveness of school-based intervention aimed at preventing or treating obesity among youth in Latin America.	Date range: 1965 - Dec 2010 Databases: PsycINFO, Medline, CINAHL, Cochrane Library, Current Controlled Trials, LILACS, Global Health, Global Index Medicus, WoS Language: English, Spanish, Portuguese	Study design: RCT, CBA, Crossover design Setting: School Participants: Children and adolescents (age unspecified) Primary outcome focus: Obesity-related Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (CDC's Community Guide) Funding Sources: CDC 1U48DP001917	7
Malik *et al.* 2013 [113]	Conduct a systematic review and meta-analyses of prospective cohort studies and RCTs in children and adults and to provide a comprehensive summary of the literature evaluating SSBs and body weight gain	Date range: up to Mar 2013 Databases: PubMed, Embase, The Cochrane library, reference lists Language: English	Study design: RCT, PCS Setting: Any Participants: whole population Primary outcome focus: body weight Intervention type: SSB Synthesis: Meta-analysis Assessed study quality: Yes (Newcastle Ottawa scale; Cochrane risk of bias tool) Funding Sources: NIH grants DK58845, P30 DK46200, U54CA155626, and HL60712	6

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review **	AMSTAR score
Marsh *et al.* 2014 [114]	Systematically synthesize evidence from RCTs of interventions with a family component that targeted reduction of sedentary time, including TV viewing, video games and computer use, in children.	Date range: up to Mar 2012 Databases: Medline, PubMed, PsycINFO, CINAHL, Embase, reference lists, experts contacted Language: English	Study design: RCT Setting: Family-based Participants: 2-18 years Primary outcome focus: Sedentary behaviour Intervention type: Active parental involvement Synthesis: Narrative Assessed study quality: Yes (Cochrane risk of bias tool) Funding Sources: Not reported	4
Pérez-Morales *et al.* 2012 [115]	Conduct a systematic review of childhood overweight and obesity prevention interventions among Hispanic children in the United States.	Date range: Jan 2001 - Jan 2012 Databases: PubMed, CINAHL, EBSCO Language: English	Study design: RCT, QE Setting: Any Participants: Hispanic children in the US Primary outcome focus: Obesity-related Intervention type: Any Synthesis: Narrative Assessed study quality: No Funding Sources: Not reported	1
Peterson and Fox 2007 [116]	Review the evidence on the effectiveness of school-based interventions and contribute to the design and implementation of the "next generation" of school-based obesity prevention interventions.	Date range: 1966 – 2001 Databases: Not reported (referred to a 'parent' CDC Guide to Community Preventive Services Task Force report) Language: English	Study design: RCT, QE Setting: School Participants: Children and adolescents (age unspecified) Primary outcome focus: Obesity-related Intervention type: Any Synthesis: Narrative Assessed study quality: No Funding Sources: Not reported	3
Reilly and McDowell 2003 [117]	Systematically review and critically appraise intervention studies in paediatric obesity prevention and treatment; examine the clinical relevance of intervention effects and make suggestions for further research	Date range: Jun 2000 - May 2002 Databases: Medline, Embase, CINAHL, Healthstar, Cochrane Library, internet search, reference lists Language: Not reported	Study design: RCT Setting: Any Participants: Children and adolescents (age unspecified) Primary outcome focus: Obesity-related Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (Scottish Intercollegiate Guidelines Network) Funding Sources: Sport Aiding Medical Research for Kids (SPARKS), the British Heart Foundation and the Scottish Executive Health Department.	4
Sbruzzi *et al.* 2013 [118]	Assess the effectiveness of educational interventions to prevent or treat childhood obesity through a	Date range: up to May 2012 Databases: Medline, CENTRAL, Embase, reference lists Language: No restrictions	Study design: RCT Setting: School/Home Participants: 6-12 years	6

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review **	AMSTAR score
	systematic review and meta-analysis of randomized trials.		Primary outcome focus: Obesity-related Intervention type: Any Synthesis: Meta-analysis Assessed study quality: Yes (GRADE) Funding Sources: Instituto de Cardiologia grant MCT/CNPq/CT-Saúde/MS/SCTIE/DECIT (no. 067/2009); Conselho Nacional de Desenvolvimento Científico e Tecnológico; CAPES	
Sharma 2007 [119]	Review and summarise international (excluding the US) school-based interventions for preventing obesity in children aged between 3 - 18 years	Date range: 1999 – 2005 Databases: CINAHL, ERIC, Medline Language: English	Study design: RCT, nRCT, QE Setting: School Participants: 3-18 years Primary outcome focus: Any Intervention type: Any Synthesis: Narrative Assessed study quality: No Funding Sources: Nor reported	2
Shirley *et al.* 2014 [120]	Update the findings of an AHRQ review on obesity prevention programs for children and adolescents, focusing on elementary school students in the US. A secondary aim was to examine the importance of parental and community involvement in the success of school-based obesity prevention programmes.	Date range: Jan 2007 - Dec 2012 Databases: PubMed, CINAHL Language: English	Study design: Experimental, QE Setting: School Participants: 6-12 years Primary outcome focus: Obesity-related Intervention type: Educational, PA or nutrition modification Synthesis: Narrative Assessed study quality: No Funding Sources: National Institute on Drug Abuse; NIH grants K12 DA031794 and K23DA034879	6
Showell *et al.* 2013 [121]	Review the effectiveness of home-based interventions on weight, intermediate (e.g. diet and physical activity), and clinical outcomes.	Date range: up to Aug 2012 Databases: Medline, Embase, PsycINFO, CINAHL, clinical-trails.gov, Cochrane Library, reference lists, grey literature search Language: Not reported	Study design: RCT, QE, NE Setting: Home Participants: 2-18 years Primary outcome focus: Obesity-related Intervention type: Diet/PA/Sedentary behaviour modification Synthesis: Narrative Assessed study quality: Yes (Down and Black) Funding Sources: AHRQ contract 290-2007-10061-I; NICHD grant U54HD070725; AHRQ grant T32 HS19488-01	8
Silveira *et al.* 2013 [122]	Assess the effectiveness of school-based nutrition education interventions in reducing or preventing overweight and obesity among children and adolescents	Date range: up to May 2010 (additional PubMed search up to May 2012) Databases: PubMed/Medline, Embase, WoS, CENTRAL, ERIC, CINAHL, LILACS, PsycINFO, SPORTDiscus,	Study design: RCT Setting: School Participants: 5-18 years Primary outcome focus: bmi Intervention type: Nutrition education	6

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review **	AMSTAR score
		ASSIA, PEI, Social Care Online, Social Services Abstracts, Sociological Abstracts, reference lists Language: Any language except those based on logograms (e.g. Chinese and Japanese)	Synthesis: Meta-analysis Assessed study quality: Yes (Aggregate score derived using: (i) GRADE; (ii) Effective Public Health Practice Project Quality Assessment Tool) Funding Sources: FAPESP protocol no. 09/12438-5).	
Silveira *et al.* 2011 [123]	Examine the effectiveness of school-based nutrition education interventions to prevent and reduce obesity in children and adolescents	Date range: up to May 2010 Databases: PubMed, Embase, WoS, CENTRAL, ERIC, CINAHL, LILACS, PsycINFO, SPORTDiscus, ASSIA, PEI, Social Care Online, Social Services Abstracts, Sociological Abstracts Language: No restrictions	Study design: RCT Setting: School Participants: 5-18 years Primary outcome focus: Obesity-related or dietary Intervention type: Behavioural Synthesis: Narrative Assessed study quality: Yes (Effective Public Health Practice Project Quality Assessment Tool) Funding Sources: FAPESP; CAPES	7
Small *et al.* 2007 [124]	Identify effective early treatment or prevention intervention programmes for use in primary care for young children who are overweight or obese, or who are at high risk of obesity	Date range: not reported Databases: Medline, PsychInfo, CINAHL Language: Not reported	Study design: RCT Setting: Primary care Participants: 4-7 years Primary outcome focus: Any Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (Not formally assessed; aspects of study quality were assessed and reported in table form) Funding Sources: Not reported	2
Sobol-Goldberg *et al.* 2013 [125]	Evaluate the effectiveness of school-based obesity prevention programmes	Date range: 2006 – Jan 2012 Databases: Medline, ERIC, Embase, CINHAL, PyscInfo, DAI, SCI, SSCI, CENTRAL Language: English	Study design: RCT Setting: School Participants: 5-18 years Primary outcome focus: BMI Intervention type: Any Synthesis: Meta-analysis Assessed study quality: Yes (No specific tool used; quality assessment criteria included: allocation concealment; blinding of patients ,healthcare providers, data collectors; use of intention to treat analysis; and loss to follow up) Funding Sources: Not reported	8
Stice *et al.* 2006 [126]	Evaluate obesity prevention programmes for children and adolescents, and to assess the characteristics of those interventions associated with larger effects.	Date range: 1980 - Oct 2005 Databases: PsycINFO, Medline, CINAHL, DAI, reference lists, experts contacted Language: Not reported	Study design: CT Setting: Any Participants: 0-22 years Primary outcome focus: Obesity-related	5

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review **	AMSTAR score
			Intervention type: Any Synthesis: Meta-analysis Assessed study quality: No Funding Sources: NIH grants MH/DK61957 and MH70699	
Towns *et al.* 2014 [127]	Identify and describe interventions specifically aimed at reducing overweight or obesity risk among Aboriginal children and to present evidence of their effectiveness.	Date range: Jan 2000 - Jun 2013 (additional search on Google Scholar in Oct 2013) Databases: PubMed, PsycINFO, Databases: ERIC, Medline, WoS, reference lists, Google Scholar Language: Not reported	Study design: RCT, QE, Pre-Post test Setting: Any Participants: 0-18 years Primary outcome focus: Any Intervention type: Any Synthesis: Narrative Assessed study quality: No Funding Sources: Canadian Institutes for Health Research/Institute	4
van Grieken *et al.* 2012 [128]	Evaluate the effects of interventions, at school or in the community, to prevent excessive sedentary behaviour, in children and adolescents, on their sedentary behaviour and BMI.	Date range: 1990 - Mar 2011 Databases: PubMed, Embase, WoS, PsycINFO, CDSR, reference lists Language: Not reported	Study design: RCT, CT Setting: Any Participants: 0-18 years Primary outcome focus: Obesity-related Intervention type: Sedentary behaviour Synthesis: Meta-analysis Assessed study quality: Yes (Cochrane risk of bias tool) Funding Sources: Netherlands Organisation for Health Research and Development project no. 121020027)	6
Vasques *et al.* 2014 [129]	Assess the efficacy of school-based and after-school interventions programs on children and adolescents' BMI reduction addressing the correlation between some moderating variables.	Date range: 2000 – 2011 Databases: PubMed, Medline, WoS, Academic Search Complete, Latindex, SciELO.org and editors: Elsevier, Wiley, Springer, Taylor & Francis, reference lists Language: Not reported	Study design: RCT, nRCT Setting: School Participants: 0-18 years Primary outcome focus: BMI, % Overweight and obese, body fat Intervention type: Any Synthesis: Meta-analysis Assessed study quality: No Funding Sources: Not reported	6
Verstraeten *et al.* 2012 [130]	Systematically review the evidence on the effectiveness of school-based interventions targeting dietary behavior and/or physical activity for the primary prevention of obesity in children and adolescents aged 6–18 y in low- and middle-income countries.	Date range: Jan 1990 - Jul 2011 Databases: Medline, Embase, WoS, CENTRAL, ERIC, Cochrane Library, CRD Language: English, Spanish, French, German, Dutch	Study design: CT Setting: School Participants: 6-18 years Primary outcome focus: Diet/PA, anthropometric Intervention type: Dietary/PA behaviour Synthesis: Narrative Assessed study quality: Yes (Effective Public Health Practice Project Quality Assessment Tool) Funding Sources: No external funding sources	7

Author	Review aim	Search Strategy*	Study design eligible for inclusion in the review **	AMSTAR score
Waters *et al.* 2011 [131]	Update the previous Cochrane review and determine the effectiveness of educational, health promotion and/or psychological/family/behavioural therapy/counselling/management interventions which focus on diet, physical activity or lifestyle support, or both and were designed, or had an underlying intention to prevent obesity/further weight gain, in children.	Date range: 1990 - Mar 2010 Databases: CENTRAL, Medline, Embase, PsycINFO, CINAHL, reference lists, experts contacted; grey literature: The Campbell Library, CRD, The Cochrane Library, DARE, Health evidence - Canada, (http://www.health-evidence.ca/), NHS Evidence, EPPI-Centre database, ICTRP, Google Language: No restrictions	Study design: C-RCT, CT Setting: Any Participants: 0-18 years Primary outcome focus: Any (BMI for meta-analysis) Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (Cochrane risk of bias tool) Funding Sources: Department of Health, UK; WHO; Victorian Health Promotion Foundation (VicHealth), Victoria, Australia; Commonwealth Department of Health and Ageing, Australia; the National Health and Medical Research Council Capacity Building Grant, Australia; the Jack Brockhoff Foundation, Australia and other author-specific sources	11
Williams *et al.* 2013 [132]	Evaluate the effects of policies related to diet and physical activity in schools, either alone, or as part of an intervention programme on the weight status of children aged 4 to 11 years	Date range: up to Jun 2011 Databases: Medline, Embase, PsycINFO, SportDISCUS, WoS, ERIC, BEI, AEI, CINAHL Plus, Cochrane Library, reference lists; Grey literature search (in July 2011): metaRegister of Controlled Trials, Clinical Trials.gov, International Clinical Trials Registry Platform, Robert Wood Johnson Foundation website Language: Not reported	Study design: RCT, CBA, ITS, CS, XS Setting: School Participants: 4-11 years Primary outcome focus: Obesity-related Intervention type: Nutrition/PA policy Synthesis: Meta-analysis Assessed study quality: Yes (Newcastle-Ottawa Scale) Funding Sources Medical Research Council Doctoral Training; University of Exeter; NIHR; CLAHRC	7
Wolfenden *et al.* 2014 [133]	Evaluate the effects of whole of community interventions to prevent excessive population weight gain.	Date range: 1990 – 2011 Databases: Medline, Embase, CENTRAL, Google Scholar, reference lists Language: English	Study design: RCT, C-RCT, QE with a parallel control group Setting: Community Participants: whole population Primary outcome focus: Obesity-related Intervention type: Any Synthesis: Meta-analysis Assessed study quality: Yes (Cochrane risk of bias tool) Funding Sources: Not reported	7
Zenzen and Kridli 2009 [134]	Conduct an integrative review using Cooper's framework to provide an overview of the degree of variability in the methodological approaches and theoretical frameworks of school-based obesity programs.	Date range: 2000 – 2007 Databases: Medline, PsycINFO, CINAHL, reference lists Language: English	Study design: Not reported Setting: School Participants: 4-18 years Primary outcome focus: Any Intervention type: Any Synthesis: Narrative Assessed study quality: Yes (Stetler's quality criteria of research) Funding Sources: Not reported	2

* Databases: AEI (Australian Education Index), AHRQ (Agency for Healthcare Research and Quality), ASSIA (Applied Social Sciences Index and Abstracts), BEI (British Education Index), BIOSIS (Biosciences Information Service), CDSR (Cochrane Database of Systematic Reviews), CCTR (Cochrane Controlled Trials Register), CENTRAL (Cochrane Central Register of Controlled Trails), CINAHL (Cumulative Index to Nursing and Allied Health Library), CPCI (Conference Proceedings Citation Index), CRD (The Centre for Reviews and Dissemination), DAI (Dissertation Abstracts International), DARE (Database of Abstracts of Reviews of Effects), DoPHER (Database of Promoting Health Effectiveness Reviews), , Embase (Excerpta Medica database), EPPI-Centre (The Evidence for Policy and Practice Information and Coordinating Centre database for health promotion research), ERIC (Education Resource Information Center), HMIC (Health Management Information Consortium), IBSS (International Bibliography of the Social Sciences), ICTRP (World Health Organization International Clinical Trials, Registry Platform), LILACS (Literatura Latino Americana em Ciências da Saúde), Medline (Medical Literature Analysis and Retrieval System Online), NCCHTA (NIHR Coordinating Centre for Health Technology), NICE (National Institute for Health and Care Excellence), PAIS (Public Affairs Information Service), PEI (Physical Education Index), PsycINFO (Psychological Information Database), SCI (Science Citation Index), SSCI (Social Sciences Citation Index), SciELO (Scientific Electronic Library Online), SIGN (Scottish Intercollegiate Guidance Network), SIGLE (System for Information on Grey Literature in Europe), TRoPHI (Trials Register of Promoting Health Interventions, WoK (Web of Knowledge, including WoS and ISI databases), WoS (Web of Science)

** Study design specified for inclusion in the SR: CT (Controlled Trial, with or without randomisation), CCT (Controlled Clinical Trial), RCT (Randomized controlled trial), nRCT (non-RCT), Q-RCT (Quasi-RCT); Q-nRCT (Quasi-experimental nRCT), NRNCT (Non-Randomised Non-Controlled Trials) C-RCT (Cluster RCT), CBA (Controlled before-and-after study), PCS (Prospective cohort study), RCS (Retrospective cohort study), PCCS (Prospective controlled cohort studies), HCT (Historically controlled trial), NCC (Nested case-control study), CC (Case-control study), XS (Cross-sectional study), CR/CS (Case report/Case series), ITS (Interrupted Time Series), NE (Natural experiments), QE (Quasi-experimental study), PPT (Pre- and Post-test repeated measures design), QE-PPT (Quasi-experimental Pre- and Post-test evaluation), PA (Physical activity)

*** % BF (Percentage Body Fat), BMI (Body Mass Index), FFST (fat-free soft tissue), FMI (Fat Mass Index) RR (Relative Risk), SFT (Skin Fold Testing), TSF (Triceps Skin Fold), WC (Waist Circumference), WHR (Waist-to-Hip Ratio)

Appendix 3D – Characteristics of SRs (Part 2)

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
Avery et al. 2015 [72]	Inclusion criteria: (i) trial involves ≥100 healthy children; (ii) focus on reducing consumption of sugary drinks; (iii) control data available; (iv) change in consumption of SSBs and weight outcomes; (v) ≥6 months duration Exclusion criteria: not reported	School-based education programmes focusing on reducing SSB consumption, and which include follow-up modules, are effective. Peer support and changing the school environment could improve effectiveness. There is a lack of relevant reported interventions carried out outside of the school environment.	Practice: Medium intensity (4 - 10 x 1-h sessions over 6 weeks to 12 months) nutrition education programme focussing on beverage choices could be an effective way of reducing consumption of sugary drinks in school-aged children. The use of computer or web-based nutrition education may offer an effective contemporary educational route Research: Rigorous trials including maintenance sessions are key to long-term effectiveness	Small number of studies selected for comparison; heterogeneous studies; exclusion of unpublished data and studies
Baker *et al.* 2011 [73]	Inclusion criteria: (i) ≥6 month follow up from the start of the intervention to measurement of outcomes; (ii) Community wide interventions had to comprise at least two broad strategies aimed at physical activity for the whole population Exclusion criteria: Studies which randomised individuals from the same community were excluded	There was a noticeable inconsistency of findings, confounded by serious methodological issues within the included studies. The most intense interventions failed to demonstrate consistent improvements. Further, effectiveness was not demonstrated in the long term studies, which some shorter included studies had recommended. The body of evidence in this review does not support the hypothesis that multi-component community wide interventions effectively increase population levels of physical activity.	Practice: No evidence that adherence to a particular theoretical framework or model is advantageous. There are significant challenges to implementing multi-strategic community wide interventions. Research: review demonstrates a need for: (i) further exploration of combined community interventions using rigorously designed studies; (ii) more sensitive, reliable and valid tools to measure PA at multiple points; (iii) consideration of gender differences in effectiveness and during study design; (iv) a focus on outcomes by population characteristics; (v) publication of process evaluations with information on potential facilitators and barriers; (vi) economic evaluations	Potential publication bias: the inclusion criteria required studies to have at least two intervention strategies and this excluded a number of large scale mass media interventions. Studies showing a single strategy approach without evidence of multiple strategies were excluded
Barr-Anderson *et al.* 2014 [74]	Inclusion criteria: (i) > 12 weeks duration; (ii) study sample ≥80% African American or results specific to African American youth available); (iii) intervention conducted outside school time; (iv) intervention included pre- and post-measurements; (v) conducted in the United States Exclusion criteria: not reported	The inconsistency in MQ scores, imbalance of full trials vs. pilot studies and variability of study designs among the interventions made it challenging to draw overarching conclusions about effective strategies in minority youth. Findings were inconsistent due to a lack of scientific rigor, dearth of full trials powered to detect differences compared to the excess of pilot studies, and heterogeneity of study designs. There was no consistent pattern of cultural adaptation or community engagement for eligible programmes. However, regardless of the study design, after-school studies tended to positively impact physical activity,	Practice: After-school and summer programmes, alone or in combination, may favourably influence diet and physical activity behaviour in African American youth Research: More high-quality, full-length trials with consistent methodologies are needed	None reported

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
		fruit/vegetable consumption and caloric intake and body composition		
Beauchamp *et al.* 2014 [75]	Inclusion criteria: (i) studies aimed at whole population; (ii) interventions aimed at primary prevention of weight gain or with a primary goal of preventing further weight gain in overweight/obese children Exclusion criteria: Interventions that (i) are clinical in nature; (ii) specifically target weight loss in overweight/ obese populations; (iii) are directed at particular ethnic, socioeconomic or otherwise minority groups (unless the study results were stratified by a measure of SEP)	Information-based interventions targeting individual-level behaviour change may be less successful in lower SEP populations. Studies that were shown to be effective in lower SEP participants primarily included community-based strategies or policies aimed at structural changes to the environment. Such Interventions must be given priority in order to reduce population levels of obesity without increasing socioeconomic inequalities in population weight, although it is difficult to draw firm conclusions due to the generally weaker quality of interventions that were not effective in lower SEP groups.	Practice: Effective interventions in lower SEP groups tend to be those of longer duration that incorporate some environmental, structural, community or social support for behaviour change (e.g. improved community access to physical activity or mandatory school nutrition policies); Information-based interventions risk increasing existing health inequalities. Research: Further research is required to identify and evaluate appropriate support strategies for obesity prevention; strategies based solely on information provision should be evaluated for their socioeconomic impact and supported by additional strategies targeted towards preventing weight gain among lower SEP groups, in addition to being embedded within broader strategic initiatives	Publication bias: only English-language papers included; It was unclear whether interventions were sufficiently powered to stratify by SEP; Studies reporting unadjusted BMI percentiles do not take into account normal BMI variation with age and must be interpreted with caution
Bleich *et al.* 2013 [76]	Inclusion criteria: (i) community-based studies; (ii) at least 1 year of follow up after baseline; (iii) control group present; (iv) reported differences in anthropometric outcomes Exclusion criteria: Studies that (i) targeted only overweight or obese subjects or those with a chronic medical condition; (ii) observational studies; (iii) studies expressly targeted at weight loss; (iv) qualitative studies	Moderate evidence that community-based interventions that include a school component and use interventions focused on both diet and physical activity effectively prevent obesity or overweight in children, regardless of study design	Practice: Combination interventions implemented in multiple settings may be more effective at preventing weight gain in children than single-component interventions located in the community only. Research: More research and more consistent methods are needed to understand the comparative effectiveness of these intervention programs	Sub-optimal design of included studies; restriction to interventions located primarily in the community setting excluded several studies that included the community as a secondary component; Possible publication bias as successful programs may not have been included in the analysis because of a lack of published data; English language articles only
Brandt *et al.* 2010 [77]	Inclusion criteria: interventions that (i) had anthopometric and behavioural primary outcomes; (ii) > 6 months duration; (iii) took place in the school and/or involved the environment; (iv) aimed at children	Combined interventions including nutrition, physical activity, and television viewing modification lasting at least one year are effective. Installation of water fountains in schools, implementation of the topics "sugar-containing drinks" and "television viewing" in	Practice: None stated Research: More research needed to: determine ideal starting age and duration of interventions; to determine whether use of BMI to determine the effectiveness of an intervention is appropriate; to investigate the role of	Language restrictions not reported, search was only performed in PubMed

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
	of any weight Interventions designed to address both normal weight and overweight children Exclusion criteria: Not reported	the curriculum, modification of existing physical education and more physical activity during the school day are effective prevention strategies	parents and the family play; to evaluate cost and potential savings; need to include variables such as cultural background and socio-economic status of children/families in analysis; develop guidelines for the content and implementation of school-based interventions	
Branscum and Sharma 2011 [78]	Inclusion criteria: (i) any form of intervention strategy for the treatment or prevention of childhood obesity (ii) the primary audience for intervention was Hispanic, Latino or Mexican American Exclusion criteria: Reviews were excluded	Interventions were more likely to be successful when participants were at higher risk for obesity, a parental component was included, the intervention contained theoretical underpinnings, the intervention was delivered by a dedicated staff, the intervention served older children and the intervention was of longer duration	Practice: interventions should target both physical activity (participation in 60 min of MVPA on most days of the week) and dietary behaviours (e.g. increasing fruit and vegetable consumption, decreasing fat intake, decreasing the consumption of SSB, adequate consumption of water and/or non-caloric beverages and restricting portion sizes of meals and snacks) Research: Study evaluation should be a priority. Theories should also be better operationalized and evaluated for future studies; important constructs that would be important to target include self-efficacy, proxy-efficacy, and self-control. Culturally appropriate and sensitive materials and approaches should be developed and utilized	Risk of publication bias: Few databases searched (no grey literature searched); search restricted to English only; no appraisal of risk of bias
Brown and Summerbell 2009 [79]	Inclusion criteria: Studies were (i) lifestyle interventions; (ii) set in schools; (iii) > 12 weeks duration. Study designs that compared lifestyle interventions with usual care or with other active interventions were included. Exclusion criteria: Studies on children with critical illnesses or eating disorders	Studies were grouped by type of intervention: dietary interventions alone, physical activity interventions alone, combination of diet and physical activity. Of 38 studies, one out of three diet studies, five out of 15 physical activity studies and nine out of 20 combined diet and physical activity studies found significant and positive differences between intervention and control for BMI. Evidence is insufficient to assess the effectiveness of dietary interventions or diet vs. physical activity interventions to prevent obesity in school children, but overall results suggest that combined diet and physical activity school-based interventions may prevent children from becoming overweight in the long term	Practice: The success of interventions varies by gender, age or weight status of children Research: Existing studies need to be better evaluated. Studies need to be adequately powered and of sufficient length and intensity to produce a change in weight or BMI. Better reporting is needed to enable meta-analysis. There is a need for research that views behaviour change within the context of an obesogenic environment.	Poor analysis plan and synthesis of findings. Results summarized methods of studies but did not synthesis or draw together general findings or summary conclusions. Did not include critical appraisal.
Brown *et al.* 2015 [80]	Inclusion criteria: any type of lifestyle intervention, of any length of follow-up, that reported any	Meta-analysis of a limited number of controlled trials found an unclear picture of the effects of interventions on BMI for South Asian children.	Practice: None stated	Possible publication bias: studies which undertook subgroup analysis by

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
	anthropometric measure for children or adults of South Asian ethnicity, regardless of health status Exclusion criteria: interventions focused on food supplementation, fortification, or complementary feeding; the prevention or treatment of undernutrition; eating disorders; surgery or drug treatment	The quality of evidence varied considerably. One high quality study in South Asian children found that a culturally sensitive, school-based physical activity intervention that was delivered within the normal school day was effective.	Research: More research on obesity interventions targeting South Asian populations, particularly those targeting pre-school children and their families, is needed. These studies should report: (i) culturally adaptations; (ii) types of underpinning behaviour change techniques and theories; (iii) anthropometric outcomes by measures of SES; (iv) implementation and running costs; (v) differential effects of lifestyle interventions for South Asians compared with other ethnicities	South Asian ethnicity but did not report this in the abstract might have been missed
Budd and Volpe 2006 [81]	Inclusion criteria: (i) studies including BMI for age and gender as an outcome, (ii) studies conducted in US schools during the school day, (iii) publication in a peer-reviewed journal Exclusion criteria: studies with non-significant findings or which cannot be implemented in the typical school setting	Several successful interventions targeted older children who were better-suited participants for the behaviour change curriculum. Older adolescents are more likely to possess the needed competencies for health-related instruction and behaviour change. In addition, the use of a multicomponent, comprehensive, and detailed nutrition and physical activity curricula for the students in higher grades greatly contributed to the success of programs	Practice: Schools must consider classroom and policy strategies to prevent the problem of childhood obesity, tailored to the age of students. Strategies might include: (i) using behaviour modification techniques with younger students to reduce sedentary behaviour, increase physical activity, and encourage proper nutrition; (ii) instituting a schedule of physical education classes with longer and more vigorous exercise; (iii) working with the broader health community to maximise efficiency Research: Few research studies have examined BMI as an end point of school-based obesity prevention interventions and many are more than 5 years old. There was significant study heterogeneity in type of intervention, duration of follow up and study population, making concrete conclusions difficult	Results summarized methods of studies but did not synthesise general findings or summary conclusions. Did not include critical appraisal
Calancie *et al.* 2015 [82]	Inclusion criteria: Studies that reported findings from empirical formative, process, or outcome research related to policy or environmental obesity-prevention strategies in rural communities in the United States or Canada. Articles that included both rural and urban communities were included only if they reported rural-specific findings Exclusion criteria: Not reported	The CDC Recommended Community Strategies and Measurements to Prevent Obesity in the United States (COCOMO) strategies most commonly implemented in rural areas focused on increasing the availability of healthy foods and beverages in small retail food outlets and increasing access to farmers markets and limiting the availability of unhealthy ones. Fewer studies examined approaches to limiting advertising of less healthy foods and beverages or modifying portion sizes. None of the studies reviewed sought to improve the geographic availability of supermarkets.	Practice: None stated Research: Need for research that (i) compares the effectiveness of interventions in urban and suburban settings versus rural settings; (ii) assessed policy and environmental, social, psychosocial, behavioural, and biological outcomes associated with nutrition-related policy and environmental strategies; (iii) is applied to a variety of intervention settings (e.g. parks, recreational sites and hospitals) to identify the mix of settings that will yield the greatest population-level reach and effects; (iv) explores the possibility of aligning federal food and nutrition assistance programs with efforts to increase access to local foods; (v) reports on the costs	None reported

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
			and economic impact; (vi) explores the role of local champions related to increasing access to local foods	
Campbell *et al.* 2002 [83]	Inclusion criteria: (i) > 3 months duration; (ii) reported report one or more of the following primary outcomes: % BF, BMI, ponderal index, SFT; (iv) reported outcome data at baseline and at post-intervention, or at baseline and change from baseline Exclusion criteria: (i) drug or surgical interventions ; (ii) Pregnant women; (iii) people with eating disorders and the critically ill	Ten studies were included; seven were long-term (> 1 year), three were shorter term (at least 3 months). Eight were school/nursery-based interventions, one was a community-based intervention targeting low-income African-American families, and one was a family-based intervention that targeted non-obese children of obese parents. There is limited high quality data on the effectiveness of obesity prevention programs and no generalizable conclusions can be drawn. However, concentration on strategies that encourage reduction in sedentary behaviours and increase in physical activity may be fruitful	Practice: None stated Research: the need for well-designed studies which examine a range of interventions remains a priority. Future studies should pay attention to: (i) Sufficient power-adequate numbers; (ii) Adequate follow-up ; (iii) Reliability of outcome measurements (reporting of BMI); (iv) Process indicators; (v) Cost effectiveness; (vi) Appropriate and adequate statistical analysis; (vii) Sustainability and generalisability	Not reported by authors. No appraisal of risk of bias
Chen and Wilkosz 2014 [84]	Inclusion criteria: (i) primary outcome including BMI or BMI z-score and health behaviours; (ii) trials that tested lifestyle/weight management interventions; (iii) using at least one eHealth/mHealth component including web (Internet)-based, social media, and mobile communication technology Exclusion criteria: (i) primary prevention interventions; (ii) majority of participants were over 18 years of age; (iii) non-English language articles	All effective interventions utilized dietary and physical activity strategies as part of intervention components. Because of the variation in duration of intervention (range 10 weeks to 2 years), it is not clear what length of intervention is most effective	Practice: None stated Research: Future research should include rigorous evaluation of cost-effectiveness as well as the mediating and moderating factors associated with effective technology based interventions. More long-term follow-up and assessment of weight-related health outcomes, such as physical activity, sedentary activity, dietary behaviours, self-efficacy, and quality of life, should be included in future research	Not reported

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
Chriqui 2013 [85]	Inclusion criteria: To be included, the study must have empirically examined a formal, public policy adopted at the state, local, and/or school district level in the United States Exclusion criteria: Simulation models, extrapolation studies, survey studies that contain data on policies reported by respondents, or summaries of the literature that failed to document the formal public policy(ies) studied	Most studies were cross-sectional and focused on policies affecting school environments, primarily reporting on policy implementation rather than impacts on physical activity behaviours, food intake, and/or obesity-related outcomes. Existing state and school district policies can influence school PE and PA environments, but they alone are not sufficient to change the rates of child and adolescent PA to meet the national recommendations of 60 minutes of daily PA	Practice: Schools are only one piece of the obesogenic environment. Thus, it is important for policy makers to start to look beyond schools by focusing on broader population-based strategies that aim to improve all aspects of society, particularly given that school-level changes alone are insufficient for addressing the obesity problem. Research: More research is needed to: (i) examine the influence of state and local natural policy experiments affecting non-school environments; (ii) study impacts beyond policy implementation, without which it will be difficult to convince policy makers to adopt such policies. Policy impacts are critical to facilitate the diffusion and adoption of such policies nationwide	Not reported
Chriqui *et al.* 2014 [86]	Inclusion criteria: Studies that (i) were based in the United States based; (ii) focused on the food and beverage environment in schools; (ii) examine the effects of a formally adopted policy at state and/or district levels; (iv) focus on the relationship between the policy and BMI and weight outcomes or student consumption, purchasing, and dietary intake or in-school availability/access to competitive foods Exclusion criteria: (i) non peer-reviewed; (ii) describe self-reported policies or information obtained from surveys; (iii) report categories that are not related to Competitive Food & Beverages; (iv) qualitative, pilot or non-scientific studies; (v) do not report on outcomes of interest	The studies reported mixed results, and many lacked rigorous study designs. Furthermore, many had very limited (if any) time lags between their policy date and the outcomes examined, which could have contributed to the mixed results. However, in 15 of the 24 studies reviewed, state laws and/or district policies have influenced outcomes in the expected direction. Most of the studies reporting results in the expected direction focused on in-school availability and/or in-school consumption, but studies examining BMI and weight outcomes and overall consumption were mixed	Practice: Societal changes may be required to facilitate sustained changes to overall consumption and student BMI/weight outcomes, but schools play a critical role in shaping children's food and beverage environments and should be a national focal point for obesity prevention. Changes made in schools should be reinforced in environments outside the school setting Research: more research is needed to understand the influence of CF&B policies on overall (in- and out-of-school) student consumption behaviours and student BMI and weight outcomes. In particular: (i) more robust, longitudinal study designs; (ii) examining the impact of CF&B policies on changes in NSLP/SBP participation rates and food service revenues; (iii) examine whether implementation of the impending federal rule will vary based on the strength of existing state and/or district policies; (iv) resources are clearly needed for more longitudinal outcome data nationwide	No quality assessment of included studies was carried out; threats to internal and external validity due to the inherent nature of the included studies were acknowledged

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
Cole et al. 2006 [87]	Inclusion criteria: (i) school-based; (ii) manipulation of at least one of the variables of healthy lifestyle education, dietary habits, and/or physical activity; (iii) statistically significant decrease in BMI or weight Exclusion criteria: Studies not meeting inclusion criteria	The majority of school-based interventions used multiple treatment modalities. Providing education in a nonthreatening, familiar setting with a supportive network of friends and family is an effective educational strategy for targeting childhood overweight. In addition, the provision of incentives to promote positive behavioural changes may be effective in younger children. Teachers were commonly responsible for the teaching of the healthy lifestyle curriculum and are important role models in the school setting for children	Practice: Social Cognitive Theory is a sound theoretical perspective for designing and implementing successful interventions with children. Modeling is a primary techniques that should be encouraged when designing interventions for children in the school setting. Demonstration of and the opportunity to rehearse behaviours that improve overweight in children by teachers, peers, and students themselves should be highlighted. The use of contracts with goals and rewards can regulate and reinforce new behaviours and improve self-efficacy Research: Not reported	Only trials with statistically significant decrease in BMI were reported; No attempt made to evaluate the quality of the studies, including sample size and power. No conclusion about the actual effectiveness of the interventions can be drawn.
Cook-Cottone *et al.* 2009 [88]	Inclusion criteria: Studies that (i) are published in English; (ii) school based (during or after school hours); (iii) obesity-prevention programs; (iv)have an objective anthropometric outcome measure;(v) targeting children of normal weight along with children who may have been at risk for overweight or who were overweight at the time of the program's implementation Exclusion criteria: Treatment interventions; trials measuring only PA or dietary outcomes; clinical populations; eating disorder prevention programs; Head Start and community programs	Of studies reviewed, only 38% yielded significant weight gain prevention effects. Overall the findings indicated small effects on BMI for school-based obesity prevention programmes ($r = 0.05$ [0.04, 0.06], $P = 0.000$) with significant variance among outcomes (Q [65] = 626.40, $P < 0.001$). The most significant moderators included interventions delivered predominately among Asian students; by combination of school teachers and interventionists; with high parental involvement; which encouraged healthy eating and which were aimed at reducing sedentary behaviours.	Practice: Weight prevention programmes must be carefully planned and suited to each school's population, risk and needs. Goals must include more than BMI reduction or weight loss Research: Research that assesses the efficacy of integrating a holistic approach with integral prevention of binge eating and eating disorders is required. Further analysis is required to explore possible interaction between moderator variables. For example, more research is needed to explore the relationships between program length and outcomes, given that this meta-analysis found programs with longer durations to be associated with efficacy, whereas others have found brevity to be associated with efficacy	Poor description of study selection. Did not provide flow chart of selection process. Did not perform a critical appraisal of the quality of included studies
De Bourdeaudhuij *et al.* 2010 [89]	Inclusion criteria: studies had to report at least the effects on behaviour or on measures of obesity. Studies were considered regardless of their design Exclusion criteria: (i) non-European studies; (ii) published before 1990; (iii) conducted mainly	European studies constitute only a small proportion (around 10%) of the literature. Interventions that include only an educational component without any environmental strategy seem to be ineffective. There was moderate evidence that multi-component interventions focussing on healthy diets and PA habits that combining an educational and an environmental component had a positive impact upon obesity	Practice: There is a need to implement sustainable interventions under real life conditions, without a continued need for external help or support from a research team. A combination of approaches combining educational and environmental strategies focussing on both nutrition and PA habits seems to be most effective. Policy initiatives to ensure that schools are able to implement these strategies locally are warranted	The authors' conclusions appear somewhat strong given the evidence and so should be interpreted with some caution.

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
	outside the school setting (e.g. community, family); (iv) treatment interventions; (v) studies that did not report the effect on behaviour and/or on measures of obesity	measures in adolescent girls. Combining computer interventions providing tailored feedback with an environmental component for PA (including opportunities to be physically active during breaks, at noon or after school; organization of noncompetitive activities; extra sports and PE classes) and for nutrition (including changes in school canteens; reduced price/increased availability of water and fruit and increased price/reduced availability of soft drinks and sweet desserts) are promising strategies in preventing overweight in adolescent girls in Europe. The evidence for effectiveness in younger children (6–12 years old) is inconclusive	Research: Future research should combine educational and environmental components and focus on both sides of the energy balance equation. Studies should preferably use effectiveness trials, with strong study designs, objective methods to measure behaviour, BMI and other outcomes, longer follow-up periods and specific attention to selection and allocation biases. Further research is also needed to investigate whether computer-tailored education is really superior to generic classroom-based education	
de Sa and Lock 2008 [90]	Inclusion criteria: (i) controlled studies; (ii) schoolbased intervention to encourage fruit and/or vegetable; (iii) > 3 months follow up; (iv) record one change in intake of fruit and/or vegetables or a change in knowledge, attitude or preference to fruit and/or vegetables Exclusion criteria: Not reported	School schemes are effective at increasing both intake and knowledge, and results can be maintained long term, but multiple changes in social, economic and physical aspects of children's environments are also likely to be required to sustain increased FV intake. The EU agriculture policy for school fruits and vegetables schemes should be an effective approach with both public health and agricultural benefits	Practice: Implementation of effective school-based interventions to promote fruit/vegetable consumption requires careful consideration of context-specific factors such as differences in education systems, school meal programmes, producer organisations, supply chains and food cultures Research: None stated	Lack of details on data extraction and validity assessment make it difficult to rule out reviewer error and/or bias or to assess the reliability of the primary studies. Pooling of different study designs without explicitly consideration of quality means that the results may not be reliable
Dobbins *et al.* 2013 [91]	Inclusion criteria: (i) health promotion study; (ii) not conducted by physicians but implemented, facilitated, or promoted by staff in local public health units; (iii) school setting; (iv) aimed at increasing PA; (v) included all school-attending children; (vi) > 12 weeks duration Exclusion criteria: studies not focused on changing PA and fitness levels or were not implemented primarily in the school setting	There is evidence that school-based PA interventions have a positive impact on duration of PA, television viewing, VO2 max, and physical activity rates (MVPA during school hours; odds ratio (OR) 2.74, 95% confidence interval (CI), 2.01 to 3.75). There was no positive impact on blood cholesterol. However, given these studies are at a minimum of moderate risk of bias, and the magnitude of effect is generally small, these results should be interpreted cautiously.	Practice: (i) PA interventions should continue; (ii) school-based PA interventions should focus on fostering positive attitudes toward PA and be geared toward the developmental level of students; (iii) staff should encourage students to be more physically active during the course of the school day, including PA during school-based interventions; (iv) Parental involvement could be an integral part of such interventions; (v) collaboration with public health staff to increase resources for the promotion of PA within the school system would be beneficial	It is possible that bias was introduced during the review process despite the implementation of strategies to reduce bias. Publication bias due to focus on English-language articles (e.g. articles published in Chinese that were not indexed in English language databases were not eligible for inclusion).

