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Disparities in the availability of fruit, vegetables and snack foods by neighborhood socioeconomic status in supermarkets and grocery stores in Montréal, Canada

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ABSTRACT

Background: Socioeconomic gradients in diet have been documented in numerous countries and cities including Montréal, Canada. The availability of food products in food stores has the potential to influence food purchases and intakes.

Objective: This study examined whether availability of fruit, vegetables (FV) and snack foods in grocery stores and supermarkets in Montréal is associated with the neighborhood socioeconomic level using various measurement methods.

Methods: The availability of FV and snack foods was measured in 27 supermarkets and grocery stores in 12 areas of lower socioeconomic status (SES) and 13 areas of higher SES using four shelf space measures, two checklists of fresh FV and a physical audit of end-of aisle displays and cash register queues.

Results: FV tended to be more available in higher SES areas while snack foods tended to be more available in lower SES areas. However, this varied depending on the measure used. 15 % more end-of aisle displays offered snack foods in stores in lower SES areas ($p = 0.001$). Availability of FV and particularly snack foods was correlated with the size of the store. The density of stores was greater in lower SES areas but stores were 225 % larger in higher SES areas ($p < 0.05$).

Conclusion: This study highlights the necessity of assessing in-store food availability using a comprehensive set of measures. To improve access to a healthier diet, changes in in-store content are needed across the social gradient and require the support of store managers, chain head offices and costumers.

TABLE OF CONTENTS

1. ABREVIATIONS

CI	Confidence interval
DA	Dissemination area, explained on p. 12
FV	Fruit and vegetables
IQR	Interquartile range
Mdn	Median
NAICS	North American Industry Classification System
NEMS-S	Nutrition Environment Measures Survey in Stores
NS	Not significant
RSL	Ratio of shelf length to floor area
RSS	Ratio of shelf surface to floor area
SE	Standard error
SES	Socioeconomic status
$\bar{x}$	Mean

2. INTRODUCTION

Diet is one of the major underlying causes of diseases causing morbidity and mortality.[1] While socioeconomic disparities in dietary intake have been identified in numerous developed countries[1-3], their origin is unclear. Characteristics of individuals such as knowledge and attitude cannot explain alone such divergences.[4] Taking into account the structural influences on food choices, Gloria et al argue that "individuals can only be as healthy as the community in which they reside".[5] Indeed, individuals' behaviors and inequalities in health are shaped by the physical and social environment in which people live.[6] The right for adequate food, which implies physical and economic access at any times, has been endorsed in a number of international declarations and treaties including the Universal Declaration of Human Rights.[7]

Similar to other cities and countries in the world, Montréal, in the province of Québec, Canada, experiences socioeconomic inequalities in diet. To identify potential underlying causes, this paper first examines the existent literature on physical access to food with a focus on the food store environment. Considering the major contribution of supermarkets and grocery stores to food intake in the province of Québec, this study will then investigate whether supermarkets and grocery stores in deprived areas in Montréal have different in-store food exposure compared to those in advantaged areas. This will be followed by recommendations for future research and public health practice.

3. BACKGROUND

Montréal is the second most populated region of Canada with a city of 1.65 million inhabitants[8] and a metropolitan area of 3.82 million inhabitants[9]. In 2005, 29 % of the population of the metropolitan area was overweight and 13 % was obese.[10] According to the World Health Organization, the risk of obesity and some health-related consequences such as cardiovascular diseases, type 2 diabetes and some cancers can be reduced with a daily consumption of at least 400 g (5 portions) of fruit and vegetables (FV).[11] However, in the city of Montréal, approximately two-thirds of the population eat less than five portions of FV everyday.[12] In Montréal and in the province of Québec, FV intake is positively related to education and income.[12, 13] Socioeconomic gradients in diets have also been observed in other regions of Canada, the US, Europe and Australia, especially for FV and snack foods (energy-dense but nutrient poor foods such as crisps and sweets typically eaten between meals).[1-3, 14-16] Findings from these studies demonstrate that people with higher socioeconomic status (SES) tend to eat more FV, while those of lower SES eat less FV and more snack foods. These disparities in diet are particularly problematic for Montréal since 29 % of residents in private households in the metropolitan area live under the low-income line (2005, before tax).[17]

To address potential causes of disparities in diet, food access has been investigated from three dimensions: a) geographic access to food outlets (e.g. food stores and restaurants); b) food available in food outlets; and c) "multi-dimensional assessments of access" which according to Rose et al[18] combine dimensions of geographic access and food availability.

In the province of Québec, food is mainly bought in retail stores including traditional food retailers (e.g. supermarkets and convenience stores) and nontraditional ones (e.g. pharmacies and general merchandise stores).[19] Among traditional food retailers, supermarkets and grocery stores account for 67 % of sales[20]. Accordingly, this section will describe recent findings on food access and socioeconomic disparities from studies on geographic access to food stores (section 3.1) and in-store food availability (section 3.2). An emphasis will be put on supermarkets, grocery stores and studies conducted in Montréal.

3.1 Geographic access to food stores in Montréal

Since the 1990's, there has been increasing scientific interest in geographic mapping of stores and investigating whether deprived neighborhoods have poorer access to supermarkets than wealthy ones.[21] From the beginning of this period, areas where healthy food is less available or economically limited compared to others were named "food deserts" by British scholars. In Canada, eight studies[22-29] verified whether similar patterns exist for access to food retailers using geographic methods, of which three[22-24] took place in Montréal and two[21, 23] in Québec City. Seven[22-28] counted the number of stores within an area. In addition, using the centroid of blocks in census tracts or individual addresses as a reference, three[18, 24, 25] studies measured the distance to the closest store and two[18, 25] calculated the average distance to the two and/or three nearest stores.

In Montréal, Bertrand et al noted a concentration of large supermarkets in wealthier areas and a greater number of convenience stores in deprived areas[23]. Daniel et al found no correlation between the number of FV stores in census tracks and household median income, but a positive association with education[24]. Finally, Apparicio et al observed a limited access to supermarkets in some low-income and highly socially deprived areas, which they considered as not problematic since residents of these areas had on average access to a supermarket within 816 m and access to three supermarkets within 1.34 km.[22] However, the latter did not specify whether residents of some areas would need to travel greater distances than reported averages. Furthermore, Apparicio concluded that Montrealers have in general a good access to supermarkets, while British studies and policy-makers suggest the use of 500 m as a maximal reasonable walking distance in cities[30, 31]. Whether the distance of 500 m can be applied to Montréal is unclear given possible differences in urban topography with the UK. Thus, these studies illustrate the diversity of geographic measures used to demonstrate spatial inequality of access to food, and that there is no standard way to establish the presence of food deserts even within the same city.