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
	among healthy children aged 6 to 18 years, or were implemented by physicians, or fitness experts.		Research: Future research should: (i) assess the impact on PA rates, duration and intensity; (ii) assess the validity and appropriateness of outcomes, including: student satisfaction, health-related quality of life, self-esteem, self-efficacy for PA, reduction in alcohol/drug consumption, involvement in extracurricular activities, and cost-effectiveness; (iii) assess known barriers and facilitators of PA, particularly among children of various socioeconomic status and ethnicity and urban/rural location; (iv) conduct subgroup analysis (e.g. differences in PA by gender, age and ethnicity); (v) collect long-term follow-up impact data; (vi) national funding agencies need to prioritise research related to PA promotion, funding projects that span multiple years	Given a meta-analysis was not conducted, it is possible that the review team may have overestimated treatment effects when interpreting the results across studies
Flodmark *et al.* 2006 [92]	Inclusion criteria: studies that (i) address prevention of overweight or obesity; (ii) > 12 months follow-up; (iii) include a control group; (iv) relevant outcome measures, primarily the percentage of overweight or obese subjects, BMI or SFT; (v) address a normal population Exclusion criteria: Treatment interventions	Many studies do not demonstrate positive effects, suggesting that it is difficult to create an effective program based only on limited interventions in schools. No differences in the occurrence of positive effects were reported for low quality studies in comparison with high and medium quality studies. Positive effects were found in 41% of cases. Overall, the results suggest that it is possible to avoid overweight and obesity in children and adolescents by using preventive interventions	Practice: None stated Research: None stated	Unclear how papers were selected for review, how data were extracted, how study validity assessment was carried out and how the quality of studies was assessed. Study data were tabulated and outcomes summarised in terms of the overall positive or negative effect, rather than reporting individual numerical data, without outlining the differences between the studies. Conclusions contradict the findings that few interventions showed positive effects
Gao and Chen 2014 [93]	Inclusion criteria: (i) peer reviewed, data-based research articles; (ii) published in English; (iii) studied some type of exergames (e.g. DDR, Eyetoy, Wii, etc.) in relation to obesity-related outcomes; (iv)	The effects of field-based exergames on children's habitual PA and obesity-related outcomes remain unclear due to design problems, measurement issues and other methodology concerns	Practice: None stated Research: Future studies should: (i) investigate the effects of different exergame types (whole body vs. lower/upper body) and systems (e.g. Wii, Xbox, PS3) on children's health outcomes; (ii) quantify the role of exergame accumulated PA vs daily PA, and determine	Not reported

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	studied children and/or adolescents in field-based settings Exclusion criteria: Not reported		whether children use exergaming replace their screen times as opposed to traditional sports or PA; (iii) investigate the extent to which exergaming can promote children's learning and maintenance of new movement skills and cognitive skills; (iv) examine the long-term efficacy of exergame use in non-structured home settings, and the potential benefits of family/group play and potential barriers; (v) consider moderating variables, such as gender, age and socioeconomic status, when evaluating efficacy of exergames; (vi) enhance process evaluation of exergaming programmes; (vii) be conducted on younger children; (viii) seek to ascertain the effectiveness of using multiplayer mode in comparison to single player mode; (ix) establish a standard metric that allows statistical techniques for data analyses; (x) Meta-analysis is warranted	
Haynos and O'Donohue 2012 [94]	Inclusion criteria: Studies that (i) used randomization procedures and controls; (ii) obesity prevention programs.; (iii) reported outcomes on at least one weight- or adiposity-related variable, such as BMI or % BF Exclusion criteria: Interventions that specifically targeted particular high-risk groups based on variables such as sex, ethnicity, weight status, etc.	Of those programs identified to produce outcomes on weight and adiposity, results are generally modest and not uniform across prevention studies, possibly due to problems with intervention or research design	Practice: None stated Research: Need for (i) well-powered studies with greater effect sizes, and thus more clinically significant outcomes; (ii) replication of prevention programs found to positively affect obesity outcomes by independent research groups; (iii) improving the quality and effectiveness of the already modestly effective prevention programs available; (iv) developing better-designed, theory-based studies that are generalizable to the general population and which publish economic costs	Not reported
Holub *et al.* 2014 [95]	Inclusion criteria: interventions that (i) focused on obesity-related topics (eg, not general health promotion); (ii) sample included at least 50% Latino/Latin American participants or had results stratified by race/ethnicity; (iii) evaluated and included obesity-related outcome measures; (iv) controlled study; (v) was conducted in a community setting; (vi) and (vii) was published	Mixed results observed: while many studies received the highest marks in study design suitability, few had significant results related to obesity outcomes and effect sizes ranged considerably. Studies that were able to demonstrate a statistically significant reduction in weight or BMI z-scores also included strategies to improve behavioural skills (e.g. goal setting, self-monitoring) or an intensive, daily program. The strategies implemented in these studies provide promising directions for	Practice: The evidence around targeted interventions for overweight/obese children is more limited and strategies require greater intensity and tailoring compared with prevention interventions Research: Need for suitable study designs with control groups, and to apply methods and protocols that would reduce the potential for error (e.g. lack of measurement to gauge exposure, not correcting for potential biases or confounders, maintaining less than 80% of the sample at follow-up, and various selection biases)	Narrow focus on obesity-related measures as the outcome of interest, excluding interventions that target nutrition and physical activity as the primary outcome may also impact obesity; inability to compare effect sizes due to the variety in

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	in a format with viable information for abstraction and quality evaluation Exclusion criteria: interventions that (i) utilize prescribed medications or involve a non-representative sample; (ii) lab studies; (iii) focused on one-on-one health education, counselling, or advice in a health care setting	future research aimed at obesity prevention and treatment among Latino students in the United States		study designs and methodologies
Ickes *et al.* 2014 [96]	Inclusion criteria: (i) primary research; (ii) overweight or obesity prevention interventions; (iii) school-based; (iv) child-based interventions, which could include parents; and (v) reported outcome data Exclusion criteria: (i) preschool, early childcare, or after-school programs; (ii) not available in the English language; (iii) treatment interventions; (iv) articles reporting study design and/or process evaluation only; (v) non-primary research; (vi) intervention not conducted during regular school hours	Each of the global school-based interventions included in this review resulted in at least one positive, measurable outcome. Elementary schools appear to be an ideal setting for childhood obesity prevention interventions given the vast array of opportunities for promoting physical activity and nutrition education through practice, policy, and supportive environments. Targeting specific grades and classrooms within elementary schools may be easier when compared to targeting middle schools and high schools due to scheduling, built in opportunities for physical activity, and flexibility in the curriculum	Practice: A critical component of successful school-based obesity prevention interventions is tailoring the program to the targeted audience Research: Future research should (i) include theoretical frameworks; (ii) be tailored to target audience; (iii) Integrate a combination of nutrition and PA strategies; (iv) include parents; (v) consider environmental strategies; (vi) involve training of teachers; (vii) last longer than one year; (viii) incorporate multiple outcomes, including knowledge, attitudes, behaviours, related theoretical constructs, and anthropometric data; (ix) Implement follow-up measures to determine long-term efficacy	Possible publication bias: only peer-reviewed studies in English included; excluded studies that were conducted outside of regular school hours and studies published prior to 2002
Jaime and Lock 2009 [97]	Inclusion criteria: (i) food or nutrition policies (nutrition guidelines, regulation of food and beverage availability, price intervention) Exclusion criteria: (i) Not school-based nutrition policy; (ii) focus on education or behavioural interventions without changes in school food environment; (iii)	Nutrition guidelines and price interventions were effective in improving school food environments and dietary intake. Only one included study evaluated the impact of school food policies on BMI	Practice: None stated Research: Need for research to evaluate the effect of school nutrition policies on childhood obesity, with particular focus on which were most effective and cost-effective, and for emphasis on which school policies could tackle the influence of the food industry in school environments.	Possible publication bias: It was unclear whether the authors used language restrictions. Study abstracts were screened by only one reviewer and no details were provided on how data was extracted, with the possibility of reviewer error and bias in the review process. No

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	targeting students having a specific medical problem			assessment of study quality was carried out
Kaiser *et al.* 2013 [98]	Inclusion criteria: (i) human trials, (ii) 3 weeks duration;, (iii) random assignment to conditions differing only in consumption of SSBs; (iv) including a BWI outcome Exclusion criteria: Not reported	The currently available randomized evidence for the effects of reducing SSB intake on obesity is equivocal. Even if statistical significance is ignored, the point estimates of effects on BMI reduction are small, accounting for only 1.5% of the variance observed in those who were overweight at baseline. However, the lower limit of the confidence interval around the estimated effect of SSB reduction is very close to statistical significance	Practice: None stated Research: Additional, larger or otherwise stronger studies are needed to provide clear and convincing evidence that lowering SSB consumption will reduce obesity and obesity-related disease prevalence	Not reported
Kamath *et al.* 2008 [99]	Inclusion criteria: interventions that (i) are aimed at changing lifestyle behaviours to prevent obesity; (ii) simple or multimodal; (iii) delivered by a healthcare professional, community member or health authority in a home, school, clinic or community setting; (iv) reporting on self-reported or objective outcomes of interest Exclusion criteria: (i) participants with eating disorders; (ii) only obese participants; (iii) mostly adult participants; (iv) study targeted the consequences of obesity (e.g. cardiovascular risk factors)	Interventions caused small changes on their respective target behaviours and no significant effect on BMI compared with control. Further exploration found: (i) a lack of sex-treatment interaction; (ii) trials in children found larger reductions in sedentary activity than trials in adolescents; (iii) trials of long treatments > 6 months found larger reductions in sedentary activity and BMI than shorter trials, which were more effective in reducing unhealthy dietary behaviours; and (iv) trials measuring outcomes during treatment found larger reductions in sedentary activity and smaller reductions in BMI than trials that measured these outcomes after treatment. Behavioural interventions to prevent paediatric obesity had small beneficial effects on target behaviours and no significant effect on BMI	Practice: None stated Research: Need for studies of promising long term interventions for prevention of childhood obesity, with detailed definition and measurement of target behaviours, extended follow up and improved reporting of details of interventions. They suggested that systematic reviews in this area should be structured to permit comparison of intervention types across studies	Review was restricted to published studies and may be subject to publication bias; unclear whether there were language restrictions
Kanekar and Sharma 2008 [100]	Inclusion criteria: (i) English language peer-reviewed publication; (ii) USA or UK study; (iii) focus on general population; (iv). having an explicit school-based curriculum for prevention of	This review concluded that school-based childhood obesity interventions did not seem to modify BMI	Practice: None stated Research: The authors stated that it would be desirable to repeat the meta-analysis using different outcome measures, such as physical activity, fruit and vegetable intake, soft drink intake and sedentary behaviour	Possible publication and language bias. Quality assessment was limited and did not fully assess risk of bias. Methods used for study selection and

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	obesity; (v) report change in BMI as an outcome Exclusion criteria: Studies not meeting inclusion criteria			quality assessment were not reported; risk of reviewer errors as data extraction was performed by only one reviewer; Use of meta-analysis was probably inappropriate and the results may not be meaningful.
Katz *et al.* 2008 [101]	Inclusion criteria: (i) controlled studies; (ii) school setting; (iii) > 6 months follow up; (iv) reported on common weight-related outcomes (e.g. BMI) Exclusion criteria: (i) data presented in graphs or which were categorical; (ii) unknown sample size; (iii) poor methodological quality; (iv) lack of standard deviation	Meta-analysis indicated a significant weight reduction among intervention participants. Combination nutrition and PA interventions with a parent or family component were effective at achieving weight reduction in school settings. No single intervention, in school or elsewhere, is likely to be sufficient to reverse the childhood obesity trend	Practice: None stated Research: Interventions that modify school policies and the physical environment in ways that support improved dietary practices and regular physical activity but do not provide behavioural programs, and evaluation of these (preferably with anthropometric outcomes), are needed.	Quality criteria were not described in the review; poor reporting of validity criteria, and results of the validity assessment were not shown; Possible publication bias as only English language publications were sought. Statistical heterogeneity was present in most of the analyses, so pooling of results may not have been appropriate.
Kesten *et al*. 2011 [102]	Inclusion criteria: (i) > 3 months duration; (ii) Community, Family, School (or/and combination) setting; (iii) primary prevention Intervention modifying: PA behaviours, eating behaviours, attitudes and knowledge, BMI or other indices of fat mass; (iv) present results separately for girls Exclusion criteria: (i) treatment interventions; (ii) results presented for boys exclusively; (iii) participants exclusively <7 years of age or >12 years of age; (iv) systematic reviews, meta-analysis, editorials, cross-sectional studies	The majority of the interventions failed to produce medium to large effect sizes over the long term in a broad range of behavioural and physical measures. There was potential for interventions aimed at pre-adolescent girls to reduce the risk factors associated with childhood overweight and obesity. The sustainability of intervention effects was unclear	Practice: Although a simple recommendation for best practice is difficult, potentially successful interventions might have included reducing sedentary behaviours and modifying school food provision, with longer term follow up. Interventions should take account of cultural, age and gender characteristics across a broad range of social settings. Research: funding the follow-up of interventions is crucial in order to produce sustainable, effective interventions	Included studies show inconsistencies with the inclusion criteria in terms of participant age and outcomes; potential language and publication biases could not be excluded

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Knowlden and Sharma 2013 [103]	Inclusion criteria: interventions that (i) were aimed at preventing obesity or overweight; (ii) were conducted in the United States, (iii) targeted African American or Hispanic children, (iv) school settings, (v) incorporated at least one anthropometric outcome variable Exclusion criteria: interventions that (i) did not employ an experimental or quasi-experimental design; (ii) did not target African American or Hispanic children	Efficacy of school-based interventions targeting minorities can be enhanced through explicit operationalization of behavioural theories, incorporation of systematic process evaluation, long- term follow- up of intervention outcomes, and inclusion of the family and home environment.	Practice: Need to (i) culturally adapt interventions; (ii) include the family and home environment (e.g. targeting parents over summer and winter break periods to preserve or improve school- based intervention effects, newsletters, weekend programmes to recruit parents Research: Need to (i) create or adopt psychometrically valid and reliable instruments; (ii) before-after measures; (iii) include and improve implementation process evaluation; (iv) measure long- term intervention effects	Not reported
Kropski *et al.* 2008 [104]	Inclusion criteria: (i) experimental or quasi-experimental design, (ii) report primary or secondary outcomes in terms of BMI, a measure of body fat or obesity/overweight prevalence; (iii) report outcomes at least 6 months post-baseline; (iv) be curricular and/or environmental (as opposed to extracurricular) in design; (v) apply preventive interventions involving both overweight and normal-weight children Exclusion criteria: (i) extracurricular programs specifically targeting overweight children; (ii) lasting <6 months	Studies were grouped by type of intervention: dietary interventions alone, PA interventions alone, combination of diet and PA. Quantity and quality of evidence were deemed to be insufficient for firm conclusions. Twelve of 14 studies reported significant improvement in at least one measure of dietary intake, physical activity and/or sedentary behaviour. Girls may respond better to educational components while boys are more influenced by structural and environmental changes. Programs including younger children were generally not effective in reducing BMI or obesity prevalence. Studies demonstrating significant findings frequently involved subjects more overweight than peers. Cognitive and physiological developments likely influence impact of interventions	Practice: High-quality evaluation protocols are essential Research: Future studies require adequate power (sample sizes) and need to examine issues related to sustaining health behaviour climate and 'upstream factors'. Further research is needed to examine if novel or more aggressive approaches to address health behaviours at home through school-based programs are effective	No description of data extraction or data analysis plan. No description of selection process. Focus on quality of evidence instead of actual findings

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Lamboglia *et al.* 2013 [105]	Inclusion criteria: (i) focus on children and adolescents aging 6–15 years; (ii) cross-sectional and experimental study design; (iii) evaluate energy expenditure during exergaming; (iv) discuss the association between active games and health behaviour; (v) evaluate changes in the level of physical activity, body composition, musculoskeletal system, and cardiovascular system Exclusion criteria: (i) full text unavailable; (ii) exergaming used for rehabilitation or cognitive therapy; (iii) did not quantify outcome variables	Exergaming was found to increase physical activity levels, energy expenditure, maximal oxygen uptake, heart rate; and to reduce waist circumference and sedentary screen time. Thus, exergaming may be considered a highly relevant strategic tool for the adoption of an active and healthy lifestyle and may be useful in the fight against childhood obesity	Practice: None stated Research: None stated	Discussion limited to description of interventions; no recommendations made to enhance the effectiveness of exergaming as a strategy to prevent obesity
Lavelle *et al.* 2012 [106]	Inclusion criteria: (i) children aged <18 years; (ii) any intervention delivered in a school setting and aimed at decreasing BMI or weight; (iii) effect reported as the mean change in BMI, or this could be calculated from the pre- and post-intervention data provided; (iv) inclusion of a control group for which change in BMI was also reported or able to be calculated; (v) Non-randomized intervention studies were not excluded Exclusion criteria: Not reported	There is reasonably consistent evidence that school-based interventions can significantly reduce children's BMI, especially if they include a physical exercise component. The effect size did not vary by length of follow-up, suggesting that the benefits may be maintained over time, but only one study has followed-up participants for more than 4 years. Evidence of significant benefit is currently lacking for interventions that do not include a physical activity component. The absolute reduction in BMI was greater for interventions targeted at overweight and obese children, but studies delivered to all children nonetheless produced a small, significant reduction in overall BMI that is unlikely to be clinically significant at an individual level	Practice: Reduction in BMI was unlikely to be clinically significant at an individual level. Research: Further randomized studies are needed to determine duration of benefit and the ideal type of intervention. Studies should take not only efficacy but also cognisance and cost effectiveness into consideration.	Studies that used other measures were excluded; Possible publication bias (English language articles only); unclear whether appropriate steps to minimise error or bias were taken; unclear whether quality of the included trials was assessed; details on interventions were limited (no mention of dropout rates); Substantial statistical heterogeneity was found in the primary meta-analysis so pooling may not have been appropriate; It was unclear whether or not participants were included more than once in the meta-analyses

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LeBlanc *et al.* 2013 [107]	Inclusion criteria: (i) subjective or objective measure of time spent using active video games and a measure of at least one relevant health or behaviour indicator; (ii) published, peer-reviewed articles in English or French; (iii) mean age of study participants < 18 years Exclusion criteria: (i) evaluated only passive video games; (ii) risk of a confounding intervention (such as diet modification)	Although active video games could increase light-to-moderate physical activity, it was unclear if such games could lead to increase in habitual physical activity or decreases in sedentary behaviour	Practice: None stated Research: There is a need for better quality studies that involve larger sample sizes, use both direct and indirect measures of total active video game use, and involve follow-up measurements at longer time points. The authors advised comparing active video games with traditional physical exercise in addition to comparison with rest or sedentary behaviour.	Restrictions to published articles in English and French may have led to publication bias
Leung et al. 2012 [108]	Inclusion criteria: (i) intervention aimed at decreasing SB, separately or in combination with BMI or other anthropometric changes; (ii) children and adolescents aged 6 to 19 years; (iii) randomized trials, conducted in the community, school, home, or clinic setting; (iv) > 12 weeks duration; (v) strategies such as educational, health promotion, behavioural therapy, counselling, or management strategies at the individual and family levels; Exclusion criteria: (i) not published in English; (ii) controlled laboratory setting	Interventions aimed at reducing SB appear to be effective in decreasing SB and improvements in anthropometric measures of childhood obesity	Practice: Feasibility is an important consideration when implementing interventions in real-world settings Research: need for (i) more comprehensive study designs, which include post-intervention follow-up measures, to better understand the impact and potential sustainability of different strategies on outcomes measures related to SB and anthropometry; (ii) more valid and reliable measures of SB; (iii) Inequalities related to race/ethnicity, SES and gender should be incorporated into the design of future interventions (iv) Collection and provision of cost data	Not reported
Li *et al.* 2008 [109]	Inclusion criteria: interventions that (i) are population-based; (ii) lifestyle behavioural interventions for the prevention or control of overweight and obesity in children and adolescents in China; (iii) reporting on prevalence of overweight and obesity, weight and BMI, SFT, blood glucose and lipid profile, aerobic fitness and blood	All trials indicated at least one significant results for at least one outcome. Eighteen studies showed a significant difference ($p<0.05$) in body adiposity as measured by the prevalence of overweight and obesity, weight, BMI or SFT. The methodological shortcomings inherent in most of the included studies prevent any conclusions being drawn regarding the effectiveness of any of the interventions studied	Practice: None stated Research: There is a clear and urgent need for well-designed trials of interventions for the prevention and treatment of overweight and obesity among children and adolescents in China. Quantitative and qualitative research is required to identify important lifestyle behaviours and environmental risk factors, and to assess the needs and acceptance of health programmes in schools and among children and their parents	Possible publication bias: by including only studies published in English and Chinese some studies may have been missed; it was unclear whether appropriate methods were used when selecting studies for inclusion

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	pressure, and changes in knowledge and behaviour Exclusion criteria: clinical studies; (ii) pharmacotherapy treatment studies			
Liao *et al.* 2014 [110]	Inclusion criteria: (i) all study participants aged < 18 years; (ii) randomized controlled intervention with a no-treatment control; (iii) the intervention must have components to reduce sedentary behaviours Exclusion criteria: intervention used PA promotion as a method to reduce sedentary behaviours (rather than specifically designed to limit time spent in sedentary behaviours); (ii) no reporting of BMI before and after the intervention; (iii) study only reported adjusted BMI at post-intervention	Interventions that target to reduce sedentary behaviours among children are effective in reducing BMI, although the difference in BMI was not clinically significant. However it could be effective in reducing BMI at a population level for non-obese children. Adding a physical activity promotion and diet improvement component to the intervention program did not appear to have an additive effect. A comprehensive sedentary behaviour intervention that targets to reduce multiple sedentary activities may be as effective as multi-component programs in BMI reduction, and could be a promising way to prevent obesity in children.	Practice: Clinical health practitioners could consider focusing on limiting sedentary behaviour to reduce BMI in paediatric patients Research: None stated	The restriction to English-language publications means that relevant trials may have been missed. Unclear study selection was carried out by two researchers independently, so reviewer error and bias cannot be ruled out. Given the small effects, and limitations in the review methods and generalisability, the authors' conclusions seem overstated and may not be reliable
Lissau 2007 [111]	Inclusion criteria: (i) school setting with a main purpose of preventing overweight; (ii) control group present; (iii) at least one of the following outcome parameters: BMI, SFT, WC, %BF Exclusion criteria: Not reported	Of 14 included studies, half were successful and had an effect on either overweight or obesity. Studies differed in age group, type and length of intervention, the type and number of intervention components, and the measures used to evaluate the effect differed. Programmes that were theory based were not more successful than those not based on theory.	Practice: Barriers to school-based obesity programs include: (i) programs are considered a low priority; (ii) lack of support at the school; (iii) school staff are not motivated or are too burdened by workload; (iv) poor or lack of supervision of the school meals Research: More research is needed to understand how school-based obesity interventions may prevent obesity in different groups. Future studies need statistical power, and should use several measures of obesity in order to accurately detect a possible effect	No description of study selection, thus unclear why studies were excluded. No description of data extraction or data analysis plan. Did not critically appraise studies. Only provided aggregate study findings. Insufficient information on individual studies (e.g. no quantitative study results reported).

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Lobelo et al. 2013 [112]	Inclusion criteria: interventions that (i) focused on obesity; (ii) evaluated and included obesity-related objective outcome measures; (iii) controlled studies; (iv) reported in a format with viable information for abstraction and quality evaluation Exclusion criteria: interventions that (i) focused on general health promotion	This review found sufficient evidence to recommend school-based interventions to prevent overweight and obesity among children and adolescents in Latin America. Two studies also were identified showing significant improvements in obesity-related outcomes among overweight/obese youth, although this was not sufficient evidence to recommend obesity treatment interventions in school settings in LA. At least 3 interventions from different countries were identified with adequate design and execution that led to statistically (and clinically) sufficient improvements in obesity-related outcomes. The most successful interventions were characterized by their focus on prevention rather than treatment, by having longer follow-ups (>6months), involvement of teachers as well as allied health professionals, better study designs, and fewer limitations in execution	Practice: Future efforts should include continued replication and refinement of evidence-based, scalable prevention approaches in school settings as important components for integrated programs, policies, and monitoring frameworks aimed at reversing childhood obesity; there needs to be a strong collaboration between health and education authorities and other stakeholders for the implementation of obesity prevention activities in school settings Research: Alternative frameworks for gathering evidence may be useful to summarize the literature on behavioural interventions by allowing inclusion of data from promising and emerging interventions	The restriction to English, Portuguese and Spanish-language publications means that relevant trials may have been missed; the review was restricted to published studies, which may have increased the possibility of publication bias
Malik *et al.* 2013 [113]	Inclusion criteria: (i) original research; (ii) prospective cohort studies or clinical trials conducted in children or adults; (iii) reported multivariable-adjusted coefficients for the association between SSBs and body weight from prospective cohort studies or the difference in changes in body weight between intervention and control groups from clinical trials; (iv) did not combine SSBs with other beverages, foods, or lifestyle factors as a composite exposure; (v) had a control group and intervened for at least 2 weeks in clinical trials. Exclusion criteria: (i) non- English language articles; (ii) cross-sectional or ecologic studies	Results showed an overall positive association between consumption of SSBs and body weight gain in both children and adults with the exception of trials in children from the random-effects model. Trials in children were of 2 modalities, either reducing SSBs by substitution with non-caloric beverages or school-based education programs aimed at discouraging intake of SSBs. In sensitivity analysis, we showed that the substitution trials resulted in significantly less BMI gain compared with the education interventions. Eliminating SSBs from the diet could be an effective way to prevent age-related weight gain	Practice: Results suggest the need for targeted strategies to reduce SSB consumption among high-risk populations, particularly children who are already overweight to prevent further weight gain, and highlight the importance of sustained strategies Research: None stated	Possible publication bias: the restriction to English-language publications means that relevant trials may have been missed; the relatively high degree of unexplained heterogeneity observed in the analyses may limit the validity of summary estimates; the data transformations performed to obtain consistent units across studies may further limit the validity of estimates; the assumption of a 12-oz serving size for some studies may have introduced misclassification and

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				further attenuated summary estimates
Marsh *et al.* 2014 [114]	Inclusion criteria: (i) family based interventions (ii) reporting changes in sedentary time; (iii) active involvement of a parent with the intervention team (e.g. via telephone, counselling or group sessions, or use of a TV-monitoring device at home, which required parental monitoring and therefore participation) was required; (iv) no restrictions on body-weight status and intervention setting Exclusion criteria: (i) comparison group was actually an intervention (e.g. if a study compared the effects of increasing PA vs. decreasing sedentary activity); (ii) participation in family component was voluntary; (iii) no active parental involvement (e.g. newsletters or brochures sent to parents)	This review revealed inconsistent evidence with respect to improvements in sedentary time. Differences in the study population, level of family involvement, setting, study aim and intervention type warrant further consideration of specific study characteristics that may have contributed to differences. The review supports the need for interventions that focus on the family and, more specifically, interventions that involve a parent at more than just a supervisory or administrative level. There is also a need to consider child characteristics and the motivation of the parent, with interventions tailored accordingly.	Practice: A more difficult (though, as this review suggests, potentially more fruitful) approach is to involve the parent and family unit as a whole in efforts to reduce children's screen time. It seems unreasonable to expect children to restrict their level of exposure to a media saturated environment, while simultaneously dismissing the interest of parents in the health and well-being of their children by neglecting to address the role they play in creating a healthy family environment Research: more research is required to (i) address how food-related behaviours moderate the relationship between screen time and overweight in youth; (ii) assess whether interventions that target pre-school children are sustained over time; (iii) assess whether targeting of parents considered to be at high risk for low intervention compliance may help improve outcomes. More studies are also required that either primarily target the parent, or utilize a more intensive parent component.	Inadequate reporting on study quality by authors meant that the risk of bias for a number of domains (allocation concealment and random sequence generation) could not be established. Other limitations included reliance on studies with small sample sizes and short follow-up
Pérez-Morales *et al.* 2012 [115]	Inclusion criteria: interventions that (i) are published in English; (ii) are conducted in the USA; (iii) > 6 months follow-up; (iv) target low income Hispanic children; (iv) obesity prevention studies; (v) at least one indicator of adiposity (weight, BMI, z-BMI, % BF) Exclusion criteria: Not reported	Few interventions have been implemented in underserved populations. The overall quality rate of evidence with respect to reducing BMI or the prevalence of childhood obesity among Hispanic children was low. The overall findings were inconsistent improvements in BMI, z-BMI, and % BF	Practice: None stated Research: None stated	Not reported

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
Peterson and Fox 2007 [116]	Inclusion criteria: (i) controlled studies; (ii) > 6 months follow up Exclusion criteria: Not reported	CDC's recommendations to foster healthy eating and physical activity behaviours in schools nationwide by utilizing a Coordinated School Health Program (CSHP) approach provides a good model for supporting schools. Adoption of evidence-based approaches to impact weight-related measures is a process that poses challenges in time, resources, and training, and may require school systems to make trade-offs among competing demands. School personnel need additional assistance in training and maintaining skills in delivering different intervention components, developing teams and collaborations with community organizations and providers, and in grant-making and support for networking.	Practice: school-based interventions should be multi-component in nature and address nutrition, PA and sedentary behaviours; Integrating nutrition and PA messages into core subjects might be a useful model for future interventions, which should target easily understood modifiable health behaviours such as fruit and vegetable consumption, or MPA. School environments and policies should support and promote healthy food choices and active lifestyles. Research-practice partnerships also will be useful in helping schools identify, monitor, and evaluate current and emerging best practices as well as novel approaches Research: None stated	Not reported
Reilly and McDowell 2003 [117]	Inclusion criteria: RCTs with: (i) > 12 months follow up; (ii) studies on prevention had to have included non-clinical groups of subjects; (iii) studies on obesity treatment were required to have objective criteria to classify children as obese; (iv) objective outcome measures of body weight, BMI or body composition Exclusion criteria: short term studies	The evidence on childhood obesity prevention is not encouraging, although promising targets for prevention are now clear, notably reduction in sedentary behaviour. There is stronger evidence that targeting activity and/or inactivity might be effective in paediatric obesity treatment, but doubts as to the generalisability of existing interventions, and the clinical relevance of the interventions is unclear	Practice: None stated Research: Recommendation for interventions to: (i) focus wholly on reducing inactivity; (ii) focus trial outcomes on more measurable variables such as activity or inactivity, while avoiding less measurable outcomes such as fruit and vegetable consumption; (iii) recognise that that inactivity is best considered as a distinct construct from activity; (iv) quantify potential harm	Short timeframe for search (2 years); quality rating of included RCTs unclear; no information on data extraction and search strategy

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
Sbruzzi *et al.* 2013 [118]	Inclusion criteria: RCTs that (i) assessed the impact of educational interventions for prevention or treatment of childhood obesity; (ii) > 6 months duration; (iii) reported outcomes in BMI, BMI z-score, weight, WC, blood pressure levels, total cholesterol and high-density lipoprotein cholesterol; (iii) included euthrophic, overweight or obese school children 6-12 years old; (iv) were delivered in a school-based program and/or family-based programs; (v) there was a deliberate approach to increase physical activity, decrease participation in sedentary activities, improve dietary behaviours, decrease intake of dietary fat and sugar, or a combination of the above approaches Exclusion criteria: RCTs with: (i) < 6 month follow up; (ii) insufficient or no information regarding magnitude of the effect of the intervention; (iii) lacking an intervention component	Educational interventions to treat childhood obesity resulted in reduction of anthropometric measurements and diastolic blood pressure. However, it was not possible to show that educational interventions to prevent childhood obesity were effective in improving outcomes as compared with usual care or no intervention. No significant changes determined by education interventions to prevent childhood obesity in non-selected paediatric populations in anthropometric measurements, blood pressure and lipids, as compared to usual care or no intervention, were observed. In conclusion, educational interventions are effective in treating, but not preventing, childhood obesity and its consequences (specifically diastolic blood pressure).	Practice: None stated Research: It is necessary for authors to make available sufficient detail about their strategies, about the theoretical basis and components of interventions, and of the dose and intensity of the interventions to improve these results; new studies should be carried out with a larger number of participants	Low methodological quality of included studies
Sharma 2007 [119]	Inclusion criteria: (i) English language; (ii) conducted outside the United States (iii) focus on general population of children in school settings (including pre-school) for children between 3 and 18 years old Exclusion criteria: (i) non- English language publications; (ii) US studies; (iii) studies outside school settings; (iv) non-peer-reviewed; (v) focused solely on overweight/obese children or adolescents	Mixed results for overweight and adiposity indices (6 out of 14 trials had significant effects); other outcomes: significant effects in 16 out of 19 interventions. All interventions that documented parental involvement successfully influenced obesity indices. Most interventions targeting primary school children and focused on individual-level behaviour change approaches. Few are theory-based	Practice: Primary school settings are the most ideal settings for school-based interventions as obesity prevention behaviours are formed at these ages. School-based interventions directed towards addressing childhood obesity prevention should target improvement of physical activity, healthy nutrition and reduction of TV watching behaviours Research: need to base interventions on robust and culturally appropriate behavioural theories; need to supplement individual behaviour change strategies with policy and environmental changes	The restriction to English-language publications means that relevant trials may have been missed

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
Shirley *et al.* 2014 [120]	Inclusion criteria: (i) were published in English; (ii) targeted children ages 6–12; (iii) were school-based and aimed to prevent obesity through school-based physical activity, education, and/or nutrition modification; (iv) were implemented in the US; (v) utilized an experimental or quasi-experimental study design with a control group Exclusion criteria: Studies: (i) of programs organized primarily by churches or other community groups; (ii) primarily aimed at preventing diabetes or other metabolic syndromes	Strategies involving a combination of PA, nutritional, and educational interventions are likely to yield better outcomes than single component strategies, although no nutrition-only studies were reviewed. When the use of all three interventions is not possible, schools should invest in nutritional interventions accompanied by some increase in physical activity. Research does not support the effectiveness of physical activity beyond mandated state physical education requirements as a single component strategy. Parental involvement may be a beneficial program addition, and schools should involve community stakeholders when feasible. The ideal length of obesity prevention programs remains undetermined	Practice: Schools should regularly monitor outcomes of interest (e.g., student BMI) when implementing an intervention to ensure effectiveness and inform modifications. There is some evidence that gains attenuate after interventions cease, so the systematic and continuous implementation of programs throughout the elementary school years is likely necessary to sustain effects Research: None reported	Study heterogeneity precluded the use of meta-analyses, which would have provided more definitive conclusions regarding effect sizes
Showell *et al.* 2013 [121]	Inclusion criteria: Studies conducted in high income countries that: (i) reported the effects of interventions to prevent obesity in children and adolescents aged 2 to 18 years old; (ii) were RCTs, quasi experimental studies, or natural experimental studies with at least 1 year follow-up; (iii) targeted children in their homes or included significant family involvement; (iv) involved a modification of diet, PA, sedentary behaviours, or a combination of these; (v) reported the effect(s) of the intervention on weight-related outcomes Exclusion criteria: focus on overweight or obese children or children with pre-existing medical conditions	Only a small number of studies examined childhood obesity prevention programs in the home setting. The strength of evidence is low, at best, to support the effectiveness of home-based programs on childhood obesity prevention	Practice: None stated Research: More research is needed to test home-based interventions with larger sample sizes, greater intervention duration and intensity, and adequate participant follow-up to improve statistical power of studies. Widespread integration of parenting strategies in home-based interventions should also be considered and additionally evaluated. Implementing and testing the effectiveness of home-based interventions that address important physical environmental influences on obesity-risk behaviours should be a research priority	Not reported

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
Silveira *et al.* 2013 [122]	Inclusion criteria: RCTs of nutrition education interventions conducted in schools to reduce or prevent overweight in children and adolescents (5 to 18 years) Interventions had to be administered by health professionals or school teachers Exclusion criteria: (i) studies on children with eating disorders, dyslipidaemia, mental or physical disabilities, diabetes or anaemia; (ii) afterschool interventions were excluded.	School-based nutrition education interventions were effective in reducing the BMI of children and adolescents, particularly where the intervention duration was longer than one school year. Only two of the eight trials reported statistically significant reductions in BMI and some trials had wide confidence intervals. The overall effect size was small and its clinical significance is unclear.	Practice: None stated Research: There is a need for future research to identify the most effective approaches over medium and long term periods and consider theoretical framework and intervention components.	Only one reviewer extracted data so reviewer error and bias could not be ruled out; there was significant statistical heterogeneity for both overall and subgroup analyses and the reasons for this were not explored; few trial details were reported (e.g. participant characteristics)
Silveira *et al.* 2011 [123]	Inclusion criteria: RCTs that assessed the effectiveness of school-based behavioural lifestyle change interventions recommended by health professionals or school teachers in children aged five to 18 years and which reported absolute or standardised measures of BMI, SFT, WC and % BF or lean mass, or dietary outcomes Exclusion criteria: Trials that assessed: (i) children with illnesses; (ii) afterschool interventions; (iii) drugs or food supplements as components of interventions; (iv) addressed impacts of different follow-up periods	Evidence from RCTs show that school-based interventions were effective in reduced rates of overweight and obesity, and increased fruit and vegetable consumption. Characteristics of interventions that demonstrated effectiveness are: duration > 1 year, introduction into the regular activities of the school, parental involvement, introduction of nutrition education into the regular curriculum, and provision of fruits and vegetables by school food services	Practice: None stated Research: None stated	Only one reviewer performed the data extraction hence reviewer error and bias could not be ruled out

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
Small *et al.* 2007 [124]	Inclusion criteria: Studies that compared prevention or early treatment programmes with a control or comparison programme, with children aged 4-7 years who were overweight, obese, or at risk of obesity Exclusion criteria: Not reported	Currently, there is a paucity of RCTs designed to test intervention strategies (e.g. prevention or treatment) with young children who are overweight/obesity or at risk for later-life obesity. Intervention strategies for which there is some evidence of effectiveness include: (i) a combination of nutritional and activity information; (ii) a cognitive-behavioural aspect to the intervention; (iii) parent-directed activities; (iv) limiting sedentary child behaviours; (v) positive approaches with children by parents and practitioners (e.g., emphasize positive rewards for healthy behaviours, encourage self-efficacy)	Practice: None stated Research: There is an urgent need for future research that develops and tests theory-based reproducible interventions with overweight/obese or at-risk young children and their parents.	Inclusion criteria unclear with regards to intervention type; possibility of publication bias: it is unclear whether language restrictions were applied; no reporting of methods used to asses validity and to extract data not described, hence unclear whether there was reviewer error and bias
Sobol-Goldberg *et al.* 2013 [125]	Inclusion criteria: Studies with at least an English language abstract; School-based intervention programs relative to control groups who did not receive any intervention Exclusion criteria: Trials that only included obese children, and those of interventions for eating disorders or other medical conditions, were excluded	Unlike earlier studies, more recent studies showed convincing evidence that school-based prevention interventions are at least mildly effective in reducing BMI in children, possibly because these newer studies tended to be longer (at least 1 year), more comprehensive and included parental support	Practice: None stated Research: Further research is required to develop and test school-based interventions to reduce BMI in teenagers. These trials should clearly identify the theoretical model guiding the intervention and compare various weight reduction programmes and other school-based health interventions that might result in weight loss	No efforts were made to locate unpublished data; it was unclear whether language restrictions were applied

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
Stice *et al.* 2006 [126]	Inclusion criteria: primary obesity prevention programmes or other interventions that were expected to reduce weight gain or risk of obesity, such as physical activity programmes, eating disorder prevention programmes and psycho- educational interventions Exclusion criteria: Studies that only compared active interventions and studies described as obesity treatment programmes	Most interventions did not produce the hypothesised weight gain prevention effects. The overall intervention effect was small. Larger effects emerged for programs targeting children and adolescents (versus preadolescents) and females, programs that were relatively brief, programs solely targeting weight control versus other health behaviours (e.g., smoking), programs evaluated in pilot trials, and programs wherein participants must self-select into the intervention. Other factors, including mandated improvements in diet and exercise, sedentary behaviour reduction, delivery by trained interventionists, and parental involvement, were not associated with significantly larger effects	Practice: None stated Research: Future trials should follow up promising findings with improved methodology (randomisation, blinded outcome assessment, direct measures of body fat and attempts to minimise attrition), in particular the use of long-term follow-up post-intervention	Unclear whether appropriate methods were used when extracting data; no formal assessment of study validity was carried out
Towns *et al.* 2014 [127]	Inclusion criteria: Studies on prevention or community health addressing child, youth (ages 0 to 18 years), or family health Exclusion criteria: no description or evaluation of intervention; Articles focusing on clinical treatment and individual outcomes	None of the published evaluations reported significant reductions in obesity or overweight or sustained increases in PA, although some evaluations presented evidence of positive effects on children's diets or on nutrition knowledge or intentions. Two programs (SHARE-AP and KDSPP) combined participatory, community-based approaches and environmental supports for behaviour change with strong evaluation and measurement designs. Even for these interventions the evidence for intervention effectiveness was mixed. Only the KDSPP found some evidence of improvement in obesity, but this was not sustained. One explanation may be that aspects of the broader social and economic environment may limit the potential effectiveness of local interventions	Practice: Structural factors may limit the effectiveness of even community-based, multi-component intervention programs for reducing overweight or obesity among Aboriginal children. It may therefore be more appropriate for practitioners to focus on intermediate outcomes such as dietary knowledge or self-efficacy. Collaborative programs might also yield unmeasured benefits in community capacity and control, which may work to reduce structural barriers in the longer term Research: Future intervention research should focus on improvements made at community service provision and how they might lead to improved health outcomes in a range of Aboriginal community contexts	Not reported

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
van Grieken *et al.* 2012 [128]	Inclusion criteria: controlled studies that (i) detailed an intervention, of any duration, that aimed to reduce the level of sedentary behaviour in children aged 0–18 years, or targeted sedentary behaviour with other behaviours, such as PA or dietary behaviours and explicitly stated the intervention elements aimed at sedentary behaviour; (ii) included a sedentary behaviour outcome (TV viewing, snacks during TV viewing) and/or a weight related outcome (e.g. BMI, BMI-z, percentage overweight children) Exclusion criteria: Studies that: (i) were performed in laboratory settings; (ii) had a pre-post test design; (iii) did not have a control group; (iv) cohort studies; (v) were aimed at high-risk (overweight or obese) populations; (vi) did not have sedentary behaviour elements in their intervention	Thirty-four controlled trials were included. Interventions aimed at preventing excessive sedentary behaviour significantly reduced sedentary behaviour by around 18 minutes per day (MD -17.95, 95% CI -26.61 to -9.28; 22 trials). There was some evidence of heterogeneity between study results. There was a mean difference in BMI of -0.25 (95% CI -0.40 to -0.09; 14 trials; I^2=0) favouring the intervention group. The change in BMI from baseline to after intervention mean difference was -0.14 (95% CI -0.23 to -0.05; 13 trials; I^2=33%) in favour of the intervention group. There were no significant differences in the effects on sedentary behaviour and BMI, between single and multiple health behaviour interventions. No moderating effects of age and intervention setting were found for either outcome. Interventions, at school or in the community, could help prevent excessive sedentary behaviour, preventing unfavourable health outcomes, for children and adolescents	Practice: None stated Research: Studies with long-term follow-up are needed to evaluate the sustainability of the intervention effects. These studies should provide details on the intervention, and the types of outcome measures, to explore effective intervention elements. This should include the health behaviours targeted and the alternatives provided for sedentary behaviour. Mediation analyses could explore the relationship between sedentary behaviours and weight-related outcomes	Unclear whether appropriate steps were taken to minimise reviewer error and bias during data extraction. The quality assessment raised notable concerns about selection, performance and detection biases, which could have overestimated the intervention effects
Vasques *et al.* 2014 [129]	Inclusion criteria: (i) School and after-school intervention; (ii) children < 19 years old (iii) RCTs or nRCTs with a control group; (iv) > 6 weeks duration; (v) reported the effect size of intervention or the pre- and post-intervention values on children's BMI, BMI z score, BMI d score, BMI percentile, percentile of overweight/ obesity, or body fat Exclusion criteria: Interventions that: (i) did not have a control group; (ii) intervened only in subjects' diets; (iii) involved children suffering from eating	Intervention programs had a positive effect in prevention and in decreasing the obesity in children, although this effect is of low magnitude (r = .068). The programs with older children seem to be more effective compared with those targeted at younger children. Girls achieved higher effect sizes than boys. Mixed gender intervention programs produced a greater effect than the intervention programs with girls only. After-school programs had a very similar effect to those interventions developed in school settings. The results of the current study also demonstrate that intervention programs of 1 year in length had a greater effect size than those with longer or shorter durations. The intervention programs that best contribute to the	Practice: easier access to and reduced price of healthier food, as well as the ability to pay sports activity fees, can make a difference in the effect of an obesity prevention program Research: Reviews should be conducted using several anthropometric measurements and evaluating their impact on the metabolic profile of children; further meta-analytical studies are needed to determine the effect size of high-intensity activity	Not reported