3.2 Assessing the in-store environment

This section describes the most common measures to assess in-store food availability and highlights the importance of considering the presence of food items at particular locations within the stores.

3.2.1 Examining the overall availability of food items

Although research on geographic access to stores provides important information on access to food, a recent study suggests that proximity to supermarkets is not associated with healthy diet including FV intake.[32] One potential reason is that studies on geographic access do not account for food availability within the stores. Indeed, research suggests a relationship between in-store availability of specific foods and consumption of the latter.[33-38]. Secondly, the amount of shelf space and the number of varieties of a type of food strongly influence purchase of the latter[36, 39-41]. Thirdly, although geographic studies have identified the presence of food deserts, as argued by Farley et al[42], opening new stores without guidance on store content could increase access to not only healthy foods but snack foods as well. Finally, Rose et al[18] believe that modifying the store content is easier and more sustainable than building new supermarkets since it is cheaper, quicker and less complex. Taking these points into account, investigating the in-store environment becomes necessary to verify the presence of disparities between neighborhoods of lower and higher SES.

Compared with studies on geographic access to stores, relatively fewer researchers have measured in-store food availability with an increase in the number of publications in the past five years[43]. As far as the author is aware, the first study was conducted in the US in 1986 by Sallis et al, who examined the presence of 71 low-sodium and low-fat packaged foods according to the neighborhood SES using a checklist.[44] Results showed a greater number of low-sodium and low-fat foods in supermarkets compared to neighborhood grocery stores and convenience stores, as well as in middle-income neighborhoods compared to lower- and higher- ones. In 1990, in the US as well, Cheadle et al assessed the proportion of displays occupied by healthy versions of foods in supermarkets and grocery stores.[45] For this, they measured shelf space of poultry and fish, reduced-fat milk, and 100% whole wheat bread relatively to shelf space of fresh meat, milk and bread sections respectively. Ratios for the three food categories did not differ much between chain and independent stores (no test of significance).

Measures and audit tools used to measure in-store food availability

Since Sallis et al and Chealde et al, checklists and shelf space measurements are still the tools that are the most commonly used to measure in-store food availability. First developed by food security studies to assess the presence and price of food items that are part of a basic diet, checklists now generally consist of healthy food baskets[26, 46] or lists of varieties of foods including varieties of FV or types of snack foods[27, 47]. Recently, to get a more comprehensive picture of food availability, Glanz et al[48] developed and validated the Nutrition Environment Measures Survey in Stores (NEMS-S), a standardized instrument that combines information on availability, price and quality of ten food categories including milk, fruit, vegetables, ground beef, hot dog, frozen dinners, baked goods, beverage, bread and baked chips. Indicators of availability include the presence/absence of products, shelf space measurements of low-fat milk as well as the number of varieties, size of packages and number of calories and grams of a few items. As for shelf space, measures include shelf length[42, 49], shelf length multiplied by shelf height[50] or by shelf width[27], as well as ratios of these to floor area[42] or to the store's total shelf space[42, 50]. Widely used measuring tools include measuring tape and measuring wheel *(Figure 1)*.

Figure 1: Measuring wheel.
To measure a distance, the wheel simply needs to be rolled from point A to point B. The distance can be read on the box to the left of the wheel.

Source of image: http://www.bionicsscientific.com/testing-measuring-meter/measuring-wheels.html

In-store food availability according to the neighborhood SES

Although the studies are few, scholars have examined the presence of disparities in in-store content of food retailers such as supermarkets and grocery stores according to neighborhood SES. Table 1 describes eleven studies using either a checklist or shelf space measures that focused on snack foods or healthy food items including FV and were published from 2007. Results are contradictory. Indeed, seven[5, 47, 48, 51-54] recorded a higher availability of healthy items in higher SES areas, one[55] observed a greater availability in medium-SES areas, two[27, 56] found no difference in the availability of FV according to the neighborhood SES level and two[47, 50] found no difference for snack foods. These discrepancies could potentially be explained by the use of different measurement tools or country difference. Indeed, of the nine studies that used a checklist, seven[5, 47, 48, 51-53, 57] recorded a higher availability of healthy foods in higher SES areas whereas none of the three studies[27, 50, 56] that

conducted comprehensive shelf space measurements of fresh FV or snack foods detected a difference by SES area. Furthermore, all US studies[5, 48, 51-53] but one[55] found a higher availability of healthy foods in higher SES areas. In Australia, two studies[47, 54] also found a greater availability of FV in higher SES areas and two[47, 50] found no difference in the availability of snack foods SES area. In Québec, two studies[27, 56] found no difference in the availability of fresh FV by SES area. Lastly, results could also have been influenced by differences in shelf space measures and checklists as well as by the food items and the types of store that were included.

Table 1: Country, measurement tools used and results of 11 studies on in-store availability of snack foods and healthy food items including FV published from 2007

Author, year	Country	Checklist	Shelf space	Food items	Results	Relationship between availability and SES
Glanz et al, 2007[48]	USA	X		Fresh FV, milk, ground beef, hot dog, frozen dinners, baked goods, beverage, bread and baked chips	Healthier options were more available in higher SES areas	+
CCNSW, 2007[54]	Australia	X		FV, legumes, bread, cereals, meat, dairy products and snack foods	There was a higher number of varieties of FV in higher SES areas	+
Ball et al, 2008[47]	Australia	X		Fresh FV and snack foods	FV were slightly more available in higher SES areas. No difference for snack foods.	+ / ⦸
Bertrand et al, 2008[56]	Canada (Québec)		X	Fresh FV	No difference in availability of FV by SES area.	⦸
Franco et al, 2008[52]	USA	X		Fresh and canned FV, milk, ground beef, chicken, frozen dinners, low-sodium food items, bread and cereals	Healthier options were more available in higher SES areas	+
Vinkeles et al, 2009[50]	Australia		X	Snack foods	No difference by SES area.	⦸
Pouliot et al, 2009[27]	Canada (Québec)	X	X	FV	No difference by SES area.	⦸
Krokowoski , 2010[55]	USA	X		Idem Glanz et al	Healthier options were more available in medium-SES areas.	+ / -
Gloria et al, 2010[5]	USA	X		106 healthy foods including fresh, canned and frozen FV and items from the NEMS-S except meat	Healthier options were more available in higher SES areas	+
Leone et al, 2011[53]	USA	X		Idem Glanz et al + canned FV	Healthier options were more available in higher SES areas	+
Andreyeva et al, 2012[51]	USA	X		Fresh, canned and frozen FV, milk, ground beef, beverage, bread and baked chips	Healthier options were more available in higher SES areas	+