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
	disorders or drug or alcohol problems; (iv) were only descriptive	prevention of obesity in children use a multifaceted approach including PA, nutrition and parental involvement		
Verstraeten *et al.* 2012 [130]	Inclusion criteria: studies (i) in a school setting in an lower middle income country; (ii) healthy children 6–18 years of age; (iii) controlled trial design; (iv) focus on primary prevention of overweight or obesity through dietary and/or PA behaviour; (v) baseline and post-intervention measurements of dietary and PA behaviour outcomes and/or anthropometric outcomes Exclusion criteria: (i) letters, book chapters, dissertations, conference proceedings, and abstracts; and (ii) secondary prevention interventions targeting only overweight, obese, or underweight subjects	Most interventions had a positive effect on dietary behaviour and physical activity behaviour (effect size ranged from 20.48 to 1.61). BMI decreased in 8 studies (effect size ranged from 20.7 to 0.0). Effective interventions targeted both diet and physical activity, involved multiple stakeholders, and integrated educational activities into the school curriculum. School-based interventions have the potential to improve dietary and physical activity behaviour and to prevent unhealthy body weights in low- and middle-income countries	Practice: None stated Research: future studies should consider (i) stronger evaluation designs; (ii) information on cost-effectiveness; (iii) use of WC as an outcome measure; (iv) use of accelerometers and the measurement of physical fitness; (v) a theoretical framework to develop their intervention, and need to carefully document the pathways through which the interventions have their effect in order to learn from program implementation and adoption to identify which intervention components are effective and feasible	A potential limitation of this review was the exclusion of studies based on language, and the exclusion of grey literature
Waters *et al.* 2011 [131]	Inclusion criteria: childhood obesity prevention studies that used a controlled study design with a minimum duration of 12 weeks, and if they evaluated interventions, policies or programs in place for twelve weeks or more. If studies were randomised at a cluster level, 6 clusters were required. Exclusion criteria: treatment interventions	Childhood obesity prevention may be effective at reducing adiposity in children. A meta-analysis of 37 studies with a combined sample of 27,946 children revealed that these interventions may be effective in reducing the magnitude of the change in BMI/zBMI from pre- to post-intervention by -0.15 units (95% confidence interval (CI): -0.21 to -0.09), relative to the change in the control group, which would correspond to a small but clinically important shift in population BMI if sustained over several years. Subgroup analysis revealed that the effectiveness of interventions in young children and adolescents is less clear. There was a high level of observed heterogeneity (I2=82%) in all three age groups that could not explained by randomisation status or the type, duration or setting of the intervention. Interventions did not appear to increase health inequalities	Practice: Interventions need to be developed that can be embedded into ongoing practice and operating systems; all studies should monitor the potential occurrence of unhealthy practices and adverse outcomes; The following activities have been included in beneficial programmes: (i) school curriculum that includes healthy eating, physical activity and body image; (ii) increased sessions for physical activity and the development of fundamental movement skills throughout the school week; (iii) improvements in nutritional quality of the food supply in schools · environments and cultural practices that support children eating healthier foods and being active throughout each day; (iv) support for teachers and other staff to implement health promotion strategies and activities (e.g. professional development, capacity building activities); (v) parent support and home activities that encourage children to be more active, eat more nutritious foods and spend less time in screen based activities	Substantial unexplained heterogeneity of effects and the likelihood of publication bias exist

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
			Research: Testing short-term, behaviourally focused school-based interventions for 6-12 year old children may no longer be warranted; More evidence is needed to determine effective interventions in young children, particularly those aged 0-3 years, and adolescents; there is a continued need to strengthen trial design, measurement instruments, and reporting of process, impact and outcomes; future trials should be larger, longer term and include assessments of costs, harm, equity impacts, implementation factors and sustainability; translational research is required to embed effective interventions into standard practice across children's settings.	
Williams *et al.* 2013 [132]	Inclusion criteria: Studies that: (i) addressed children undertaking primary education aged between 4 and 11 years; (ii) assessed diet or PA-related school policies either alone or as part of intervention programmes; (iii) assessed anthropometric outcomes; (iv) were of experimental or observational study design; (v) > 6 months follow up Exclusion criteria: studies where (i) policy components were insufficiently described to enable replication; (ii) outcomes assessed were change in diet, physical activity or knowledge; (iii) conducted in clinical settings; (iv) had less than 6 months follow up	The pooled effects of the PA, and other diet related policies on BMI-SDS were non-significant. The multifaceted interventions tended to include policy elements related to both diet and physical activity (combined cluster), and although these interventions were too varied to pool their results, significant reductions in weight-related outcomes were demonstrated. There is evidence to suggest that when implemented alone, school diet and physical activity related policies have little effect. However, they appear to have an effect when developed and implemented as part of a more extensive intervention programme, hence diet and physical activity related policies need to be located within more complex approaches focusing on multiple factors (e.g. diet, PA, sedentary behaviour, self-esteem) and at multiple levels of influence (e.g. home, school, neighbourhood)	Practice: Diet and physical activity related policies need to be located within more complex approaches to preventing childhood obesity which focus on multiple factors (e.g. diet, physical activity, sedentary behaviour, self-esteem) and at multiple levels of influence (e.g. home, school, neighbourhood) to be effective Research: natural experiments (e.g. controlled before and after studies, interrupted time series studies) could be used to evaluate new policies. Future studies should be comprehensively reported and have a duration of years rather than months	None reported
Wolfenden *et al.* 2014 [133]	Inclusion criteria: RCTs and quasi--experimental designs with (i) a parallel control group; (ii) examining the effects of any population-based, whole of community intervention seeking to prevent population weight gain; (iii)	The review suggests that populationbased, whole-of-community interventions could be effective in achieving modest reductions in population weight gain among children, albeit with very substantial heterogeneity between trials. Seven of the eight trials reported a positive intervention effect on at least one	Practice: None stated Research: Rigorous evaluation of population- based whole of community interventions is needed, particularly for adults	Language and publication restrictions raised the possibility that relevant studies were overlooked

Author	Inclusion and Exclusion criteria	Main findings of the SR	Implications for practice & research	Limitations of the SR
	targeting more than one determinant of weight gain; (iv) objectively measured indicators of adiposity, including weight, BMI, WC, % BF, SFT or population prevalence of overweight or obesity; (v) include community consultation or engagement to inform intervention development or delivery. Exclusion criteria: studies recruiting exclusively overweight or obese people, and studies of interventions primarily focusing on chronic disease reduction, or where obesity prevention was among other targeted risk factors	measure of adiposity and meta-analysis of six trials demonstrated a significant reduction in BMI z-score. No eligible interventions which sought to prevent excessive weight gain among adults were identified.		
Zenzen and Kridli 2009 [134]	Inclusion criteria: studies (i) published between 2000 and 2007; (ii) in the English language; (iii) involved children ages 4 to 18 years or in grades kindergarten through high school; (iv) school-based curriculum programs for obesity prevention; and (v) a manipulation of at least one of the variables of dietary habits, physical activity, healthy lifestyle education, and/or parental involvement Exclusion criteria: Not reported	Studies were grouped by duration of interventions, use of theoretical frameworks, level of evidence and whether interventions demonstrated a reduction in BMI or weight loss. Nine studies included parental involvement in the intervention. None of the studies found a significant lowering of BMI, and only one achieved a statistically significant difference between intervention group and control group. All studies included a healthy lifestyle education component which was associated with significant increases in knowledge. Dietary habit modification was associated with significant changes in fat intake and in food-related and health-related knowledge and behaviours, while studies which included a PA component found little change in PA patterns	Practice: The most effective school-based obesity intervention programs should be guided by behavioural theoretical frameworks Research: Future studies need to have longer interventions, include parental involvement as an interventional component and report long-term post-intervention follow-up of outcome measures. Studies should include an experimental research design that includes the intervention components of dietary habit modification, physical activity modification, healthy lifestyle education, and parental involvement. BMI should be one of the outcome measures	No description of study selection or data analysis. No summary of study findings and whether school-based programs are actually effective.

% BF (Percentage Body Fat), BMI (Body Mass Index), FFST (fat-free soft tissue), FMI (Fat Mass Index), MVPA (Moderate to Vigorous Physical Activity), PA (Physical Activity), RR (Relative Risk), SFT (Skin Fold Testing), SSB (Sugar Sweetened Beverages), TSF (Triceps Skin Fold), WC (Waist Circumference), WHR (Waist-to-Hip Ratio)

Appendix 3E – Methodological Quality of Systematic Reviews (AMSTAR) criteria

Citation	a priori design provided	duplicate study selection and data extraction carried out	comprehensive literature search performed	status of publication used as inclusion criterion	list of included and excluded studies provided	characteristics of included studies provided	quality of included studies assessed and documented	quality of included studies used appropriately in formulating conclusions	appropriate methods used to combine study findings	likelihood of publication bias assessed	conflict of interest included	Total score
Avery *et al.* 2015 [72]	0	0	1	0	0	1	1	0	0	0	0	**3**
Baker *et al.* 2011 [73]	1	1	1	1	1	1	1	1	1	1	1	**11**
Barr-Anderson *et al.* 2014 [74]	1	1	1	0	0	1	1	1	1	0	0	**7**
Beauchamp *et al.* 2014 [75]	0	1	1	1	0	1	1	1	0	0	0	**6**
Bleich *et al.* 2013 [76]	0	1	0	0	0	1	1	1	1	1	0	**6**
Brandt *et al.* 2010 [77]	0	0	0	0	0	1	0	0	0	0	0	**1**
Branscum and Sharma 2011 [78]	0	0	1	0	0	1	0	0	0	0	0	**2**
Brown and Summerbell 2009 [79]	1	0	0	1	0	1	0	0	0	0	0	**3**
Brown *et al.* 2015 [80]	1	1	1	1	0	1	1	1	1	1	1	**10**
Budd and Volpe 2006 [81]	0	0	1	1	0	1	0	0	0	0	0	**3**
Calancie *et al.* 2015 [82]	0	1	1	1	0	1	0	0	1	0	0	**5**
Campbell *et al.* 2002 [83]	1	1	1	1	1	1	1	1	1	0	0	**9**
Chen and Wilkosz 2014 [84]	1	0	1	0	0	1	1	1	1	0	0	**6**

Citation	a priori design provided	duplicate study selection and data extraction carried out	comprehensive literature search performed	status of publication used as inclusion criterion	list of included and excluded studies provided	characteristics of included studies provided	quality of included studies assessed and documented	quality of included studies used appropriately in formulating conclusions	appropriate methods used to combine study findings	likelihood of publication bias assessed	conflict of interest included	Total score
Chriqui 2013 [85]	1	0	0	0	0	0	0	0	0	0	1	**2**
Chriqui *et al.* 2014 [86]	1	1	1	0	0	0	0	0	1	0	0	**4**
Cole *et al.* 2006 [87]	0	0	0	0	0	1	0	0	0	0	0	**1**
Cook-Cottone *et al.* 2009 [88]	1	1	1	1	0	1	0	0	1	0	0	**6**
De Bourdeaudhuij *et al.* 2010 [89]	1	0	1	1	0	1	1	1	1	0	0	**7**
de Sa and Lock 2008 [90]	1	0	1	1	0	1	0	0	1	0	0	**5**
Dobbins *et al.* 2013 [91]	1	1	1	1	1	1	1	1	1	1	0	**10**
Flodmark *et al.* 2006 [92]	0	0	1	1	0	1	1	1	0	0	0	**5**
Gao and Chen 2014 [93]	0	0	1	1	0	1	1	1	1	0	0	**6**
Haynos and O'Donohue 2012 [94]	0	0	0	0	0	1	0	0	0	0	0	**1**
Holub *et al.* 2014 [95]	1	1	1	0	0	1	1	1	0	0	0	**6**
Ickes *et al.* 2014 [96]	1	1	0	0	0	1	0	0	0	1	0	**4**
Jaime and Lock 2009 [97]	1	0	1	1	0	1	0	1	1	0	0	**6**
Kaiser *et al.* 2013 [98]	1	1	1	1	0	1	1	1	1	1	0	**9**

Citation	a priori design provided	duplicate study selection and data extraction carried out	comprehensive literature search performed	status of publication used as inclusion criterion	list of included and excluded studies provided	characteristics of included studies provided	quality of included studies assessed and documented	quality of included studies used appropriately in formulating conclusions	appropriate methods used to combine study findings	likelihood of publication bias assessed	conflict of interest included	Total score
Kamath *et al.* 2008 [99]	1	1	1	1	0	1	1	1	1	0	0	**8**
Kanekar and Sharma 2008 [100]	1	0	1	0	0	1	0	1	0	0	0	**4**
Katz *et al.* 2008 [101]	1	1	1	1	0	1	0	0	0	0	0	**5**
Kesten *et al.* 2011 [102]	1	0	1	0	0	1	1	1	1	0	0	**6**
Knowlden and Sharma 2013 [103]	0	0	0	0	0	1	0	0	0	0	0	**1**
Kropski *et al.* 2008 [104]	0	0	1	1	0	1	1	1	1	0	0	**6**
Lamboglia *et al.* 2013 [105]	0	1	0	1	0	1	0	0	0	0	0	**3**
Lavelle *et al.* 2012 [106]	1	0	1	1	0	1	0	0	1	1	0	**6**
LeBlanc *et al.* 2013 [107]	1	1	0	1	0	1	1	1	1	0	0	**7**
Leung et al. 2012 [108]	0	0	0	0	0	1	0	0	0	0	0	**1**
Li *et al.* 2008 [109]	1	0	1	0	0	1	1	1	1	0	0	**6**
Liao *et al.* 2014 [110]	1	1	1	0	0	1	1	1	1	1	0	**8**
Lissau 2007 [111]	1	0	1	0	0	1	0	0	0	0	0	**3**
Lobelo *et al.* 2013 [112]	0	1	1	1	0	1	1	1	1	0	0	**7**

Citation	a priori design provided	duplicate study selection and data extraction carried out	comprehensive literature search performed	status of publication used as inclusion criterion	list of included and excluded studies provided	characteristics of included studies provided	quality of included studies assessed and documented	quality of included studies used appropriately in formulating conclusions	appropriate methods used to combine study findings	likelihood of publication bias assessed	conflict of interest included	Total score
Malik *et al*. 2013 [113]	0	0	1	0	0	1	1	1	1	1	0	**6**
Marsh *et al*. 2014 [114]	0	1	1	0	0	1	1	0	0	0	0	**4**
Pérez-Morales *et al*. 2012 [115]	0	0	0	0	0	1	0	0	0	0	0	**1**
Peterson and Fox 2007 [116]	1	1	0	0	0	1	0	0	0	0	0	**3**
Reilly and McDowell 2003 [117]	0	0	1	0	0	1	1	1	0	0	0	**4**
Sbruzzi *et al*. 2013 [118]	0	1	1	0	0	1	1	1	1	0	0	**6**
Sharma 2007 [119]	0	0	0	0	0	1	0	0	1	0	0	**2**
Shirley *et al*. 2014 [120]	1	1	1	1	0	1	0	0	1	0	0	**6**
Showell *et al*. 2013 [121]	1	1	1	1	0	1	1	1	1	0	0	**8**
Silveira *et al*. 2013 [122]	1	0	1	0	0	1	1	1	1	1	0	**7**
Silveira *et al*. 2011 [123]	1	0	1	0	0	1	1	1	1	0	0	**6**
Small *et al*. 2007 [124]	1	0	0	0	0	1	0	0	0	0	0	**2**
Sobol-Goldberg *et al*. 2013 [125]	1	1	1	0	0	1	1	1	1	1	0	**8**
Stice *et al*. 2006 [126]	1	0	1	1	0	1	0	0	1	0	0	**5**

Citation	a priori design provided	duplicate study selection and data extraction carried out	comprehensive literature search performed	status of publication used as inclusion criterion	list of included and excluded studies provided	characteristics of included studies provided	quality of included studies assessed and documented	quality of included studies used appropriately in formulating conclusions	appropriate methods used to combine study findings	likelihood of publication bias assessed	conflict of interest included	Total score
Towns *et al.* 2014 [127]	0	0	1	1	0	1	0	0	1	0	0	**4**
van Grieken *et al.* 2012 [128]	1	0	1	0	0	1	1	1	1	0	0	**6**
Vasques *et al.* 2014 [129]	1	0	1	0	0	1	0	1	1	1	0	**6**
Verstraeten *et al.* 2012 [130]	1	1	1	0	0	1	1	1	1	0	0	**7**
Waters *et al.* 2011 [131]	1	1	1	1	1	1	1	1	1	1	1	**11**
Williams *et al.* 2013 [132]	0	1	1	1	0	1	1	1	1	0	0	**7**
Wolfenden *et al.* 2014 [133]	0	1	1	1	0	1	1	1	1	0	0	**7**
Zenzen and Kridli 2009 [134]	0	0	0	0	0	1	1	0	0	0	0	**2**

*score of 1 = 'Yes' according to AMSTAR criteria; score of 0 = 'No' or 'Can't Answer' or 'Not Applicable' according to AMSTAR criteria. High methodological quality: 8-11 times a score of 1; medium methodological quality: 5-7 times a score of 1; low methodological quality: 0-4 times a score of 1.

Appendix 3F. Characteristics of primary studies having an eligible environmental component

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Angelopoulos et al. 2009 [135]	Angelopoulos, P.D., et al., Changes in BMI and blood pressure after a school based intervention: the CHILDREN study. Eur J Public Health, 2009. 19(3): p. 319-25.	School	RCT	646	10 - 11	12 mo: educational component integrated in the existing school curriculum; playgrounds and school yards were made accessible for children to play in after the end of the curricular programme; school canteens were also obliged to have fresh fruit and freshly made juices throughout the whole intervention period; parental involvement and support in the home.	3	BMI, BMI z-score	BMI: -1.1 (CI: -1.2 to -0.9; P = 0.047); BMI z-score: -+0.46 (CI: -0.5 to -0.42; P = 0.074)	Significant	Yes	Not reported
Ask et al. 2006 [136]	Ask, A.S., et al., Changes in dietary pattern in 15 year old adolescents following a 4 month dietary intervention with school breakfast--a pilot study. Nutr J, 2006. 5: p. 33.	School	RCT	54	15	4 mo: a 'healthy' breakfast was served at the beginning of each school day. Students were also offered a food supplement	No follow up	BMI	Boys: -0.11 (P = <0.05); Girls: -0.2 (P = <0.05). No significant increase in BMI in the intervention group)	Significant	Yes	Møllers AS, Mills, TINE BA, COOP Lista and Young Enterprise, West-Agder provided food and the food supplements; the National Association for Nutrition and Health provided their Data program "Mat på data" for free to the school.
Ask et al. 2010 [137]	Ask, A.S., et al., Serving of free school lunch to secondary-school pupils - a pilot study with health implications. Public Health Nutr, 2010. 13(2): p. 238-44.	School	RCT	141	14 - 15	4 mo: a 'healthy' free lunch was introduced consisting of wholemeal bread, different kinds of cheese, cold cuts of lean meat, fish and jam, low-fat milk and fresh fruit and vegetables. Lunch was prepared by the students and eaten in class.	No follow up	BMI	BMI did not increase among the girls at the intervention school, but increased significantly among the boys at the intervention school and among the control school groups	Significant	Mixed	University of Agder, Kristiansand, Norway

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Barbeau et al. 2007 [138]	Barbeau, P., et al., Ten months of exercise improves general and visceral adiposity, bone, and fitness in black girls. Obesity (Silver Spring), 2007. 15(8): p. 2077-85.	School	RCT	278	8 - 12	10 mo: daily after-school intervention of 2hrs duration which included provision of a free healthy snack, and 80 minutes of PA (25 minutes of skills development; 35 minutes of MVPA, and 20 minutes of toning and stretching). Subjects wore heart rate monitors throughout.	No follow up	BMI, WC, % BF	BMI: -0.45 CI: (-0.79 to -0.12; P = 0.008); WC: -1.34 (CI: -2.78 to 0.09; P = 0.068); % BF: -2.01 (CI: -2.98 to -1.04; P = <0.0001)	Significant	Yes	NIH grant HL64972
Caballero et al. 2003 [139]	Caballero, B., et al., Pathways: a school-based, randomized controlled trial for the prevention of obesity in American Indian schoolchildren. Am J Clin Nutr, 2003. 78(5): p. 1030-8.	School	RCT	1704	8 - 11	36 mo: Pathways Obesity Prevention Program involved: (i) nutrition education; (ii) skill building and practical tools meals for food service to reduce fat content in school meals to less than 30%; (iii) sessions of 30 minutes of MVPA weekly (based on SPARK curriculum); (iv) Take home family action packs and family events at schools; (v) Control schools—normal instruction	No follow up	BMI, % BF, SFT	BMI: -0.2 (CI: -0.5 to 0.15; P = 0.29); % BF: +0.2 (CI: -0.84 to 1.31; P = 0.66); SFT: +0.1 (CI: -0.67 to 0.70; P = 0.837)	Not significant	Yes	NHLBI grants U01 HL-508869, -50867, -50905, -50885, -50907
Chomitz et al. 2010 [140]	Chomitz, V.R., et al., Healthy Living Cambridge Kids: a community-based participatory effort to promote healthy weight and fitness. Obesity (Silver Spring), 2010. 18 Suppl 1: p. S45-53.	Community, School	Cohort	1858	8	36 mo: city policies, community awareness campaigns, physical education enhancements, food service reforms, farm-to-school-to-home programs, family outreach, BMI and fitness reports	No follow up	BMI, BMI z-score	BMI z-score: -0.04 (P = < 0.001)	Significant	Yes	Cambridge Public Health Department, School Health, Institute for Community Health, other
Coffield et al. 2011 [141]	Coffield, J.E., et al., A multivariate analysis of federally mandated school wellness policies on adolescent obesity. J Adolesc Health, 2011. 49(4): p. 363-70.	School	NE	40713	17 - 19	NA: School wellness policies mandated by the 2004 Child Nutrition and WIC Reauthorization Act, implemented by 2006	26	overweight and obesity prevalence	Each additional component included in a district's wellness policy was associated with a 3.2% lower odds in the prevalence of adolescent overweight (OR 0.968; CI: 0.941–0.997), 2.5% lower odds of obesity (OR: 0.975;CI: 0.952–0.997), and 3.4% lower odds of severe obesity (OR 0.966; CI: 0.938–0.995).	Significant	Yes	Institute of Public and International Affairs and the Vice President for Research, University of Utah

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Coleman et al. 2005 [142]	Coleman, K.J., et al., Prevention of the epidemic increase in child risk of overweight in low-income schools: the El Paso coordinated approach to child health. Arch Pediatr Adolesc Med, 2005. 159(3): p. 217-24.	School	Matched control	896	8 - 9	36mo: adaptation of the Child and Adolescent Trial for Cardiovascular Health (CATCH) involving (i) purchase of new PE equipment; (ii) staff training; (iii) CATCH events throughout the year	No follow up	BMI percentile (RR of > 85th percentile at year 3)	Girls: significantly lower rate of increase in risk of overweight compared to control (2% vs 13%); Boys: significantly lower rate of increase in risk of overweight compared to control (1% vs 9%) over 3 years	Significant	Yes	Patient Care and Outcomes Research Grant from the American Heart Association (9970182N)
Crespo et al. 2012 [143]	Crespo, N.C., et al., Results of a multi-level intervention to prevent and control childhood obesity among Latino children: the Aventuras Para Ninos Study. Ann Behav Med, 2012. 43(1): p. 84-100.	Community, School	RCT	808	4 - 7	36 mo: in the Aventuras para Niños (APN) study, school and community-based interventions targeted the home, school and community environments via social and physical changes. Measures in the home included having cut-up vegetables within a child's reach and moving a TV out of a child's bedroom, setting of rules and boundaries by parents, discipline methods etc. Measures in the community were designed to alter physical structures (e.g., improve playgrounds and introduce well-stocked salad bars), social structures and policies (e.g., teachers' discipline and classroom practices and public park maintenance), availability of protective or harmful products (e.g., physical education equipment and healthy children's menus in restaurants),	No follow up	BMI z-score	Unclear	Not significant	No	NHLBI grant 5R01HL073776, CDC grant 5U48DP000036, American Cancer Society grants RSGPB 113653 and PFT-04-156-01, NIDDK grant F31DK079345, NHLBI grant T32HL079891
de Ruyter et al. 2012 [144]	de Ruyter, J.C., et al., A trial of sugar-free or sugar-sweetened beverages and body weight in children. N Engl J Med, 2012. 367(15): p. 1397-406.	School	RCT	641	4 - 12	18 mo: children provided with 1 can per day of a noncaloric, artificially sweetened, noncarbonated beverage or a sugar-containing noncarbonated beverage. Daily intake confirmed by teachers.	No follow up	BMI z score, SFT, WC	BMI: -0.13 (CI: -0.21 to -0.05; P = 0.001); WC: -+0.66 (CI: -1.23 to -0.09; P = 0.02); SFT: -2.2 (CI: -4.0 to -0.4)	Significant	Yes	Netherlands Organization for Health Research and Development, DRINK ClinicalTrials.gov number, NCT00893529

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Donnelly et al. 1996 [145]	Donnelly, J.E., et al., Nutrition and physical activity program to attenuate obesity and promote physical and metabolic fitness in elementary school children. Obes Res, 1996. 4(3): p. 229-43.	School	CCT	108	8 - 11	24 mo: (i) Nutrition education (ii) Physical activity program: 3 weekly sessions 30-40 minutes, focused on individual, noncompetitive activities; (iii) ''Lunch Power!'' program to reduce energy, fat, and sodium in school lunches; (iv) Control group: existing lunch program, team sports activity program	No follow up	BMI	Body weight and body composition were similar between control and intervention schools both at baseline and at the end of the intervention	Not significant	No	National Livestock and Meat Board, Health Management Resources, and the Research Services Council, University of Nebraska
Dzewaltowski et al. 2010 [146]	Dzewaltowski, D.A., et al., HOP'N after-school project: an obesity prevention randomized controlled trial. Int J Behav Nutr Phys Act, 2010. 7: p. 90.	School	RCT	246	8-10	36 mo: Healthy Opportunities for Physical Activity and Nutrition (HOP'N): included an organised daily after- school PA session for at least 30 minutes, a daily healthful snack that included fruit and vegetables, and a weekly nutrition and PA education experience	?	BMI z-score	BMI z-score: -0.1 (P = 0.11)	Not significant	Yes	National Research Initiative grant 2005- 35215-15418 from the USDA National Institute of Food and Agriculture
Ebbeling et al. 2006 [147]	Ebbeling, C.B., et al., Effects of decreasing sugar-sweetened beverage consumption on body weight in adolescents: a randomized, controlled pilot study. Pediatrics, 2006. 117(3): p. 673-80.	Home	RCT	103	13 - 18	6 mo: four 12-oz servings of non-caloric beverages per day provided by weekly home deliveries; motivational phone calls; mailed fridge magnets with intervention messages	No follow up	BMI	BMI: Overall sample: -0.14 (CI: -0.54 to 0.26); Children in the upper tertile of BMI: -0.75 (P = 0.03)	Significant (for high-BMI children only)	Yes (for high-BMI children only)	NIDDK grants R01 DK63554 and K01 DK62237, the Charles H. Hood Foundation, NIH grant M01 RR02172
Economos et al. 2007 [148]	Economos, C.D., et al., A community intervention reduces BMI z-score in children: Shape Up Somerville first year results. Obesity (Silver Spring), 2007. 15(5): p. 1325-36.	Community, School, Home	nRCT	1178	7 years	8 mo: physical activity options and availability of healthy foods before, during and after school, improved school food service; new equipment; social marketing; walk to school campaign, family outreach and engagement,	36 (1st year results only)	BMI z-score	BMI z-score: -0.10 (CI: -0.12 to -0.086)	Significant	Yes	CDC grant R06/CCR121519-01

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Engels et al. 2005 [149]	Engels HJ, Gretebeck RJ, Gretebeck KA, Jiménez L. Promoting healthful diets and exercise: efficacy of a 12-week after-school program in urban African Americans. J Am Diet Assoc 2005; 105: 455–459	School	NRNCT	56	9 - 12	3 mo: Active involvement in design, implementation and evaluation of study: (i) 60–75 min sessions 4 d/week; (ii) Dance, sport games and other fitness activities; (iii) Pedometers provided; (iv) Targeted educational handouts on nutrition and fitness; (v) Recording of fruit and vegetable intake and step counts; (vi) Poster board displays in school	No follow up	BMI, % BF	BMI: +0.1 (P = 0.446); BF: -0.3 (P = 0.428)	Not significant	No	Aramark Service Master/Aramark Gourmet
Foster et al. 2008 [150]	Foster, G.D., et al., A policy-based school intervention to prevent overweight and obesity. Pediatrics, 2008. 121(4): p. e794-802.	School	RCT	1349	9 - 12	24 mo: multi-component school-based intervention involving the introduction of a School Nutrition Policy that banned all sodas, sweetened drinks and snacks that did not meet nutritional standards from vending machines and cafeteria line. In addition, there was a nutrition education component, parental involvement and social marketing.	No follow up	Incidence of overweight and obesity	Incidence of overweight and obesity combined: 15% lower for intervention group [OR 0.85 (CI: 0.74 to 0.99; P = <0.05)]	Significant	Yes	CDC grant R06/CCR321534-01 and the USDAFNS

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Foster et al. 2010 [151]	Foster, G.D., et al., A school-based intervention for diabetes risk reduction. N Engl J Med, 2010. 363(5): p. 443-53.	School	C-RCT	4603	11 - 12	36 mo: IG: intervention consisted of four integrated components: nutrition (improvement in nutritional quality of school food environment); physical activity (increase in time spent performing MVPA); behavioural knowledge and skills (classroom-based curricular changes); and communication/social marketing.	No follow up	BMI, WC	Odds of having BMI > 95th percentile: - 19% (OR 0.81; 95% CI: 0.66 to 1.00; P = 0.05); Odds of WC > 90th percentile: -20% (OR 0.80; 95% CI: 0.64–0.99; P = 0.04); reduction in prevalence of obesity occurred in both IG and CG after 2 years, but was greater in the intervention schools compared to control schools (OR 0.79; CI: 0.63 to 0.98; P = 0.04)	Significant	Yes	NIDDK grants U01-DK61230, U01-DK61249, U01-DK61231, and U01-DK61223, additional support from the American Diabetes Association

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Fotu et al. 2011 [152]	Fotu, K.F., et al., Outcome results for the Ma'alahi Youth Project, a Tongan community-based obesity prevention programme for adolescents. Obesity reviews : an official journal of the International Association for the Study of Obesity, 2011. 12 Suppl 2: p. 41-50.	Community, School	QE	2479	11 - 19	36 mo: Community consultation and engagement processes with government health and education departments and other community stakeholders were conducted to develop community actions plans. In addition to TV, radio and print media strategies a range of initiatives were implemented in schools, churches and villages including village walking groups, school and community vegetable gardens, school canteen and church nutrition policies, sports tournaments and the provision of healthy eating and physical activity information.	No follow up	BMI, BMI z-score, % BF, % overweight and obese	% BF: −1.46 (p = 0.01); BMI: −0.02 (p = 0.36); BMI z-score: −0.03 (p = 0.26); proportion of participants who are overweight or obese: −0.05 (p = 0.84).	Significant (for % BF only)	Yes	The Wellcome Trust (UK), the National Health and Medical Research Council (Australia) and the Health Research Council (New Zealand) through the International Collaborative Research Grant Scheme.
French et al. 2011 [153]	French, S.A., et al., Household obesity prevention: Take Action - a group-randomized trial. Obesity, 2011. 19(10): p. 2082-8.	Home	RCT	90	12 - 17	12 mo: intervention included both household environment and individual-level behavioural components such as placement of TV time-limiting devices, provision of guidelines about food availability, face-to-face group sessions, and monthly newsletters.	No follow up	BMI z-score,	BMI z-score: +0.0638 (P = 0.53)	Not significant	No	NIH grants 1U54CA116849 and R21CA137240
Gao and Xiang 2014 [154]	Gao, Z. and P. Xiang, Effects of exergaming based exercise on urban children's physical activity participation and body composition. J Phys Act Health, 2014. 11(5): p. 992-8.	School	PPT	185	8 - 12	9 mo: 4th grade children were assigned to the intervention group, particpating in 30-minute Dance Dance Revolution (DDR)-based exercise 3 times per week during recess periods; DDR is an active video game that combines real physical dancing requiring fast-foot movement with energetic music and visuals. Third and fifth grade children were in the comparison group.	No follow up	% BF	% BF: Chi square = 5.42, df = 3, P = 0.14	Not significant	No	Robert Wood Johnson Foundation: Award number 66347 and The University of Utah Interdisciplinary Seed Grant: Award number 19309

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Gombosi et al. 2007 [155]	Gombosi, R.L., R.M. Olasin, and J.L. Bittle, Tioga County Fit for Life: a primary obesity prevention project. Clin Pediatr (Phila), 2007. 46(7): p. 592-600.	Community, School, Home	PPT	4804	5 - 14	60 mo: school-based education initiative; community-based physical activity events; initiation of menu labeling in participating restaurants	No follow up	BMI	BMI increased less among children in intervention versus comparison community	Unclear	No	American Academy of Pediatrics (AAP); NIH Maternal and Child Health Bureau; Healthy Tomorrows Partnership for Children Program, Pennsylvania Department of Health, Bureau of Chronic Disease and Risk Reduction, Cardiovascular Risk Reduction grant; US Department of Health and Human Services Administration (HRSA)
Graves et al. 2010 [156]	Graves, L.E., et al., The effect of active video gaming on children's physical activity, behavior preferences and body composition. Pediatric exercise science, 2010. 22(4): p. 535-46.	Home	RCT	58	8 - 10	3 mo: a peripheral device (jOG), a step-powered video game, was given to children to encourage light-tomoderate intensity activity and reduce sedentary time.	No follow up	BMI, % BF	BMI: -0.2 (CI: -0.6–0.2); % BF: -0.1 (CI: -0.7–0.6)	Not significant	No	Not reported
Greening et al. 2011 [157]	Greening, L., et al., Efficacy of a school-based childhood obesity intervention program in a rural southern community: TEAM Mississippi Project. Obesity (Silver Spring), 2011. 19(6): p. 1213-9.	Community, School	RCT	450	6 - 10	9 mo: intervention program included monthly family events that alternated between nutrition and physical activities/contests; changes to the intervention school's food service including replacing the deep frying equipment with baking ovens	No follow up	WC, % BF	WC: +0.1 (P = 0.92); % BF: -0.96% (P = 0.02)	Significant (for % BF only)	Yes	University of California, San Francisco, National Center of Excellence in Women's Health and the Johnson & Johnson Company

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Gutin et al. 2008 [158]	Gutin, B., et al., Preliminary findings of the effect of a 3-year after-school physical activity intervention on fitness and body fat: the Medical College of Georgia Fitkid Project. Int J Pediatr Obes, 2008. 3 Suppl 1: p. 3-9.	School	C-RCT	206	8.5	36 mo: 2-hour after-school intervention sessions were offered 5 days/wk on school days. The programme included 40 min of academic enrichment activities, during which healthy snacks were provided (healthy snacks could be construed as a modest dietary intervention) followed by 80 min of moderate-to-vigorous PA (MVPA) including 40 min of vigorous PA. Control group received regular health screenings and diet/PA information	No follow up	% BF, FFST, BMI, WC	Over the six measurement points, the intervention group increased more than the control group in fat-free soft tissue ($p < 0.01$) and BMI ($p < 0.05$)	Significant (for BMI only)	No	Unclear
Haerens et al. 2006 [159]	Haerens, L., Deforche, B., Maes, L., Stevens, V., Cardon, G., & De Bourdeaudhuij, I. (2006). Body mass effects of a physical activity and healthy food intervention in middle schools. Obesity Research, 14(5), 847 – 854	School	C-RCT	2291	12 - 14	21 mo: IG: Schools were encouraged to: (i) create more opportunities to be physically active during breaks, at noon or after school hours (extra sports material/PE equipment provided); (ii) increase fruit consumption and reduce soft drink and increase water consumption (free or low-price water and fruit made available) (iii) education on nutrition and physical activity provided (iv) Parental education	No follow up	BMI z-score	Boys: No significant positive intervention effects found; Girls: significant lower increase in BMI ($F = 12.52$, $P = <0.05$) and BMI z-score ($F = 2.68$, $P = <0.05$)	Significant (for girls only)	Yes (among girls only)	Policy Research Centre for Sport, Physical Activity and Health
Heelan et al. 2009 [160]	Heelan, K.A., et al., Evaluation of a walking school bus for promoting physical activity in youth. J Phys Act Health, 2009. 6(5): p. 560-7.	Community	QE-PPT	324	3 - 10	24 mo: Walking school bus program. Neighborhood walk stops within 1-mile radius of the school. The WSB leader met children at stops and walked them to their school in the morning and back to the stop in the afternoon. Routes resulted in an average of 0.65 miles of walking each way	No follow up	BMI	BMI: No significant difference between groups on BMI or % BF.	Not significant	No	Unclear

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Ho et al. 2008 [161]	Ho, L.S., et al., An integrated multi-institutional diabetes prevention program improves knowledge and healthy food acquisition in northwestern Ontario First Nations. Health Educ Behav, 2008. 35(4): p. 561-73.	Community, School	QE-PPT	95	Whole population	9 mo: multicomponent intervention including nutrition education in schools; modification of school nutrition policies and meals; community mass media promotion and events; participation of stores in the community (stocking and promotion of healthier foods and drinks)	No follow up	BMI, % BF	BMI: -0.3 (P = 0.89); %BF: -0.1 (P = 0.74)	Not significant	Yes	American Diabetes Association Clinical Research Award No. 7-04-CR-15 and a US-Canada Fulbright Award
Hoelscher et al. 2010 [162]	Hoelscher, D.M., et al., Reductions in child obesity among disadvantaged school children with community involvement: the Travis County CATCH Trial. Obesity (Silver Spring), 2010. 18 Suppl 1: p. S36-44.	Community, School	Serial XS	1107	9 - 10	12 mo: CATCHBasicPlus program with a community involvement component. Intervention given to 4th-grade students via classroom curricula, PE program, child nutrition services component, and family involvement. Community was involved for larger partnerships to extend school programs to surrounding community.	No follow up	% overweight and obese	% overweight (>85th percentile): −7.0 (P = 0.051); % obese (>95th percentile): −1.7 (P = 0.33)	Significant (for obese only)	Yes	Flaghouse, Inc. and the Michael & Susan Dell Foundation
Hollar et al. 2010a [163]	Hollar, D., et al., Effective multi-level, multi-sector, school-based obesity prevention programming improves weight, blood pressure, and academic performance, especially among low-income, minority children. J Health Care Poor Underserved, 2010. 21(2 Suppl): p. 93-108.	School	RCT	3769	4 - 12	24 mo: Healthier options for public schoolchildren (HOPS): a multilevel (individual, community, and policy) and multi agency collaboration. Teachers were trained on curriculum and given technical assistance. Components included modified school meal menus, nutrition/lifestyle educational curricula, in-school PE, and wellness projects like growing gardens.	No follow up	BMI z-score	BMI z-score: -1.26 (P = 0.004)	Significant	Yes	W.K. Kellogg Foundation

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Hollar et al. 2010b [164]	Hollar, D., et al., Effect of a two-year obesity prevention intervention on percentile changes in body mass index and academic performance in low-income elementary school children. Am J Public Health, 2010. 100(4): p. 646-53.	School	QE	3769	4 - 12	24 mo: Description: Nutritious school meals; healthy nutrition and lifestyle curricula; school-based wellness activities	No follow up	BMI percentile	More children in the intervention group remained within the normal BMI percentile range (P = 0.02)	Significant	Yes	Agatston Research Foundation
Hollar et al. 2010c [165]	Hollar, D., et al., Healthier options for public schoolchildren program improves weight and blood pressure in 6- to 13-year-olds. J Am Diet Assoc, 2010. 110(2): p. 261-7.	School	QE	2494	6 - 13	24 mo: Healthier Options for Public Schoolchildren (HOPS) included: provision of nutritious ingredients and whole foods in school breakfasts, lunches, and extended day snacks; nutrition and PA education; and the implementation of other school-based wellness activities such as fruit and vegetable gardens	No follow up	BMI z-score	BMI z-score: Boys: -0.11 (P = 0.86); Girls: -0.03 (P = 0.0031)	Significant (for girls only)	Yes	Agatston Research Foundation
Howe et al. 2011 [166]	Howe, C.A., R.A. Harris, and B. Gutin, A 10-month physical activity intervention improves body composition in young black boys. J Obes, 2011. 2011: p. 358581.	School	RCT	106	8 - 12	10 mo: after school PA program for boys delivered by study personnel and school teachers. 80 min of PA after school every day, consisting of 25 min of skill development, 35 min of moderate-to- vigorous PA, and 20 min of stretching/toning. Boys wore heart rate monitors to record PA intensity and asked to maintain a heart rate of at least 150 bpm. Healthy snack provided.	No follow up	BMI, % BF, WC	<u>For boys attending > 60% of program:</u> % BF: -2.9 (P = 0.029); BMI: -0.6 (P = 0.009); WC: -0.9 (P = >0.05)	Significant	Yes	NIH grant HL69999
Jansen et al. 2011 [167]	Jansen, W., et al., Effectiveness of a primary school-based intervention to reduce overweight. Int J Pediatr Obes, 2011. 6(2-2): p. e70-7.	School	C-RCT	2622	6 - 12	12 mo: IG: Multi-component, school-based intervention program consisting of (i) implementation of an additional PE session weekly; (ii) organization of additional sports activities outside of school hours; (iii) classroom-based education; (iv) administration of a fitness test; (v) sports events. CG: usual curriculum	No follow up	BMI, WC, % overweight and obese	<u>For ages 9 - 12 years</u>: no effects; <u>For ages 6 - 8 years</u>: BMI: -0.10 (CI: -0.22 – -0.03; P = >0.05); % overweight children (OR 0.53; CI: 0.36 – 0.78); WC: -1.29 cm (CI: -2.16 to -0.42; P = < 0.05)	Significant (for younger children only)	Yes	Not reported

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Jordan et al. 2008 [168]	Jordan, K.C., et al., Evaluation of the Gold Medal Schools program. J Am Diet Assoc, 2008. 108(11): p. 1916-20.	School	CBA	577	8 - 11	12 mo: Gold Schools Program consisted of criterion-based implementation of multi-component policies with the goal of establishing policy and environmental supports that give students and staff more opportunities for nutritious food choices, regular physical activity, and tobacco prevention.	No follow up	BMI z-score	BMI z-score increased significantly in the comparison group (0.53 +/- 0.38; P = < 0.05), but not in the intervention group (0.21 +/-0.47; P = 0.484)	Not significant	Yes	Utah Department of Health and the Children's Health Research Center
Kain et al. 2004 [169]	Kain, J., et al., School-based obesity prevention in Chilean primary school children: methodology and evaluation of a controlled study. Int J Obes Relat Metab Disord, 2004. 28(4): p. 483-93.	School	Longitudinal controlled evaluation	3086	6 - 14	8 mo: IG: nutrition education to children, parents and school kiosk owners; physical activity intervention that included an additional PE lesson, purchase of PA equipment and playing music to encourage active play during recess. CG: standard curriculum	No follow up	BMI, BMI z-score,	<u>Boys</u>: BMI: -0.3 (P = <0.001); BMI z-score: -0.14 (P = <0.001); <u>Girls</u>: no change	Significant (for boys only)	Yes	Chilean Ministry of Education, Chile Deportes (Government Sports Promotion Agency) and an unrestricted grant from Corpora Tresmontes
Kremer et al. 2011 [170]	Kremer, P., et al., Reducing unhealthy weight gain in Fijian adolescents: results of the Healthy Youth Healthy Communities study. Obesity reviews: an official journal of the International Association for the Study of Obesity, 2011. 12 Suppl 2: p. 29-40.	Community	QE	2936	13 - 18	36 mo: Community consultation and engagement processes with school, parent and church representatives and other stakeholders. Community workshops were held to develop actions plans. In addition to small media strategies such as newspaper articles and pamphlets, a range of initiatives were implemented in schools, faith organisations and the community including walking groups, school food gardens, provision of water bottles and activity equipment, provision of training for school staff, poster displays, community events, and student aerobics clubs.	No follow up	BMI, BMI z-score, weight, % BF, % overweight or obese	% BF: −1.17 (p = < 0.01). No significant differences in weight (+0.05 kg; p = 0.81); BMI (+0.10; p = 0.13); BMI-z (+0.02; p = 0.33); or proportion of participants who are overweight or obese (+0.34%; p = 0.07).	Significant (for % BF only)	Yes	Ministry of Health, AusAID.