3.2.2 Examining the presence of food items at strategic locations

The measures described above provide information on in-store overall availability of specific food items. However, marketing studies suggest that the location of products within the stores can also strongly influence food purchases. This particularly refers to the use of special displays, i.e. displays that are located at extra places in addition to the regular shelf space.[58] US marketing studies from the 70's to present suggest that special displays can have a powerful impact on purchases[41, 58-60]. For instance, in an experiment in a store in the US with four branded products (soap, apple juice, rice and frozen pie shells), while doubling shelf space increased the sales of these by 16 % to 39%, the use of special displays increased their sales by 77 % to 243 %.[41] End-of aisle displays *(Figure 2a)* and displays at the cash registers *(Figure 2b)* could particularly trigger impulse or unplanned purchases, i.e. purchases that were not planned before shopping.[58, 59] The efficacy of end-of aisle displays could be due to the greater likelihood to be seen compared to displays within the aisles[59], whereas cash registers displays could trigger impulse buys because of the captive status of costumers, who are bored and have little other distraction.[61]

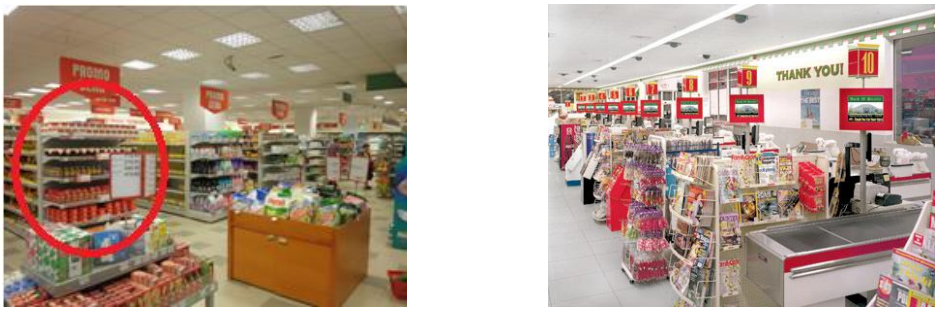


Figure 2. Special displays: a) End-of aisle display (circled, left); b) Cash registers displays (right)
Source of images: a) en.wikipedia.org/wiki/Supermarket;
b)blog.scoutapp.com/articles/2009/10/09/choosing-between-the-mysql-myisam-and-innodb-table-types

As far as the author is aware, only two studies, both supervised by Lukar E Thornton, assessed the availability of food items within special displays. The first one took place in Melbourne, Australia, and investigated the presence of snack foods within end-of aisle displays and cash registers in chain supermarkets.[62] Results showed that snack foods where present in a high proportion of these special displays in both lower and higher SES areas. The second study is an international project to which this present study takes part. It aims at comparing shelf space, the number of varieties and the presence on special displays of fresh FV and snack foods between selected countries using standardized measures. Preliminary findings from Australia, Denmark, Sweden and the Netherlands

suggest that cash registers in major chain supermarkets are more likely to display chocolate and soft drinks in Australia compared to the other countries.[63]

3.3 Combining measures of the in-store food environment

Considering the limitations of studies on geographic access to food stores as well as the contradicting results of studies on in-store food availability by SES area, this pilot study examined whether FV and snack foods availability in grocery stores and supermarkets in Montréal is associated with the neighborhood SES using three tools previously described, i.e. checklists, shelf space measures and audits of special displays. Data on the latter were collected for the international study mentioned above lead by Lukar E Thornton.

4. AIM AND OBJECTIVES

Research question :

Do grocery stores and supermarkets in lower SES neighborhoods have different in-store exposure to FV and snack foods than those located in higher SES neighborhoods?

Aim

To investigate whether availability of FV and snack foods in grocery stores and supermarkets is associated with the neighborhood socioeconomic level using various measurement methods.

Objectives

1. To use four methods to calculate shelf space between lower and higher SES neighborhoods: a) shelf length; b) shelf surface (length x height or width); c) ratio of shelf length to floor area (RSL); and d) ratio of shelf surface to floor area (RSS).
2. To use two checklists to measure the number of varieties of fresh FV between lower and higher SES neighborhoods: a) the list of FV included in the NEMS-S; b) a pilot tool developed for this study.
3. To measure the presence of FV and snack foods within end-of aisle displays and cash register queues between lower and higher SES neighborhoods.

5. METHODOLOGY

This is a cross-sectional, ecological study of in-store exposure to foods within grocery stores and supermarkets in lower and higher SES neighborhoods on the island of Montréal.

5.1 Literature search

Articles in English and in French from peer-reviewed journals on in-store measurements of food availability were searched in the database MEDLINE (via Pubmed) and by checking references of the selected articles. The following keywords as well as variations in spelling and indices of these were searched: supermarket, grocery, food store, availability, shelf, variety, market basket, audit, fruit, vegetable, snack food, food access, food security, socioeconomic, deprivation, income. Due to the abundance of literature and time constraint, only articles published from 2007 were searched. The full strategy is presented in Appendix A. In addition, publications from organisations in Montréal such as the Montréal Public Health Department were searched on Google and the organisations‘ websites.

5.2 Inclusion criteria

Criteria for the study involved selection of study areas (section 5.2.1), supermarkets and grocery stores (section 5.2.2) and food items in the audits (section 5.2.3).

5.2.1 Selection of areas

Stores were selected in socioeconomically contrasting areas using the 2006 version of the Deprivation index for health in Canada[64]. The latter, developed by Pampalon at the Québec National Institute of Public Health, is based on Canadian census information and the Québec health system administrative boundaries. Explanation of the index will include description of the health system administrative boundaries in Montréal, followed by the index itself.

The island of Montréal is divided into 12 Health and Social Services Center Areas. Each area is divided into two or three Local Community Service Center Areas *(Figures 3-4)*, which contains between one to nine sectors. In total, there are 111 sectors. Each sector contains many dissemination areas (DAs). DAs are the smallest geographic units measured by the Canadian census and include between 400 and 700 inhabitants.[65] They are relatively homogeneous regarding socioeconomic conditions.[64] In Montréal, there are 3.238 DAs.