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Luepker et al. 1996 [171]	Luepker, R.V., et al., Outcomes of a field trial to improve children's dietary patterns and physical activity. The Child and Adolescent Trial for Cardiovascular Health. CATCH collaborative group. Jama, 1996. 275(10): p. 768-76.	School	RCT	5106	8 - 11	36 mo: The Child and Adolescent Trial for Cardiovascular Health (CATCH) involved (i) Diet and physical activity patterns classroom lessons; (ii) Physical activity intervention; (iii) Family involvement; (iv) School food service modification; (v) Control schools—usual PE, food service, and health education	No follow up	BMI, SFT	BMI: +0.06 (P = 0.32); SFT: +0.1 (P = 0.7)	Not significant	No	NHLBI Grants U01-HL-39880, U01-HL39906, U01-HL-39852, U01-HL-39927, and U01-HL39870
Maloney et al. 2008 [172]	Maloney, A.E., et al., A pilot of a video game (DDR) to promote physical activity and decrease sedentary screen time. Obesity (Silver Spring), 2008. 16(9): p. 2074-80.	Community	RCT	60	7 - 8	2.5 mo: families in the intervention group were provided with all equipment necessary to play DDR in the home (PlayStation2 game console, DDR MAX2 game, and two padded dance mats). Children were given a written physician prescription to play 120 minutes per week of DDR, preferably divided over four sessions.	4.5	BMI, BMI z-score	Across all groups, BMI z-scores were stable from baseline to week 10	Not significant	No	Gatorade Foundation via the UNC at Chapel Hill, School of Public Health. Research support was provided in part by the NIH grants T32-MH19011 and T32 HD 40127.
Marcus et al. 2009 [173]	Marcus, C., et al., A 4-year, cluster-randomized, controlled childhood obesity prevention study: STOPP. Int J Obes (Lond), 2009. 33(4): p. 408-17.	School	C-RCT	3135	6 - 10	46 mo: IG: modification of school meals; promotion of low fat dairy products and whole-grain bread; elimination of all sweets and sweetened drinks in intervention schools; restriction of sedentary behaviour during after school care time; increase of PA during school hours. CG: normal curriculum	No follow up	BMI SD, Overweight and obesity prevalence	O&O prevalence: -6% (-10.6% to -1.3%; P = <0.05); BMI SD: no change	Significant (for overweight and obesity prevalence only)	Yes	Stockholm County Council, Swedish Council for working life and social research, Swedish Research Council, Freemason's in Stockholm Foundation for Children's Welfare and Signhild Engkvist Foundation

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Martinez Vizcaino et al. 2008 [174]	Martinez Vizcaino, V., et al., Assessment of an after-school physical activity program to prevent obesity among 9- to 10-year-old children: a cluster randomized trial. Int J Obes (Lond), 2008. 32(1): p. 12-22.	School	C-RCT	1044	9 - 10	6 mo: IG: free PA sessions after school (three 90-min sessions per week). CG: usual curriculum	3	% overweight and obese, BMI, % BF, SFT	Boys: % overweight and obese: OR 0.72 (CI: 0.39 to 1.31; P = 0.28); BMI: -0.13 (CI: -0.41 to 0.16; P = 0.38); SFT: -1.87mm (CI: -3.43 to -0.32; P = 0.01); % BF -0.67 (CI: -1.32 to -0.01; P = 0.05)	Significant	Yes	La Consejerıa de Sanidad de Castilla-La Mancha (grant GC03060-00). Additional funding was obtained from the Ministerio de Sanidad y Consumo, Instituto de Salud Carlos III, Red de Investigacio´n en Actividades Preventivas y de Promocio´n de Salud (grant RD06/0018/0038)
Millar et al. 2011 [175]	Millar, L., et al., Reduction in overweight and obesity from a 3-year community-based intervention in Australia: the 'It's Your Move!' project. Obesity reviews : an official journal of the International Association for the Study of Obesity, 2011. 12 Suppl 2: p. 20-8.	Community	QE	3040	12 - 18	36 mo: Community consultation and engagement processes were conducted with school staff and students. In addition to media strategies, a range of initiatives were implemented, predominately in schools, including training for students and staff; water bottles; installation of drinking fountains; removal of soft drink from vending machines; lunch time physical activity opportunities, sports excursions and walking groups.	No follow up	BMI, BMI z-score, % BF, % overweight and obese	BMI z-score: −0.07 (p = 0.03); No-significant differences in proportion of participants who are overweight or obese (0.75 OR; p = 0.12), BMI (−0.22; p = 0.06) and % BF (−0.23, p = 0.58).	Significant (for BMI z-score only)	Yes	Victorian Department of Health, the National Health and Medical ResearchCouncil in conjunction with the Health Research Council (NZ) and the Wellcome Trust (UK) as part of the International Collaborative ResearchGrant Scheme, AusAID.

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Muckelbauer et al. 2009 [176]	Muckelbauer, R., Libuda, L., Clausen, K., Toschke, A.M., Reinehr, T. & Kersting, M. (2009) Promotion and provision of drinking water in schools for overweight prevention: randomized, controlled cluster trial. Pediatrics 123, E661– E667	School	RCT	2950	8	11 mo: Water fountains and water bottles provided in schools plus educational programme of four 45-min lessons on water	No follow up	BMI SD score	BMI SDS: -0.004 (-0.045 to 0.036; P = 0.829); risk of being overweight was reduced by 31% (P = 0.04) in the intervention group	Significant	Yes	Grant 05HS026 from the German Federal Ministry of Food, Agriculture and Consumer Protection; Intervention materials provided by the Association of German Gas and Water Industries.
Nader et al. 1999 [177]	Nader, P.R., et al., Three-year maintenance of improved diet and physical activity: the CATCH cohort. Child and Adolescent Trial for Cardiovascular Health. Arch Pediatr Adolesc Med, 1999. 153(7): p. 695-704.	School	RCT	3714	11 - 15	36mo: The Child and Adolescent Trial for Cardiovascular Health (CATCH) involved (i) Diet and physical activity patterns classroom lessons; (ii) Physical activity intervention; (iii) Family involvement; (iv) School food service modification; (v) Control schools—usual PE, food service, and health education	36	BMI, SFT	BMI at 36 mo: 0.0 (P = 0.88); SFT at 36mo: -0.1 (P = 0.83)	Not significant	No	NHLBI Grants U01-HL-39880, U01-HL39906, U01-HL-39852, U01-HL-39927, and U01-HL39870
Ni Mhurchu et al. 2008 [178]	Ni Mhurchu, C., et al., Couch potatoes to jumping beans: a pilot study of the effect of active video games on physical activity in children. Int J Behav Nutr Phys Act, 2008. 5: p. 8.	Community	RCT	20	12	3 mo: intervention group received an active video game upgrade package consisting of an EyeToy® camera, EyeToy® active games, and dance mat. Participants and their parents or guardians were instructed to substitute usual non-active video game play with active video games at home	No follow up	Weight, WC	Body weight: -0.13 kg (CI:. -1.97 to 1.7; P = 0.9); WC: -1.4 cm (CI: -2.68 to -0.04; P = 0.04)	Not significant (insufficient study power)	No	Health Research Council of New Zealand (05/228). Sony Computer Entertainment New Zealand provided the gaming software for the study

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Ni Mhurchu et al. 2009 [179]	Ni Mhurchu, C., et al., Effect of electronic time monitors on children's television watching: pilot trial of a home-based intervention. Prev Med, 2009. 49(5): p. 413-7.	Home	RCT	29	9 - 12	1.5 mo: Intervention group received an electronic TV time monitor (Time Machine) designed to reduce access to TV by controlling the TV signal, using tokens administered by parents which activate the TV for 30 min per token, and advice to restrict TV watching to 1 h per day or less. TV signal was interrupted after the allotted time period thus limiting further TV viewing. Parents received advice on how to manage time allotted by providing a weekly or daily 'allowance' with the tokens, such as by creating rules around household TV viewing (e.g. no TV during meal times, TV free days, and recording programmes to skip adverts) and moving the TV to a less accessible location. The control group was given verbal advice to restrict TV watching	No follow up	BMI	BMI: +0.05 (P = 0.83)	Not significant	No	Health Research Council of New Zealand (07/384) and the NewZealand National Heart Foundation (Grant 1303)
Owens et al. 2011 [180]	Owens, S.G., et al., Changes in physical activity and fitness after 3 months of home Wii Fit use. J Strength Cond Res, 2011. 25(11): p. 3191-7.	Community	PPT	21 (12 children)	8 - 13	3 mo: Four Wii Fit units were loaned to 8 families enrolled in the study in pairs such that 1 family from each pair was randomly selected and loaned a Wii Fit for use in the home during the first 3 months of the study, with the other family scheduled to use the Wii Fit during the second 3 months	3	BMI, % BF	No change in BMI or % BF	Not significant	No	School of Applied Sciences, the University of Mississippi

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Paradis et al. 2005 [181]	Paradis, G., et al., Impact of a diabetes prevention program on body size, physical activity, and diet among Kanien'keha:ka (Mohawk) children 6 to 11 years old: 8-year results from the Kahnawake Schools Diabetes Prevention Project. Pediatrics, 2005. 115(2): p. 333-9.	Community, school	nRCT	1622	6 - 12	96 mo: Health education curriculum involving diet and physical activity delivered in grades 1-6 in community's elementary schools. Establishment of a school nutrition policy and modification of school canteen. Community activities and creation of supportive environments including recreational pathways.	96	SFT, BMI	Some early positive effects on SFT but not BMI. Benefits not maintained at 8 years, as repeat cross-sectional measures from 1994 to 2002 showed increases in skinfold thickness and BMI.	Not significant	No	Health Canada through the National Health Research and Development Program (grants 6605-4188-ND and 6605-4187-ND) and the Canadian Institutes for Health Research, the Kahnawake community, and private foundations.
Pate et al. 2005 [182]	Pate, R.R., et al., Promotion of physical activity among high-school girls: a randomized controlled trial. Am J Public Health, 2005. 95(9): p. 1582-7.	School	RCT	2744	15 - 16	12 mo: LEAP approach including enhanced physical activity during school hours; environmental change to create a supportive environment included role modelling and promotion of PA by school staff, and family and community-based activities	No follow up	% overweight and obese	% ≥ 85th percentile: +1.1% (P = 0.5); % ≥95th percentile: +0.1% (P = 0.97)	Not significant	No	NHLBI Grant R01HL057775
Raczynski et al. 2009 [183]	Raczynski, J.M., et al., Arkansas Act 1220 of 2003 to reduce childhood obesity: its implementation and impact on child and adolescent body mass index. J Public Health Policy, 2009. 30 Suppl 1: p. S124-40.	State-wide	QE-PPT	Unclear	Whole population	48 mo: annual measurement of BMI for all children attending public schools and reporting of BMI and associated risks to parents; elimination of student access to vending machines in elementary schools; hiring of community health promotion specialists to work with schools and communities; public reporting of vending contracts	No follow up	% overweight and obese	% overweight: -3.7%; % obese: + 3.4%	Unclear	No	Robert Wood Johnson Foundation grants 051737, 60284, 30930
Ramirez-Lopez et al. 2005 [184]	Ramirez-Lopez, E., et al., [Effect of a School Breakfast Program on the prevalence of obesity and cardiovascular risk factors in children]. Salud Publica de Mexico, 2005. 47(2): p. 126-33.	School	QE-prospective	360	6 - 10	9 mo: the intervention group consisted of 254 children participating in a School Breakfast Program	No follow up	BMI	BMI: 0.0 (P = 0.05)	Not significant	No	Not reported

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Resnicow et al. 1992 [185]	Resnicow, K., et al., A three-year evaluation of the know your body program in inner-city schoolchildren. Health Educ Q, 1992. 19(4): p. 463-80.	School	Cohort	1209	5 - 12	31 mo: (i) 30-45 minute weekly health education curriculum; (ii) School food service intervention; (iii) Poster and essay contests, student aerobics, and special health lectures; (iv) Student health committees, peer leader training, and food-tasting parties; (v) Control schools—usual PE, food service, and health education	No follow up	BMI	BMI: -0.3 (P = > 0.05)	Not significant	No	The Ford Foundation and the Cancer Research Foundation of America
Robinson 1999 [186]	Robinson, T.N., Reducing children's television viewing to prevent obesity: a randomized controlled trial. Jama, 1999. 282(16): p. 1561-7.	School, Home	RCT	192	8 - 10	7 mo: IG: Intervention consisted of: (i) 18 sessions curricular education to teach students to ''budget'' television viewing time to 7 hours/week; (ii) challenge to watch no television for 10 days at the end of the curriculum; (iii) Electronic television time manager device placed in homes of intervention group students. CG: standard curriculum	No follow up	BMI, SFT, WC, WHR	BMI: -0.45 (CI: -0.73 to -0.17; P = 0.002); SFT: -1.47 (CI: -2.41 to -0.54; P = 0.002); WC: -2.3 (CI: -3.27 to -1.33; P = <0.001); WHR: -0.02 (CI: -0.03 to -0.01; P = <0.001)	Significant	Yes	American Heart Association; NHLBI (grant RO1 HL54102)
Robinson et al. 2003 [187]	Robinson, T.N., et al., Dance and reducing television viewing to prevent weight gain in African-American girls: the Stanford GEMS pilot study. Ethn Dis, 2003. 13(1 Suppl 1): p. S65-77.	Community, Home	RCT	61	8 - 10	3 mo: (i) After-school dance classes with healthy snack, homework period and discussion of increased physical activity (dance) and reduced TV screen time, (ii) family intervention, (iii) newsletters	No follow up	BMI, WC	BMI: -0.32 (CI: -0.77 to 0.12; P = 0.16); WC: -0.63 (CI: -1.92 to 0.67; P = 0.35)	Not significant	Yes	NHLBI (Cooperative agreement UO1 HL62663) and a Robert Wood Johnson Foundation Generalist Physician Faculty Scholar Award
Robinson et al. 2010 [188]	Robinson, T.N., et al., A randomized controlled trial of culturally tailored dance and reducing screen time to prevent weight gain in low-income African American girls: Stanford GEMS. Arch Pediatr Adolesc Med, 2010. 164(11): p. 995-1004.	Community, Home	RCT	284	8 - 10	24 mo: Community-based intervention including (i) provision of small snack, (ii) 45-60 minutes of dance, (iii) education component to reduce screen time (iv) health education component	No follow up	BMI	BMI: +0.04 (CI: -0.18 to 0.27)	Not significant	No	NHLBI (Cooperative agreement UO1 HL62663)

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Sahota et al. 2001 [189]	Sahota, P., et al., Randomised controlled trial of primary school based intervention to reduce risk factors for obesity. Bmj, 2001. 323(7320): p. 1029-32.	School	RCT	634	7 - 11	10 mo: Active Programme Promoting Lifestyle in Schools (APPLES): an intervention consisting of school lunch modifications and school action plans designed to promote healthy nutrition and physical activity	No follow up	BMI SD score	BMI SD score: 0.00 (CI: -0.1 to 0.1)	Not significant	No	Northern and Yorkshire Region Research and Development Unit
Saksvig et al. 2005 [190]	Saksvig, B.I., et al., A pilot school-based healthy eating and physical activity intervention improves diet, food knowledge, and self-efficacy for native Canadian children. J Nutr, 2005. 135(10): p. 2392-8.	School	PPT	122	8 - 12	9 mo: multicomponent intervention including nutrition education; students as role models; family component; implementation of a school-wide policy banning high-fat an high-sugar snack foods in schools; implementation of a healthy breakfast snack program	No follow up	BMI, % BF	BMI: +0.95 (P = <0.001); % BF: +1.18 (P = <0.001)	Significant	No	Health Canada, The Ontario Ministry of Health, Kraft Foods, Eli Lilly, and a Canada-U.S. Fulbright Scholarship
Salanave et al. 2009 [191]	Salanave, B., et al., Stabilization of overweight prevalence in French children between 2000 and 2007. Int J Pediatr Obes, 2009. 4(2): p. 66-72.	Community, School	Repeat XS	1582	7 - 9	96 mo (implemented in 2001 and ongoing as of article publication date): In schools, nutrition added to curriculum, healthy eating and activity encouraged, changes to nutritional environment; Food-based guides for general population; Annual mass media campaigns	No follow up	overweight and obesity prevalence	Non-significant decrease in overweight prevalence in each SEP category	Not significant	Unclear	Unclear
Sallis et al. 2003 [192]	Sallis, J.F., et al., Environmental interventions for eating and physical activity: a randomized controlled trial in middle schools. Am J Prev Med, 2003. 24(3): p. 209-17.	School	RCT	1678	11 - 14	24 mo: IG: PA component included environmental changes to increase physical activity before, during and after school (e.g. increased supervision, purchased PA and kitchen equipment, organized activities, increased accessibility of activity areas, promotion of PA outside of PE); Nutrition component included changes to school food service; reduced fat in school diet, student restaurants. CG: no change	No follow up	BMI	BMI: Girls: -0.09 (P = 0.77); Boys: -0.64 (P = 0.044)	Significant (for boys only)	Yes (among boys only)	NIH grant HL54564

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Sanchez-Vaznaugh et al. 2010 [193]	Sanchez-Vaznaugh, E.V., et al., 'Competitive' food and beverage policies: are they influencing childhood overweight trends? Health Aff (Millwood), 2010. 29(3): p. 436-46.	School	NE	5,389,819	10 - 12	NA: Implementation of new school policies in the state of California restricting sales of competitive foods and beverages and setting stricter nutrition standards for certain food and beverages sold to students (implementation started in 2004)	36	% overweight and obese	% change in the odds of overweight and obese per year after 2004: 5th grade girls: -53.9% (P = 0.111); 5th grade boys: -93.5% (P = 0.001); 7th grade girls: -87.5% (P=<0.001); 7th grade boys: -112.1% (P=<0.001)	Significant	Yes	Robert Wood Johnson Foundation's Healthy Eating Research, New Connections Program, and the W.K. Kellogg Health Scholars Program
Sanigorski et al. 2008 [194]	Sanigorski, A.M., et al., Reducing unhealthy weight gain in children through community capacity-building: results of a quasi-experimental intervention program, Be Active Eat Well. Int J Obes (Lond), 2008. 32(7): p. 1060-7.	School	QE-prospective		4 - 12	36 mo: IG: Nutrition strategies included improved school nutrition policies, canteen menu changes, healthy breakfast days, community garden and educational material. PA strategies included after-school activities, walking school buses, walk to school days and new equipment. CG: no change	No follow up	BMI z-score, WHR, WC	BMI z-score: -0.11 (CI: -0.21 to -0.01; P = 0.04); WHR: -0.02 (CI: -0.03 to -0.04; P = 0.01); WC: -3.4cm (CI: -5.07 to -1.22; P = 0.01)	Significant	Yes	Commonwealth Department of Health and Aging, Victorian Department of Human Services, VicHealth
Sichieri et al. 2009 [195]	Sichieri, R., et al., School randomised trial on prevention of excessive weight gain by discouraging students from drinking sodas. Public Health Nutr, 2009. 12(2): p. 197-202.	School	RCT	1140	9-12	7 mo: implementation of a healthy lifestyle education programme encouraging water consumption instead of SSB; banners hung promoting water consumption; water bottles with campaign logo were distributed	No follow up	BMI, overweight and obesity prevalence	BMI: +0.1 (CI: 0.06 to 0.10)	Not significant	No	Brazilian National Research Council (CNPq) Grant number: 500404/2003-8-CNPq

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Siegrist et al. 2013 [196]	Siegrist, M., et al., Effects of a physical education program on physical activity, fitness, and health in children: the JuvenTUM project. Scand J Med Sci Sports, 2013. 23(3): p. 323-30.	School	RCT	427	8.4 (mean)	12 mo: Multi-component JuvenTUM intervention was on directly educating and encouraging children, teachers, and parents to live active and healthy lifestyles. Additionally, school environmental settings were altered to promote more physical activity (classrooms, the halls and the playgrounds at school were modified so that more physical activity was encouraged). Measures were taken to improve the quality of food sold at school snack bars and/ or at school stores. These changes were designed to increase physical movement, promote healthier food availability and choices, and reduce media consumption.	No follow up	WC, BMI, BMI z-score	WC: -1.7 (CI: 1.2 to 2.3; P < 0.001)	Significant (for WC only)	Yes	Unclear
Simon et al. 2004 [197]; Simon et al. 2008 [198]	Simon, C., et al., Intervention centred on adolescents' physical activity and sedentary behaviour (ICAPS): concept and 6-month results. Int J Obes Relat Metab Disord, 2004. 28 Suppl 3: p. S96-S103. Simon, C., et al., Successful overweight prevention in adolescents by increasing physical activity: a 4-year randomized controlled intervention. Int J Obes (Lond), 2008. 32(10): p. 1489-98.	School	RCT	954	12	48 mo: IG: multilevel intervention involving (i) educational component; (ii) new opportunities for physical activity at lunchtime, during breaks and after-school hours; (iii) Sporting events, free transfers to PA areas and ‘cycling to school’ days were organized. CG: no change	No follow up	BMI, FMI, % overweight	BMI: -0.36 (CI: -0.6 to -0.11, P <0.001); FMI: -0.2 (CI: -0.39 to -0.01) at 4 years; 5.6% fewer children who were initially normal weight were overweight in the intervention schools (OR: 0.41; CI: 0.22 to 0.75)	Significant (in initially normal weight students only)	Yes	The Regional Health Insurance of Alsace-Moselle; National Program of Research in Human Nutrition (INSERM and INRA); French Public Authorities within the National Nutritional Health Program; Conseil General du Bas-Rhin; Municipalities of Drusenheim, Illkirch-Graffenstaden, Obernai and Schiltigheim and The International Longevity Centre

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Singh et al. 2007 [199], Singh et al. 2009 [200] (FU study)	Singh, A.S., et al., Short-term effects of school-based weight gain prevention among adolescents. Arch Pediatr Adolesc Med, 2007. 161(6): p. 565-71. (2007 article); Singh AS, Chin A Paw MJ, Brug J, van Mechelen W. Dutch obesity intervention in teenagers: effectiveness of a school-based program on body composition and behavior. Arch Pediatr Adolesc Med. 2009;163(4): 309–317 (2009 article)	Community, school	C-RCT	1108	12.7 (mean)	8 mo: education in biology and physical activity, environmental change options for schools (physical education classes, changes to school cafeteria)	20	BMI; SFT (sum)	**Girls**: BMI: +0.2 (CI: -0.1 to 0.5); SFT (sum): -2.0 (CI: -3.9 to -0.1); WC: +0.9 (CI: -1.1 to 0.6); Boys: BMI: +0.2 (CI: -0.1 to 0.4); SFT (sum): -1.1 (CI: -4.4 to 0.2); WC: +1.1 (CI: 0.1 to 2.0)	Significant (for sum of SFT only in girls and boys; undesirable effect on BMI and WC in both genders)	Unclear (undesirable effect on WC in boys)	Netherlands Research Programme for Weight Gain Prevention; Grant 2000Z002
Singhal et al. 2010 [201]	Singhal, N., et al., Effects of controlled school-based multi-component model of nutrition and lifestyle interventions on behavior modification, anthropometry and metabolic risk profile of urban Asian Indian adolescents in North India. Eur J Clin Nutr, 2010. 64(4): p. 364-73.	School	RCT	201	15 - 17	6 mo: IG: multi-component intervention including: (i) educational component (ii) policy-level changes in school such as modification of school canteen menu and banning the sale of soft drinks and high calorie foods (iii) parental involvement. CG: no change	No follow up	BMI, WC, WHR	BMI: -0.01 (CI: -0.18 to 0.34); WC: -1.2 (CI: -2.43 to −0.17; P = 0.02); WHR: -0.022 (CI: -0.03 to -0.004; P = 0.02)	Significant (for WC and WHR only)	Yes (for WC only)	World Diabetes Foundation, Denmark (WDF05-120)
Story et al. 2003 [202]	Story, M., et al., An after-school obesity prevention program for African-American girls: the Minnesota GEMS pilot study. Ethn Dis, 2003. 13(1 Suppl 1): p. S54-64.	School, Home	RCT	54	8 - 10	3 mo: after-school multi-component intervention with (i) PA programme offering a variety of activities (ii) club meetings with educational/behavioural themes (iii) weekly food packets sent to families	No follow up	BMI, WC	BMI: +0.2 (P = 0.35); WC: +1.4 (P = 0.08)	Significant (for WC only)	No	NHLBI Cooperative agreement UO1 HL62668-02

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Taber et al. 2012 [203]	Taber, D.R., et al., Weight status among adolescents in States that govern competitive food nutrition content. Pediatrics, 2012. 130(3): p. 437-44.	State-wide	NE	6300	10 - 15	36 mo: Introduction of food and beverage state laws in 40 states between 2003 and 2006	No follow up	BMI	BMI: -0.25 (CI: -0.54 to 0.03)	Significant (for strong laws)	Yes	Robert Wood Johnson Foundation grant number R01HL096664 from the NHLBI; and contracts HHSN261201000350P and HHSN261201100522P from the National Cancer Institute to the University of Illinois at Chicago
Taylor et al. 2007 [204], Taylor et al. 2008 [205] (FU study)	Taylor, R.W., et al., APPLE Project: 2-y findings of a community-based obesity prevention program in primary school age children. Am J Clin Nutr, 2007. 86(3): p. 735-42. (2007 article); Taylor, R.W., et al., Two-year follow-up of an obesity prevention initiative in children: the APPLE project. Am J Clin Nutr, 2008. 88(5): p. 1371-7. (2008 article)	Community, School	nRCT	730	5 - 12	24 mo: IG: APPLE components involved: (i) nutrition education; (ii) employment of activity coordinators to manage an activity program that focused on non-curricular lifestyle-based activities during and after school (e.g. community walks); (ii) some environmental modification including provision of cooled water filters, provision of free fruit for 6 months, and increased promotion and availability of sport and play equipment to enhance 'free play'. CG: No change	24	BMI z-score, RR of being overweight (overweight prevalence)	At end of intervention: BMI z-score: -0.30 (CI: -0.36 to -0.25); RR overweight : 0.70 (CI: 0.54 to 0.9); At 2 year follow-up: BMI z-score: -0.21 (CI: -0.29 to -0.14); RR overweight: 0.81 (CI: 0.69 to 0.94)	Significant	Yes	Health Research Council, the National Heart Foundation, The Community Trust of Otago, The University of Otago, the Otago Diabetes Research Trust
Tian et al. 2006 [206]	Tian, B., et al., Impact evaluation on obesity control among primary school students in 4 cities in China. Chin J School Health, 2006. 27: p. 869-871.	School	C-RCT	Unclear	8 - 11	12 mo: health education including dissemination through notice boards; Family involvement; improvement to school environment by providing sports facilities in intervention schools	No follow up	overweight and obesity prevalence	Prevalence of Overweight and obesity: -3.1% (P = <0.01)	Significant	Yes	Unclear

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Todd et al. 2008 [207]	Todd, M.K., et al., Effect of a family-based intervention on electronic media use and body composition among boys aged 8--11 years: a pilot study. J Child Health Care, 2008. 12(4): p. 344-58.	Home	RCT	22	8 - 11	5 mo: Children and parents attended family-centred interactive session designed to reduce TV-viewing time and increase awareness to minimize electronic media use. TV and computer-locking devices were installed to help monitoring and limiting children's TV and computer use.	No follow up	BMI	No significant change	Not significant	No	Unclear
Utter et al. 2011 [208]	Utter, J., et al., Evaluation of the Living 4 Life project: a youth-led, school-based obesity prevention study. Obesity reviews : an official journal of the International Association for the Study of Obesity, 2011. 12 Suppl 2: p. 51-60.	Community, School	QE with repeated XS	1634	12 - 18	36 mo: Community consultation and engagement processes were conducted with government health departments, school staff and students, local health providers, non-government organisations and other community stakeholders to develop community actions plans. A range of initiatives were implemented in schools, including breakfast clubs, lunch time activities, after school dance, improvements in school food quality, installation of water fountains, distribution of drink bottles, and provision of physical activity equipment.	No follow up	BMI, BMI z-score, % BF	BMI: +0.34 (P = 0.18); BMI z-score: +0.14 (P = 0.13); % BF: +1.07 (P = 0.16)	Not significant	No	The Wellcome Trust (UK), the National Health and Medical Research Council (Australia) and the Health Research Council (New Zealand) through the International Collaborative Research Grant Scheme
Wang et al. 2008 [209]	Wang, L.Y., et al., Cost-effectiveness of a school-based obesity prevention program. J Sch Health, 2008. 78(12): p. 619-24.	School	RCT	601	8.5	36 mo: IG: FitKid after-school program offered 2-hour after-school intervention sessions daily. Sessions started with a 40-min period during which the youths were provided with a healthy snack and academic enrichment activities, followed by 80 min of physical activity included a variety of activities designed to improve sport skills, aerobic fitness, strength, and flexibility (40 min were devoted to vigorous physical activity)	No follow up	% BF	% BF: -0.76 (CI: -1.42 to -0.09)	Significant	Yes	NIH DK63391

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Webber et al. 2008 [210]	Webber, L.S., et al., Promoting physical activity in middle school girls: Trial of Activity for Adolescent Girls. Am J Prev Med, 2008. 34(3): p. 173-84.	Community, School	RCT	8727	11 - 15	24 mo: intervention consisted of (a) cues, messages and incentives to be more physically active; (b) environmental and organizational changes supportive of PA were introduced, including lunch-time dance sessions, after-school step-aerobics classes, before-school open gym. Aimed at girls.	12	BMI, % BF	BMI: +0.1 (CI: -0.4 to 0.7); %BF: +0.2 (CI: -0.6 to 1.1)	Not significant	No	NHLBI grants U01 HL066855 (Tulane University); U01HL066845 (University of Minnesota); U01HL066852 (University of South Carolina); U01HL066853 (University of North Carolina at Chapel Hill); U01HL066856 (San Diego State University); U01HL066857 University of Maryland); U01HL066858 (University of Arizona)
Williamson et al. 2007 [211]	Williamson, D.A., et al., Wise Mind project: a school-based environmental approach for preventing weight gain in children. Obesity (Silver Spring), 2007. 15(4): p. 906-17.	School	RCT	586	7 - 12	18 mo: Wise Mind Project: an environmental intervention focusing on changing the school ecology through policy and physical changes including cafeteria menu modification, poster and boards promoting healthy eating, purchase of equipment to encourage PA, staff development etc., and educational components	No follow up	BMI z-score	BMI z-score: -0.03 (P = 0.55)	Not significant	Yes	NIH Grant R01DK063453-01
Williamson et al. 2012 [212]	Williamson, D.A., et al., Effect of an environmental school-based obesity prevention program on changes in body fat and body weight: a randomized trial. Obesity (Silver Spring), 2012. 20(8): p. 1653-61.	School	C-RCT	325	9 - 11	28 mo: Multi-component intervention: PP + SP—the PP program modified the school environment to promote healthy nutrition and physical activity with three primary objectives: modify environmental cues related to healthy eating and activity, modify the cafeteria food service program, and modify the physical education programs. The SP program employed a classroom instruction component combined with an internet-based approach	No follow up	% BF, BMI	Environmental modification decreased% BF for boys compared to control (-1.7% ± 0.38% versus −0.14% ± 0.69%) and attenuated fat gain for girls (2.9% ± 0.22% versus 3.93% ± 0.37%), but standardized effect sizes were relatively small (< 0.30)	Not significant	Yes	National Institute for Child Health and Human Development grant R01 HD048483, the U.S. Department of Agriculture grant 58-6435-4-90, the NORC Center grant #1P30 DK072476 and NIH grant K23 DK068052

Author date	URL	Setting	Study design*	Sample size	Age range (years)	Intervention Time: Elements included in intervention	Follow up period from end of intervention (months)	Anthropometric outcome **	Difference in change from baseline for intervention vs control (95% CI)	Significance	Desirable Effect	Funding
Yin et al. 2006 [213]	Yin, Z., et al., An environmental approach to obesity prevention in children: Medical College of Georgia FitKid Project year 1 results. Obesity Research, 2005. 13(12): p. 2153-61.	School	RCT	601	8 - 9	8 mo: a 2 hour after-school programme consisting of 40 minutes of academic activity, a healthy snack, followed by an 80-minute period of PA that provided 20 minutes of warm-up and skills instruction, 40 minutes of continuous MVPA, and 10 minutes of calisthenics and cool-down, delivered by professionals.	No follow up	BMI, % BF, WC	BMI: -0.16 (CI: -0.40 to -0.07; P = 0.18); % BF: -0.76 (CI: -1.42 to -0.09; P = 0.027); WC: -0.4 (CI: -1.1 to 0.4; P = 0.32)	Significant (for % BF only)	Yes (for % BF only)	NIH grant RO1 DK63391

* Study design: CT (Controlled Trial, with or without randomisation), CCT (Controlled Clinical Trial), RCT (Randomized controlled trial), nRCT (non-RCT), Q-RCT (Quasi-RCT); Q-nRCT (Quasi-experimental nRCT), NRNCT (Non-Randomised Non-Controlled Trials) C-RCT (Cluster RCT), CBA (Controlled before-and-after study), PCS (Prospective cohort study), RCS (Retrospective cohort study), PCCS (Prospective controlled cohort studies), HCT (Historically controlled trial), NCC (Nested case-control study), CC (Case-control study), XS (Cross-sectional study), CR/CS (Case report/Case series), ITS (Interrupted Time Series), NE (Natural experiments), QE (Quasi-experimental study), PPT (Pre- and Post-test repeated measures design), QE-PPT (Quasi-experimental Pre- and Post-test evaluation), PA (Physical activity)
** % BF (Percentage Body Fat), BMI (Body Mass Index), FFST (fat-free soft tissue), FMI (Fat Mass Index) RR (Relative Risk), SFT (Skin Fold Testing), TSF (Triceps Skin Fold), WC (Waist Circumference), WHR (Waist-to-Hip Ratio)

Appendix 3G. Overlap of primary studies across systematic reviews

SRs * → Primary Studies	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
Angelopoulos 2009 [135]																				x			x		
Ask 2006 [136]								x																	
Ask 2010 [137]																									
Barbeau 2007 [138]			x																	x					
Caballero 2003 [139]						x		x		x							x				x				
Chomitz 2010 [140]				x	x																			x	
Coffield 2011 [141]															x										
Coleman 2005 [142]						x	x			x														x	
Crespo 2012 [143]																									
De Ruyter 2012 [144]	x																								
Donnelly 1996 [145]						x		x		x		x													
Dzewaltowski 2010 [146]																									
Ebbeling 2006 [147]																									
Economos 2007 [148]					x												x								
Engels 2005 [149]			x																						
Foster 2008 [150]																									x
Foster 2010 [151]																								x	
Fotu 2011 [152]																									
French 2011 [153]																									
Gao and Xiang 2014 [154]																						x			
Gombosi 2007 [155]											x														
Graves 2010 [156]																									
Greening 2011 [157]																									
Gutin 2008 [158]																									
Haerens 2006 [159]								x									x	x		x					

SRs * → Primary Studies	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Angelopoulos 2009 [135]										x														
Ask 2006 [136]																								
Ask 2010 [137]																								
Barbeau 2007 [138]										x														x
Caballero 2003 [139]			x	x	x			x		x					x							x		
Chomitz 2010 [140]						x																		
Coffield 2011 [141]																								
Coleman 2005 [142]						x	x	x							x				x					
Crespo 2012 [143]																			x					
De Ruyter 2012 [144]		x															x							
Donnelly 1996 [145]								x							x									
Dzewaltowski 2010 [146]																						x		
Ebbeling 2006 [147]																	x							
Economos 2007 [148]						x																		
Engels 2005 [149]																								
Foster 2008 [150]										x												x		x
Foster 2010 [151]																								
Fotu 2011 [152]																								
French 2011 [153]														x				x						
Gao and Xiang 2014 [154]																								
Gombosi 2007 [155]																								
Graves 2010 [156]														x										
Greening 2011 [157]							x															x		x
Gutin 2008 [158]																								
Haerens 2006 [159]										x														

SRs → Primary Studies	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
Heelan 2006[160]																									
Ho 2008[161]											x														
Hoelscher 2010[162]																								x	
Hollar 2010a[163]																								x	
Hollar 2010b[164]				x																					x
Hollar 2010c[165]																									
Howe 2011[166]																									
Jansen 2011[167]																									
Jordan 2008[168]																									
Kain 2004[169]						x		x									x								
Kremer 2011[170]																									
Luepker 1996[171]						x		x		x										x					
Maloney 2008[172]																									
Marcus 2009[173]						x																			
Martinez Vizcaino 2008[174]																				x			x		
Millar 2011[175]																									
Muckelbauer 2009[176]	x					x																			x
Nader 1999[177]						x											x								
Ni Mhurchu 2008[178]																						x			
Ni Mhurchu 2009[179]																									
Owens 2011[180]													x									x			
Paradis 2005[181]																			x						
Pate 2005[182]								x																	
Raczynski 2009[183]											x														
Ramirez-Lopez 2005[184]																									
Resnicow 1992[185]																									
Robinson 1999[186]						x		x		x		x				x	x			x			x		
Robinson 2003[187]			x																						

SRs → Primary Studies	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Heelan 2006[160]																								x
Ho 2008[161]																								
Hoelscher 2010[162]																			x					x
Hollar 2010a[163]							x												x					
Hollar 2010b[164]																								
Hollar 2010c[165]						x													x					x
Howe 2011[166]																								x
Jansen 2011[167]																						x		
Jordan 2008[168]																								
Kain 2004[169]					x			x							x								x	
Kremer 2011[170]																								
Luepker 1996[171]			x					x													x	x		
Maloney 2008[172]									x		x			x				x						
Marcus 2009[173]						x																		
Martinez Vizcaino 2008[174]						x																		
Millar 2011[175]																								
Muckelbauer 2009[176]																						x		
Nader 1999[177]					x			x		x										x				
Ni Mhurchu 2008[178]									x		x							x						
Ni Mhurchu 2009[179]																								
Owens 2011[180]											x													
Paradis 2005[181]																								
Pate 2005[182]			x																					
Raczynski 2009[183]																								
Ramirez-Lopez 2005[184]																x								
Resnicow 1992[185]																								
Robinson 1999[186]			x		x					x		x		x	x					x		x		
Robinson 2003[187]			x			x						x												

SRs → Primary Studies	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
Robinson 2010 [188]			x																					
Sahota 2001 [189]						x		x				x					x	x					x	
Saksvig 2005 [190]											x													
Salanave 2009 [191]				x																				
Sallis 2003 [192]					x			x													x			
Sanchez-Vaznaugh 2010 [193]															x									
Sanigorski 2008 [194]				x																				
Sichieri 2009 [195]	x																							
Siegrist 2013 [196]																								
Simon 2004 [197]																				x				
Simon 2008 [198]		x		x																			x	
Singh 2007 [199]								x									x	x						
Singh 2009 [200]	x				x	x														x			x	
Singhal 2010 [201]									x											x				
Story 2003 [202]			x																					
Taber 2012 [203]														x	x									
Taylor 2007 [204]						x		x											x					
Taylor 2008 [205]						x																		
Tian 2006 [206]																								
Todd 2008 [207]																								
Utter 2011 [208]																								
Wang 2008 [209]																				x				
Webber 2008 [210]																				x				
Williamson 2007 [211]								x									x			x			x	
Williamson 2012 [212]																								
Yin 2006 [213]																								

SRs → Primary Studies	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Robinson 2010 [188]																									
Sahota 2001 [189]		x		x		x			x							x						x		x	
Saksvig 2005 [190]																									
Salanave 2009 [191]																									
Sallis 2003 [192]		x		x		x			x																
Sanchez-Vaznaugh 2010 [193]																									
Sanigorski 2008 [194]																									
Sichieri 2009 [195]											x							x					x		
Siegrist 2013 [196]																							x		
Simon 2004 [197]				x									x												
Simon 2008 [198]											x				x										
Singh 2007 [199]																									
Singh 2009 [200]											x				x										
Singhal 2010 [201]											x														
Story 2003 [202]				x																					
Taber 2012 [203]																									
Taylor 2007 [204]																									
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Tian 2006 [206]														x											
Todd 2008 [207]															x										
Utter 2011 [208]																									
Wang 2008 [209]																									
Webber 2008 [210]																									
Williamson 2007 [211]																									
Williamson 2012 [212]																							x		
Yin 2006 [213]																x									

*SRs→ the top row of this table contains numbered references to eligible systematic reviews that have been included in this overview

SRs → **Primary Studies**	121	122	123	124	125	126	127	128	129	130	131	132	133	134
Angelopoulos 2009 [135]					x				x					
Ask 2006 [136]			x		x									
Ask 2010 [137]		x	x		x									
Barbeau 2007 [138]									x					
Caballero 2003 [139]									x		x			x
Chomitz 2010 [140]												x		
Coffield 2011 [141]														
Coleman 2005 [142]											x			x
Crespo 2012 [143]														
De Ruyter 2012 [144]														
Donnelly 1996 [145]						x								
Dzewaltowski 2010 [146]									x					
Ebbeling 2006 [147]											x			
Economos 2007 [148]									x				x	
Engels 2005 [149]														
Foster 2008 [150]		x	x		x				x		x	x		
Foster 2010 [151]					x									
Fotu 2011 [152]													x	
French 2011 [153]	x													
Gao and Xiang 2014 [154]														
Gombosi 2007 [155]														
Graves 2010 [156]								x						
Greening 2011 [157]														
Gutin 2008 [158]											x			
Haerens 2006 [159]					x				x		x			
Heelan 2006 [160]												x		

SRs → Primary Studies	121	122	123	124	125	126	127	128	129	130	131	132	133	134
Ho 2006 [161]														
Hoelscher 2010 [162]														
Hollar 2010a [163]														
Hollar 2010b [164]														
Hollar 2010c [165]														
Howe 2011 [166]														
Jansen 2011 [167]					x									
Jordan 2008 [168]												x		
Kain 2004 [169]						x			x	x	x			x
Kremer 2011 [170]													x	
Luepker 1996 [171]						x								
Maloney 2008 [172]								x						
Marcus 2009 [173]											x			
Martinez Vizcaino 2008 [174]									x		x			
Millar 2011 [175]													x	
Muckelbauer 2009 [176]		x	x		x									
Nader 1999 [177]														
Ni Mhurchu 2008 [178]								x						
Ni Mhurchu 2009 [179]								x						
Owens 2011 [180]														
Paradis 2005 [181]							x							
Pate 2005 [182]											x			
Raczynski 2009 [183]														
Ramirez-Lopez 2005 [184]										x		x		
Resnicow 1992 [185]						x								
Robinson 1999 [186]						x		x						
Robinson 2003 [187]						x					x			
Robinson 2010 [188]														