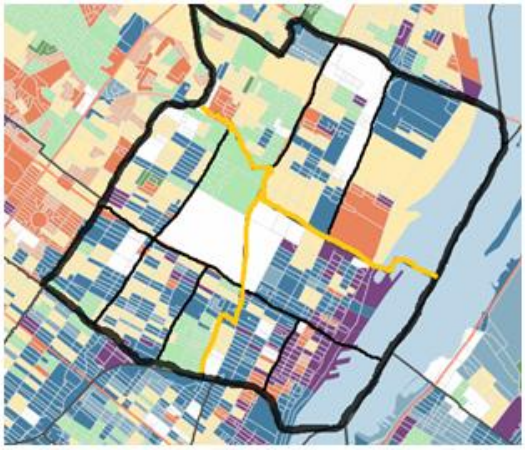


Figure 3 : The Quebec Health system administrative boundaries (example)

A Health and Social Services Center Area is surrounded by a bold black line and divided into 3 Local Community Service Center Areas (orange lines). These are divided into 3 to 5 sectors (thin black lines) for a total of 11 sectors. Each colored rectangle is a dissemination area and corresponds to a SES described in figure 4.

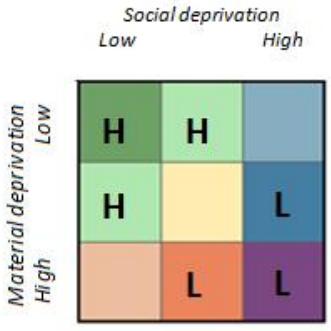


Figure 4 : Colour code used by the deprivation index for health planning in Canada to identify the SES of the dissemination areas.

For the present study, "H" represents areas of higher SES and "L" represents areas of lower SES.

(Modified versions of images from the Québec Ministry of Health and Social Services [Ministère de la Santé et des Services Sociaux du Québec], 2011[66])

The Deprivation index for health in Canada is based on information on DAs and covers about 98% of the Canadian population.[64] Sparsely populated DAs are excluded as well as those where more than 15 % of the population or more than 80 persons live in collective households, which include commercial establishments (e.g. hotels), institutions (e.g. hospitals) and communal dwellings (e.g. shelters and military bases)[67]. The index consists of six indicators representing material and social deprivation *(Table 2)*. All indicators except the proportion of single-parent families are adjusted for age and sex. For each DA, scores for material and social deprivation are divided into quintiles and then combined. The scores obtained are then distributed into a matrix of nine levels of deprivation *(Figure 4)*. Since deprivation is "relative to the local community or the wider society or nation to which an individual, family or group belongs"[68]*(p.125)*, the index is available in four versions from the national level to the metropolitan areas.[66] For study purposes, as shown in Figure 4, DAs where the population is: a) highly materially and socially deprived; b) medium-materially deprived; or c) medium-socially deprived; were considered as having a low SES. On the other hand, DAs where the population is: a) highly advantaged materially and socially; b) medium-materially advantaged;

or c) medium-socially advantaged were considered as having a high SES. The version of index at the Montréal administrative level was used.

Table 2: Indicators for the Deprivation index for health in Canada[64]

- Proportion of people ≥ 15 y. old with no high school diploma	- Proportion of individuals ≥ 15 y. old living alone
- Employment/population ratio of people ≥ 15 y. old	- Proportion of individuals ≥ 15 y. old who are separated, divorced or widowed
- Average income of people ≥ 15 y. old	- Proportion of single-parent families

Areas for this study were selected using previous work done by the Montréal Public Health Department. Using information from the DAs at the Montréal level, the Department divided the population of Montréal into the following quintiles: Q1) materially and socially advantaged; Q2) on the average; Q3) socially deprived only; Q4) materially deprived only; and Q5) materially and socially deprived. The percentage of the population of each Health and Social Services Center Area, Local Community Service Center Area and sector belonging to each quintile was then calculated.[69] For the purpose of this study, to use the most accurate information and limit heterogeneity, sectors were identified as the proxy measure of neighborhood. The 12 sectors with the highest percentages of advantaged material and social levels (quintile 1) were selected, as well as the 11 with the highest percentages of material and social deprivation (quintile 5). The geographic distribution of selected study sectors in Montréal is shown in Figure 5, highlighting lower SES areas in yellow and higher SES areas in orange. The 12th most deprived sector was not included due to time constraints.

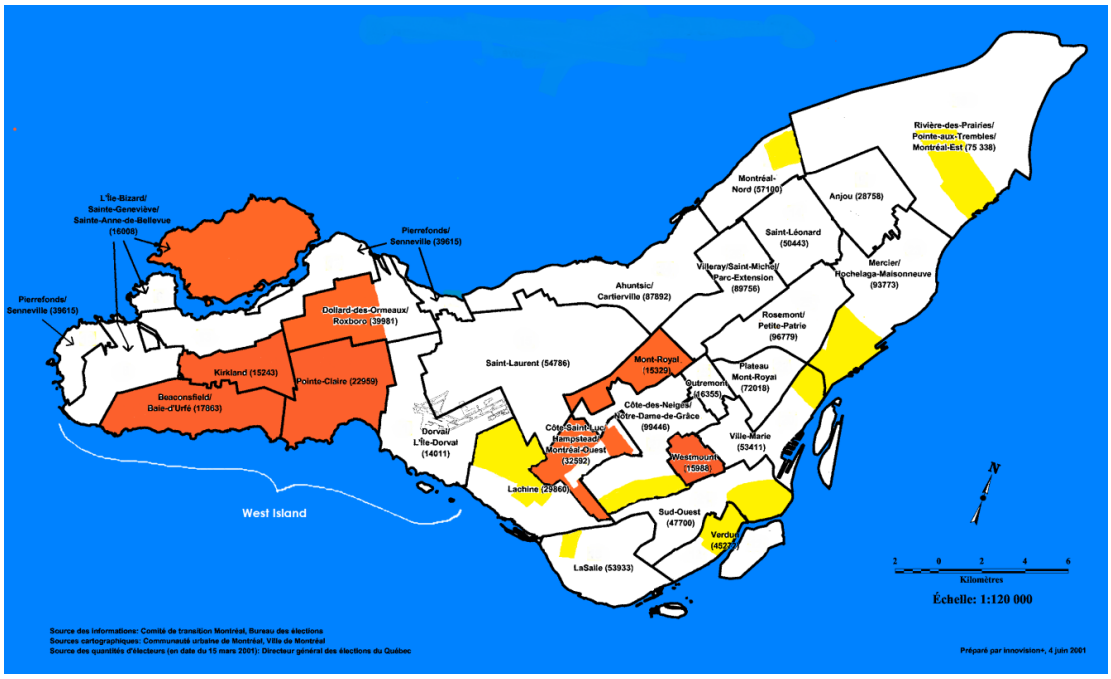


Figure 5: Location of the lower SES (yellow) and higher SES (orange) sectors on the Island of Montréal

(Modified version of a map prepared by Innovision+ with information on sectors from the Montréal Health and Social Services Agency [Agence de la Santé et des Services Sociaux de Montréal][69])

5.2.2 Selection of stores

A summary of inclusion criteria is presented in Table 3. Selection of stores was based on the North American Industry Classification System (NAICS)[70], store size, food content and the SES of the DA in which stores are located. The NAICS categorizes all businesses according to standardized definitions.