SRs → Primary Studies	121	122	123	124	125	126	127	128	129	130	131	132	133	134
Sahota 2001[189]														
Saksvig 2005[190]							x							
Salanave 2009[191]														
Sallis 2003[192]														
Sanchez-Vaznaugh 2010[193]														
Sanigorski 2008[194]											x		x	
Sichieri 2009[195]		x	x		x					x	x			
Siegrist 2013[196]														
Simon 2004[197]														
Simon 2008[198]					x			x			x			
Singh 2007[199]					x				x					
Singh 2009[200]					x			x			x			
Singhal 2010[201]										x				
Story 2003[202]						x			x		x			
Taber 2012[203]														
Taylor 2007[204]									x		x		x	
Taylor 2008[205]											x			
Tian 2006[206]														
Todd 2008[207]														
Utter 2011[208]													x	
Wang 2008[209]														
Webber 2008[210]					x						x			
Williamson 2007[211]									x					
Williamson 2012[212]														
Yin 2006[213]									x					

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Appendix 4 – Maltese Built Environment

	Q1	Q2	Q3	Q4	Q5	Difference (p value)
Built up area (km²)	M: 2.00 ±0.28 R: 1.80 – 2.20	M: 2.00 ±0.71 R: 1.50 – 2.50	M: 1.35 ±0.07 R: 1.30 – 1.40	M: 1.80 ±1.41 R: 0.80 – 2.80	M: 1.35 ±0.49 R: 1.00 – 1.70	0.604
Area audited	M: 0.45 ±0.21 R: 0.30 – 0.60	M: 0.40 ±0.14 R: 0.30 – 0.50	M: 0.60 ±0.14 R: 0.50 – 0.70	M: 0.40 ±0.14 R: 0.30 – 0.50	M: 0.40 ±0.14 R: 0.30 – 0.50	0.620
Public Open Space quality	M: 3.00 ±0.00 R: 3.00 – 3.00	M: 2.63 ±0.53 R: 2.25 – 3.00	M: 2.54 ±0.19 R: 2.40 – 2.67	M: 3.32 ±0.21 R: 3.30 – 3.33	M: 2.50 ±0.71 R: 2.00 – 3.00	0.203
Playground quality	M: 1.75 ±1.06 R: 1.00 – 2.50	M: 0.00 ±0.0 R: 0.00 – 0.00	M: 1.86 ±0.18 R: 1.75 – 2.00	M: 1.00 ±0.00 R: 1.00 – 1.00	M: 1.63 ±0.18 R: 1.50 – 1.75	0.332
Public Open Space density (km²)	M: 13.70 ±16.50 R: 2.00 – 25.33	M: 12.33 ±6.13 R: 8.00 – 16.67	M: 9.07 ±2.93 R: 7.00 – 11.14	M: 9.00 ±2.83 R: 7.00 – 11.00	M: 15.00 ±1.41 R: 14.00 – 16.00	0.715
Bus Stop density (km²)	M: 26.67 ±9.43 R: 20.00 – 33.33	M: 27.33 ±0.94 R: 26.67 – 28.00	M: 22.86 ±4.04 R: 20.00 – 25.71	M: 14.00 ±8.49 R: 8.00 – 20.00	M: 17.33 ±0.94 R: 16.67 – 18.00	0.173
Bus stop quality	M: 2.88 ±0.88 R: 2.25 – 3.50	M: 3.40 ±0.28 R: 3.20 – 3.60	M: 3.30 ±0.57 R: 2.90 – 3.71	M: 2.75 ±1.06 R: 2.00 – 3.50	M: 2.70 ±0.28 R: 2.50 – 2.90	0.608
Bus frequency at peak times (minutes)	M: 51.00 ±5.66 R: 47.00 – 55.00	M: 32.93 ±8.86 R: 26.67 – 39.20	M: 41.50 ±4.95 R: 38.00 – 45.00	M: 25.00 ±14.14 R: 15.00 – 35.00	M: 22.50 ±3.53 R: 20.00 – 25.00	0.120
Bus frequency at non-peak times (minutes)	M: 60.00 ±0.00 R: 60.00 – 60.00	M: 60.00 ±0.00 R: 60.00 – 60.00	M: 61.50 ±12.02 R: 53.00 – 70.00	M: 60.00 ±0.00 R: 60.00 – 60.00	M: 58.50 ±2.120 R: 57.00 – 60.00	0.911
Traffic volume	M: 63.28 ±7.74 R: 57.80 – 68.75	M: 41.90 ±9.05 R: 35.50 – 48.30	M: 73.15 ±3.23 R: 70.80 – 75.50	M: 60.00 ±15.56 R: 49.00 – 71.00	M: 198.50 ±232.64 R: 34.00 – 363.00	0.496
Road crossing density (km²)	M: 7.50 ±3.53 R: 5.00 – 10.00	M: 35.33 ±12.26 R: 26.67 – 44.00	M: 25.71 ±6.06 R: 21.43 – 30.00	M: 24.00 ±8.49 R: 18.00 – 30.00	M: 28.67 ±6.60 R: 24.00 – 33.33	0.248
Road crossing quality	M: 1.35 ±0.49 R: 1.00 – 1.70	M: 2.33 ±0.60 R: 1.90 – 2.75	M: 1.65 ±0.49 R: 1.30 – 2.00	M: 2.00 ±0.14 R: 1.90 – 2.10	M: 1.60 ±0.14 R: 1.50 – 1.70	0.268

Pavement coverage	M: 1.82 ±0.02 R: 1.80 – 1.83	M: 1.80 ±0.57 R: 1.40 – 2.20	M: 1.70 ±0.14 R: 1.60 – 1.80	M: 2.50 ±0.70 R: 2.00 – 3.00	M: 1.84 ±0.23 R: 1.67 – 2.00	0.473
Pavement quality	M: 2.50 ±0.24 R: 2.33 – 2.67	M: 2.50 ±0.70 R: 2.00 – 3.00	M: 2.05 ±0.21 R: 1.90 – 2.20	M: 1.75 ±0.35 R: 1.50 – 2.00	M: 1.80 ±0.0 R: 1.80 – 1.80	0.184

Table S1: Built environment variables by area-level SE quintile
(M = Mean ±SD; Md = Median; R = Range)

Appendix 5 – The Maltese Food Environment

Appendix 5A – Audited localities, Maltese Islands

Source: Google Earth 7.0, "Malta," Data CNES/Astrium & Digital Globe, 2014, http://www.google.com/earth/index.html.

Appendix 5B. Classification of food stores based on criteria adapted from Lake et al. (2010)

Main category	Food outlet type	Definition/Example
Specialised food store	Convenience	Small size and usually independently owned; sells groceries (but no fresh fruit and vegetables), newspapers/magazines, snacks, drinks, tobacco and alcohol products
	Green Grocer (F&V only)	Sells fresh fruit and vegetables only
	Butcher	Fresh meat is prepared and sold in store; may sell snacks and drinks
	Confectionery	Sell only loose or packaged sweets, chocolates and pastries
	Fishmonger	Fresh fish is prepared and sold in store
	Other	Does not fit into any other category e.g. Health food shop, wine seller, bakery, delicatessen etc.
Grocery stores	Mini-market/Discount store (small)	Small size (1-2 checkouts) and usually independently owned; sells a variety of food and household items including fresh fruit and vegetables
	Supermarket (large)	Large size (≥ 3 checkouts), departmentalised, self-service food store selling food and household goods, including fresh fruit and vegetables
Take Away	Instant fast food	Sells predominately less healthy fried foods; no seating - takeaway only (e.g. pastizzeria; pizzeria; Kiosk selling hot dogs, burgers, chips, fried chicken etc.)
Bar	Food served	Sells predominantly alcohol; freshly prepared snack food (hot or cold) for takeaway or on-site consumption
	Drinks only	Sells predominantly alcohol; may offer packaged snacks (e.g. crisps)
Restaurant or Café	Cafeteria/Wine Bar	Predominantly selling coffee and hot beverages (Cafeteria) or wine (Wine bar); informal seating area with waiter service or order at the counter; pre-made/made to order food and confectionery available
	Fast casual	Order and pay for food at counter; similar to fast food but offers both sit down and takeaway options (e.g. KFC, Pizza Hut, KFC, Burger King, McDonalds)
	Sit-down/traditional	Sit down restaurant; staff take your order; pay for meal after eating
	With takeaway	Primarily a restaurant but has the option to order for takeout; examples include Pizzerias, Turkish/Indian/Chinese restaurants
Mobile vendor	Fruit and vegetables	Mobile vendor selling fresh fruit and vegetables only
	Ice cream/sweets	Mobile vendor selling ice cream/granita only
	Baker	Mobile vendor selling freshly baked bread and biscuits
	Doughnuts	Mobile vendor selling exclusively doughnuts
	Fast food	Mobile vendor selling fast food items such as hot dogs, burgers, chips
	Fish	Mobile vendor selling exclusively fresh fish products

Source: Lake A a, Burgoine T, Greenhalgh F, Stamp E, Tyrrell R. The foodscape: classification and field validation of secondary data sources. *Health Place*. 2010;16(4):666-673. doi:10.1016/j.healthplace.2010.02.004.

Appendix 5D. Food and beverage items – descriptive data

Food items			
Fruit	**Availability***	**Quality****	**Price (€ per unit)**
Apples (per kg)	M: 1.00 ±0.00 Md: 1.0	M: 1.07 ±0.25 Md: 1.0 R: >50% - 75% acceptable to >75% acceptable	M: 2.13 ±0.38 Md: 2.0 R: 1.5 - 3.0
Bananas (per kg)	M: 0.97 ±0.18 Md: 1.0	M: 1.10 ±0.31 Md: 1.0 R: >50% - 75% acceptable to >75% acceptable	M: 1.55 ±0.29 Md: 1.6 R: 1.0 - 2.0
Grapes (per kg)	M: 0.87 ±0.35 Md: 1.0	M: 1.04 ±0.19 Md: 1.0 R: >50% - 75% acceptable to >75% acceptable	M: 4.04 ±0.82 Md: 3.97 R: 2.4 - 5.8
Honeydew melon (per kg)	M: 0.80 ±0.41 Md: 1.0	M: 1.00 ±0.00 Md: 1.0 R: >75% acceptable	M: 1.53 ±0.84 Md: 1.0 R: 0.5 - 3.0
Kiwi (per kg)	M: 0.97 ±0.18 Md: 1.0	M: 1.03 ±0.19 Md: 1.0 R: >50% - 75% acceptable to >75% acceptable	M: 3.07 ±0.63 Md: 3.0 R: 1.89 - 5.0
Oranges (per kg)	M: 0.97 ±0.18 Md: 1.0	M: 1.00 ±0.00 Md: 1.0 R: >75% acceptable	M: 1.54 ±0.35 Md: 1.5 R: 0.9 - 2.5
Peaches (per kg)	M: 0.53 ±0.51 Md: 1.0	M: 1.00 ±0.00 Md: 1.0 R: >75% acceptable	M: 3.04 ±0.93 Md: 2.70 R: 2.0 - 5.3
Pears (per kg)	M: 0.80 ±0.41 Md: 1.0	M: 1.00 ±0.00 Md: 1.0 R: >75% acceptable	M: 2.64 ±0.00 Md: 2.64 R: 2.0 - 3.3
Plums (per kg)	M: 0.40 ±0.50 Md: 0.0	M: 1.00 ±0.00 Md: 1.0 R: >75% acceptable	M: 3.43 ±0.68 Md: 3.50 R: 2.5 - 4.9
Strawberries (per kg)	M: 0.50 ±0.51 Md: 0.5	M: 1.27 ±0.46 Md: 1.0 R: >50% - 75% acceptable to >75% acceptable	M: 5.280 ±2.37 Md: 4.50 R: 3.0 - 9.6
Watermelon (per kg)	M: 0.47 ±0.51 Md: 0.0	M: 1.00 ±0.00 Md: 1.0 R: >75% acceptable	M: 0.93 ±0.53 Md: 0.73 R: 0.7 - 2.6
Vegetables	**Availability***	**Quality****	**Price (€ per unit)**
Broccoli (per pc)	M: 0.70 ±0.46 Md: 1.0	M: 1.05 ±0.21 Md: 1.0 R: >50% - 75% acceptable to >75% acceptable	M: 1.56 ±0.48 Md: 1.50 R: 0.7 - 2.5
Cabbage (per pc)	M: 0.90 ±0.31 Md: 2.0	M: 1.00 ±0.00 Md: 1.0 R: >75% acceptable	M: 0.99 ±0.24 Md: 1.0 R: 0.5 - 1.6
Carrots (per kg)	M: 0.83 ±0.38 Md: 1.0	M: 1.08 ±0.40 Md: 1.0 R: 25 - 49% acceptable to >75% acceptable	M: 1.36 ±0.23 Md: 1.40 R: 0.90 - 1.90
Cauliflower (per pc)	M: 0.90 ±0.31 Md: 2.0	M: 1.11 ±0.42 Md: 1.0 R: 25 - 49% acceptable to >75% acceptable	M: 1.57 ±0.53 Md: 1.50 R: 0.5 - 2.5
Celery (per pkt)	M: 0.47 ±0.51 Md: 0.0	M: 1.00 ±0.00 Md: 1.0 R: >75% acceptable	M: 1.49 ±0.41 Md: 1.40 R: 0.50 - 2.00

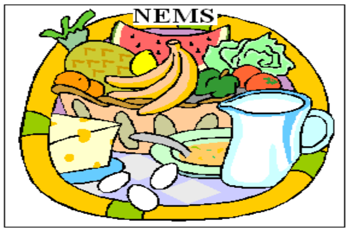
Cucumber (per kg)	M: 0.73 ±0.45 Md: 1.0	M: 1.00 ±0.00 Md: 1.0 R: >75% acceptable	M: 1.89 ±0.78 Md: 1.50 R: 0.85 - 3.53
Lettuce (per pc)	M: 0.80 ±0.41 Md: 1.0	M: 1.09 ±0.29 Md: 1.0 R: >50% - 75% acceptable to >75% acceptable	M: 0.95 ±0.24 Md: 0.97 R: 0.50 - 1.50
Onions (per kg)	M: 0.97 ±0.18 Md: 1.0	M: 1.00 ±0.00 Md: 1.0 R: >75% acceptable	M: 1.01 ±0.42 Md: 0.99 R: 0.50 - 2.25
Potatoes (per kg)	M: 1.00 ±0.00 Md: 1.0	M: 1.00 ±0.00 Md: 1.0 R: >75% acceptable	M: 0.89 ±0.48 Md: 0.77 R: 0.23 - 2.50
Sweet coloured peppers (per kg)	M: 0.97 ±0.18 Md: 1.0	M: 1.04 ±0.19 Md: 1.0 R: >75% acceptable	M: 3.98 ±0.62 Md: 3.99 R: 2.99 - 4.75
Sweet green peppers (per kg)	M: 0.97 ±0.18 Md: 1.0	M: 1.04 ±0.19 Md: 1.0 R: >75% acceptable	M: 2.02 ±0.72 Md: 1.77 R: 1.25 - 3.90
Tomatoes (per kg)	M: 0.97 ±0.18 Md: 1.0	M: 1.14 ±0.35 Md: 1.0 R: >50% - 75% acceptable to >75% acceptable	M: 1.64 ±0.50 Md: 1.50 R: 0.55- 2.95
Zucchini (per kg)	M: 0.97 ±0.18 Md: 1.0	M: 1.00 ±0.00 Md: 1.0 R: >75% acceptable	M: 1.38 ±0.55 Md: 1.40 R: 0.60 - 2.90
Canned/ Frozen Vegetables	**Availability***	**Quality****	**Price (€ per unit)**
Canned beans (per kg)	M: 0.83 ±0.38 Md: 1.0	N/A	M: 2.55 ±0.82 Md: 3.00 R: 1.23 - 3.83
Canned carrots (per kg)	M: 0.50 ±0.51 Md: 0.5	N/A	M: 3.04 ±0.16 Md: 3.05 R: 2.78 - 3.23
Canned sweet corn (per kg)	M: 0.67 ±0.48 Md: 1.0	N/A	M: 3.16 ±0.79 Md: 3.00 R: 1.88 - 4.30
Canned peas (per kg)	M: 0.80 ±0.41 Md: 1.0	N/A	M: 1.40 ±0.25 Md: 1.39 R: 1.06 - 2.31
Canned tomatoes (per kg)	M: 0.73 ±0.45 Md: 1.0	N/A	M: 1.61 ±0.28 Md: 1.62 R: 0.98 - 2.50
Frozen carrots (per kg)	M: 0.47 ±0.51 Md: 0.0	N/A	M: 2.75 ±0.21 Md: 2.78 R: 2.31 - 3.11
Frozen corn (per kg)	M: 0.57 ±0.51 Md: 1.0	N/A	M: 3.33 ±0.62 Md: 3.51 R: 1.60 - 3.89
Frozen vegetable mix (per kg)	M: 0.60 ±0.50 Md: 1.0	N/A	M: 2.75 ±0.40 Md: 2.72 R: 1.99 - 3.67
Frozen peas (per kg)	M: 0.63 ±0.49 Md: 1.0	N/A	M: 2.82 ±0.64 Md: 2.73 R: 1.55 - 4.89

Dairy products	Availability*	Quality**	Price (€ per unit)
Yoghurt, plain, fat free (per kg)	M: 0.70 ±0.46 Md: 1.0	N/A	M: 1.89 ±0.23 Md: 1.73 R: 1.73 - 2.20
Yoghurt, plain, full cream (per kg)	M: 0.80 ±0.41 Md: 1.0	N/A	M: 2.54 ±1.95 Md: 2.20 R: 1.73 - 8.82
Cheddar cheese, low fat (per kg)	M: 0.33 ±0.48 Md: 0.0	N/A	M: 10.97 ±0.83 Md: 10.90 R: 9.85 - 11.95
Cheddar cheese, regular (per kg)	M: 0.80 ±0.41 Md: 1.0	N/A	M: 7.90 ±1.44 Md: 7.23 R: 5.90 - 11.17
Milk, skimmed (per 1L)	M: 0.93 ±0.26 Md: 1.0	N/A	M: 0.85 ±0.13 Md: 0.81 R: 0.81 - 1.25
Milk, whole (per 1L)	M: 0.93 ±0.26 Md: 1.0	N/A	M: 0.88 ±0.12 Md: 0.86 R: 0.83 - 1.30
Shelf space (Milk)	**Availability***	**Quality****	**Price (€ per unit)**
Shelf space for skimmed milk	M: 4.82 ±4.36 Md: 3.0 R: 1 - 19	N/A	N/A
Shelf space for whole milk	M: 7.43 ±6.89 Md: 6.0 R: 1 - 27	N/A	N/A
Pasta/Rice/ Bread	**Availability***	**Quality****	**Price (€ per unit)**
Pasta, wholegrain (per kg)	M: 0.67 ±0.48 Md: 1.0	N/A	M: 2.29 ±0.26 Md: 2.37 R: 1.58 - 2.60
Pasta, white (per kg)	M: 0.87 ±0.35 Md: 1.0	N/A	M: 1.69 ±0.34 Md: 1.67 R: 0.78 - 2.60
Rice, wholegrain (per kg)	M: 0.70 ±0.46 Md: 1.0	N/A	M: 3.86 ±0.74 Md: 3.85 R: 2.59 - 5.48
Rice, white, long grain (per kg)	M: 0.96 ±0.19 Md: 1.0	N/A	M: 3.21 ±0.88 Md: 3.64 R: 1.19 - 5.00
Bread, wholemeal (per 400g loaf)	M: 0.63 ±0.49 Md: 1.0	N/A	M: 1.02 ±0.17 Md: 0.95 R: 0.69 - 1.50
Bread, white (per 400g loaf)	M: 0.70 ±0.46 Md: 1.0	N/A	M: 0.84 ±0.08 Md: 0.85 R: 0.65 - 0.98
Meat products	**Availability***	**Quality****	**Price (€ per unit)**
Beef mince, lean (per kg)	M: 0.37 ±0.49 Md: 0.0	N/A	M: 8.11 ±0.84 Md: 7.95 R: 6.55 - 9.50

Beef mince, regular (per kg)	M: 0.66 ±0.48 Md: 1.0	N/A	M: 7.04 ±0.26 Md: 7.74 R: 6.50 - 7.50
Sausages, low fat (per kg)	M: 0.47 ±0.51 Md: 0.0	N/A	M: 4.06 ±1.64 Md: 3.80 R: 2.48 - 8.20
Sausages, regular (per kg)	M: 0.83 ±0.38 Md: 1.0	N/A	M: 4.50 ±1.83 Md: 4.82 R: 3.75 - 9.15
Cereals	**Availability***	**Quality****	**Price (€ per unit)**
Cereal, high-fibre, low sugar (per kg)	M: 0.83 ±0.38 Md: 1.0	N/A	M: 7.37 ±1.83 Md: 7.74 R: 3.75 - 9.15
Cereal, low-fibre, high sugar (per kg)	M: 0.83 ±0.38 Md: 1.0	N/A	M: 8.31 ±1.55 Md: 8.85 R: 2.49 - 10.00
Baked goods, low fat (rice crackers) (per kg)	M: 0.43 ±0.51 Md: 0.0	N/A	M: 14.17 ±5.29 Md: 10.83 R: 7.45 - 20.08
Chocolate, Cadbury Dairy Milk (per kg)	M: 1.00 ±0.00 Md: 1.0	N/A	M: 13.94 ±2.84 Md: 15.56 R: 7.27 - 17.78
Baked crisps (per 25g pkt)	M: 0.30 ±0.47 Md: 0.0	N/A	M: 0.87 ±0.20 Md: 0.8 R: 0.78 - 1.41
Beverages	**Availability***	**Quality****	**Price (€ per unit)**
Coca Cola, diet (per 1.5L)	M: 0.90 ±0.31 Md: 1.0	N/A	M: 1.51 ±0.32 Md: 1.50 R: 0.38 - 2.00
Coca Cola, regular (per 1.5L)	M: 0.97 ±0.18 Md: 1.0	N/A	M: 1.51 ±0.30 Md: 1.50 R: 0.45 - 2.00
Coca Cola, diet (per 500mL)	M: 0.59 ±0.50 Md: 1.0	N/A	M: 0.96 ±0.13 Md: 0.90 R: 0.80 - 1.20
Coca Cola, regular(per 500mL)	M: 0.67 ±0.48 Md: 1.0	N/A	M: 0.95 ±0.24 Md: 0.97 R: 0.50 - 1.50
100% juice (per 1L)	M: 0.97 ±0.18 Md: 1.0	N/A	M: 1.33 ±0.25 Md: 1.29 R: 0.88 - 2.20
Juice drink (per 1L)	M: 0.77 ±0.43 Md: 1.0	N/A	M: 1.37 ±0.27 Md: 1.30 R: 0.99 - 2.20

M = mean ±SD; Md = Median; R = range
* 1 = Available; 0 = Unavailable
** 1 = high quality; >1 = mixed quality

Appendix 5 C - Nutrition Environment Measures Survey (NEMS)
Food Outlet Cover Page



Rater ID: ☐☐

O Grocery Store
O Convenience Store
O Other ______________________________

Store ID: ☐☐-☐ - ☐☐ - ☐☐☐

Date: ☐☐/☐☐/☐☐
Month Day Year

Start Time: ☐☐:☐☐ O AM O PM

End Time: ☐☐:☐☐ O AM O PM

Number of cash registers: ☐☐

O SD O FC O FF O Specialty O Other

Restaurant ID: ☐☐ - ☐-☐☐-☐☐☐

Site Visit Date: ☐☐/☐☐/☐☐
Month Day Year

Start Time: ☐☐:☐☐ O AM O PM
End Time: ☐☐:☐☐ O AM O PM

Menu/Internet Review Date: ☐☐/☐☐/☐☐
Month Day Year

Start Time: ☐☐:☐☐ O AM O PM
End Time: ☐☐:☐☐ O AM O PM

Other Visit/Interview Date: ☐☐/☐☐/☐☐
Month Day Year

Start Time: ☐☐:☐☐ O AM O PM
End Time: ☐☐:☐☐ O AM O PM

Comments: ______________________________

____

Nutrition Environment Measures Survey (NEMS)
Cover Page

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
Measure #1: MILK

Rater ID: ☐☐

Date: ☐☐ / ☐☐ / ☐☐
Month Day Year

Store ID: ☐☐-☐ - ☐☐ - ☐☐☐

○ Grocery Store ○ Convenience Store ○ Other

Marking Instructions

Please use a pencil or blue or black ink. Correct ● Incorrect

A. Reference Brand

1. BBennanna (preferred) ○ Yes ○ No

2. Alternate Brand Name: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

B. Availability

1. a. Is low-fat (skim or 1%) available? ○ Yes ○ No

b. If not, is 2.5% available? ○ Yes ○ No ○ NA

2. **Shelf space:**

Type	500mls	1 Litre
a. Skim	☐☐	☐☐
b. 1%	☐☐	☐☐
c. Whole	☐☐	☐☐

C. Pricing All items should be same brand

	Benna	Cheapest Brand:__________	Most expensive Brand:___________
1. Whole milk, 500mls	€ ☐.☐☐	€ ☐.☐☐	€ ☐.☐☐
2. Whole milk, 1 Litre	€ ☐.☐☐	€ ☐.☐☐	€ ☐.☐☐
3. Skimmed milk,500mls	€ ☐.☐☐	€ ☐.☐☐	€ ☐.☐☐
4. Skimmmed milk, 1 Litre	€ ☐.☐☐	$ ☐.☐☐	€ ☐.☐☐

Alternate Items:

5. 2.5%, 5500mls € ☐.☐☐ ○ N/A

6. 2.5%, 1 1 Litre € ☐.☐☐ ○ N/A

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
Measure #1a: Yoghurt and Cheese

A. Plain Yogurt Reference Brand

1. Benna (preferred) ○ Yes ○ No

2. Alternate Brand Name: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

B. Availability

1. a. Is plain fat free yoghurt available? ○ Yes ○ No

b. If not, is low-fat available? ○ Yes ○ No ○ NA

Type	Benna Price	Benna Pot size (grams)	Cheapest Brand:__________ Price	Cheapest Pot size (grams)	Most expensive Brand:__________ Price	Most expensive Pot size (grams)
a. Plain fat free	€☐.☐☐	☐☐☐☐	€☐.☐☐	☐☐☐☐	€☐.☐☐	☐☐☐☐
b. Plain low fat	€☐.☐☐	☐☐☐☐	€☐.☐☐	☐☐☐☐	€☐.☐☐	☐☐☐☐
c. Plain full cream	€☐.☐☐	☐☐☐☐	€☐.☐☐	☐☐☐☐	€☐.☐☐	☐☐☐☐

C. Cheese Reference Brand

1. Cheddar (preferred) ○ Yes ○ No

2. Alternate: ____________________ ○ Yes ○ No ○ NA

D. Availability

Comments:

____

1. a. Is low fat cheddar cheese available? ○ Yes ○ No

b. If not, is low fat cheese of another brand available? ○ Yes ○ No ○ NA

Alternate brand: __________________

Type	Price/kg (€)
a. Low fat cheddar	€☐.☐☐
b. Regular cheddar	€☐.☐☐
c. Low fat cheese (alternate brand)	€☐.☐☐
d. Regular cheese (alternate brand)	€☐.☐☐

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
Measure #2: FRUIT

Rater ID: ☐☐

Date: ☐☐ / ☐☐ / ☐☐
Month Day Year

Store ID: ☐☐-☐ - ☐☐ - ☐☐☐

○ Grocery Store ○ Convenience Store ○ Other

Availability and Price

Produce Item		Available Yes	Available No	Price	#	Unit pc	Unit kg	Quality A	Quality UA	Comments
1. **Bananas**		○	○	€ ☐.☐☐	☐	○	○	○	○	______
2. **Apples**	○ Red delicious ○ ______	○	○	€ ☐.☐☐	☐	○	○	○	○	______
3. **Oranges**	○ Navel ○ ______	○	○	€ ☐.☐☐	☐	○	○	○	○	______
4. **Grapes**	○ Red seedless ○ ______	○	○	€ ☐.☐☐	☐	○	○	○	○	______
5. **Plums**	○ Red ○ ______	○	○	€ ☐.☐☐	☐	○	○	○	○	______
6. **Peaches**		○	○	€ ☐.☐☐	☐	○	○	○	○	______
7. **Strawberries**		○	○	€ ☐.☐☐	☐	○	○	○	○	______
8. **Honeydew Melon**		○	○	€ ☐.☐☐	☐	○	○	○	○	______
9. **Watermelon**	______	○	○	€ ☐.☐☐	☐	○	○	○	○	______
10. **Pears**	○ Anjou ○ ______	○	○	€ ☐.☐☐	☐	○	○	○	○	______
11. **Kiwis**		○	○	€ ☐.☐☐	☐	○	○	○	○	

12. **Total Types:** (Count # of yes responses) ☐☐

13. **Total number of fruit varieties present in store:** ☐☐

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
Measure #2a: FROZEN FRUIT

Rater ID: ☐☐

Date: ☐☐ / ☐☐ / ☐☐
Month Day Year

Store ID: ☐☐-☐ - ☐☐-☐☐☐

○ Grocery Store ○ Convenience Store ○ Other

Availability and Price

Produce Item	Available Yes	Available No	Package size (g)	Price
1. **Strawberries**	○	○	☐☐☐☐	€☐.☐☐
2. **Raspberries**	○	○	☐☐☐☐	€☐.☐☐
3. **Blueberries**	○	○	☐☐☐☐	€☐.☐☐
4. **Other ____________**	○	○	☐☐☐☐	€☐.☐☐

5. **Total number of frozen fruit varieties available in store:** ☐☐

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
Measure #3: VEGETABLES

Rater ID: ☐☐

Date: ☐☐ / ☐☐ / ☐☐
Month Day Year

Store ID: ☐☐-☐ - ☐☐-☐☐☐

○ Grocery Store ○ Convenience Store ○ Other

Availability and Price

Produce Item		Available Yes	Available No	Price	#	Unit pc	Unit kg	Quality A	Quality UA	Comments
1. **Carrots**	○ Loose	○	○	€ ☐.☐☐	☐	○	○	○	○	
	○									
2. **Tomatoes**	○ Loose	○	○	€ ☐.☐☐	☐	○	○	○	○	
	○									
3. **Sweet Peppers**	○ Green bell peppers	○	○	€ ☐.☐☐	☐	○	○	○	○	
	○									
4. **Broccoli**	○ Bunch	○	○	€ ☐.☐☐	☐	○	○	○	○	
	○									
5. **Lettuce**	○ Green leaf	○	○	€ ☐.☐☐	☐	○	○	○	○	
	○									
6. **Onions**	○ White	○	○	€ ☐.☐☐	☐	○	○	○	○	
	○									
7. **Celery**		○	○	€ ☐.☐☐	☐	○	○	○	○	
8. **Cucumbers**	○ Regular	○	○	€ ☐.☐☐	☐	○	○	○	○	
	○									
9. **Cabbage**	○ Head	○	○	€ ☐.☐☐	☐	○	○	○	○	
	○									
10. **Cauliflower**		○	○	€ ☐.☐☐	☐	○	○	○	○	
11. **Zucchini**		○	○	€ ☐.☐☐	☐	○	○	○	○	
12. **Potatoes**	○ Loose	○	○	€ ☐.☐☐	☐	○	○	○	○	
	○									

13. **Total Types:** (Count # of yes responses) ☐☐

14. **Total number of vegetable varieties present in store:** ☐☐

Measure Complete ☐

Nutrition Environment Measures Survey
(NEMS) Measure #3a: FROZEN VEGETABLES

Rater ID: ☐☐   Store ID: ☐☐-☐-☐☐-☐☐☐

Date: ☐☐/☐☐/☐☐
Month Day Year

O Grocery Store   O Convenience Store   O Other

Availability and Price

Item		Package Size (g)	Available Yes	Available No	Price		Comments
1. Peas	O ________	☐☐☐☐	O	O	€☐.☐☐	☐	________
2. Corn	O ________	☐☐☐☐	O	O	€☐.☐☐	☐	________
3. Mixed Vegetables	O ________	☐☐☐☐	O	O	€☐.☐☐	☐	________
4. Carrots	O ________	☐☐☐☐	O	O	€☐.☐☐	☐	________

5. **Total number of frozen vegetable varieties present in store:** ☐☐

Measure Complete ☐

Nutrition Environment Measures Survey
(NEMS) Measure #3b: CANNED VEGETABLES

Rater ID: ☐☐

Store ID: ☐☐☐-☐☐-☐☐☐-☐☐☐☐

Date: ☐☐/☐☐/☐☐
Month Day Year

O Grocery Store O Convenience Store O Other

Availability and Price

Item		**Can Size (g)**	**Available Yes**	**No**	**Price**		**Comments**
1. Tomatoes	O **Mayor**	☐☐☐ g	O	O	€☐.☐☐	☐	____________
	O Other____________		O	O	€☐.☐☐	☐	
2. Corn	O **Bonduelle**	☐☐☐ g	O	O	€☐.☐☐	☐	____________
	O Other____________	☐☐☐ g	O	O	€☐.☐☐	☐	
3. Peas	O **Elite**	☐☐☐ g	O	O	€☐.☐☐	☐	____________
	O Other____________		O	O	€☐.☐☐	☐	
4. Green Beans	O **Bonduelle**	☐☐☐ g	O	O	€☐.☐☐	☐	____________
	O Other________	☐☐☐ g	O	O	€☐.☐☐	☐	
5. Carrots	O **Bonduelle**	☐☐☐ g	O	O	€☐.☐☐	☐	____________
	O Other____________		O	O	€☐.☐☐	☐	

6. **Total number of canned vegetable varieties present in store:** ☐☐

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
MEASURE #4: GROUND BEEF

Rater ID: ☐☐

Date: ☐☐ / ☐☐ / ☐☐
Month Day Year

Store ID: ☐☐-☐ - ☐☐ -☐☐☐

O Grocery Store O Convenience Store O Other

Availability and Price

Item	Available			Price/kg.		Comments
	Yes	No	N/A	Cheapest	Most expensive	
Healthier option:						
Brand: __________				__________	__________	
1. Lean minced beef, **90% lean, 10% fat** (Ground Sirloin)	O	O		€☐.☐☐	€☐.☐☐	__________
Alternate Items:						
2. Lean ground beef, (<10% fat) ☐☐ **% fat**	O	O	O	€☐.☐☐	€☐.☐☐	__________
3. Ground Turkey, (≤10% fat) ☐☐ **% fat**	O	O	O	€☐.☐☐	€☐.☐☐	__________

Regular option:						
5. Standard ground beef, **80% lean, 20% fat**	O	O		€☐.☐☐	€☐.☐☐	__________
Alternate Item:						**Comments**
6. Standard alternate ground beef, if above is not available ☐☐ **% fat**	O	O	O	€☐.☐☐	€☐.☐☐	__________

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
MEASURE #5: Sausages

Rater ID: ☐☐ Store ID: ☐☐-☐-☐☐-☐☐☐

Date: ☐☐/☐☐/☐☐
Month Day Year

○ Grocery Store ○ Convenience Store ○ Other

Availability and Price

Item	Available Yes	No	N/A	Price/pkg.	Comments
Healthier option:					
1. 98% Fat Free Sausages (e.g. turkey/beef) ~0.5g fat	○	○		€☐.☐☐	________
Alternate Items: (≤ 10g fat)					
2. Zwan light sausages 9.5g fat	○	○	○		
☐☐☐☐☐☐☐☐☐☐☐☐☐☐ Brand name	☐☐☐ Kcal/svg			€☐.☐☐	________
3. Light Wieners (turkey/pork)	○	○	○	€☐.☐☐	________
4. Light beef Franks (usually 1/3 less calories, 50% less fat)	○	○	○	€☐.☐☐	________
5. Turkey Wieners (1/3 less fat)	○	○	○	€☐.☐☐	________
6. Other ☐☐☐☐☐☐☐☐☐☐☐☐	○	○	○	€☐.☐☐	☐☐ g pkg ☐☐ Hot dogs/pkg ☐☐ g fat ☐☐☐ kcal/svg ________
Regular option:					
7. Wudy (pork) - regular >12g fat	○	○		€☐.☐☐	________
Alternate Items: (≥10g fat)					
8. Beef Franks (regular)	○	○	○	€☐.☐☐	________
9. Other ☐☐☐☐☐☐☐☐☐☐☐☐	○	○	○	€☐.☐☐	☐☐ g pkg ☐☐ Hot dogs/pkg ☐☐ g fat ☐☐☐ kcal/svg ________

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
MEASURE #6: FROZEN DINNERS

Rater ID: ☐☐ Store ID: ☐☐-☐ - ☐☐ - ☐☐☐

Date: ☐☐ / ☐☐ / ☐☐
Month Day Year

○ Grocery Store ○ Convenience Store ○ Other

A. Reference Brand

1. (preferred) ○ Yes ○ No

2. Alternate brand (with reduced-fat dinners available) Brand Name: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Comments: ______________________________

B. Availability

1. Are reduced-fat frozen dinners available? (≤9g fat/250-300g.) ○ Yes ○ No ______________

Shelf space:(measure only if reduced-fat frozen dinners are available)

2. Reduced-fat dinners/regular dinners: Proportion ○ < = 10% ○ 11-33% ○ 34-50% ○ 51%+

C. Pricing (All items must be same brand)

Reduced-Fat Dinner	Price/ Pkg	Regular Dinner	Price/ Pkg	Comments
1. **Lasagna**	€ ☐☐.☐☐	**Lasagna**	€ ☐☐.☐☐	______
☐☐ g. ☐☐☐ Kcal. ☐☐ g fat		☐☐ g. ☐☐☐ Kcal. ☐☐ g fat		
2. **Roasted Turkey Breast**	€ ☐☐.☐☐	**Roasted Turkey Breast**	€ ☐☐.☐☐	______
☐☐ g. ☐☐☐ Kcal. ☐☐ g fat		☐☐ g. ☐☐☐ Kcal. ☐☐ g fat		
3. **Meatloaf**	€ ☐☐.☐☐	**Meatloaf**	€ ☐☐.☐☐	______
☐☐ g. ☐☐☐ Kcal. ☐☐ g fat		☐☐ g. ☐☐☐ Kcal. ☐☐ g fat		

Reduced-Fat Alternate (≤ 9g fat)	**Price/ Pkg**	**Regular Alternate** (≥ 10g fat)	**Price/ Pkg**	**Comments**
4. Other ______	€ ☐☐.☐☐	Other ______	€ ☐☐.☐☐	______
☐☐ g. ☐☐☐ Kcal. ☐☐ g fat		☐☐ g. ☐☐☐ Kcal. ☐☐ g fat		
5. Other ______	€ ☐☐.☐☐	Other ______	€ ☐☐.☐☐	______
☐☐ g. ☐☐☐ Kcal. ☐☐ g fat		☐☐ g. ☐☐☐ Kcal. ☐☐ g fat		
6. Other ______	€ ☐☐.☐☐	Other ______	€ ☐☐.☐☐	______
☐☐ g. ☐☐☐ Kcal. ☐☐ g fat		☐☐ g. ☐☐☐ Kcal. ☐☐ g fat		

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
MEASURE #7: BAKED GOODS

Rater ID: ☐☐

Date: ☐☐ / ☐☐ / ☐☐
Month Day Year

Store ID: ☐☐-☐ - ☐☐-☐☐☐

○ Grocery Store ○ Convenience Store ○ Other

Availability & Price

Low-fat baked goods ≤3g fat/serving

Item	Available Yes No N/A	Amt. per package	g fat/ per item	kcal/ per item	Price	Comments
Healthier option:						
1. Rice Crackers						
Single	○ ○		☐☐	☐☐☐	€☐.☐☐	______
Package	Yes No N/A ○ ○ ○	☐☐	☐☐	☐☐☐	€☐.☐☐	______
Alternate Items:	Yes No N/A					
2. Bagel	○ ○ ○	☐☐	☐☐	☐☐☐	€☐.☐☐	______
3 a. Low-fat muffin ☐☐☐☐☐☐☐☐☐☐	○ ○ ○	☐☐	☐☐	☐☐☐	€☐.☐☐	______
b. # varieties of low fat muffins	○ 0 ○ 1 ○ 2 ○ 3+					

Regular option (≥ 4g fat/serving or 400 Kcal/serving):

Item	Available Yes No N/A	Amt. per package	g fat/ per item	kcal/ per item	Price	Comments
4. Regular muffin	○ ○	☐☐	☐☐	☐☐☐	€☐.☐☐	______
Alternate Items:	Yes No N/A					
5. Regular Danish	○ ○ ○	☐☐	☐☐	☐☐☐	€☐.☐☐	______
6. Other	○ ○ ○	☐☐	☐☐	☐☐☐	€☐.☐☐	______

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
MEASURE #8: BEVERAGE

Rater ID: ☐☐ Store ID: ☐☐-☐ - ☐☐-☐☐☐

Date: ☐☐ / ☐☐ / ☐☐
Month Day Year

○ Grocery Store ○ Convenience Store ○ Other

Availability & Price

Healthier option:

	Size	Available: Yes	No	N/A	Price	Comments
1. Diet Coke	1.5 L.	○	○		€ ☐.☐☐	________
	500ml	○	○		€ ☐.☐☐	________
2. Alternate brand of diet soda ☐☐☐☐☐☐☐☐☐☐☐☐	1.5 L	○	○	○	€ ☐.☐☐	________
☐☐☐☐☐☐☐☐☐☐☐☐	500 ml	○	○	○	€ ☐.☐☐	________

Regular option:

	Size	Yes	No	N/A	Price	Comments
3. Coke	1.5 L	○	○		€ ☐.☐☐	________
	500 ml	○	○		€ ☐.☐☐	________
4. Alternate brand of sugared soda ☐☐☐☐☐☐☐☐☐☐☐☐	1.5 L	○	○	○	€ ☐.☐☐	________
☐☐☐☐☐☐☐☐☐☐☐☐	500 ml	○	○	○	€ ☐.☐☐	________

Healthier option: — Available

5. **100% juice, 1L.** — Yes No

○ Safari ○ Pfanner ○ Other — ○ ○ — € ☐.☐☐ ________

Alternate Items: — Yes No N/A

6. **100% juice, 500ml**

○ Safari ○ Pfanner ○ Other — ○ ○ ○ — € ☐.☐☐ ________

7. **100% juice,** ○ ______ml.

○ Safari ○ PPfanner ○ Other — ○ ○ ○ — € ☐.☐☐ ________

Regular option: — Yes No

8. **Juice Drink, 1L**

○ Safari Peach Nectar ○ Pfanner ○ Other — ○ ○ — € ☐.☐☐ ________

Alternate Items: — Yes No N/A

9. **Juice Drink, 500ml**

○ Safari ○ Pfanner ○ Other — ○ ○ ○ — € ☐.☐☐ ________

10. **Juice Drink,** ○ ______ml.

○ Safari ○ Pfanner ○ Other — ○ ○ ○ — € ☐.☐☐ ________

11. **Variety of regular sodas available:** ☐☐

12. **Variety of diet sodas available:** ☐☐

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
MEASURE #9: BREAD

Rater ID: ☐☐

Date: ☐☐ / ☐☐ / ☐☐
Month Day Year

Store ID: ☐☐-☐-☐☐-☐☐☐

○ Grocery Store ○ Convenience Store ○ Other

Availability & Price

Item	Available Yes No N/A	Loaf size (g)	Price/loaf	Comments
Healthier Option: Whole grain bread (100% whole wheat bread and whole grain bread)				
1. Golden Harvest 100% Wholemeal bread	○ ○	☐☐☐☐	€☐.☐☐	________
Alternate Items:				
2. Jesper's 100% Wholemeal Bread	○ ○ ○	☐☐	€☐.☐☐	________
3. Other: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐	○ ○ ○	☐☐	€☐.☐☐	________
4. # of varieties of 100% wholemeal and whole grain bread (all brands)	○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6+			
Regular Option: White bread (Bread made with refined flour)				
5. Goldren Harvest Sliced White Bread	○ ○	☐☐☐☐	€☐.☐☐	________
Alternate Items:				
6. Jesper's Sliced White Bread	○ ○ ○	☐☐	€☐.☐☐	________
7. Other: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐	○ ○ ○	☐☐	€☐.☐☐	________

	Cheapest Brand:________		Most expensive Brand:________	
	Price	**Loaf size (grams)**	**Price**	**Loaf size (grams)**
White Bread	€☐.☐☐	☐☐☐☐	€☐.☐☐	☐☐☐☐
Whole Meal Bread	€☐.☐☐	☐☐☐☐	€☐.☐☐	☐☐☐☐

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
MEASURE #9a: RICE AND PASTA

Rater ID: ☐☐

Date: ☐☐ / ☐☐ / ☐☐
Month Day Year

Store ID: ☐☐-☐ - ☐☐ - ☐☐☐

○ Grocery Store ○ Convenience Store ○ Other

RICE Availability & Price

Item	Available Yes	No	N/A	Pkt size (g)	Price/pkt	Comments
Healthier Option: Brown rice (100% whole grain rice)						
1. Tilda 100% Whole Grain Rice	○	○		☐☐☐☐	€ ☐.☐☐	____
Alternate Items:						
2. Uncle Ben's 100% Whole Grain Rice	○	○	○	☐☐☐☐	€ ☐.☐☐	____
3. Other: ____	○	○	○	☐☐☐☐	€ ☐.☐☐	____
4. # of varieties of 100% whole grain rice (all brands)	○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6+					
Regular Option: White Long Grain rice						
5. Tilda 100% Long Grain White Rice	○	○		☐☐☐☐	€ ☐ ☐☐	
6. Other: ____	○	○		☐☐☐☐	€ ☐ ☐☐	

PASTA Availability & Price

Item	Available Yes	No	N/A	Pkt size (g)	Price/pkt	Comments
Healthier Option: Brown Pasta (100% whole grain pasta)						
1. Barilla Spaghetti Integrale	○	○		☐☐☐☐	€ ☐.☐☐	____
Alternate Items:						
2. Buitoni 100% Whole Grain spaghetti	○	○	○	☐☐☐☐	€ ☐.☐☐	____
3. Other: ____	○	○	○	☐☐☐☐	€ ☐.☐☐	____
4. # of varieties of 100% whole grain pasta (all brands)	○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6+					
Regular Option: White Pasta						
5. Barilla Spaghetti Regular	○	○		☐☐☐☐	€ ☐ ☐☐	
6. Other: ____	○	○		☐☐☐☐	€ ☐ ☐☐	

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS) MEASURE #10: BAKED CRISPS

Rater ID: ☐☐ Store ID: ☐☐-☐ - ☐☐ - ☐☐☐

Date: ☐☐ / ☐☐ / ☐☐
Month Day Year

O Grocery Store O Convenience Store O Other

Availability & Price

Low-fat crisps ≤3g fat/serving

Item	Size (g.)	Available	Price	Comments
Healthier Option :		**Yes No**		
1. Walkers Baked Potato Crisps Original Salted	☐☐ g.	O O	€ ☐.☐☐	______
Alternate Item:		**Yes No N/A**		
2. ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐	☐☐ g.	O O O	€ ☐.☐☐	______

3. # of varieties of low-fat chips (any brand) O 0 O 1 O 2 O 3 O 4 O 5 O 6+

Regular Option (select most comparable size to healthier option available):

Item	Size (g.)	Available	Price	Comments
		Yes No		
4. Walkers Salted Crisps Classic	☐☐ g.	O O	€ ☐.☐☐	______

5. # of varieties of regular chips (any brand) O 0 O 1 O 2 O 3 O 4 O 5 O 6+

Item	Size (g.)	Available	Price	Comments
Alternate Item:		**Yes No N/A**		
6. ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐	☐☐ g.	O O O	€ ☐.☐☐	______

Chocolate

Item	Available	Weight (g)	Price	Comments
7. Cadbury Milk Chocolate	O Yes O No	☐☐	€ ☐.☐☐	______
Alternate: Mars Bar	O Yes O No O NA			

8. # of varieties of chocolates (any brand) ☐☐☐☐

9. # of varieties of low-fat or low-sugar chocolates (any brand) ☐☐☐☐

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
MEASURE #11: CEREAL

Rater ID: ☐☐ Store ID: ☐☐-☐-☐☐-☐☐☐

Date: ☐☐/☐☐/☐☐
Month Day Year

○ Grocery Store ○ Convenience Store ○ Other

Availability & Price

Healthier cereals < 7 g sugar per serving

Item	Available Yes No N/A	Size (grams)	Price	Comments
Healthier Option :				
1. Cheerios (Plain)	○ ○	☐☐☐	€☐.☐☐	______
Alternate Item:				
2. Cornflakes	Yes No N/A ○ ○ ○	☐☐	€☐.☐☐	______
3. Other ______	Yes No N/A ○ ○ ○	☐☐	€☐.☐☐	
4. # of varieties of healthier cereals	○ 0 ○ 1 ○ 2 ○ 3+			

Regular Option ($\geq$7g of sugar per serving):

Item	Available Yes No N/A	Size (grams)	Price	Comments
4. Cheerios (Flavoured)	○ ○	☐☐	€☐.☐☐	______
Alternate Item:				
5. Frosties	Yes No N/A ○ ○ ○	☐☐	€☐.☐☐	______
6. Other ______	Yes No N/A ○ ○ ○	☐☐	€☐.☐☐	

NEMS Scoring Sheet for Stores (Malta)

Item	Availability of Healthier Item	Avail Total Points	Price	Price Total Points	Quality	Quality Total Points
Milk	YES low-fat/skim = 2 pts		Lower for lowest-fat = 2 pts Same for both = 1 pt Higher for low-fat = -1 pt			
	Proportion (lowest-fat to whole) ≥ 50% = 1 pt					
Fruits	0 varieties = 0 pts 1-6 varieties = 1 pt 7-11 varieties = 2 pts 12+ varieties = 3 pts				25-49% acceptable = 1 pt 50-74% acceptable = 2 pts 75%+ acceptable = 3 pts	
Frozen Fruit	0 varieties = 0 pts 1-2 varieties = 1 pt 3+ varieties = 2 pts					
Vegetables	0 varieties = 0 pts 1-6 varieties = 1 pt 7-11 varieties = 2 pts 12+ varieties = 3 pts				25-49% acceptable = 1 pt 50-74% acceptable = 2 pts 75%+ acceptable = 3 pts	
Frozen Vegetables	0 varieties = 0 pts 1-3 varieties = 1 pt 4+ varieties = 2 pts					
Canned Vegetables	0 varieties = 0 pts 1-3 varieties = 1 pt 4+ varieties = 2 pts					
Ground Beef	YES lean meat = 2 pts 2-3 varieties = 1 pt 3+ varieties = 2 pts		Lower for lean meat = 2 pts Higher for lean meat = -1 pt			
Hot dogs	YES fat-free = 2 pts Light, not fat-free = 1pt		Lower for fat-free or light = 2 pts Higher for fat-free or light = -1 pt			
Frozen dinners	YES all 3 reduced-fat types = 3 pts YES 1 or 2 reduced-fat types = 2 pts		*Lower for reduced-fat = 2 pts Higher for reduced-fat = -1 pt			
Baked goods	YES low-fat items = 2 pts		Lower for low-fat (per piece) = 2 pts Higher for low-fat (per piece) = -1 pt			
Beverages	YES diet soda = 1 pt		Lower for diet soda = 2 pts			
	YES 100% juice = 1 pt		Higher for 100% juice = -1 pt			
Bread	YES whole grain bread = 2 pts		Lower for whole wheat = 2 pts Higher for whole wheat = -1 pt			
	>2 varieties whole wheat bread = 1 pt					
Pasta	YES whole grain pasta = 2 pts		Lower for whole grain pasta = 2 pts			

NEMS Scoring Sheet for Stores (Malta)

	>2 varieties whole grain pasta = 1 pt		Higher for whole grain pasta = -1 pt			
Baked chips	YES baked chips = 2 pts		**Lower for baked chips = 2 pts Higher for baked chips = -1 pt			
	> 2 varieties baked chips = 1 pt					
Cereal	YES healthier cereal = 2 pts		**Lower for healthier cereal = 2 pts Higher for healthier cereal=-1 pt			
	Availability Subtotal=		**Price Subtotal=**		**Quality Subtotal=**	
					Total NEMS Store Score =	

Ranges- **Availability Subtotal**: 0 to 44 **Price Subtotal**: -10 to 24 **Quality Subtotal**: 0 to 6
TOTAL NEMS SCORE RANGE: -10 to 74

Appendix 6 - GroPromo Instrument

Date ______ Store Name ____________ Location address and zip code ____

Coder (your name) ________________ Flier collected in store ☐ on web ☐ Store ID____________________

How many check outs are there in the store? _______________How many numbered aisles are there? ___________

Location Type	Product Category	Diet, low sugar, or low fat versions	Promotion/ Seasonal (circle all that apply) S= Size TH= Theme D= Display	Are there 5 or more items from the key category here?	Child Height?	Child Focused?
Outside	Fruit & Vegetables	Yes No NA	S TH D None	Yes No	Yes No	Yes No
Entrance	Sweets or Chocolates	Yes No NA	S TH D None	Yes No	Yes No	Yes No
Endcaps facing entrance	Soda drink	Yes No NA	S TH D None	Yes No	Yes No	Yes No
Endcaps facing away from entrance	Crisps	Yes No NA	S TH D None	Yes No	Yes No	Yes No
Island	Crisps	Yes No NA	S TH D None	Yes No	Yes No	Yes No
Edge	Fruit & Vegetables	Yes No NA	S TH D None	Yes No	Yes No	Yes No
Aisle	Child focused cereal	Yes No NA	S TH D None	Yes No	Yes No	Yes No
Aisle	Crisps	Yes No NA	S TH D None	Yes No	Yes No	Yes No
Aisle	Soda drink	Yes No NA	S TH D None	Yes No	Yes No	Yes No
Aisle	Soda drink	Yes No NA	S TH D None	Yes No	Yes No	Yes No
Checkout Side	Sweets or Chocolates	Yes No NA	S TH D None	Yes No	Yes No	Yes No
Checkout End	Soda drink	Yes No NA	S TH D None	Yes No	Yes No	Yes No

Store ID___________________

MAIN CEREAL AISLE PLACEMENT, CHILD FOCUS CEREALS (CFC)

Shelf # 1=lowest	% of shelf that is CFC	Notes
1	<25 25-50 50-75 75-100	
2	<25 25-50 50-75 75-100	
3	<25 25-50 50-75 75-100	
4	<25 25-50 50-75 75-100	
5	<25 25-50 50-75 75-100	
6	<25 25-50 50-75 75-100	
7	<25 25-50 50-75 75-100	
8	<25 25-50 50-75 75-100	
9	<25 25-50 50-75 75-100	
10	<25 25-50 50-75 75-100	

KEY DEFINITIONS

- ✓ **Child Height/ Focused: Note if any categories are at child-height (defined as <4 feet- measure this on your own body for reference around the store), and/or if they're child focused (meaning they have a cartoon, pictures of kids, a contest, or something that is geared towards children e.g. a movie or TV program etc etc).**

Appendix 7 – Topic Guides for Interviews and Focus Groups

Childhood Obesity in Malta – Interview Topic Guide (Non-Industry)

Equipment

- Audio recording devices
- Consent form

Interview datasheet:	
Locality………………………………………	Date………/……../201…
Institution ………………………………………………………	Sex M F
Occupation………………………………………………….	
Present position…………………………………………………	Time in the present position………………………

INTRODUCTION (2 minutes)

1. Introduction
2. Have you read the information letter? If not, explain research. Do you have any questions?
3. Ask whether interviewee is happy to be tape-recorded
4. *Switch on audio recorder and audio check*

Key area	Themes and rationale	Issues I want to cover	Comments/Points
Introduction	Consent; Introduction		

Background information (structure and agenda)	**Explore organisation**: structure, funding, affiliations	Tell me about your organisation and the job you have here; how does it work? How long have you been in this position? What are your current responsibilities? Did you hold any other positions in the same field before your current position? What were your responsibilities then?	
Reasons for obesity problem in Malta	Explore ideas and opinions on childhood obesity	What do you know about obesity, particularly childhood obesity, in Malta?	
	Reasons for childhood obesity (questions to elicit interviewee's views on how the cultural, political, environmental and physical environment contribute to childhood obesity)	If yes, then what do you think are the reasons for this? Why? *(is the environment a reason for this?)* **Probe further (e.g. why families put more soft drinks on the table; why there are more fast food outlets)…..** If no, then: my statistics say…how do you respond to that? *Prompt on whatever has not been mentioned previously:* • *Attitudes and beliefs* (about different food types; influence of school environment) • *policy / economic context*: adherence of Malta to international treaties e.g. on food advertising, use of media, PR campaigns, lobbying etc; Drivers of current governmental obesity policy, how it is set to be implemented, what the barriers may be • *influence of trade agreements and treaties* • *Media and advertising* • *Community, demographic and societal characteristics* • *Community level* - influence of neighbourhood availability of fast food and different food outlets; influence of parenting styles and family characteristics on child dietary/PA patterns) In your view, what are some drivers and barriers to successful reversal of current obesity trends or to implementation of policy? • *Retail environment:* access to healthy food, cost	
Obesity prevention in Malta	Assess interviewee's knowledge about past	<u>*Government interviewees*</u> What do you know about what the government is doing to address obesity? Do you think it is enough?	

	and present obesity prevention efforts	- If no: WHY? / what do you think are shortcomings at government level? *(dig deeper - this might inform on barriers)* Ideally, what could be improved? <u>*Non-government interviewees*</u> How do you think the government is responding to childhood obesity? Do you think it is enough? Ideally, what could the government do? *Example prompts depending on interviewee:* • *Specific examples:* opinions about a potential 200m buffer zone around schools within which permits for fast food stores cannot be approved; voluntary pledge vs regulation of advertising or nutritional labelling etc • What measures do you think will be of most benefit and/or most cost-effective in reducing childhood obesity? • reformulation	
	Ask about potential policies concerning food/PA → include those mentioned in Obesity Strategy/NCD strategy etc	(*e.g. government regulation of the advertising of fast food aimed at children; tax on HFSS or SSBs; use of proceeds to subsidise production and distribution of nutritious food; food labelling regulation dedicated centres; regulating advertising; acceptability of regulation*)	
Role of the organisation and corporate social responsibility	Explore beliefs about the role of their organisation with regards to childhood obesity Explore current and potential organisational	<u>*Non-government*</u> What are you currently doing, and what do you have in mind, which could affect obesity? Can you tell me about specific ways in which you or your organisation might be involved in addressing childhood obesity? How much influence do you think that your institution has on childhood obesity? Explain.	

	involvement in childhood obesity		
Consultation & the evidence-policy gap	Is your organisation consulted on issues of obesity? How?	*Non-government* With regards to government strategy/policy related to obesity, were you consulted? Would you have liked to be consulted? How does that work? Is this something you wish you could do? Ideally would you wish for your org to be more involved? How can your org be more involved?	
Barriers/Facilitators	Explore barriers and facilitators	We've discussed/you've mentioned that xyz is a barrier… 1. How can [barriers mentioned] be overcome? a. what else is needed to make people 'sit up and take note'? 2. What other barriers, do you think? 3. How can these problems (mentioned above) be overcome? 4. What should be done instead, or what needs to be in place?	
Conclusion	Snowballing	Can you think of anybody else I should speak to?	
	Final comments	Any final comments?	

Childhood Obesity in Malta – Interview Topic Guide (Industry)

Equipment

- Audio recording devices
- Consent form

Interview datasheet:	
Locality……………………………………….	Date……../……../201…
Institution ………………………………………………………….	Sex M F
Occupation………………………………………………….	
Present position………………………………………………….	Time in the present position………………………

INTRODUCTION (2 minutes)

5. Introduction
6. Have you read the information letter? If not, explain research. Do you have any questions?
7. Ask whether interviewee is happy to be tape-recorded
8. *Switch on audio recorder and audio check*

NB – The term 'Organisation' also refers to 'Business', where relevant

Key area	**Themes and rationale**	**Issues I want to cover**	**Comments/Points**
Introduction	Consent		
Background information	**Explore organisation**: structure, funding, affiliations, products	Tell me about your organisation and the job you have here: **How long have you been in this position? What are your current responsibilities**?	

		Can you briefly describe what your company produces, imports, distributes, sells or manufactures?	
Reasons for obesity problem in Malta	Explore ideas and opinions on childhood obesity	As I've mentioned, my research is about how our environment influences obesity – particularly the increase in childhood obesity rates – in Malta. What are your views about childhood obesity in Malta?	
	Reasons for childhood obesity (questions to elicit interviewee's views on how the cultural, political, environmental and physical environment contribute to childhood obesity)	If yes (i.e. a problem exists), then what do you think are the reasons for this? Why? If no, then…how would you respond to the following statistics? (present Malta statistics for childhood obesity) *Prompt on whatever has not been mentioned previously:* • *Attitudes and beliefs* (about different food types; influence of school environment; portion size; lack of knowledge?) • *Influence or related to personal choices (individual responsibility?)* • *Policy / economic context*: adherence of Malta to international treaties e.g. on food advertising • *Influence of trade agreements and treaties* • *Media and advertising – promotion of unhealthy food* • *Community level* - influence of neighbourhood availability of fast food and different food outlets; influence of parenting styles and family characteristics on child dietary/PA patterns)	
Obesity prevention in Malta	Assess interviewee's knowledge about past and present obesity prevention efforts	Does the government have a role in addressing childhood obesity? How do you think the government is responding? What do you think of this response? What would be your advice to the government to address childhood obesity? In your view, what are some drivers and barriers to successful reversal of current obesity trends or to implementation of policy?	

	Ask about potential policies concerning food/PA → include those mentioned in Obesity Strategy/NCD strategy etc	Explore acceptability of govt-imposed regulation (*example prompts depending on interviewee:* • *Specific examples:* opinions about a potential 200m buffer zone around schools within which **permits** for fast food stores cannot be approved; voluntary pledge vs imposed **regulation of advertising** or nutritional **labelling**; **taxation and subsidies**; **reformulation** etc. • What measures do you think will be of most benefit and/or most cost-effective in reducing childhood obesity? Why?	
Role of the organisation and corporate social responsibility	Explore beliefs about the role of their organisation with regards to childhood obesity Explore current and potential organisational involvement in childhood obesity	Do you think your organisation is related in any way to the high childhood obesity rates in Malta? Why/why not? What specific actions by your org. do you think contribute to/help to respond to childhood obesity? • Corporate social responsibility (CSR) strategy? • Reformulation • New products • Labelling Have you/your org. perceived a change (increase or decrease) in fast food demand on the past 20 years? New outlets opened? In your marketing strategy, do you promote healthy aspects of your product? Does this impact sales and consumer demand? Do you see yourself as part of the solution to childhood obesity, as part of the problem, or both? Can you elaborate on this?	
Consultation & engagement	If the question of decision-making & engagement with govt. has not come up yet, ask now:	How would you describe your relationship with the public sector, including the health sector? Do you see scope for collaboration with the public health sector? What would encourage collaboration/open discourse?	

		With regards to government strategy/policy <e.g. Healthy Weight for Life Strategy 2012; Food and Nutrition Action Plan 2014>, were you consulted? Why do you think they did/did not consult you? Would you have liked to be consulted/engaged? How could your org be more involved/engaged in the future?	
Barriers/Facilitators	Explore barriers and facilitators	What do you think about the introduction of food labelling regulations? (Food Information (Labelling) Regulation (EU) No 1169/2011). Have you had enough opportunity to comment and/or participate in the drafting/implementation of the regulations? What consultation was carried out? -> what do you think about the traffic light labelling system specifically? If you were to help re-design the regulations, what would you change, or how would you do it differently? We've discussed/you've mentioned that [something] is a barrier… 5. How can <the barriers mentioned> be overcome? a. what else is needed to make people 'sit up and take note'? 6. Do you think other barriers exist? What are they? 7. What should be done instead, or what needs to be in place to make change happen?	
Conclusion	Documents	Any documents (e.g. Corporate Social Responsibility) I can access?	
	Final comments/ Snowballing	Any final comments? Is there anybody else you think I should speak to?	

Childhood Obesity in Malta – Focus Group Topic guide (Children)

Equipment

- Audio recording devices
- Consent forms
- Healthy refreshments

Focus Group Schedule

INTRODUCTION (5-10 minutes)

9. Welcome and greet participants
10. Introduce yourself
11. Explain the purpose of the interview as was described in the information letter sent out to parents and students
12. Remind focus group participants of the researcher's ethical obligations and briefly explain how confidentiality will be maintained
13. Remind participants that the session will be audio recorded to allow for final objections or concerns to be raised
14. Ask for permission to switch on audio recording device and take notes during the session
15. *Switch on audio recorder and audio check*
16. Remind participants that they need to speak clearly for recording purposes
17. Ask participants to switch off any mobile phones
18. Remind participants that there are no incorrect responses, that all ideas are important, and not to wait for permission to talk; however everybody's views are important
19. Allow the respondent to ask any last questions that they may have with regard to the focus group session

Prompt

I would like to hear what you have to say about the foods you eat, the places where you eat, and why you might prefer certain kinds of food over others. We will also be talking about physical activity and exercise inside school as well as outside of the school (e.g. at home, in your neighbourhood). I expect that this focus group will take one to one and a half hours.

SEMI-STRUCTURED FG GUIDE

Key area of investigation	Themes and Rationale	Example questions
Introduction	Introduction (as above)	Put focus group participants at ease
Concept of obesity and overweight	Explore participants' understanding of obesity and overweight; similarities and differences Explore why is childhood obesity increasing Explore ideas on relationships between obesity and overweight and health	My research is about obesity – who knows what that means? Do you think people are overweight here in Malta? Why do you think people put on too much weight? Do you think it could have something to do with the food we eat or the amount of activity we take? Does it matter if people are overweight or obese?
Lifestyle - Diet and PA	Perceived lifestyle Identify sources of knowledge Explore understanding of food behaviour and 'diet' and physical activity	**<u>Diet/Food behaviour:</u>** What are your favourite things to eat? Can you tell me some of the things that are important to you when selecting the food and drinks that you eat and drink? (*e.g. hunger and food cravings, visual/smell appeal of food, time considerations of adolescents and parents, convenience of food, food availability, branding, emotional state, parental influence on eating behaviours (including the culture or religion of the family), benefits of foods (including health), situation-specific factors, mood, body image, habit, cost, media, and vegetarian beliefs)* What do you typically eat on a normal day (at school and at home, other places)? Do you like it? Wish it were different? Is the food you eat when out with friends different?

	Explore reasons behind poor diet and lack of physical activity	Does your mother/father/grandmother etc talk about good diet at home? What do they say? What else influences what you wish to eat? Is there anything that stops you from eating more healthily? *e.g. family, TV commercials, relatives, school, magazines, internet, health professionals, friends, lack of sense of urgency about personal health in relation to other concerns, and taste preferences for other foods.* Do you sometimes feel like having a different diet than what you currently have? If you could change one thing that would help you improve your diet, what would it be? *e.g. making healthful food taste and look better, limiting the availability of unhealthful options, making healthful food more available and convenient, teaching children good eating habits at an early age, and changing social norms to make it "cool" to eat healthfully.* **Physical Activity/Sedentary behaviour** What do you think about exercise / physical activity? What type of exercise do you like to do, if any? Do you enjoy physical activity classes or sports teams at school? Why do you enjoy it? *(e.g. sense of achievement or belonging; enjoy competition, being fit and healthy; ;spending time with friends and family members, choosing activities they prefer or activities suited to their physique or skill level, choosing a variety of activities; parents paying for sport activities and equipment; parental transport; parental enthusiasm/encouragement; siblings taking part)* Do you wish you could exercise more or do more sports? If you could change one thing to increase your physical activity or to do more sports what would it be? *(e.g. make school facilities available out of hours; provide children with more information on extra-curricular activities; clean up parks, park wardens, provide more cycle paths/lanes, youth clubs etc*) Is there anything that stops you exercising? (*e.g. Access / safety / appropriate facilities /health issues, family, lack of time, beliefs, shame and embarrassment; frustration with unclear or complex rules, boredom, bad weather, preferring to do other things over sport, lack of choice or variety; parents relying on cars to drive short distances, parents' lack of enthusiasm for sports; parents' own negative childhood experiences of PE ; fear of crime/safety concerns outside of school' bullying, neglect of play areas)*)

		What about TV? What are your favourite programmes? Are you allowed to watch TV at home? How often do you watch TV? What about computer/mobiles/tablets? How many hours would you say?
Local environments	**Explore perceptions of environmental influences (in the local setting)**	**Questions exploring the cultural, political, environmental and physical environment following the ANGELO framework**
School	Explore school environment to identify challenges and opportunities for improving diet and PA levels e.g. School policies around nutrition/PA; playgrounds; canteen/cafeteria; vending machines	Tell me about a typical school day. What do you usually do after school hours? **Political:** Are there rules on what food and drink you can bring to school? Are you allowed to go outside school to buy food? What can you tell me about food available in your school canteen? Which are your favourite foods in the canteen, and why? Are there vending machines in your school? What can you tell me about food available in vending machines? Which items sold in the canteen/vending machines do you think are healthy? **Sociocultural:** Do you walk to school? Why/why not? What do you think about sports? Do you do any sports at school? How often? *(try to identify gender differences in outlook on sport participation + healthy diet and how the environment enables/challenges such behaviour)* **Economic:** Do you ever spend any money of your own on food at school? What about outside of school? **Physical:** How often do you have physical education class? Where do you do exercise within the school? Do you have space to play/structured sports? Moving about in between classes? After school PA?
Home	Explore home environment to identify challenges and	Do you ever do exercise outside of school? (e.g. at home; sport clubs) What about exercise at home, alone or with others? Do you ever go for a walk or cycle with your family? If so, when and where do you usually go? What stops you from going more often?

	opportunities for improving diet and PA levels.	*(space to run/walk at home? Chores? weekend outings? private lessons*) What can you tell me about the food you typically eat at home? Are fruit and vegetables available at home? What about soft drinks/chocolates/sweets? What can you tell me about your mealtime structure and snacking habits*?* Where do you have your meals at home? Do you typically eat with others or alone? Do you ever eat in front of the TV? Do you eat until you feel full, or do others at home encourage you to clean your plate? (*look for informal or formal rules governing eating (e.g. eating together as a family; TV dinners; portion sizes*) What do you understand by the term 'meal'? Do you think you have regular meals? *How important are the family meals and what types of food do you eat there?* *What differences do you see between yourself and other members of your family?* *Do you think home cooked meals and ready meals are both good for you or do you prefer one over the other – which one?* *Do you snack in between meals? What do you typically snack on? Snacks taken between meals? Where? What types? (e.g. fruit, crisps, chocolates, sweets etc. Ask to describe.)* Do you ever eat away from home? How often and when (dinner, lunch etc)? Where do you usually go? Why do you go there and not to other places? *(food, affordability, attractive; availability* What do you understand by the term 'junk food'? How often do you or your family eat 'junk foods'? Is this important to you? **<u>Sociocultural:</u>** What do you think about your village feast and other holidays? Do you participate in any of the activities? Is there anything you look forward to eating during feasts which you don't eat during the rest of the year? (e.g. candy floss) **<u>Economic:</u>** Do you receive pocket money to spend on food or other things? *Sports equipment*
Neighbourhood	Talk about the immediate neighbourhood around their home and school	Do you exercise, go for walks or play outside of your home in your neighbourhood? Do you walk from place to place? *(e.g. to and from school; to buy food; visit friends; garden, playing field, in the streets)*

		Political: Do you ever meet friends outside of school? What do you typically do on such occasions? **Physical:** Safety (including traffic), walkability, fast food outlets in their neighbourhood; access to and use of Fast food outlets near their home and their chools ; Are fruit and vegetables available in stores around your home or the place where you do most of your shopping?
Responsibility	Explore participants' perceptions of responsibility for health: individual vs external responsibility (e.g. self; parents; school etc)	Do you ever think about your health? Do you think exercise and eating certain types of food can help to make you healthier or less healthy? Do you think others should tell you what to eat/drink, or is it something you think you should decide for yourself? Why?
Recommendations	Explore potential action points (both informational or environmental) to induce change within and outside of the school environment	What would help you exercise more or do more physical activity? What would help you eat more healthily (i.e. more fruit and vegetables, less junk food)? What would you change in schools, in your home etc to help you eat better or do more exercise? What would you change in your neighbourhood? Do you think you yourselves can help to make this change happen?

Childhood Obesity in Malta – Focus Group Topic guide (Parents)

Equipment

- Audio recording devices
- Consent forms

Focus Group Schedule

INTRODUCTION (5-10 minutes)

20. Welcome and greet participants
21. Introduce yourself
22. Explain the purpose of the interview as was described in the information letter sent out to parents and students
23. Remind focus group participants of the researcher's ethical obligations and briefly explain how confidentiality will be maintained
24. Remind participants that the session will be audio recorded to allow for final objections or concerns to be raised
25. Ask for permission to switch on audio recording device and take notes during the session
26. *Switch on audio recorder and audio check*
27. Remind participants that they need to speak clearly for recording purposes
28. Ask participants to switch off any mobile phones
29. Remind participants that there are no incorrect responses, that all ideas are important, and not to wait for permission to talk; however everybody's views are important
30. Allow the respondent to ask any last questions that they may have with regard to the focus group session

Key area of investigation	Themes and Rationale	Example questions
Introduction	Introduction	
Concept of obesity and overweight	Explore participants' understanding of	What do you think about obesity in Malta? Do you think people, especially children are overweight here in Malta? Does it matter?

	obesity and overweight; reasons	Why do you think children are putting on too much weight?
Lifestyle - Diet and PA	Explore understanding of food behaviour and 'diet' and physical activity Explore reasons behind poor diet and lack of physical activity	*Where do you obtain your general knowledge about food and diet?* Do you think more information is needed? Where do you think it is best to get this information from? **<u>Diet/Food behaviour:</u>** *Can you tell me what foods / drinks are available at home? What do you offer your children?* *What is your opinion on fast foods restaurants and take-aways?* Prompts: - Eating away from home? How often and what meals? Are they important to you? - How often would your family eat? - What are the reasons you eat there (food, affordability, attractive for children, convenience, availability) - What is your opinion about the food served in pastizzerias? What about the quality of the food in take-away shops? **<u>Physical Activity/Sedentary behaviour</u>** *Can you describe your lifestyle and PA behaviour as a family?* Prompts: - What do you think about exercise / physical activity? How do you describe physical activity / exercise? What type of exercise do you do? How often? With children? - Do you think exercise / physical activity is important? Why? - Is there anything that prevents your children from exercising? What would help?
Local environments	**Explore perceptions of environmental influences (in the local setting)**	**Questions exploring the cultural, political, environmental and physical environment following the ANGELO framework**
Purchasing	Explore what drives purchase of certain food	*Can you tell me some of the things that are important to you when selecting the food and drinks that you eat and drink?* Do convenience, pricing and distance influence your choice of purchasing? Prompts: Convenience (types of food / where food is purchased), Quality (how is this determined), Price, Labelling, Brand, Views on food manufacturing and processing on health, Own or families health, Pleasure / social importance, Status, Appearance/ Body image, comfort eating, emotional needs, Environment e.g. sustainability (where the food comes from), organic foods, fair trade *Food shopping habits* Prompts: Supermarkets, Convenience stores / local grocer, Why chosen: convenience / price / access?; Do you read food labels? , do you understand them? What do you look for?; How do you get to the shops – walk / bus / car?

		What is your view on supermarkets and grocery stores? Prompts: - Do they offer you the choice you want? - Do they affect how often you shop for food? - Are the prices as the supermarket lower and **do the special offers affect your intention to purchase?** - Are there some foods that you wouldn't buy in a supermarket? Why?
Home	Explore home environment to identify challenges and opportunities for improving diet and PA levels.	**Sociocultural:** Do you ever exercise, or encourage your children to exercise?(e.g. at home; sport clubs) What about taking your children to perform PA (perhaps as a family)? What stops you from going more often? **Political:** Where do you have your meals at home? Do you typically eat as a family? Do you ever eat in front of the TV? What rules around eating exist in the home? (*look for informal or formal rules governing eating (e.g. eating together as a family; TV dinners; portion sizes*) Rules at home re. eating/PA/sedentary behaviour (e.g. limits to screen time; meal times structure) **Physical**: Availability and accessibility of food (particularly HFSS food) in the home; availability of space where to play in the home; use of technological devices for play **Economic:** Tell me more about the money you spend on PA equipment? *Sports equipment*
Neighbourhood	Talk about the immediate neighbourhood	What can you tell me about opportunities for PA in your neighbourhood? Do you exercise, go for walks, let your children play in your neighbourhood? Do you walk from place to place? *(e.g. to and from school; to buy food; visit friends)* **Physical:** Safety (including traffic), walkability, fast food outlets in their neighbourhood; access to and use of fast food outlets near their home and their children's schools; Are fruit and vegetables available in stores around your home or the place where you do most of your shopping?
Responsibility	Explore participants' perceptions of responsibility for children's health: individual vs external responsibility (e.g.	How much do you think can be done by individuals alone? i.e. making it an individual responsibility to make dietary & lifestyle changes versus, say, social policies that change the environment to enable better choices; how easy is it to choose healthy options with the current level of advertising, fast food outlets, expense etc? Are people able to influence the choices within the current environment (price, access, advertising etc) or is the government shifting blame to the individual?

	parents; school; government etc.)	Beliefs about where obesity fits within the role of a parent
Recommendations	Explore potential action points to induce change in their environment	What do you think can be done to alter the environment? - e.g. Reducing the number of fast food outlets e.g. fried chicken shops, pizza shops What would help you and your children exercise more or do more PA? What would help you and your children eat better (i.e. more fruit and vegetables, less fast food)? *Is there anything else you can tell me about what you feel needs to be done to enable you to make 'healthy' food choices & increase physical activity in your community?*

Appendix 7 - Coding Framework

Barriers to healthy dietary behaviour

- ***Economic environment***
  - *Cheap fast food*
  - *Expensive F&V*
  - *Industry - Economies of scale*
    - Food runs designed for the Maltese
    - Labelling costs
- ***Physical environment***
  - *Country size*
    - Dependence on food imports
    - Insular mentality
    - Market distortion
  - *Increased food availability and accessibility*
  - *Marketing techniques*
    - In-store environment
  - *Mobile vendors*
    - Doughnut hawkers
    - F&V hawkers
  - *School environment*
    - Doughnut hawkers
    - Fast food and soft drinks in school canteens or tuck shops
      - Logistical difficulty in stocking healthy food
      - Response to student demand for fast food
      - Source of school income
    - Lack of healthy food
      - contrast with nutrition education
    - School Fruit Scheme not implemented in secondary schools
  - *Ubiquitous fast food restaurants*
- ***Political environment***
  - *Home*
    - Rules and regulations
      - 'Clean your plate' mentality
      - No liquids during meals
  - *National*
    - Limited control over imported foods
    - No legislation to regulate children's exposure to TV or online advertising
  - *School*
    - Head of School
    - HELP document
      - Conflict with income generation
      - Lack of enforcement and monitoring
        - 'Black market'
    - School Fruit Scheme
- ***Sociocultural environment***
  - *Changing lifestyle*
    - Culture of eating out
    - Growing reliance on convenience food
    - Maternal employment

Role of grandparents

Cultural

Eating as a social occasion

Food preferences

Carbohydrate-rich

Highly palatable convenience foods

Food to demonstrate affection or politeness

Pleasure of eating

Portion size - quantity over quality

Historical

Catering for tourist palates

Food insecurity during post-war years

Nutrition transition (colonialism)

Starvation during WW2

Barriers to physical activity

Economic environment

Insufficient government incentives to promote PA

Maintenance and repair costs

Privatization of public open spaces

Physical environment

Neighbourhood

Lack of public open spaces

Less space for unstructured play

Road safety concerns

Urbanization

Vandalized playgrounds

Vehicular traffic

School

Academic focus

Insufficient time allocated to Physical Education

Lack of equipment and facilities

Short break time

Political environment

National politics

Inter-organizational politics

Lack of collaboration

Political interference

Five-year electoral cycle

Strong motorist lobbying

Neighbourhood

Restrictions within public open spaces

School

Inter-organizational politics limiting playground availability

PE not prioritized

School ethos

Short school day

Sociocultural environment

Academic emphasis

Car culture

Disinclination to be active

Electronic devices promoting sedentary behaviour
Equating physical activity with sports
Lack of knowledge regarding exercise
Lack of positive parental example
Parental overprotection
Safety concerns

Obesity Frames - Narratives, Arguments and Strategies

Consultation
Lack of consultation
Willingness to be involved

Diverting blame to the individual
Lack of education

Justification for selling unhealthy food
Competition
Concern about profit loss to competition
Not a level playing-field
Consumer desires do not match actions
Makes certain foods palatable to children
Other products are to blame
Products not chosen for nutrition-related reasons
Profit-driven business

Rationale for tackling obesity
Economic burden (healthcare costs)
Increasing awareness of obesity problem
Moral concern

Reasons for obesity
Biology
Individual personality
Changing lifestyles
Busy lives
Grandparental influence
Lack of time for PA
Less time to cook
Cost of living
Expectations from life
Part-time work on top of full time work
Sedentary lifestyle
Faulty priorities
Knowledge deficits
Lack of insight
Lack of self-control
Laziness
Level of education
Taste preferences
Developed at a young age
Parental influence
Prefer foods high in fat, sugar salt
Re-purchasing of foods previously liked
Obesogenic environment
Technology

Advergames
More things to do at home
Social media
Television
Video games
Responsibility for obesity
Collective or Societal
Individual
Limited industry responsibility
Consumer interests at heart
Concern for consumers' health
Provide choice to cater for all tastes
Provide foods that are attractive to children
Corporate Social Responsibility
Desire to be part of solution
Reformulation
Expand portfolio
Lack of return on R&D investment
Meet demand
No pick-up
Voluntary
Parental

Solutions for childhood obesity

Active lifestyle
Increase PA
Foster enjoyment in children
Structured PA
Unstructured PA
Education
Culinary skills
Budgeting
Healthy convenience food
Seasonal shopping
Nutritional knowledge
Target grandparents and parents
Labelling
Addresses food safety concerns
Bad for business
Good for consumers
Implications on range of products offered
Selective effect
Media
Most cost-effective at population level
Shock tactics
Moderation
Regulation
Legislation
Monitoring and enforcement concerns
Television advertising regulation
Welfare benefit obligations

- *Self-regulation*
- *Taxes*
  - Central to PH action
    - Comparison with Tobacco taxes
  - Non-staples (e.g. SSBs)
  - Regressive
    - Pass on costs to consumer

Schools

- *Extend school hours*
- *Increase PE lessons*
- *Monitoring and enforcement concerns*
- *Peer pressure*

Appendix 8 – Letters of Information and Consent forms

Letter of Invitation to owner of food retail outlet

INFORMATION SHEET:
Contributions of the environment to childhood obesity in Malta

I would like to invite you to participate in a study that aims to understand the policy and environmental landscape around childhood obesity in Malta.

Background

As prevalence rapidly continues to rise, childhood obesity has become a priority for policy-makers worldwide, motivated by concerns about the likelihood of tracking of obesity into adulthood and its association with a range of adverse metabolic and cardiovascular diseases such as coronary heart disease, stroke and diabetes. This is also a critical public health issue for Malta, which has one of the highest rates of childhood obesity in the world. In recent years, there has been a paradigm shift in public health thinking away from individual interventions towards a more complex socio-ecological approach that takes into consideration environmental aspects of health and well-being. I would like to understand how political, social, economic, cultural and physical environmental factors contribute to childhood obesity in Malta, and explore ways of tackling the problem from a broader perspective.

Aim of this study

This section of the study aims to understand the broad food and built environment influencing Maltese children's food choices and physical activity levels, in order to apply an ecological perspective to the problem of childhood obesity in Malta and identify appropriate levers and actions to address it.

This project will contribute to our understanding of childhood obesity in Malta from an ecological, multi-level perspective, providing useful contextual information on the challenges and opportunities for effective policy and/or interventions to tackle the issue.

Your participation

With your kind permission, I would like to enter your store together with another fieldworker to conduct a short assessment of food availability lasting approximately 20-30 minutes. I will need to take written notes and make use of a checklist during the review.

I will not be seeking to interview you in person, and I do not expect the in-store assessment to pose you or your customers any inconvenience or discomfort. No personal information will be sought. Taking part in the study is entirely voluntary and withdrawal is possible at any time without having to give a reason, in which case any data collected up to that point will be destroyed.

What value does the study have for you?

I intend to make available the findings of this research to all study participants through a short summary report and subsequent peer-reviewed publication/s.

How confidentiality will be ensured

All information collected about your outlet will be kept strictly confidential, with all data kept in a secured file. The outlet will be assigned a unique Study Identification Number (SID), which at the completion of the study will be de-linked from potential identifiers. Data will be destroyed within six months of the publication of the results.

Data collected might be shown in publications, however you or your store will not be identified in any way. Should you assent to the above, please read, sign and return the attached consent form to myself prior to starting the in-store assessment.

Costs and/or payments for participation in research

There will be no costs and or payments for participating in the study. If you would like to have a copy of any publications arising from the study, kindly let me know on the day.

Ethical approval

The London School of Hygiene & Tropical Medicine Ethics Committee have approved the study.

Further information

Should you have any questions about this interview please feel to contact Dr Daniel Cauchi (Daniel.cauchi@lshtm.ac.uk) or Dr Cécile Knai (Cecile.Knai@lshtm.ac.uk).

Thank you very much in advance for your cooperation with this study.

Yours sincerely,

Dr Daniel Cauchi and Dr Cécile Knai

London School of Hygiene & Tropical Medicine
Faculty of Public Health and Policy
15-17 Tavistock Place
London WC1H 9SH, United Kingdom
Tel. +44 7543731014

Consent form (food retail outlet owner)

Project title: Contributions of the environment to childhood obesity in Malta

Investigators: Dr Daniel Cauchi

London School of Hygiene & Tropical Medicine
Faculty of Public Health and Policy
15-17 Tavistock Place
London WC1H 9SH, United Kingdom
Tel. +44 7543731014

Consent to participate in the study

1. "I have read the information sheet concerning this study and I understand what will be required of me and what will happen to me if I take part in it."

2. "My questions concerning this study have been answered by the interviewer."

3. "I understand that at any time I may withdraw from this study without giving a reason."

4. "I give permission for the investigators to investigate the store I am responsible for and participate in this study."

5. "I agree for data collected from this store to be quoted anonymously in any publications arising from this study."