Table 3: Inclusion criteria for selection of stores

Characteristics	Criteria
Type of store	Grocery stores and supermarkets (NAICS code 445110)
Size	Floor area ≥ 200 m^2, where ≥ 70% of the store floor area is occupied by food products
Food content	Contains raw meat and fresh FV
Location	In contact with a DA that has a SES similar to that of the sector in which it is located. *E.g. Higher SES DA → Higher SES sector*

First, grocery stores and supermarkets were defined according to the NAICS (code 445110)[70], which described these as shops and delicatessen-type stores that are "primarily engaged in retailing a general line of food, such as canned and frozen foods; fresh fruits and vegetables; and fresh and prepared meats, fish, and poultry". Convenience stores (code 445120), specialty food stores (code 445299) and food/health supplement stores (code 446191) were excluded because of their limited variety of foods and/or their emphasis on certain food produce, which under- or overestimate exposure to FV and snack foods compared with supermarkets. For each sector, grocery stores and supermarkets were searched using the Yellow Pages (pagesjaunes.ca), maps.google.com and websites of grocery chains using the following key words: grocery store (épicerie), supermarket (supermarché), market (marché) and chain names from the three main food retailers in Québec *(Table 4)*. These three main retailers were selected since they possess 68 % of the main food retailer market share in the province and distribute about 71% of food products.[71] Moreover, 63 % of supermarkets and grocery stores are associated with one of these three food retailers[i].[71]

Table 4: Main food retailers and their supermarket chains in Québec[71]

Loblaws Companies Limited	Sobeys inc	Métro inc
Axep Club Entrepôt Intermarché Loblaws Maxi Maxi et cie Provigo	IGA IGA Extra Les Marchés Traditions Marché Bonichoix	Adonis Marché Ami Marché Extra! Marché Richelieu Métro Métro Plus Super C

[i] This was calculated from the data showing that 79 % of supermarkets and grocery stores in Québec are associated with chains, of which 80 % are Loblaws Co, Sobeys inc and Métro inc.

Second, to represent the diversity of supermarkets and grocery stores in Québec, all stores ≥ 200 m^2 were included. Floor area was assessed using a measuring wheel or estimated footage. Similarly to the definition of supermarket by the Food and Agriculture Organization[72], all stores where food products occupy ≥ 70% of floor space were included. In addition, to ensure that kiosks and convenience stores were excluded and that there was enough variety to support a week's worth of shopping, stores had to sell fresh FV and uncooked meat such as ground beef, and not only cold cuts. All stores found via the Internet were validated through on-site observation, i.e. their presence, type (supermarket, grocery store or other), size and food content were checked, and the percentage of floor space occupied by food products was estimated.

Finally, although selection of areas was determined by the sector level, there was vast range of lower and higher SES DAs within each sector. In order to specifically select stores surrounded by lower or higher SES neighborhoods, the author checked the location of the stores on a map showing the Deprivation index for health in Canada at the Montréal level[66]. In the lower SES sectors, only stores surrounded by at least one lower SES DA were included, whereas in higher SES areas, only stores surrounded by at least one higher SES DA were included. An example is shown in Figure 6. The SES of DAs was previously defined in Figure 4.

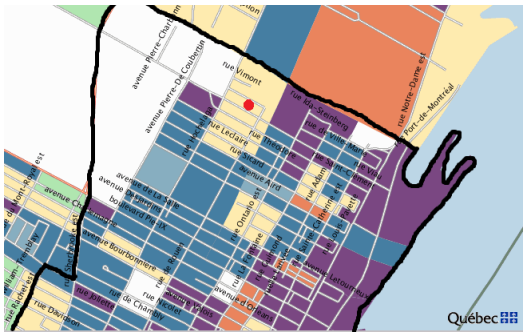


Figure 6: Example of the verification of the SES of the store location at the dissemination area level

The boundaries of a lower SES sector are identified with a black line. A store is identified by a red point. It is not surrounded by a lower SES DA (dark blue, purple or orange) so it is excluded.

(Modified version of image from the Québec Ministry of Health and Social Services [Ministère de la Santé et des Services Sociaux du Québec], 2011.[66])

In total, 27 stores were part of the study: 12 in lower and 15 in higher SES sectors. Two were independent stores (did not belong to a chain), including one ethnic shop. Figure 7 describes the store selection process. Using the Internet, almost 2 times more stores were identified in the lower SES areas. In the field, two-thirds were excluded, mainly because they were too small (< 200 m^2) and/or were convenience stores. These were mostly located in lower SES areas, where they accounted for half the stores identified. Hence, a similar number of stores qualified according to inclusion criteria in the lower (n = 17) and higher (n = 18) SES areas. Within the initial process, eight managers refused to participate. Accordingly, stores that were included represented 77 % of supermarkets and grocery stores located in the selected sectors. Among the managers who refused to participate, five asked the author to request an authorization from the chain head office. One said

she would contact the latter but never called back, and another received an authorization but on the last day of the data collection. As for the last refusal, after having travelled twice to a store and be told that the manager was absent, the author called the latter by telephone. The manager received explanation of the study and refused to participate.

Table 5 gives information on the deprivation level as well as the number of eligible stores, refusals and stores included in each study sector. Sectors of lower SES are listed from the highest (100 %) to the lowest (43 %) percentage of residents who are materially and socially deprived, while sectors of higher SES are listed from the highest (100 %) to the lowest (59 %) percentage of residents who are materially and socially advantaged. A maximum of two stores met the inclusion criteria in all sectors except in Wellington-de-l'Église (low SES), Saint-Raymond-Ouest-Haven (low SES) and Kirkland (higher SES), where there were four or five stores. Two-thirds of refusals were recorded in Wellington-de-l'Église and Saint-Raymond-Ouest-Haven. The number of stores included per sector ranged from zero to two with the exception of four in Kirkland. Finally, 7 sectors of higher SES were part of the West Island *(Figure 5 & Table 5)*, a suburb-like area where the population density is among the lowest on the island of Montréal[73] and the rates of cars per capita, the highest[74].