Name of participant____

Signature _________________________ Date ______________________________

Please sign and return this form to the interviewer, indicating your consent to take part in the study. Alternatively you may email the signed form to daniel.cauchi@lshtm.ac.uk.

Letter of Invitation to Key informants

INFORMATION SHEET:
Contributions of the environment to childhood obesity in Malta

I would like to invite you to participate in a study that aims to understand how Maltese children's environment may affect their diet and physical activity.

Background

As prevalence rapidly continues to rise, childhood obesity has become a priority for policy-makers, motivated by concerns about the likelihood of tracking of obesity into adulthood and its association with a range of adverse diseases such as coronary heart disease, stroke and diabetes.

This is a critical public health issue for Malta, which has one of the highest rates of childhood obesity in the world. I would like to understand how environmental factors (e.g. political, social, economic, cultural and physical environment) contribute to childhood obesity in Malta, and explore ways of tackling the problem.

Aim of this study

This study aims to understand whether there is an obesogenic environment in Malta and explore factors informing the current policy response and other dynamics at play

Your participation

I would like to invite you to participate in a semi-structured face-to-face interview lasting approximately 1 hour. The interview will be undertaken in English or Maltese, whichever language you feel most comfortable with. Throughout the interview some written notes will be taken, and with your kind permission, the session will be tape-recorded. I do not expect the interview questions to pose any inconvenience or discomfort. Taking part in the interview is entirely voluntary and withdrawal is possible at any time without having to give a reason.

What value does the study have for you?

I intend to make available the findings of this research to all study participants through a short summary report and subsequent peer-reviewed publication/s.

How confidentiality will be ensured

All information collected about you and your organisation during the course of the interview will be kept strictly confidential. Transcripts of the interviews will be made available only to myself and my supervisor and will be kept in a secured file. You will be assigned a unique Study Identification Number (SID), which at the completion of the study will be de-linked from personal identifiers. Original recordings will be destroyed within six months of the publication of the results.

Interview transcripts might be quoted in publications using a code with no reference to your name, age, gender or organisation. You also have the option of not being quoted at all.

Costs and/or payments for participation in research

There will be no costs and/or payments for participating in the interview.

Ethical approval

The University of Malta Research Ethics Committee and the London School of Hygiene & Tropical Medicine Ethics Committee have approved the study.

Further information

If you accept to be interviewed, please read, sign and return the attached consent form to myself at the time of the interview. Should you have any questions about this interview please feel free to contact me on 79617648 or via email on Daniel.cauchi@lshtm.ac.uk

Thank you in advance for your cooperation with this study.

Yours sincerely,

Dr Daniel Cauchi and Dr Cécile Knai

London School of Hygiene & Tropical Medicine
Faculty of Public Health and Policy
15-17 Tavistock Place
London WC1H 9SH, United Kingdom
Tel. +44 7543731014

Consent form (Key informants)

Project title:	Contributions of the environment to childhood obesity in Malta
Investigators:	Dr Daniel Cauchi

London School of Hygiene & Tropical Medicine
Faculty of Public Health and Policy
15-17 Tavistock Place
London WC1H 9SH, United Kingdom
Tel. +44 7543731014

Consent by participant

1. "I have read the information sheet concerning this study and I understand what will be required of me and what will happen to me if I take part in it."

2. "My questions concerning this study have been answered by the interviewer."

3. "I understand that at any time I may withdraw from this study without giving a reason."

4. "I agree to be interviewed for this study."

5. "I do/do not agree to be quoted anonymously in any publications arising from this study." (please delete as appropriate)

Name of participant____

Signature ___________________________ Date ________________________________

Please sign and return this form to the interviewer, indicating your consent to take part in the interview. Alternatively you may email the signed form to daniel.cauchi@lshtm.ac.uk.

Letter of Invitation to Focus Group Participants (Parents)

INFORMATION SHEET:
Contributions of the environment to childhood obesity in Malta

I would like to invite you to participate in a study that aims to understand how Maltese children's environment may affect their diet and physical activity.

Background

Diet and physical activity are essential for the healthy development of children, and if insufficient, may lead to excess weight gain and related diseases such as diabetes and stroke at an early age. Malta now has one of the highest rates of childhood obesity in the world. I would like to understand the different factors contributing to excess weight in Maltese children, and explore ways of tackling the problem.

Aim of this study

This study aims to understand your experience of the environment in which your child lives and plays and how this may affect her/her diet and physical activity. Your views on how the environment may be contributing to obesity in Maltese children, and ideas on how best to change this environment, are important.

Your participation

If you agree to take part, I will ask you to participate in one focus group lasting approximately one to one and a half hours, together with 6 – 8 other parents. You will be asked to express your views, thoughts, attitudes and opinions on how your child's physical and social environment at school, at home, in your neighbourhood/locality and other places may influence his/her diet and physical activity.

I will not ask direct questions about weight or emotional issues related to weight status.

The focus group will be undertaken in English and/or Maltese, whichever language the group feels most comfortable with. Throughout the session some written notes will be taken, and with your kind permission, it will be tape-recorded (audio only).

Questions will be entirely focused on your opinions and experience and I do not expect the interview questions to pose any inconvenience or discomfort. No personal information through which you may be identified will be sought. Taking part in the focus group is entirely voluntary and withdrawal is possible at any time without having to give a reason.

What value does the study have for you?

I intend to make available the findings of this research to all study participants through a short summary report and subsequent publication/s.

How confidentiality will be ensured

All information collected during the focus group will be kept strictly confidential. Transcripts of the focus group will be made available only to myself and my supervisor and will be kept in a secured file. Original recordings will be destroyed within six months of publication of the results.

Focus group transcripts might be quoted in publications with no reference to name, age or gender. You will also have the option of not being quoted at all.

Please read, sign and return the attached consent form to the school or to myself at the time of the focus group.

Costs and/or payments for participation in research

There will be no costs and or payments for participating in the focus group.

Ethical approval

The London School of Hygiene & Tropical Medicine Ethics Committee and the University of Malta Research Ethics Committee have approved the study.

Further information

Should you have any questions about this focus group please feel to contact Dr Daniel Cauchi via email (Daniel.cauchi@lshtm.ac.uk) or phone (79617648)

Thank you in advance for your cooperation with this study.

Yours sincerely,

Dr Daniel Cauchi and Dr Cécile Knai

London School of Hygiene & Tropical Medicine
Faculty of Public Health and Policy
15-17 Tavistock Place
London WC1H 9SH, United Kingdom
Tel. +44 7543731014

Letter of Invitation to Focus Group Participants (Children)

INFORMATION SHEET:

Contributions of the environment to childhood obesity in Malta

I would like to invite your son/daughter/legal ward to participate in a study exploring how Maltese children's environment may affect her/his diet and physical activity.

Background

Diet and physical activity are essential for the healthy development of children, and if insufficient, may lead to excess weight gain and related diseases such as diabetes and stroke at an early age. Malta now has one of the highest rates of childhood obesity in the world. I would like to understand the different factors contributing to excess weight in Maltese children, and explore ways of tackling the problem.

Aim of this study

This study aims to understand your child's experiences of the environment in which s/he lives and plays and how this may affect her/her diet and physical activity.

Your participation

If your child agrees to take part, with your permission, I will ask him/her to participate in a focus group with 6 – 10 other children from his/her school lasting approximately one to one and a half hours. Participants will be asked to express their thoughts, attitudes and opinions related to how their physical and social environment may influence their diet and physical activity. Only one focus group will be held.

I will not ask direct questions about their weight or emotional issues related to weight status.

The focus group will be undertaken in English and/or Maltese, whichever language they feel most comfortable with. Throughout the focus group some written notes will be taken, and with your kind permission, the session will be tape-recorded. Your child will also be asked whether s/he feels comfortable being recorded, and if not will be allowed to withdraw from the focus group.

Questions will be entirely focused on their opinions and experience and I do not expect the focus group questions to pose any inconvenience or discomfort. A questionnaire on their food habits or exercise levels may be administered. No personal information through which your child may be identified will be sought. Taking part in the focus group is entirely voluntary and withdrawal is possible at any time without having to give a reason.

What value does the study have for you or your child?

I intend to make available the findings of this research to all study participants through a short summary report and subsequent publication/s. I would also like to invite parents with an interest in this topic to contact me on the email address below. Your views on how the environment may be contributing to obesity in Maltese children, and ideas on how best to change this environment, are also important, and I would be very interested in organising a focus group session for parents.

How confidentiality will be ensured

All information collected about your child during the course of the focus group will be kept strictly confidential. Transcripts of the focus group will be made available only to myself and my supervisor and will be kept in a secured file. Your child will be assigned a unique Study Identification Number (SID), which at the completion of the study will be de-linked from personal identifiers. Original recordings will be destroyed within six months of the publication of the results.

Interview transcripts might be quoted in publications with no reference to name, age or gender. Your child will also have the option of not being quoted at all.

Please read, sign and return the attached consent form to the school or to myself at the time of the interview.

Costs and/or payments for participation in research

There will be no costs and or payments for participating in the focus group.

Ethical approval

The London School of Hygiene & Tropical Medicine Ethics Committee and the University of Malta Research Ethics Committee have approved the study.

Further information

Should you have any questions about this interview please feel to contact Dr Daniel Cauchi via email (Daniel.cauchi@lshtm.ac.uk) or phone (79617648)

Thank you in advance for your cooperation with this study.

Yours sincerely,

Dr Daniel Cauchi and Dr Cécile Knai

London School of Hygiene & Tropical Medicine
Faculty of Public Health and Policy
15-17 Tavistock Place
London WC1H 9SH, United Kingdom
Tel. +44 7543731014

Consent form (Focus Group Participants - Children)

Project title: Contributions of the environment to childhood obesity in Malta

Investigators: Dr Daniel Cauchi

London School of Hygiene & Tropical Medicine
Faculty of Public Health and Policy
15-17 Tavistock Place
London WC1H 9SH, United Kingdom
Tel. +44 7543731014

Consent by parent/legal guardian of participant

1. "I have read the information sheet concerning this study and I understand what will be required of my child and what will happen to him/her if my child chooses to take part in it."

2. "My and my child's questions concerning this study have been answered by the interviewer."

3. "I understand that at any time my child may withdraw from this study without giving a reason."

4. "I agree for my child to be interviewed for this study."

5. "I do/do not agree for my child to be quoted anonymously in any publications arising from this study." (please delete as appropriate)

Name of participant____

Signature ___________________________ Date ________________________________

Please sign and return this form to the school, indicating your consent for your child to take part in the focus group. Alternatively you may email the signed form to daniel.cauchi@lshtm.ac.uk.

Consent form (Focus Group Participants - Parents)

<u>Project title</u>: Contributions of the environment to childhood obesity in Malta

<u>Investigators</u>: Dr Daniel Cauchi

London School of Hygiene & Tropical Medicine
Faculty of Public Health and Policy
15-17 Tavistock Place
London WC1H 9SH, United Kingdom
Tel. +44 7543731014

Consent by participant

1. "I have read the information sheet concerning this study and I understand what will be required of me and what will happen to me if I take part in it."

2. "My questions concerning this study have been answered by the interviewer."

3. "I understand that at any time I may withdraw from this study without giving a reason."

4. "I agree to participate in a focus group for this study."

5. "I do/do not agree to be quoted anonymously in any publications arising from this study." (please delete as appropriate)

Name of participant____

Signature ________________________ Date ____________________________

Please sign and return this form to the interviewer, indicating your consent to take part in the interview. Alternatively you may email the signed form to daniel.cauchi@lshtm.ac.uk.

Appendix 9. Obesity Frames - illustrative quotes from public health and the food industry

		Public health	Quotes	Industry	Quotes
Position	**Overall**	An 'epidemic'	**"It's a disease... an epidemic which cannot be easily controlled."**	A 'complex' issue	**"Obesity is a complex issue"**
		Malta ranks highly compared to other countries	**"Childhood obesity, I think it's well known that we rank very highly."**	Worldwide problem, Malta not an exception	**"Obesity is not just a Maltese problem, it's a worldwide problem. Ok, we are at the top of the charts, but other countries have the same problem. "**
	Type of problem	Economic and moral concern	**"…when you see the cost of obesity-related disease…there is a financial concern apart from a moral responsibility."**	Economic concern	**"I would imagine it worries everybody, from a personal point of view as well as from the point of view of the nation. After all, it's costing the taxpayer many millions, so it's obviously a concern."**
		Public health (population) problem	**"This is a massive public health issue."**	Medical problem (limited to certain groups)	**"Here of course we're not talking about the majority of the population, but about a proportion who might have a different medical problem, so they cannot be compared to the rest of the population"**
		Multi-generational	**"I think that obesity is the public health threat of this generation and the following generation."**		
	Affected groups	Across social groups	**"I also believe that obese children, due to the cumulative nature of health inequalities, might actually end up as under achievers in life, although it's unclear whether the background complex social profile plays a role. So it's a chicken and egg situation."**	Socioeconomically deprived	**"Because of the culture, their socioeconomic background, and their level of education...People who are at a disadvantage because they're not well educated or not disciplined…"; "...so the more educated, perhaps higher social level are more aware and less obese...more active in taking action."**
		Socioeconomically deprived	**"Then there's the education level of the families that makes a big difference."**		
		Whole population (normalization)	**"When I was young, to be fat was not normal. Today, to be fat is normal, to be slim is abnormal…most people who are overweight don't know they are overweight, they probably think they're mostly OK because everyone around them is like that. And the people who are obese think they're a bit overweight…"**		

Causal roots	**Main cause**	Individual lifestyle	**"I do believe that physical activity plays a very important part...No PA in the school. PE lessons have been reduced to once a week. And what do they do when they go back home? Computer, play station..."**	Individual lifestyle	**"We have no control over what parents buy… often parents buy a regular meal rather than [a kid's meal] for their children. Portion size is a big issue for the Maltese"; "When I am in the supermarket and look at what people buy... lots of crisps, soft drinks and so on. So I do not think fast food restaurants are to blame."**
		Overconsumption	**"There's this culture of eating to be replete, to satisfy hunger. This is particularly the case amongst grandparents, who constantly emphasise massive portions, encouraging the child to eat. It's a generational thing…it's an achievement to clean up the plate. "**	Overconsumption	**"...because of the excessive [food] consumption from some groups of society. Because this is what it is about."; "We have grown up in a culture where parents almost try to stuff food down your throat"; "…it boils down to the fundamental principle of calories in and calories out. If calories in are in excess of your calories out , you'll start gaining weight"**
		Genetics	**"you cannot ignore genetics. These kids…many of them have been born from overweight and even obese parents. Parents who might have genetic issues but also, at the time of conception and upbringing, they were overweight and obese. I think we should not ignore this."**	Genetic	**"Part of obesity is driven by genetics."**
				Changing employment/social patterns	**"Obesity is a symptom of a wider problem, that the nuclear family, the social nucleus, is being destroyed."**
		Socio-economic	**"I think the health part of the problem is actually quite small, typically coming from the social environment, employment and so on…[it] is less of a health problem than it is a problem of other sectors"**	Knowledge deficit	**"So education is very important, in the sense of knowing what you're eating and knowing – or rather, understanding – that there is a lot of misinformation as well."**
		Skill deficit	**"...maybe they are resorting to convenience foods which are unhealthy because they have not been given the knowledge and skills how to make the best choice of what's out there, what's available."**		
		Obesogenic environment	**"…kids are living in an obesogenic environment…where they have easy access to foods which are not of the best nutritional quality..."; "So the**		

	environment, the way food is presented, access to food – making it very easy to access certain high calorie energy-dense foods…in certain portion sizes."; "You may think we are buying things of our own free will but we're being seriously nudged into buying …and marketing has a lot to do with it." ; "It's more about the layout of supermarkets, you know, having all the sweets near the cash, at eye-level for kids. I think our local supermarket shops and their marketing or sales people are telling them the tricks of the trade, and really using them. And they work"; "They go to hospital and see hamburgers and sausage rolls...then you go to the wards, and the food is uneatable because it's so heavy in fat and salt...What messages are they getting? They go to school, and they see the guy just outside the school who's selling them pastizzi. They haven't got a chance."
<u>Sociocultural influences</u>: historical influences, changing family lifestyles, price sensitivity, familial dietary behaviour	**"There is still the saying that if a child is chubby, then 'God bless, how chubby the child is!' And if they see that the child is thin, they would ask 'Aren't you feeding the child?', and try to fatten him or her up."; "Now both parents work… so the easiest thing is to buy a ready-cooked meal and pop it in the microwave"; "Now [fast food is] cheaper and easier to access, especially for low income individuals [for whom] cost is an issue...In Malta we tend to focus on value for money…"; "...we tend to wean our kids onto sugary and fatty foods from a very young age. They get used to...they like intensely sweetened and fatty-tasting things. So immediately you're setting them up for a lifetime of wanting..."**

Non-causes	Knowledge deficit	**"We're not getting anywhere with just education. We need something more...everybody knows what to eat... [people] know that pastizzi and doughnuts are not good for you, but if you're hungry and they're close by, that's what you're going to buy."**	Any single product category	**"It's not such an easy thing to say, or to pinpoint one product or one category of products. I think it's too simplistic and it will not resolve the issue."; "First of all, sweets are good, let's start from there, because children need sugar. It is the quantity they consume which is not good...sweets and soft drinks…are good in moderation."**

Main responsibility	Whole of society	**“I think the only way around childhood obesity is a “whole of government” approach – but I wouldn’t stop there. I think it requires a whole-of-society approach as well...here in Malta, society tends to look at government as the prime mover. Things need to be initiated at governmental level... There needs however to be ownership at societal level because government can only do so much."; "Government has a responsibility to protect people’s health. But not alone. Otherwise it will not be owned by the people. So responsibility needs to be carried with the grass roots."**	Individual responsibility	**"My lifestyle is what it is. I am the problem, and nothing else."; "These people might have a problem, true, but their problem shouldn’t be imposed on others. One should solve one’s own problems."; "Moderation is not the responsibility of the shop owner. It is the consumer’s responsibility."; "I am not part of the problem. I am one of the cogs that keep the wheel of the watch running. Without me, the wheel still runs, I get replaced by another cog. It is the mechanism of the cog that needs to change, not the cogs. "**
	Parental responsibility	**"Parents need to take up more responsibility. Schools do have a role, but if children do not come with a certain attitude from home...it’s unfair to throw all responsibility on schools...sometimes it seems as if parents are abdicating their responsibilities.”; “…it’s the parents and guardian’s moral responsibility to ensure that they do not make their children ill.”; "Kids really do observe what their parents do. They will realise whether their parents are eating or drinking certain items… some parents need to be made more aware of their role model influence on children.”; “Parents need to be shocked into addressing obesity. All parents know that their kids should not be obese.”**	Parental responsibility	**"I think the problem originates from home, not from restaurants...ultimately it’s parents who first direct food onto your plate..."; "I think one should address the parents, not the children. Children are too young to understand…if one teaches them healthy eating at school, but then they go home and find rubbish to eat...the child has to eat whatever there is.”; "Ultimately I think it comes from parents, the lifestyle that the family chooses to lead...if parents really wanted to [get their children to be physically active] then they would do it."; "The foundation is the basis of life. If the foundation is not strong, the building will not hold."**
	Government	**"Politically, health promotion doesn’t sell. Because the end result, the return of health promotion is much longer than the lifespan of any politician."; "In Malta, more than other countries…what is technical becomes political…And this is where we have problems, because there**	Government	**"I…would be paying for the failings of the government [if zoning laws were to be introduced]. If the government is not capable of educating the population…one can’t lock up people in cages."**
			Industry	**"We are part of the problem in that we form part of the consumption of the general population – it would be very naive to say it’s not our issue. We are part of the solution, yes, because we also have the resources, the intelligence, the insight and the information to be able to lead to a solution. "**

is no clear divide between the political and the technical [spheres]…As it is now, everything has to go through the Ministry. Everything is politicised. And that is bad"; "At the end of the day, if politicians wanted to, we could change the environment and make it a healthy environment, but no-one wants to, because at the end of the day money counts…political will is driven by money and industry"; "I've seen so many politicians come and go and they all have one thing in mind, and it's not the health of the population...they're going to have their own industrial friends...who are going to push them towards their own decisions, they don't want to listen..."; "I think it's politics. Everybody's scared of…policymakers just depend on people's votes, so if they're going to do something which is not popular…Industry are very strong. Very, very strong. I don't know how they manage to twist the policy makers around but they do."

Solutions	**Existing policy and interventions**	Criticism of overall policy: lack of policy direction, absence of referral services, focus on obesity treatment	**"We are trying to change the behaviour of people in too many ways. So we're telling people to be careful how to have sex, not to smoke, not to drink, telling people to exercise, telling them what to eat – so people are being bombarded with so many messages, it's almost negative. I feel that that's almost too much for the person...don't do this, don't do that…they'll say 'What the hell, I want to live, you know?'."; "I can do nothing about it, I am like a voice in the desert. What can I do about it …I'm pragmatic. I know what's going to happen: Nothing."** **"...it seems like the direction has been lost. There's no clear idea. We are doing good assessments, we know how many children are obese and so on, but intervention-wise there's no direction, it's totally lacking. I get referred many children with obesity, but what can I do? I can never refer them anywhere else…";"…it shouldn't be the case that eating disorder patients are placed in the same building as obesity patients. They are totally different scenarios."**	Self-regulation	**"Carrots...cost three times as much as fries, but provided at the same price...When VAT is factored in there is little profitability in it, but we are willing to include it in the price of [fast food meal] in order to be in a position to offer a choice of healthier products."; "We would not advertise on a children's program on TV. If you're advertising on [prime time programme] and a kid sees it, that's different. You're targeting adult audiences. But if you advertise anything on a kid's program in the morning... I would not do that."**
		Criticism: of national obesity strategy	**"I think that the strategy is focused too much on treating obesity rather than preventing it. And it hasn't worked in other countries, and I don't see how that's going to work here. We can't treat obesity. "** **"…the Healthy Weight for Life strategy, and my feeling at the time was that this is great, people have spent a lot of time and effort at putting it all together. It was nicely put together, but unless there is wind in the sails, it's just a limp sail in a**		

	yacht that's moored at the quay side. Our figures have gone up, nothing has happened."; "I don't believe we will reach our [national obesity] targets by 2020, being realistic - because we did not have the right launching pad to start off. I mean the Food consumption survey (currently being worked upon) is the launching pad."
Support: for national obesity strategy	**"So the basic focus of the strategy is that it looks at all aspects, but the major concept behind it is the multi-stakeholder, whole of government and whole of society approach. Because in reality 'Health' can do very little."**
Support: for fiscal incentives; school nutrition and physical activity policy	**"Now the government provides incentives so that parents of children who are sent to physical activities such as ballet and football etc. have a tax rebate. So that's already a first step."; "I think if the Healthy Eating and Lifestyle Plan [school] document is enforced – and that is the major issue, that there isn't monitoring done... then I think it is adequate. There is enough there to give a pretty good healthy nutritional environment in schools."**

Prescriptions	Multi-sectoral approach (including collaborating with industry)	**"You need an integrated approach. You cannot do something with the health sector only, or with the education sector only. You need industry, you need importation…"; "Definitely... one has to look at education, but that's the only area which I think has been tackled, which we've done a lot on...But we need to go into the home, from the community into the home...look at all the different stakeholders.... A multi-sectoral approach."; "We need to work with the food industry…to a certain extent we depend on the food industry, especially for reformulation. If we want to change the environment we need to change the food that is available to people, and what is IN that food. And unless we have industry on board then we cannot do it. Because they dictate what goes onto the market."; "You cannot ignore the industry and you cannot fight the industry. It can easily break you. It is powerful enough to be in liaison with politicians, and they are the ones who give you the go ahead. No. Work with the industry. Get them on board. Help them realise that the negative impact of their overindulgence is going to backfire. But be strong. If we agree on something and you fall short of what you have promised, then there are repercussions. Because as things stand today, industry has been allowed to get away with murder."**	Education: parents & children (portion control; food preparation skills)	**"Education is the only solution...I would educate children, and perhaps distribute free leaflets to families in homes, what is an ideal portion size."; "I have always believed that you have to start from the parents…if adults don't teach children what they should be doing, [any action] won't work."; "Knowledge about food preparation is the most important thing."; "From the day they are born, children are bombarded with products that are full of sugar and fats...People are being bombarded by subtle advertisements. To counterbalance that, you need to fight with the same tools. The more advertising there is, the more counter-advertising there should be, as otherwise people would only hear one side of the story."; "I'm sure parents…try to care for their children. The problem is that they don't know how … [We need] more education, but wiser education."**
			Lifestyle	**"...eating or choosing a good diet in moderation, and active lifestyle is important."**
			Regulations within institutions	**"Schools are a different argument. For example... we agree that we should not allow promoters to enter hospital and sell formula milk. That's up to the hospital: having hospital policies which they have a right to enforce. But what's outside hospital, or schools…that's the real world."**
			Product reformulation	**"And what I think should be done with regulation is something that encourages the development of, the research and development, of these products, rather than the other way round."; "What you have to do is educate the kitchen (the chefs) ...getting a nutritionist to teach chefs to improve the nutritional value of their products while reducing cost. So that is a win-win situation, you're giving some more benefit to the customer while getting money."**
	Regulation and legislation (including fiscal mechanisms)	**"I think both regulation and education are needed. Regulatory measures are much more effective than education on its own."; "We'll have to legislate against fast food outlets and unhealthy food outlets next to schools."; "I believe in regulation,**		

	like taxes of buffer zone around schools. And even though it may mostly affect those who are poor, ultimately it's for their benefit."; "I think it's high time that we impose some taxes – we've become a nation that only responds if our wallets are hit."; "So a simple label, besides the normal, nutritional information which is a legal requirement, I would put the traffic light system. Green, red and amber."; "I would actually try to subsidise healthy food, which is more expensive than unhealthy foods. I don't think penalising works. I think being more positive, helping them financially or through initiatives, is more effective."; "...[abroad], people who are food insecure are given vouchers to help them buy… fruit and vegetables. But then, if you are a recipient of these vouchers, you are also obliged to attend some nutrition education sessions…So I think that it would be an interesting step forward and a positive step forward."	Voluntary self-regulation	**"The first port of call should be education, and then self-regulation rather than regulation...Let us regulate ourselves in line with being more responsible and promoting responsible drinking rather than have to conform to legislation in the absence of regulation."**
		Infrastructure	**"I think government should consider promoting cycle to work or to school...because those are not just a matter of eating habits only, it's a lifestyle concept. It's not just about promoting cycling, they have to make the roads fit for cycling. "**
		Front-of-Pack GDA labelling	**"I am in favour of having an obligatory GDA, and that it is at the front of pack. So that one doesn't mind declaring the contents of one's products. Then it's up to everybody to decide [what to buy]."**
		Collaboration with industry	**"Whatever your project…it is important to guide the industry. Talk with them. Guide them towards a healthier business model. Tell them you'll help them. If you have a tuck shop in a school, find the kind of people who believe in healthy choices to manage it. It's about incentivising and guiding, creating the opportunity for them and making it clear."**
Supportive environments – community and schools	**"You cannot change behaviour unless you change the environment."; "Access is everything. And we have access to unhealthy food, but we have no access to exercise here unless you really push for it."; "Increasing PA requires an environmental change as well. It's not just about a persons' behaviour, but the environment should be adapted to encourage PA."; "Increase open spaces and family recreational areas. Have safe pedestrian areas, limit traffic within the villages…. Increase availability and accessibility of public transport; enhance availability and presentation of healthy food, making it look good..."; "Why isn't PE time increased during school hours? If**	Corporate Social responsibility	**"We try to take the 'low fat' or low sugar angle for all our products, even in the formulation... because of our corporate social responsibility. Nobody obliges us to do so."**

	necessary, PE should be compulsory even three times a week. Why not, if we have such a big problem?"
Appropriate referral (treatment) services	**"Obesity is a multidisciplinary issue that needs to be tackled that way. If you just take obesity as a dietary issue, you will always fail...You need to treat the whole family if you want to decrease obesity levels. You need psychologists, you need social workers in many cases. A dietician or nutritionist…you need a team. And there is no such team"; "The way forward should be to have a proper strategy, a referral system where a patient can be referred to a team allocated full-time on the issue."**
Long term strategies	**"And because health gains take some time to melt into the financial pot, [politicians] don't want this long-term investment, because it's too long an approach. By the time we get health gains, I'm no longer a politician, so I'm not going to work for that."; "Policy is not carried on from one government to the other, from the first 5 years to the next 5 years and so on. We always have to start from scratch, so we don't have continuity"; "We should focus on a particular area...Exercise in all policies, in all messages. If you try to focus on too many areas at once, first of all we don't have the staff to cope, and secondly people will not accept it..."**
Skill-based training/empowerment	**"Most of our actions before 2012 were focused on increasing awareness, but we know that while this is good, needs to be there, needs to continue, it is not enough. Besides enhancement of knowledge you need to empower people, provide them**

	with the skills required."; "What is really lacking is problem solving skills – we haven't taught people these skills... I think there is a huge flaw there – we are giving information to people. But we are not empowering them to change."
Consistent, targeted nutritional education	**"We need to have more targeted health promotion nutrition education. Specific things, so if you're looking at parents and we know there's an issue of convenience – so let's get a program on how to help working parents get healthier packed lunches for their kids…"; "Remember that elderly people and grandparents can influence what kids eat…so we need to focus even more on courses for grandparents."; "We're giving wrong nutritional education out there. We think that people's nutrition education out there is good, but we're giving conflicting advice…"**
Better public health advocacy	**"The political class is obviously after low-hanging fruits. Addressing childhood obesity does not deliver low-hanging fruits, and that is a major barrier [to action]... public health advocacy needs to make sure to highlight the little low-hanging fruit there might be in investing in childhood obesity. "**

Non-solutions	Education/ Legislation in isolation	**"Legislation might be good for altering the environment, but at the end of the day one cannot impose on the individual. Education is important.”; "Education on its own is not enough to generate a change in behaviour, because people ultimately go back to live in their environment. Unless a healthier environment is promoted, we will fail."**	Taxation	**"Taxation...wouldn’t work either. It didn’t work for cigarettes or alcohol. It won’t work on sugar. Cigarette consumption did not decrease because of price increases, but because of health concerns. "; "And you see that when people talk simplistically about a food tax, some countries implement a food tax and do not see results. Some countries even removed the food tax… [if you introduce a tax] there will be a shift towards cheaper alternatives...studies have been done. And instead of drinking just one, they will drink two, or three, because it is still within their previous budget. So actually consumption will have increased."; "Taxes are regressive, they affect mostly those in lower socio-economic classes. Those who earn least will suffer most."**
	Short-term strategies	**"We’re doing things in isolation, we don’t sustain and reinforce campaigns."**		
	Excessive legislation	**"So regulation around the schools could be beneficial. But for everybody in general, regulation such as fat tax, sugar tax and what not…people will rebel. They will point fingers at the government, don't go down that route."**	Legislation (zoning laws)	**"I wouldn’t agree with [zoning laws]. Because I would be paying for the failings of the government …one can’t lock up people in cages. What would they do? They would just walk beyond the buffer zone, and eat from there. So that’s not the issue, the issue is teaching people rather than restricting liberties."; "You’re reducing the temptation, but ultimately if someone wants those products they will find a way. Sometimes the more you make something a taboo, the more people want it."**
	Treatment/Health focus	**"They called us to set up these obesity clinics. And the first thing I told them is why they aren’t going to work... They don’t work. Abroad, they haven’t worked. Sure, we can try to see if they work in Malta, but let me tell you what will happen. A large percentage won’t attend. Those who attend will complete a few sessions and then stop. The few who remain will lose a bit of weight, but then have a high relapse rate. So tell me if all this effort is worth it, and how much it will cost us. That’s what happens abroad. It just doesn’t work like that."**	Traffic-light labelling	**"Labelling is very important for consumers to understand…[but] traffic light labelling, in our opinion, is over-simplistic...it may lead to consumers avoiding products without them knowing why they are avoiding those products."; "I’ve publicly spoken against the traffic light system... because traffic lights do not take into account the product type... It shouldn’t be like that. It’s not a level playing field. And unfortunately, those who suffer are those products that are high in salt or sugar, but eaten in small amounts. I call that an unjust system...If that had to be colour-coded on intake then yes...but not if it’s based on the contents of a product. That is wrong...it’s nothing but a gimmick."**

Core values	**Appeals to principle**	Evidence based solutions	**"Whenever one does something new, one will find resistance. But if you're convinced that what you do will be of benefit...because of the evidence supporting the action, not because you 'imagined' that it will be of benefit…we try to be evidence-based in everything we do."**	Individual choice	**"Still, you can't be paternalistic. Who are you to tell me what to do? By what right, as long as I am not harming others? You need to educate as much as you can, and then let the people make their own decisions. "; "It is up to customers to choose. We believe we should give customers a choice."; "We have recognised the need to offer healthier alternatives. Then it's up to you. If you come through our doors and want a burger, then we'll give you a burger."**
		Economic considerations	**"We mustn't forget how much money we'll save if we reduce obesity even by a small amount."; "...not only does [preventing obesity] prevent disease, it incidentally also saves huge amounts of cash. My tax money, frankly… We all have a personal interest in this, because this is our tax money."**	Self-discipline	**"You can put as many obstacles in my way as you like, you can regulate me however you like, but ultimately at the end of the day... until one changes their own attitude, the problem will remain."; "Personally, I link everything to discipline. If you're disciplined, you can eat sweets while remaining in shape."**
		Enforcement	**"You have to have regulation, and you have to have enforcement. Those two things are part and parcel of everything."**	Response to consumer demand	**"The truth is that what is bad for you tastes good and what is good for you tastes bad. And when you go out to eat, wherever you go, you're going to want full flavour."; "I have always believed that if we create something new, we should ask ourselves whether we can do so with less sugar, with less salt, with less fat... Unfortunately, it's not always well received by consumers."; "I would prefer not to stock [unhealthy food], for the simple reason that I would like everyone to be healthy, but ultimately the problem is that people want them. So if I don't stock them, I will lose customers to competitors who will make the profit."; "And if doughnut hawkers have a license to operate around schools, they should be able to do so. These give you an opportunity to educate children from a young age: that doughnuts should not be their choice. But it is possible that occasionally I feel like a doughnut, and I have a right to find that doughnut, not find obstacles to find the doughnut. It is a chance to educate children from a young age, to tell them that it is unhealthy to have doughnuts every day."**

	Level playing field	**"And there are advantages to be gained by collaboration with others [industry]. Because otherwise if you don't do that, then legislation comes in and you all lose. So I think there is scope to collaborate [with other industry], especially if it is all done on a fair and level playing field."**
	Moral obligation to make a profit	**"Money is not a dirty word. We're here to make a profitable business; at the end of the day we have an obligation to deliver."; "...at the end of the day we have an obligation to deliver a return to our shareholders, so we have to do all this profitably."**
	Moderation	**"I am offering a product – like any other product – that if abused, will become dangerous. Should we remove knives or weapons from shops? Alcohol? Any product, if abused, becomes dangerous. One cannot deny the majority of people the possibility of enjoying something in moderation just because of the abuse of certain individuals"; "I think soft drinks are also part of a diet. Now, if we are not controlling our children's intake of soft drinks…it's a problem.... Even drinking too much water can be a problem, because you can have problems with excessive water drinking."; "Really and truly there is nothing wrong with a sugar-sweetened soft drink. The soft drink itself does not cause harm. If you introduce it as part of a balanced diet, it can be part of a normal diet. I mean, it's not something that will harm you by taking it. It's like having a chocolate…are we saying that you should not have chocolates? I think it would be too much of a restriction to remove everything that contains sugar…I mean, then we wouldn't be able to have cakes!"; "I think obesity is the result of an imbalance between diet and exercise. It doesn't mean you can't eat any biscuits or fried products. You can eat them, in moderation. You can eat too many apples and still not have a good diet… It's eating in moderation that makes for a healthy diet."**

Appendix 10 – Microsimulation Modelling

Appendix 10A: Technical information

Summary

The micro-simulation operates by simulating representative individuals and deriving population statistics from Monte-Carlo methods. Members of any selected population are modelled individually from birth. In the course of the simulation individuals get older, give birth, their risk and disease profiles change. The individual growth patterns are arranged so that there is agreement with known population statistics and there is agreement with projected population statistics at selected times in the future. Non-communicable diseases are modelled by applying the latest incidence, prevalence, survival and mortality statistics. Relative risks define the relationship between a risk factor, individuals' background characteristics and a disease.

Equations

An individual's body mass index (BMI) is defined as:

$BMI = \frac{\mathrm{w}}{\mathrm{h}^2}$,

where w and h correspond to individual's weight and height, respectively. BMI provides a simple measure of a person's "fatness" or "thinness". Although BMI is measured on a continuous scale, it is grouped in the following five categories:

1) BMI: <18.5 (underweight)

2) BMI from 18.5 to 24.99: (healthy weight)

3) BMI from 25 to 19.99: (overweight)

4) BMI from 30 to 39.99: (obese)

5) $BMI \geq 40$: (morbidly obese)

Let g=1,...,5, denote BMI group (lower and larger values of g correspond to groups with lower and larger values of BMI on the continuous scale, respectively). Let $q_g(t)$ be the prevalence of individuals with BMI values that correspond to group g at time t. To ensure that $q_g(t)$ takes values within [0,1], we model $q_g(t)$ by

$q_g(t) = \frac{1}{2}\left[1 + \tanh\left(\beta_0^g + \beta_1^g t\right)\right]$. (1)

An alternative way to estimate $q_g(t)$ is through a logistic regression model with percentage for BMI group g as the outcome, for each time, t, as the single explanatory variable:

$$\ln\left(\frac{q_g(t)}{1-q_g(t)}\right) = \beta_0^g + \beta_1^g t. \qquad (2)$$

By solving equation (2) for $q_g(t)$we obtain

$$q_g(t) = \frac{\exp\left(\beta_0^g + \beta_1^g t\right)}{1 + \exp\left(\beta_0^g + \beta_1^g t\right)}.$$

Equations (1) and (2) are mathematically identical, but (1) provides greater numerical stability. Fitting separate models for the estimation of $q_g(t)$ for each group g, does not guarantee that

$$\sum\nolimits_{g=1}^{5} q_g(t) = 1.$$

Thus, to ensure that the estimates of prevalence of individuals in all BMI groups sum up to 1 for each time t, we estimate the prevalence of individuals with BMI values that correspond to group g at time t by

$$P_g(t) = \frac{q_g(t)}{\sum_{g=1}^{5} q_g(t)}. \qquad (3)$$

Micro simulation – BMI growth model

The distribution of BMI in the population is estimated using regression analysis stratified by both sex (S) and age group (A=0-9, 10-19,,20-29,…,70-79, 80+). The fitted models are extrapolated to forecast the distribution of BMI groups in the future. For each sex-and-age-group stratum, the set of cross-sectional, time-dependent, discrete distributions of BMI groups, $D = \{P_g(t) | g = 1, \dots 5;\ t > 0\}$, is used to construct BMI growth models for individual members of the population. This is done in a way that guarantees that the cross-sectional BMI group distributions obtained by simulation under the growth models match the BMI group distributions of the observed data. The details are as follows;

For each such discrete distribution in D, there is a continuous counterpart. Let β denote BMI in the continuous scale and let $f(\beta|A,S,t)$ be the probability density function of β for age group A and sex S at time t. Then

$$P_g(t|A,S) = \int_{\beta\in g} f(\beta|A,S,t)d\beta. \qquad (4)$$

Equations (3) and (4) both refer to the same quantity. However, equation (4) uses the definition of a probability density function to express the age-and-sex-specific percentage of individuals in BMI group g at time t. Equation (3) gives an estimate of the this quantity using model (1) for all g=0,..,5. The cumulative distribution function of β is

$$F(\beta|A,S,t) = \int_0^{\beta} f(\beta|A,S,t)d\beta. \qquad (5)$$

At a time t, a person with sex S belonging to the age group A is said to be on the p–th percentile of this distribution if $F(\beta|A,S,t) = p/100$. Given the cross-sectional information of D, it is possible to simulate longitudinal trajectories by forming pseudo cohorts within the population. A key requirement for these sets of longitudinal trajectories is that they reproduce the cross-sectional distribution of BMI groups for any year with available data. The method adopted here and in the earlier Foresight report[1] is based on the assumption that people's BMI changes throughout their lives in such a way that they always stay on the same BMI percentile. As they age, individuals move from one age group to another and their BMI changes so that they remain on the same percentile but of a different distribution. This rule is not too far from the truth; and has as a result that relatively fat people stay relatively fat and relatively thin people stay relatively thin. Crucially it meets the important condition that the cross-sectional BMI group distributions obtained by simulation match the BMI group distributions of the observed data. This can be seen as follows:

When the population's BMI distributions by sex and age are known for all years (by extrapolation of fitted model (3)), a person who is in age group A and who grows ten year older will at some time move into the next age group A' and will have a BMI that was described first by the distribution $f(\beta|A,S,t)$ and then at the later time t' by the distribution $f(\beta|A',S,t')$. If the BMI of that individual is on the p[th] percentile of the BMI distribution, his BMI will change from β to β' so that

$$\beta = F^{-1}\left(\frac{p}{100}\middle|A,S,t\right) \qquad (6)$$

$$\beta' = F^{-1}\left(\frac{p}{100}\middle|A',S,t'\right) \Rightarrow \beta' = F^{-1}(F(\beta|A,S,t)|A',S,t') \qquad (7)$$

Where F^{-1} is the inverse function of the cumulative distribution function of β guarantees that the transformation taking the random variable β to β' ensures the correct cross-sectional distribution at t'.

The micro simulation both generates individuals from the BMI distributions of the set D and, once generated, grows the individual's BMI in a way that is also determined by the set D. It is possible to implement as a suitably fast algorithm.

Micro simulation: Birth, disease and death models

Simulated people are generated with the correct demographic statistics in the simulation's start-year. In this year women are stochastically allocated the number and years of birth of their children – these are generated from known fertility and mother's age at birth statistics (valid in the start-year). If a

[1] Foresight report

woman has children then those children are generated as members of the simulation in the appropriate birth year.

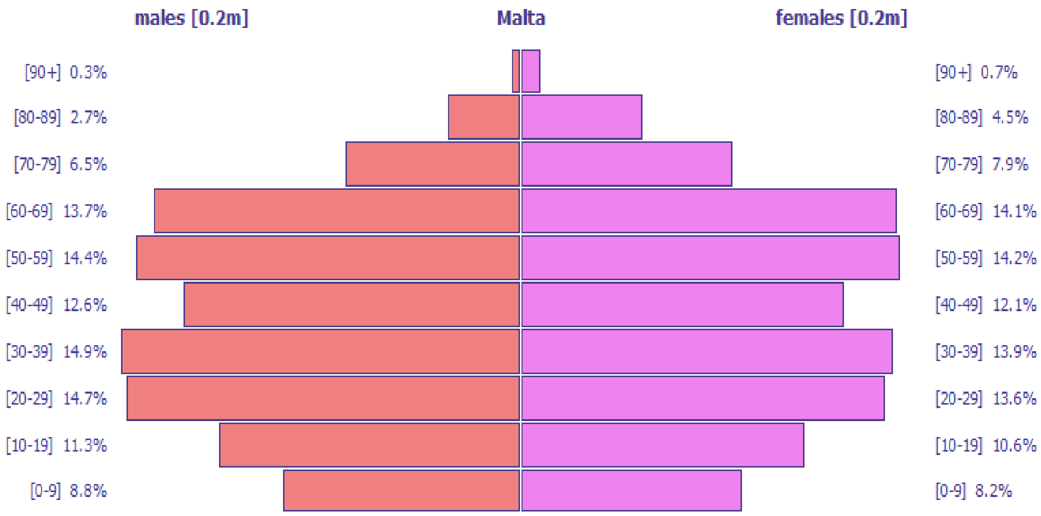
In the course of their lives, simulated people can die from one of the BMI related diseases that they might have acquired or from some other cause. The probabilities that a person of a given age and gender dies from a cause other than a BMI related disease are calculated in terms of known death and disease statistics valid in the start-year and are held constant over the course of the simulation. The death rates from BMI related diseases will change as a consequence of the population's changing BMI distribution.