5.2.3 Selection of food items

Food items included FV and snack foods. FV included fresh, canned and frozen produce excluding tomato sauce, tomato paste and marinades. Canned and frozen FV were included because they are cheap alternatives to fresh FV, they have a longer shelf life and they are part of Canada's food guide[75]. Based on projects by Thornton et al, Farley et al[42] and Vinkeles et al[50], indicators for snack foods were grouped into four categories: a) chips and similar products (e.g. Cheetos® and Fritos®) excluding popcorn, pretzels and rice chips; b) regular and diet soft drinks; c) chocolate excluding products mainly sold for cooking; d) candies excluding chewing gum. They were selected because: 1) the Canadian Food Guide recommends limiting their consumption[76]; 2) contrary to cookies and cakes, they should be classified as "unhealthy" no matter the flavor and the brand; 3) they are popular; 4) they significantly contribute to calorie intake; and 5) they have a great capacity to trigger unplanned purchases. Indeed, in a 24-hour food recall with about 35.000 Québécois, sugar/confectionery, soft drinks and chips-alike snacks had been consumed by 70 %, 38 % and 17 % of respondents respectively.[13] Soft drinks and chips-alike snacks accounted for 4.4 % of calorie intake.[13] Furthermore, in a study with 108 product categories, "Candy/Mints" and "Chips and snacks" were ranked among the top 5 for impulse buying rates.[77]

Figure 7: Store selection process

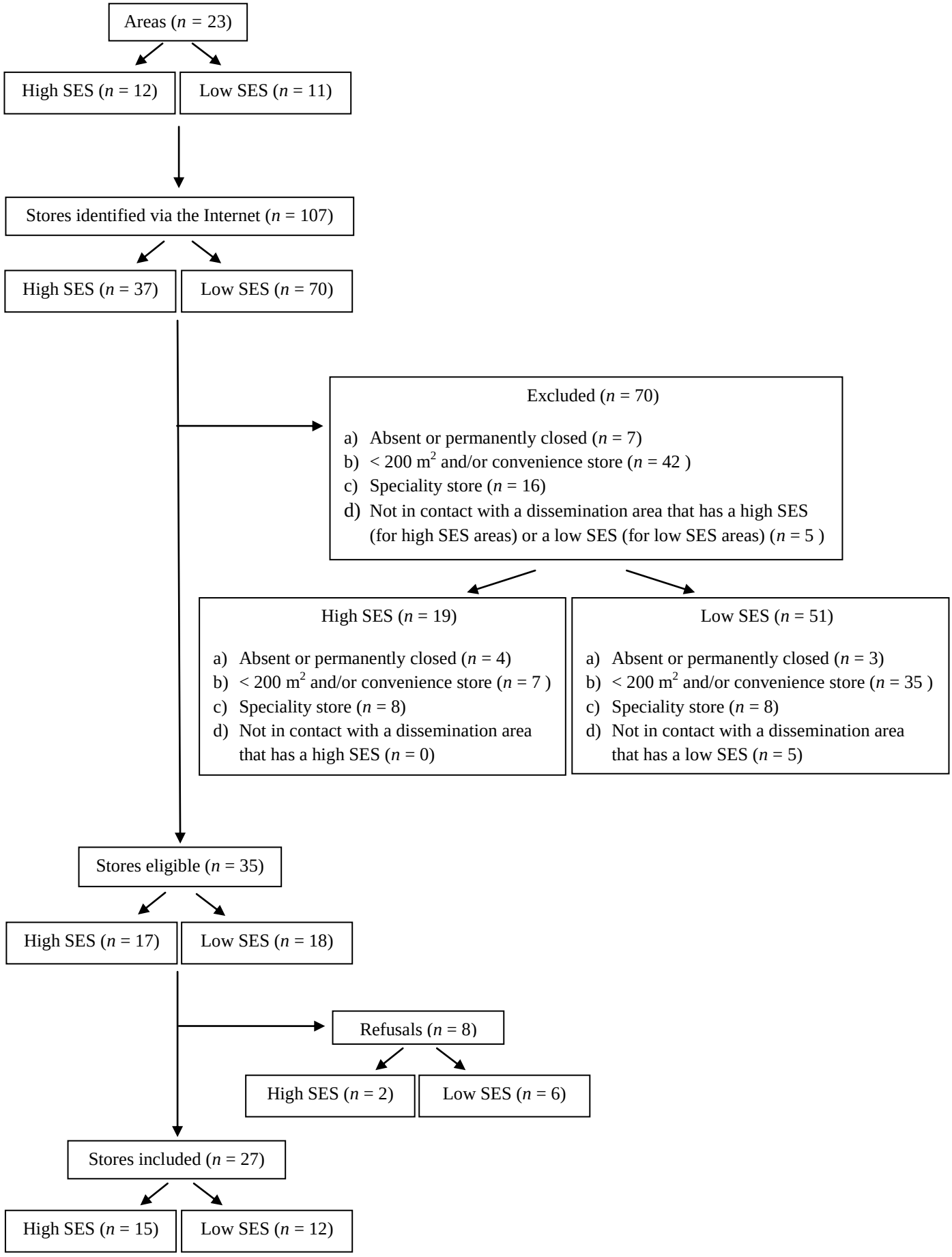


Table 5: Deprivation level and number of eligible stores, refusals and included stores in each sector by SES

Sectors of lower SES (n = 11)	**% of residents materially and socially deprived[69]**	**Stores eligible (n = 18)**	**Refusals (n = 6)**	**Stores included (n = 12)**
Lasalle Heights	100	0	0	0
Duff-Court	100	0	0	0
Hochelaga Sud	83	1	0	1
Montréal-Nord Nord-Est	79	1	0	1
Wellington-de-l'Église	66	4	2	2
Maisonneuve	58	2	0	2
Montréal-Est	55	0	0	0
Saint-Raymond-Ouest-Haven	49	5	3	2
Hochelaga Nord	47	2	0	2
Pointe St-Charles	46	1	0	1
Sainte-Marie	43	2	1	1
Sectors of higher SES (n = 12)	**% of residents materially and socially advantaged[69]**	**Stores eligible (n = 17)**	**Refusals (n = 2)**	**Stores included (n = 15)**
Baie-d'Urfé*	100	1	0	1
Montréal-Ouest	100	0	0	0
Beaconsfield*	90	1	1	0
Pointe-Claire Nord*	83	2	1	1
Kirkland*	81	4	0	4
Mont-Royal	80	2	0	2
Île-Bizard*	75	1	0	1
Hampstead	70	0	0	0
Dollard-des-Ormeaux Ouest*	67	2	0	2
Côte St-Luc Nord	64	1	0	1
Westmount	60	2	0	2
Pointe-Claire Sud*	59	1	0	1
	TOTAL	**35**	**8**	**27**

*Part of the West-Island

5.3 Data collection

Informed written or verbal consent was obtained from the store managers at the moment of data collection by explaining study objectives and providing a consent letter *(Appendix B)*. As this project did not involve the use of human subjects, ethics approval was not required from the University of Copenhagen nor the University of Sheffield. A student declaration for the latter is

available in Appendix C. Data were collected from 25 November to 2 December 2011 as well as from January 3 to 16 2012 to avoid changes in food displays due to the Christmas season. 12 stores (6 low, 6 high SES) were audited during the first phase and 15 (6 low, 9 high SES) during the second phase. To have consistent results between supermarkets and stocks on shelves, data were collected between 9h and 18h30 on week days.

5.3.1 Tools used in data collection

Exposure to FV and snack foods was assessed using: a) four shelf space measurements; b) two physical audits of products on special displays; and c) two checklists of fresh FV *(Table 6)*. Shelf space measures examined the quantity of FV and snack foods available, the checklists measured the diversity of FV, and audits of special displays provided information on the use of the latter to display FV and snack foods. Collection of data was made using standardized protocols by the author in 19 stores, and with the help of an additional recorder trained on the spot in the eight remaining stores. All audits of special displays were conducted by the author alone. The checklists of fresh FV that were conducted with the help of the additional recorder were double-checked by the author, and all measurements of shelf space were supervised by the latter.

Table 6: Types of methods used to measure food availability: shelf space, special displays and varieties

Shelf space measurements	Presence of products on special displays	Number of varieties (fresh FV only)
Shelf length Shelf surface (length x height) Ratio shelf length / floor area (RSL) Ratio shelf surface / floor area (RSS)	Physical audits at: - The end-of aisle displays - The cash registers	Checklists: - List of the FV included in the NEMS-S - The pilot tool

a) Shelf space measurements

Shelf space measurements of FV and snack foods included shelf length, shelf surface, RSL and RSS. Shelf length and shelf surface were measured with a measuring tape and a measuring wheel everywhere FV and snack foods were displayed except at the cash registers. They were measured for all the sides of a display exposed to consumers *(Appendix D)* using the audit tool in Appendix E. Extra pages were added when necessary. Sections of displays that were empty were excluded. Shelf surface was defined as length multiplied by height similarly to what Vinkeles et al[50] did. However,

for displays that consisted of a table or any approximately flat surface, the surface on the top is the one that is the most visible to consumers. Accordingly, for these, the author decided to multiply the length of one side of the display by the width of another side *(Figure 3 in Appendix D)*. Finally, ratios of shelf length (RSL) and shelf surface (RSS) to floor area (m^2) were calculated. Floor area was obtained by measuring floor length and floor width of the sale and cash register area using a measuring wheel and multiplying them. Ratios to floor area, used by Farley et al[42], were preferred to ratios to total shelf space, used by Vinkeles et al[50], because pilot tests carried out before the study by the present author showed that measuring the latter was extremely time-consuming.

b) Presence of food items within special displays

A physical audit of presence of FV and snack foods within displays at the end of the aisles and at the cash registers was undertaken using the tool from Thornton *(Appendix F)*. These displays were selected because of their strong influence on unplanned purchases. In order to prevent overrepresentation of one item within the entire display, only categories of items representing the quarter or more of a display were noted. For each cash register, drawings were made to indicate to which displays costumers are exposed while queuing *(example in Appendix F)*. This enabled the assessment of exposure to snack foods for each cash register queue.

c) Checklists of fresh FV

Given time constraints, checklists were used for fresh FV only. These were chosen because of their key role in health programs.[78-80] The number of varieties of fresh FV was counted by looking at: a) the 20 types of FV that are included in the NEMS-S *(Table 7)*; and b) all varieties. The NEMS-S was selected because it is validated and it has been used by various researchers. To count all varieties of fresh FV, a pilot checklist was developed and included 59 fruit and 76 vegetables for a total of 135 FV including those from the NEMS-S *(Appendix E)*. This tool was used to check presence of both fresh FV from the NEMS-S and all varieties. Only present items were ticked, i.e. empty spaces with labels indicating the presence of a fruit or a vegetable were ignored. To keep the pilot checklist simple, a fruit or a vegetable and its similar varieties based on taxonomy and appearance were counted as one. For instance, although Cortland, McIntosh and Lobo are three varieties of apples, they were all considered as apples. No stipulations were made to differentiate regular from organic produce.

Table 7: Fresh FV included in the NEMS-S[48]

Fruit (*n* = 10)	Vegetables (*n* = 10)
Apples	Broccoli
Bananas	Cabbage
Cantaloupe	Carrots
Grapes	Cauliflower
Honeydew melon	Celery
Oranges	Corn
Peaches	Cucumbers
Pears	Lettuce
Strawberries	Sweet peppers
Watermelon	Tomatoes

5.4 Data analysis

IBM SPSS Statistics 20 (IBM Corporation, Chicago, Il, USA) was used to calculate food availability in each store and make comparisons by SES area. First, for each store, floor area as well as total shelf length, total shelf surface, RSL and RSS of each food category were calculated *(Table 8)*. In addition, for each store, the number of varieties of fresh FV from the NEMS-S that were present was calculated, as well as the percentage of end-of aisle displays and cash register queues offering FV and snack foods. The total number of varieties of fresh FV was counted twice by hand for each store.

Table 8: Equations used for each store using fresh FV as an example

Concept	**Equations**
Floor area (m^2):	Floor length x floor width
Total shelf length of fresh FV (m):	∑ (shelf length of fresh FV in display 1, 2, 3...)
Total shelf surface of fresh FV (m^2):	1. For each display, shelf surface of fresh FV = shelf length x height 2. ∑ (shelf surface of fresh FV in display 1, 2, 3...)
Ratio shelf length to floor area:	Total shelf length of fresh FV ÷ Floor area
Ratio shelf surface to floor area:	Total shelf surface of fresh FV ÷ Floor area

Second, the frequencies of distribution of data were observed by SES area using histograms. To examine the distribution and the heterogeneity of variance of data, Shapiro-Wilk's and Levene's tests were used respectively. Then, data with normal distributions and equal variances were analyzed using independent samples *t* test while Welch's *t* test was used for those having normal

distributions but unequal variances. The Mann-Whitney U test was performed for data that was not normally distributed. All levels of significance were determined at alpha level of 0.05. Means ($\bar{x}$) and standard error (SE) were calculated for parametric methods, and medians (Mdn) and interquartile range (IQR) were calculated for the non parametric ones.