Appendix 10B: BMI proportions (Malta)

Table S1: Proportion of people in each BMI group by age and sex projected to 2035

Year	2015			2025			2035		
BMI	<25	25-30	>30	<25	25-30	>30	<25	25-30	>30
0-4, m	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0-4, f	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5-9, m	0.7	0.2	0.1	0.64	0.24	0.12	0.57	0.31	0.12
5-9, f	0.66	0.18	0.16	0.57	0.2	0.23	0.46	0.21	0.33
10-14, m	0.7	0.2	0.1	0.72	0.2	0.08	0.75	0.2	0.05
10-14, f	0.68	0.22	0.1	0.63	0.27	0.1	0.58	0.32	0.1
15-19, m	0.65	0.26	0.09	0.59	0.33	0.08	0.53	0.41	0.06
15-19, f	0.7	0.24	0.06	0.6	0.34	0.06	0.48	0.47	0.05
20-24, m	0.69	0.27	0.04	0.80	0.19	0.01	0.87	0.13	0
20-24, f	0.72	0.19	0.09	0.71	0.22	0.07	0.69	0.26	0.05
25-29, m	0.28	0.34	0.38	0.18	0.28	0.54	0.1	0.21	0.69
25-29, f	0.42	0.29	0.29	0.19	0.28	0.53	0.06	0.2	0.74
30-34, m	0.48	0.26	0.26	0.63	0.14	0.23	0.75	0.07	0.18
30-34, f	0.6	0.22	0.18	0.57	0.19	0.24	0.54	0.16	0.3
35-39, m	0.19	0.63	0.18	0.1	0.79	0.11	0.05	0.88	0.07
35-39, f	0.63	0.22	0.15	0.68	0.17	0.15	0.74	0.13	0.13
40-44, m	0.23	0.59	0.18	0.19	0.07	0.11	0.14	0.79	0.07
40-44, f	0.67	0.19	0.14	0.78	0.11	0.1	0.87	0.06	0.07
45-49, m	0.24	0.53	0.23	0.22	0.6	0.18	0.2	0.67	0.13
45-49, f	0.31	0.54	0.15	0.20	0.73	0.07	0.11	0.86	0.03
50-54, m	0.27	0.49	0.24	0.31	0.5	0.19	0.35	0.51	0.14
50-54, f	0.46	0.41	0.13	0.53	0.42	0.05	0.59	0.39	0.02
55-59, m	0.15	0.58	0.27	0.1	0.69	0.21	0.06	0.78	0.16
55-59, f	0.43	0.27	0.3	0.5	0.21	0.29	0.56	0.15	0.29
60-64, m	0.07	0.63	0.3	0.02	0.74	0.24	0	0.82	0.18
60-64, f	0.4	0.3	0.3	0.42	0.25	0.33	0.43	0.22	0.35
65-69, m	0.11	0.55	0.34	0.03	0.63	0.34	0.01	0.66	0.33
65-69, f	0.41	0.28	0.31	0.54	0.19	0.27	0.66	0.12	0.22
70-74, m	0.11	0.43	0.46	0.04	0.30	0.66	0.01	0.19	0.8
70-74, f	0.28	0.39	0.33	0.22	0.44	0.34	0.17	0.48	0.35
75+, m	0.19	0.49	0.32	0.09	0.48	0.43	0.04	0.43	0.53
75+, f	0.48	0.28	0.24	0.58	0.25	0.17	0.66	0.23	0.11

Population distribution for Malta (2015)



Appendix 10C: Annual healthcare costs, 2015-2035 (€ million)

Table S2: Scenario 0: Obesity trends continue unchecked

	Hyp	CHD	Colorectal Ca	Diabetes	Stroke	Breast Ca	Br + CR Ca	CHD + Stroke	Total
2015	11.00	4.00	2.00	9.00	4.00	2.00	4.00	8.00	32.00
2025	12.15	6.52	3.64	9.16	5.55	2.18	5.83	12.07	39.21
2035	12.97	8.55	4.24	8.84	6.63	2.33	6.57	15.18	43.57

Table S3: Scenario 1: 1% decrease in population BMI

	Hyp	CHD	Colorectal Ca	Diabetes	Stroke	Breast Ca	Br + CR Ca	CHD + Stroke	Total
2015	10.99	3.96	2.02	8.98	3.98	2.00	4.01	7.95	31.93
2025	11.68	5.81	3.37	8.11	5.22	2.11	5.49	11.03	36.30
2035	11.55	6.89	3.67	6.36	5.82	2.21	5.88	12.71	36.50

Table S3.1: Annual healthcare cost savings for Scenario 1 relative to scenario 0

	Hyp	CHD	Colorectal Ca	Diabetes	Stroke	Breast Ca	Br + CR Ca	CHD + Stroke	Total
2015	0.01	0.04	-0.02	0.02	0.02	0	-0.01	0.05	0.07
2025	0.47	0.71	0.27	1.05	0.33	0.07	0.34	1.04	2.91
2035	1.42	1.66	0.57	2.48	0.81	0.12	0.69	2.47	7.07

Table S4: Scenario 2: 5% decrease in population BMI

	Hyp	CHD	Colorectal Ca	Diabetes	Stroke	Breast Ca	Br + CR Ca	CHD + Stroke	Total
2015	10.96	3.87	2.00	8.87	3.25	2.01	4.01	7.12	30.97
2025	10.88	4.64	2.91	6.84	4.05	2.06	4.97	8.69	31.39

2035	10.42	5.72	3.35	4.99	4.77	2.17	5.51	10.48	31.40

Table S4.1: Annual healthcare cost savings for Scenario 2 relative to scenario 0

	Hyp	**CHD**	**Colorectal Ca**	**Diabetes**	**Stroke**	**Breast Ca**	**Br + CR Ca**	**CHD + Stroke**	**Total**
2015	0.04	0.13	0	0.13	0.75	-0.01	-0.01	0.88	1.03
2025	1.27	1.88	0.73	2.32	1.5	0.12	0.86	3.38	7.82
2035	2.55	2.83	0.89	3.85	1.86	0.16	1.06	4.7	12.17

Table S5: Scenario 3: -0.07 BMI (20% SSB tax)

	Hyp	**CHD**	**Colorectal Ca**	**Diabetes**	**Stroke**	**Breast Ca**	**Br + CR Ca**	**CHD + Stroke**	**Total**
2015	11.00	4.00	2.02	9.00	4.00	2.00	4.02	8.00	32.02
2025	12.13	6.49	3.64	9.11	5.54	2.14	5.78	12.02	39.05
2035	12.94	8.50	4.21	8.77	6.60	2.28	6.49	15.10	43.29

Table S5.1: Annual healthcare cost savings for Scenario 3 relative to scenario 0

	Hyp	**CHD**	**Colorectal Ca**	**Diabetes**	**Stroke**	**Breast Ca**	**Br + CR Ca**	**CHD + Stroke**	**Total**
2015	0	0	-0.02	0	0	0	-0.02	0	-0.02
2025	0.02	0.03	0	0.05	0.01	0.04	0.05	0.05	0.16
2035	0.03	0.05	0.03	0.07	0.03	0.05	0.08	0.08	0.28

Appendix 10D: Cumulative healthcare costs, 2015-2035 (€ million)

Table S6: Scenario 0: Obesity trends continue unchecked

Year	CHD	Diabetes	Hypertension	Stroke	Breast Ca	Colorectal Ca	Total
2015	2.0	4.0	2.0	9.0	11.0	4.0	32.0
2016	2.0	4.4	2.3	9.1	11.2	4.2	33.2
2017	2.0	4.7	2.6	9.1	11.3	4.4	34.1
2018	2.0	4.9	2.8	9.2	11.4	4.6	35.0
2019	2.1	5.2	3.0	9.2	11.5	4.7	35.7
2020	2.1	5.4	3.2	9.2	11.6	4.9	36.4
2021	2.1	5.6	3.3	9.2	11.7	5.0	37.0
2022	2.1	5.9	3.4	9.2	11.9	5.2	37.6
2023	2.1	6.1	3.5	9.2	12.0	5.3	38.2
2024	2.1	6.3	3.6	9.2	12.1	5.4	38.7
2025	2.1	6.5	3.7	9.2	12.2	5.6	39.2
2026	2.2	6.7	3.7	9.1	12.3	5.7	39.7
2027	2.2	7.0	3.8	9.1	12.4	5.8	40.2
2028	2.2	7.2	3.8	9.1	12.4	5.9	40.6
2029	2.2	7.4	3.9	9.0	12.5	6.0	41.1
2030	2.2	7.6	4.0	9.0	12.6	6.1	41.5
2031	2.2	7.8	4.1	9.0	12.7	6.2	42.0
2032	2.2	8.0	4.1	8.9	12.8	6.3	42.4
2033	2.3	8.2	4.2	8.9	12.8	6.4	42.8
2034	2.3	8.4	4.2	8.9	12.9	6.5	43.2
2035	2.3	8.6	4.2	8.8	13.0	6.6	43.5
	Cumulative cost of obesity-related disease by 2035:						**814.0**

Table S7: Scenario 1: 1% decrease in population BMI

Year	CHD	Diabetes	Hypertension	Stroke	Breast Ca	Colorectal Ca	Total
2015	2.0	4.0	2.0	9.0	11.0	4.0	31.9
2016	2.0	4.3	2.4	9.0	11.1	4.2	33.0
2017	2.0	4.6	2.6	9.0	11.2	4.4	33.8
2018	2.0	4.8	2.8	8.9	11.3	4.5	34.4
2019	2.0	4.9	2.9	8.9	11.4	4.6	34.8
2020	2.1	5.1	3.1	8.8	11.5	4.7	35.2
2021	2.1	5.3	3.2	8.7	11.5	4.8	35.5
2022	2.1	5.4	3.2	8.6	11.6	4.9	35.8
2023	2.1	5.5	3.3	8.4	11.6	5.0	36.0
2024	2.1	5.7	3.3	8.3	11.6	5.1	36.2
2025	2.1	5.8	3.4	8.1	11.7	5.2	36.3
2026	2.1	5.9	3.4	7.9	11.7	5.3	36.4
2027	2.1	6.1	3.4	7.8	11.7	5.4	36.4
2028	2.1	6.2	3.4	7.6	11.7	5.4	36.5
2029	2.2	6.3	3.5	7.4	11.7	5.5	36.6
2030	2.2	6.4	3.5	7.3	11.7	5.6	36.6
2031	2.2	6.5	3.5	7.1	11.7	5.6	36.6
2032	2.2	6.6	3.6	6.9	11.7	5.7	36.6
2033	2.2	6.7	3.6	6.7	11.6	5.7	36.6
2034	2.2	6.8	3.6	6.5	11.6	5.8	36.6
2035	2.2	6.9	3.7	6.4	11.6	5.8	36.5
	Cumulative cost of obesity-related disease by 2035:						**748.5**

Table S8: Scenario 2: 5% decrease in population BMI

Year	CHD	Diabetes	Hypertension	Stroke	Breast Ca	Colorectal Ca	Total
2015	2.0	3.9	2.0	8.9	11.0	4.0	31.7
2016	2.0	4.1	2.3	8.8	11.0	4.1	32.3
2017	2.0	4.2	2.5	8.6	11.1	4.2	32.6
2018	2.0	4.3	2.6	8.4	11.1	4.3	32.6
2019	2.0	4.3	2.7	8.2	11.1	4.4	32.6
2020	2.0	4.4	2.7	8.0	11.0	4.4	32.5
2021	2.0	4.4	2.7	7.7	11.0	4.5	32.4
2022	2.0	4.5	2.8	7.5	11.0	4.5	32.3
2023	2.0	4.5	2.8	7.3	10.9	4.5	32.1
2024	2.1	4.6	2.9	7.1	10.9	4.6	32.1
2025	2.1	4.6	2.9	6.8	10.9	4.6	32.0
2026	2.1	4.7	3.0	6.6	10.8	4.7	31.9
2027	2.1	4.8	3.0	6.4	10.8	4.7	31.8
2028	2.1	4.9	3.0	6.2	10.8	4.8	31.8
2029	2.1	5.0	3.1	6.0	10.7	4.8	31.8
2030	2.1	5.1	3.1	5.8	10.7	4.9	31.8
2031	2.1	5.3	3.2	5.7	10.6	5.0	31.8
2032	2.1	5.4	3.2	5.5	10.6	5.0	31.8
2033	2.1	5.5	3.2	5.3	10.5	5.1	31.8
2034	2.1	5.6	3.3	5.1	10.5	5.1	31.8
2035	2.2	5.7	3.4	5.0	10.4	5.2	31.8
		Cumulative cost of obesity-related disease by 2035:					**673.1**

Table S9: Scenario 3: -0.07 BMI (20% SSB tax)

Year	CHD	Diabetes	Hypertension	Stroke	Breast Ca	Colorectal Ca	Total
2015	2.0	4.0	2.0	9.0	11.0	4.0	32.0
2016	2.0	4.4	2.3	9.1	11.1	4.2	33.2
2017	2.0	4.7	2.6	9.1	11.3	4.4	34.1
2018	2.0	4.9	2.8	9.2	11.4	4.6	34.9
2019	2.1	5.2	3.0	9.2	11.5	4.7	35.6
2020	2.1	5.4	3.2	9.2	11.6	4.9	36.3
2021	2.1	5.6	3.3	9.2	11.7	5.0	36.9
2022	2.1	5.8	3.4	9.2	11.8	5.2	37.5
2023	2.1	6.1	3.5	9.2	11.9	5.3	38.1
2024	2.1	6.3	3.6	9.1	12.0	5.4	38.5
2025	2.1	6.5	3.7	9.1	12.1	5.5	39.1
2026	2.2	6.7	3.7	9.1	12.2	5.7	39.5
2027	2.2	6.9	3.8	9.0	12.3	5.8	40.0
2028	2.2	7.1	3.9	9.0	12.4	5.9	40.5
2029	2.2	7.3	3.9	9.0	12.5	6.0	40.9
2030	2.2	7.6	3.9	8.9	12.6	6.1	41.4
2031	2.2	7.8	4.0	8.9	12.7	6.2	41.8
2032	2.2	8.0	4.1	8.9	12.7	6.3	42.2
2033	2.3	8.2	4.2	8.8	12.8	6.4	42.7
2034	2.3	8.3	4.2	8.8	12.9	6.5	43.0
2035	2.3	8.5	4.2	8.8	12.9	6.6	43.3
		Cumulative cost of obesity-related disease by 2035:					**811.7**

Appendix 10E: Sample of the projections with 95% confidence limits

Legend:
ok = normal weight (<25kg/m^2)
ow = overweight (25-29.99 kg/m^2)
ob = obese (≥30kg/m^2)

Figure S1: BMI projections for females aged 5-9

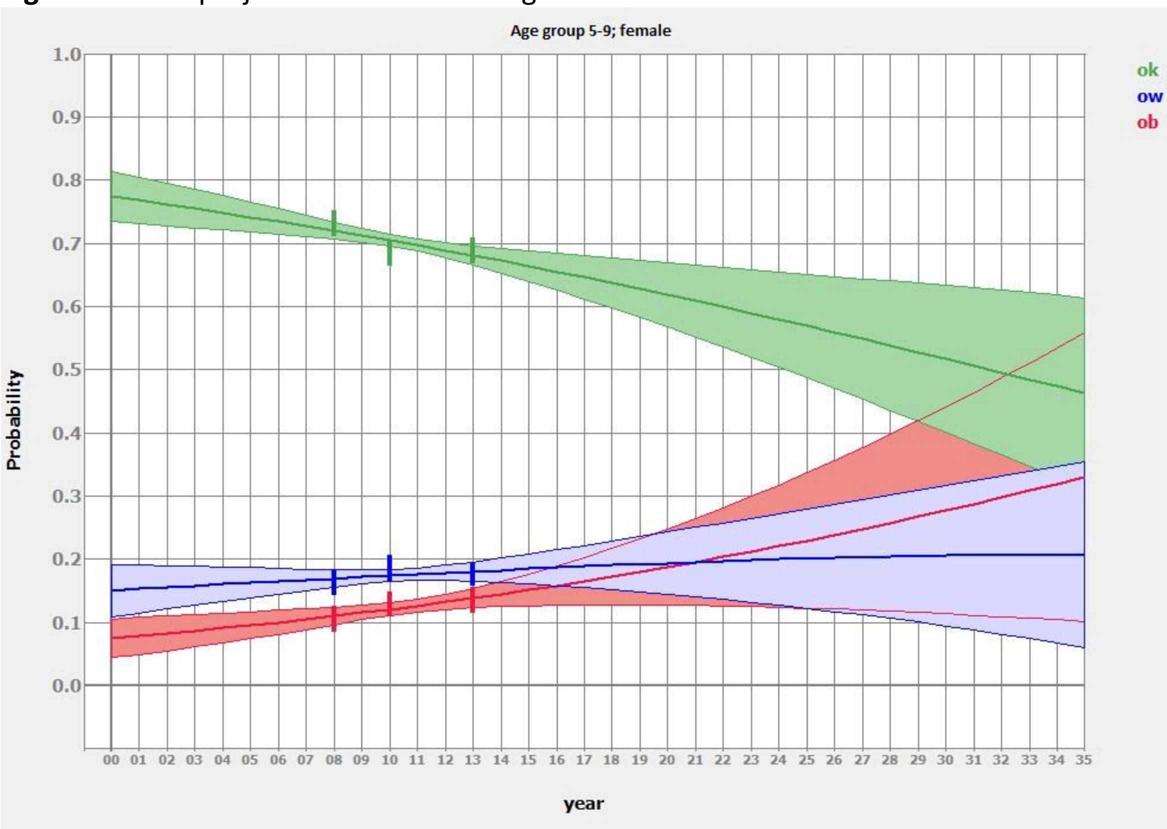


Figure S2: BMI projections for males aged 5-9

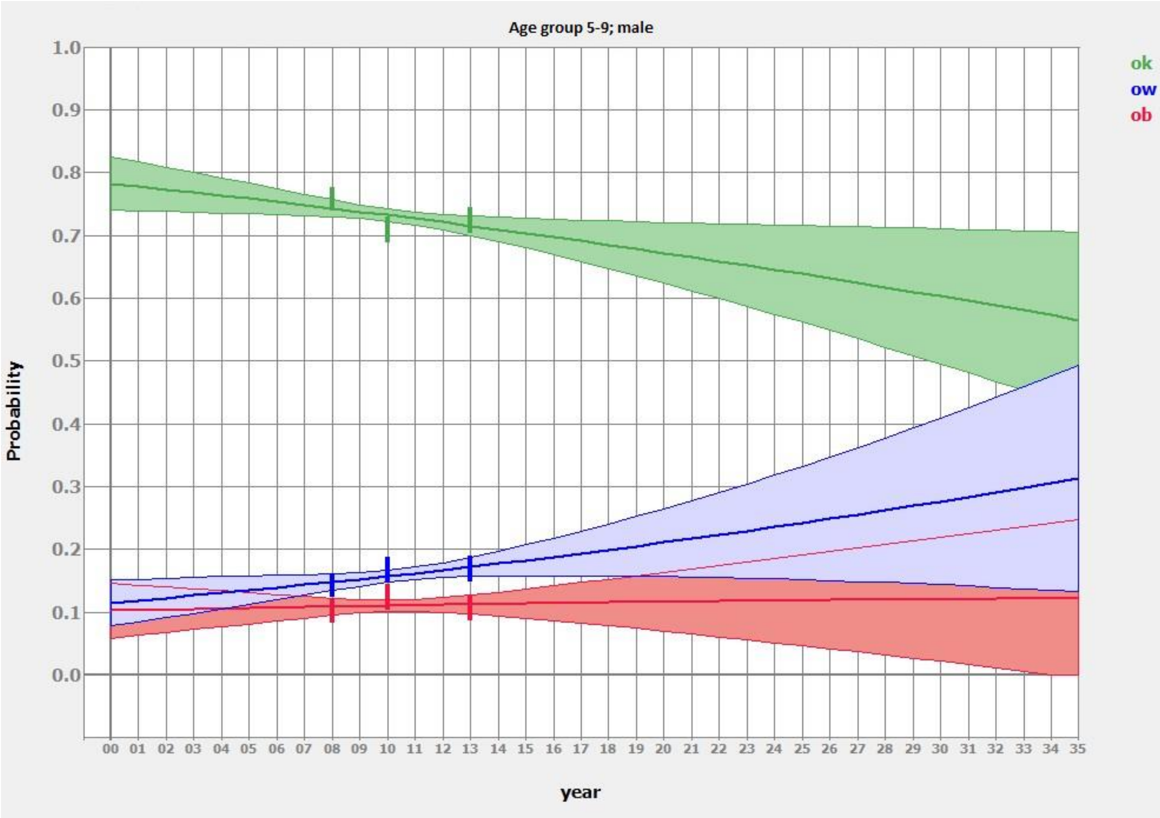


Figure S3: BMI projections for females aged 10-14

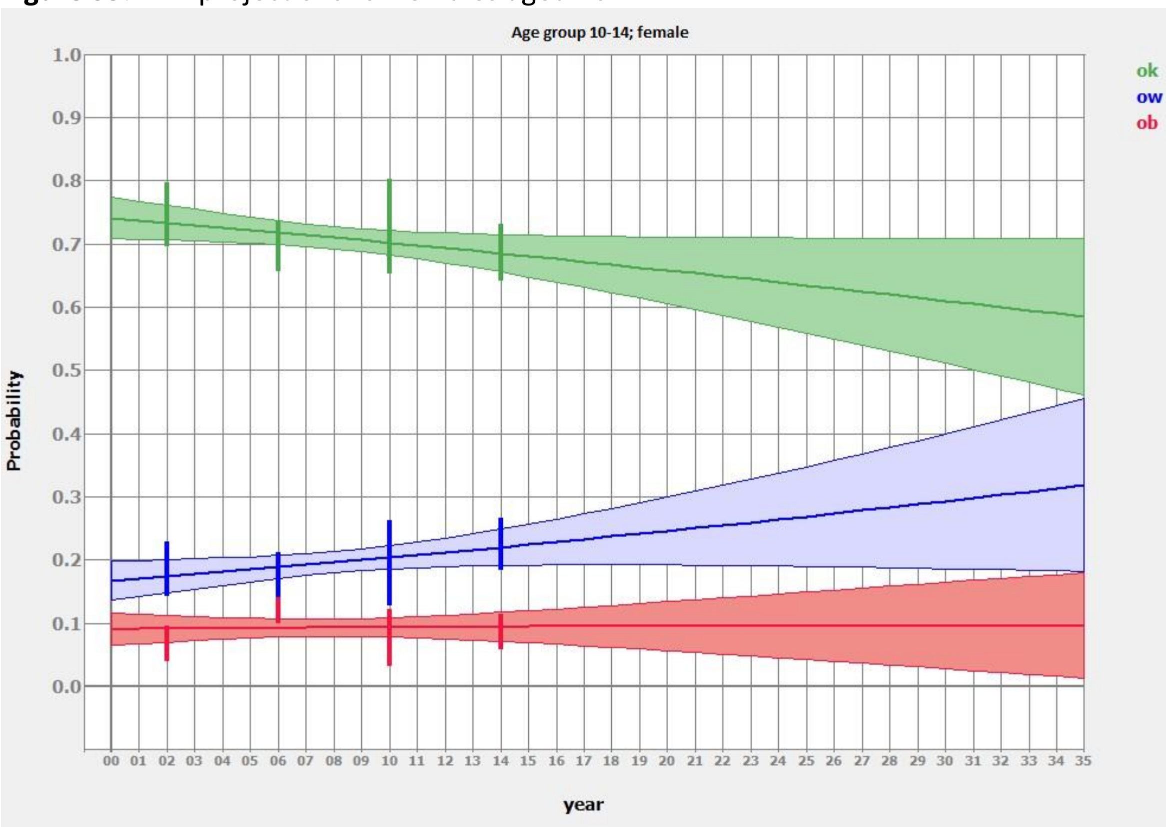


Figure S4: BMI projections for males aged 10-14

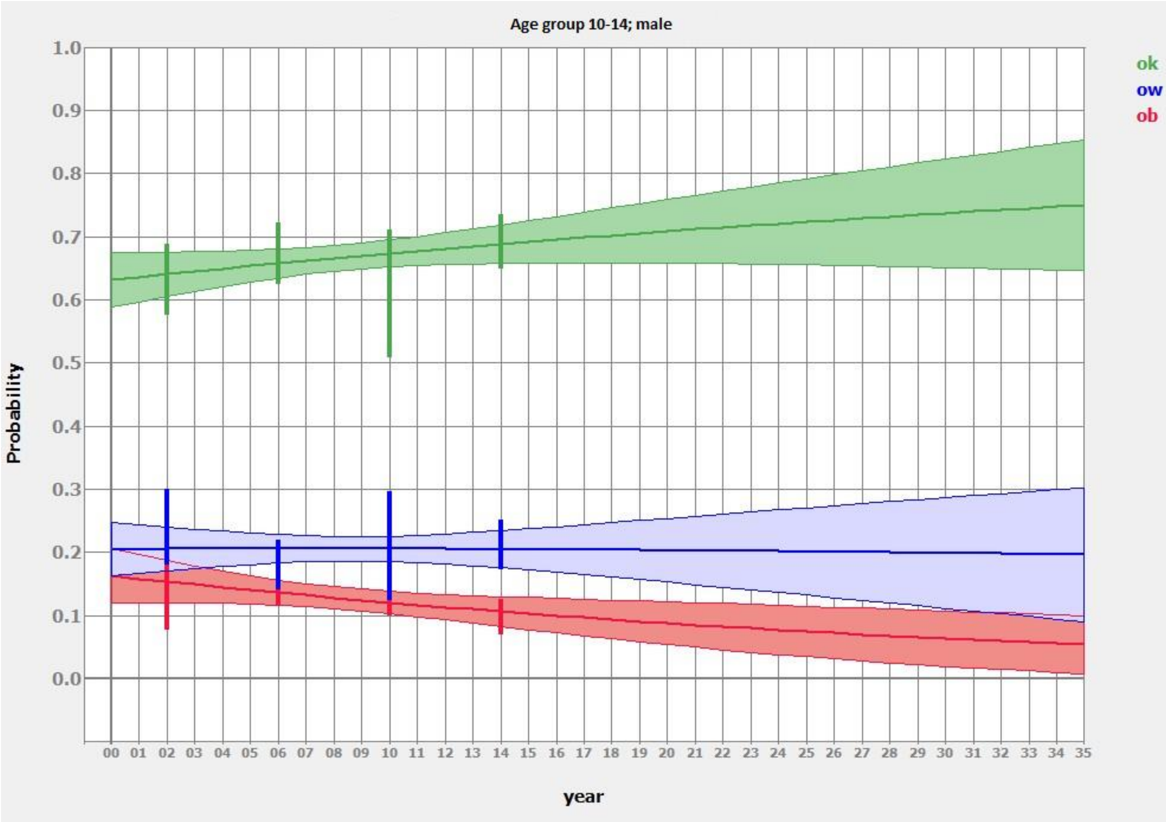


Figure S5: BMI projections for females aged 60-64

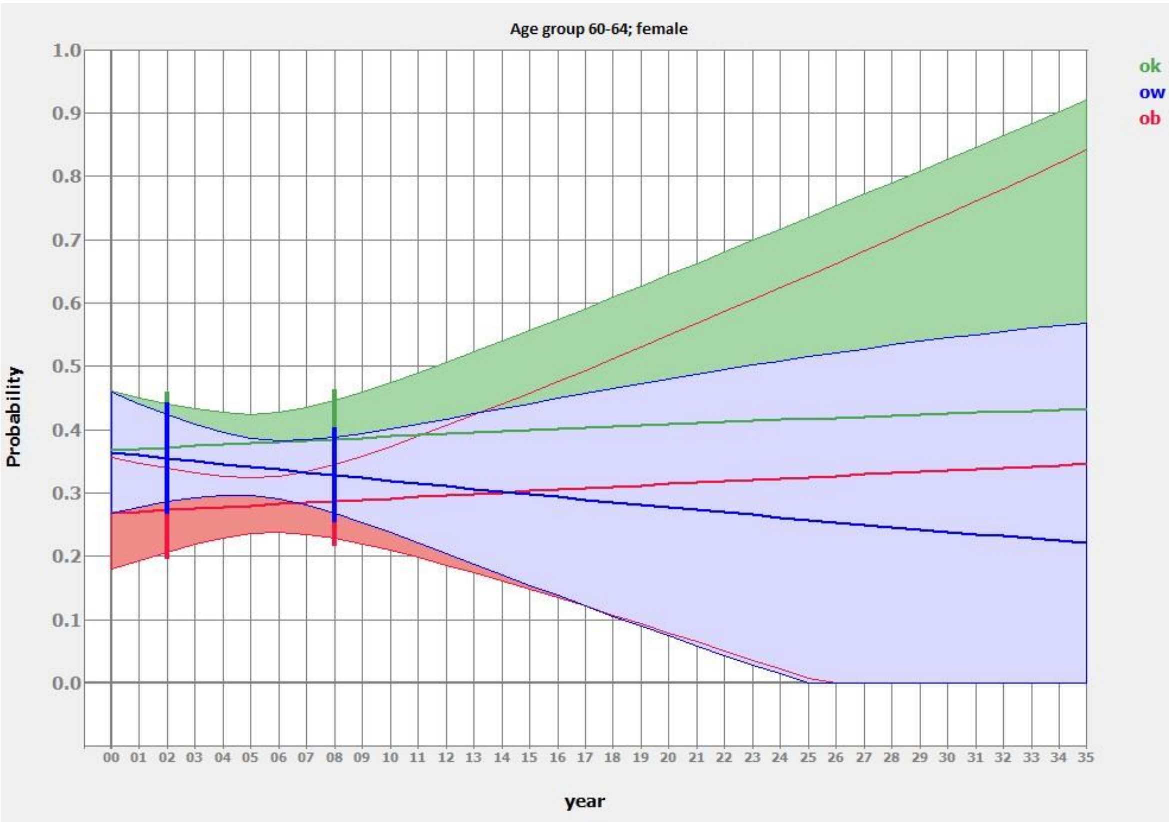
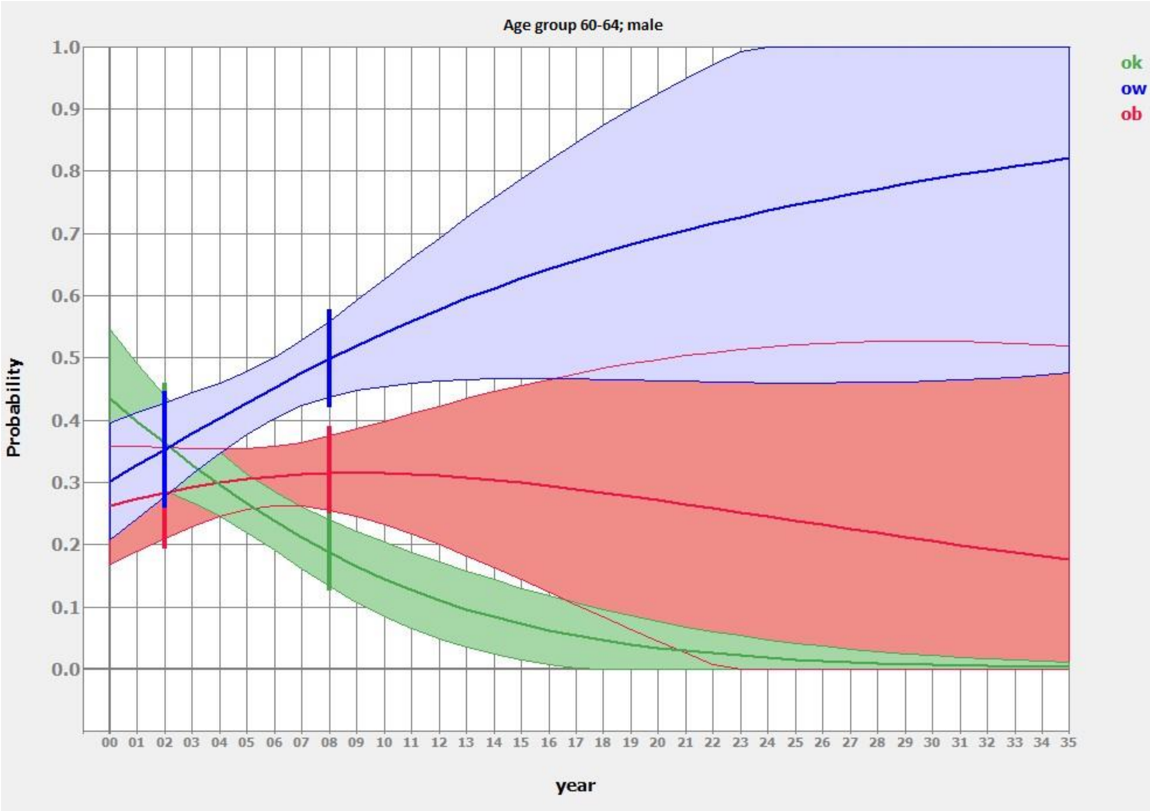


Figure S6: BMI projections for males aged 60-64



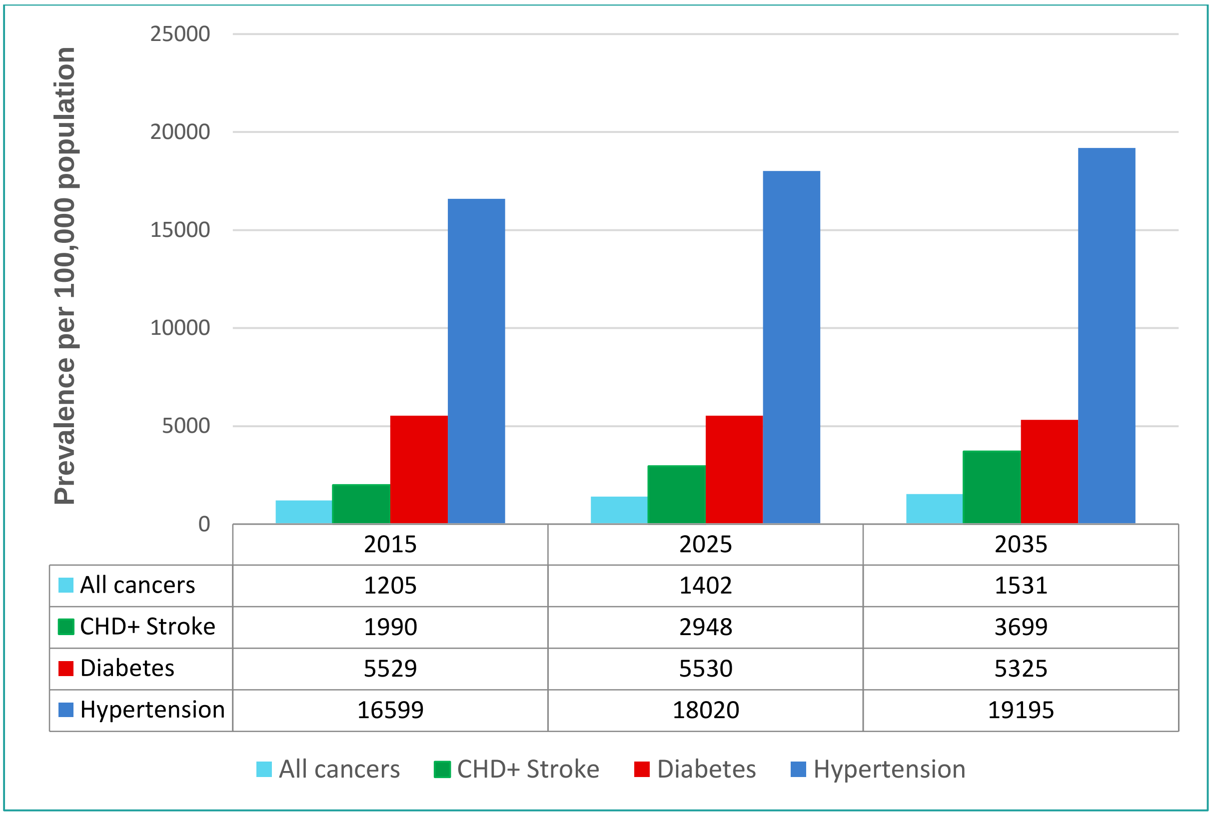
Appendix 10F: NCD Prevalence and Incidence

Prevalence [±SE]

Table S10: Prevalent cases in year per 100,000 [±SE]

Sc 0	Diabetes	CHD & Stroke	Hypertension	All cancers
2015	5529 [+/-10]	1990 [+/-8]	16599 [+/-16]	1205 [+/-9]
2025	5530 [+/-10]	2948 [+/-11]	18020 [+/-17]	1402 [+/-11]
2035	5325 [+/-10]	3699 [+/-12]	19195 [+/-18]	1531 [+/-11]
Sc 1	**Diabetes**	**CHD & Stroke**	**Hypertension**	**All cancers**
2015	5516 [+/-10]	1977 [+/-8]	16587 [+/-16]	1201 [+/-9]
2025	4898 [+/-10]	2694 [+/-10]	17311 [+/-17]	1341 [+/-10]
2035	3831 [+/-9]	3098 [+/-11]	17089 [+/-17]	1401 [+/-11]
Sc 2	**Diabetes**	**CHD & Stroke**	**Hypertension**	**All cancers**
2015	5452 [+/-10]	1946 [+/-8]	16534 [+/-16]	1203 [+/-9]
2025	4131 [+/-9]	2263 [+/-11]	16127 [+/-16]	1243 [+/-11]
2035	3003 [+/-8]	2654 [+/-12]	15415 [+/-16]	1320 [+/-11]
Sc 3	**Diabetes**	**CHD & Stroke**	**Hypertension**	**All cancers**
2015	5529 [+/-10]	1990 [+/-8]	16593 [+/-16]	1204 [+/-9]
2025	5501 [+/-10]	2937 [+/-11]	17983 [+/-17]	1398 [+/-11]
2035	5281 [+/-10]	3680 [+/-12]	19141 [+/-18]	1527 [+/-11]

Figure S7: Projected prevalence of disease per 100,000 population from 2015 to 2035 (Scenario 0)



	2015	2025	2035
All cancers	1205	1402	1531
CHD+ Stroke	1990	2948	3699
Diabetes	5529	5530	5325
Hypertension	16599	18020	19195

Table S11: Prevalent cases **avoided** in year per 100,000 population in 2015 [±SE]

Sc 1	**Diabetes**	**CHD & Stroke**	**Hypertension**	**All cancers**
2015	13 [+/-14]	13 [+/-12]	12 [+/-23]	4 [+/-11]
2025	632 [+/-14]	254 [+/-15]	709 [+/-24]	61 [+/-14]
2035	1494 [+/-13]	601 [+/-16]	2106 [+/-25]	130 [+/-15]
Sc 2	**Diabetes**	**CHD & Stroke**	**Hypertension**	**All cancers**
2015	77 [+/-14]	44 [+/-12]	65 [+/-23]	2 [+/-11]
2025	1399 [+/-13]	685 [+/-15]	1893 [+/-23]	159 [+/-12]
2035	2322 [+/-13]	1045 [+/-16]	3780 [+/-24]	211 [+/-14]
Sc 3	**Diabetes**	**CHD & Stroke**	**Hypertension**	**All cancers**
2015	0 [+/-14]	0 [+/-12]	6 [+/-23]	1 [+/-11]
2025	29 [+/-14]	11 [+/-15]	37 [+/-24]	4 [+/-15]
2035	44 [+/-14]	19 [+/-16]	54 [+/-25]	4 [+/-15]

Incidence

Table S12: Cumulative incidence cases from year 2015 per 100,000 population in 2015 [±SE]

Sc 0	Diabetes	CHD & Stroke	Hypertension	All cancers
2015	274 [+-2]	520 [+/-4]	613 [+-3]	192 [+/-4]
2025	2994 [+-8]	6166 [+/-17]	6665 [+-11]	2329 [+/-16]
2035	5741 [+-11]	13406 [+/-23]	13396 [+-15]	4937 [+/-25]
Sc 1	**Diabetes**	**CHD & Stroke**	**Hypertension**	**All cancers**
2015	259 [+-2]	508 [+/-4]	597 [+-3]	190 [+/-4]
2025	2228 [+-7]	5688 [+/-15]	5828 [+-10]	2199 [+/-16]
2035	3577 [+-8]	11750 [+/-21]	10624 [+-14]	4448 [+/-22]
Sc 2	**Diabetes**	**CHD & Stroke**	**Hypertension**	**All cancers**
2015	207 [+-2]	479 [+/-4]	549 [+-3]	185 [+/-4]
2025	1193 [+-5]	4752 [+/-14]	4354 [+-9]	1920 [+/-11]
2035	1962 [+-6]	9956 [+/-20]	8120 [+-12]	3927 [+/-21]
Sc 3	**Diabetes**	**CHD & Stroke**	**Hypertension**	**All cancers**
2015	272 [+-2]	520 [+/-4]	613 [+-3]	192 [+/-4]
2025	2959 [+-7]	6143 [+/-15]	6628 [+-11]	2326 [+/-16]
2035	5676 [+-11]	13361 [+/-23]	13324 [+-15]	4924 [+/-25]

Table S13: Cumulative incidence cases **avoided** from year 2015 per 100,000 of population in 2015 [±SE]

Sc 1	Diabetes	CHD & Stroke	Hypertension	All cancers
2015	15 [+-3]	12 [+/-6]	16 [+-4]	2 [+/-4]
2025	766 [+-11]	478 [+/-21]	837 [+-15]	130 [+/-23]
2035	2164 [+-14]	1656 [+/-31]	2772 [+-21]	489 [+/-34]
Sc 2	**Diabetes**	**CHD & Stroke**	**Hypertension**	**All cancers**
2015	67 [+-3]	41 [+/-6]	64 [+-4]	7 [+/-4]
2025	1801 [+-9]	1414 [+/-21]	2311 [+-14]	409 [+/-22]
2035	3779 [+-13]	3450 [+/-31]	5276 [+-19]	1010 [+/-33]
Sc 3	**Diabetes**	**CHD & Stroke**	**Hypertension**	**All cancers**
2015	2 [+-3]	0 [+/-6]	0 [+-4]	0 [+/-4]
2025	35 [+-11]	23 [+/-21]	37 [+-16]	3 [+/-23]
2035	65 [+-16]	45 [+/-33]	72 [+-21]	13 [+/-34]

Table S14: Cases avoided from 2015 (based on predicted total population)

	Scenario 1				Scenario 2				Scenario 3			
	Diabetes	**CHD + Stroke**	**HT**	**All Cancers**	**Diabetes**	**CHD + Stroke**	**HT**	**All Cancers**	**Diabetes**	**CHD + Stroke**	**HT**	**All Cancers**
2025	3264	2037	3566	554	7674	6025	9847	1743	149	98	158	13
2035	9241	7072	11837	2088	16137	14732	22530	4270	278	192	307	56