Third, considering the great variation in store sizes and previous findings suggesting a positive correlation between availability of food and store size, scatter plots with linear fit lines were drawn for floor area in relation with shelf length, shelf surface and the number of varieties of fresh FV by SES area. To be sure that these relations were significant, for normally distributed data, Pearson correlation coefficients and their p-values were calculated with Pearson correlation analysis. To examine whether differences in relationships between store size and various in-store measures could be detected by SES area, the equation below was used. The p-value corresponding to the $Z_{Difference}$ score was checked in a table for the standard normal distribution. As for the fit of the relations for data not normally distributed, it was checked with Kendall's tau correlations.

$$Z_{Difference} = \frac{zr1 - zr2}{\sqrt{\left(\frac{1}{N1-3}\right)+\left(\frac{1}{N2+3}\right)}}$$

Where: $zr_1 = 0.5 * \left(LN\left(\frac{1+r1}{1-r1}\right)\right)$

$zr_2 = 0.5 * \left(LN\left(\frac{1+r2}{1-r2}\right)\right)$

r_1 = Pearson correlation coefficient for stores in lower SES areas

r_2 = Pearson correlation coefficient for stores in higher SES areas

N_1 = Number of stores in lower SES areas

N_2 = Number of stores in higher SES areas

Finally, extra tests were carried out to normalize data and exclude missing values. To correct for the positive skewness of RSL and RSS, logarithmic transformations (ln and log10) were tested. The value "1" was added to all data before the transformations to avoid negative numbers. "1" was chosen because the choice of a constant can influence the results and "1" is the most commonly used.[81] In addition, as there were incomplete data in two stores regarding shelf space exposure, statistical tests were carried out without these stores where appropriate.

6. RESULTS

6.1 Store size and land area

Figure 8 illustrates store size in m^2 for all participating stores, ranging from 204 m^2 to 5.084 m^2 ($\bar{x}$ = 1.847 m^2). Of those depicted, five were < 300 m^2 and two were > 3.500 m^2, lying outside the 68 % confidence interval of the mean (CI: 627–3.067 m^2). As for comparisons by SES area, Table 9 depicts total land area, population density, total number of stores (including those who refused to participate in the study), number of stores per km^2 and mean store size by SES. Total land area occupied by higher SES sectors was 245 % bigger than that of lower SES sectors. Seven of the ten largest stores were located in the West Island *(not shown)*. There were 190 % more inhabitants per km^2 in the total area covered by lower SES sectors than that of higher SES areas. Furthermore, despite very similar numbers of sectors and stores in both lower and higher SES areas, there were 2.6 times more stores per km^2 in lower SES sectors. Stores in the latter were on average 225 % smaller compared to stores in higher SES sectors.

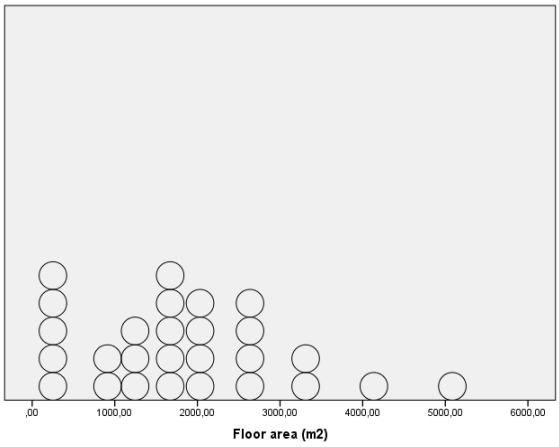


Figure 8: Dot plot of the store floor areas (m^2)

Table 9: Total land area, population density, total number of stores, ratios of stores to land area and mean store size depicted by SES

	Lower SES	Higher SES
Total land area (km^2)	40.0	99.9
Population density (inhabitants/km^2)	3728	1957
N stores	18	17
N stores/km^2	.45	0.17
Store size**: Mean (SE)	1091 (223)	2452 (307)*

* $p < .05$ using the independent *t* test
** Includes only the stores that were included in the study

6.2 Availability of FV and snack foods according to the neighborhood SES

Results in this section will report on in-store measures regarding mainly fresh FV, all FV combined (fresh, canned and frozen) and all snack foods combined (chips, soft drinks, chocolate and candies).

6.2.1 Shelf space measures

Table 10 shows means and medians of shelf length (m), shelf space (m^2), RSL and RSS by SES area for fresh FV, total FV and total snack foods. For fresh and total FV, means of shelf length and shelf surface in higher SES areas were at least double that of lower SES areas (all p-values < .001). This corresponds to differences of 60-70 m for shelf length and 50-60 m^2 for shelf surface. There was no difference between RSL and RSS by SES, suggesting that shelf space of FV was on average proportional to floor area in both lower and higher SES areas. As for snack foods, similar to FV, shelf length was 1.63 greater in higher SES sectors (a difference of 34 m), and shelf surface, 1.76 greater (a difference of 51 m^2) (all p-values < .05). However, RSL (p < .005) and RSS (p < .05) were significantly greater in stores in lower SES areas.

Table 10: Means and medians of shelf space measures for fresh FV, total FV and total snack foods compared by SES using the independent t test [(a)], the Mann-Whitney U test [(b)] and the Welch t test [(c)]

	Lower SES (n = 12)		Higher SES (n = 15)		
	$\bar{x}$(SE) or Median (IQR)	CI 95 %	$\bar{x}$(SE) or Median (IQR)	CI 95 %	p-value
Shelf length (m)	$\bar{x}$*(SE)*		$\bar{x}$*(SE)*		
Fresh FV	53.20 (8.73)	33.98–72.41	114.17 (8.92)	95.03–133.31	.000[a] ***
Total FV	68.05 (11.02)	43.80–92.29	138.13 (11.31)	113.87–162.39	.000[a] ***
Total snack foods	55.23 (9.26)	34.86–75.61	89.84 (12.16)	63.76–115.93	.040[a] *
Shelf surface (length x height) (m^2)	$\bar{x}$*(SE)*		$\bar{x}$*(SE)*		
Fresh FV	41.60 (7.59)	24.89-58.31	92.26 (8.31)	74.43-110.09	.000[a] ***
Total FV	58.02 (11.03)	33.75-82.30	119.20 (10.27)	97.18-141.23	.000[a] ***
Total snack foods	66.15 (12.01)	39.71-92.59	116.66 (16.31)	81.67-151.65	.025[a] *
Ratio length / floor area	*Mdn (IQR)*		*Mdn (IQR)*		
Fresh FV	.05 (.04-.06)	.04-.08	.05 (04-.06)	.04-.07	NS[b]
Total FV	.07 (.06-.08)	.05-.11	.06 (.05-.08)	.05-.09	NS[b]
Total snack foods	.05 (.04-.09)	.05-.08	.04 (.03-.05)	.03-.05	.003[b] **
Ratio surface / floor area					
Fresh FV: *Mdn (IQR)*	.04 (.03-.05)	.03-.06	.04 (.03-.05)	.03-.06	NS[b]
Total FV: *Mdn (IQR)*	.06 (.05-.06)	.05-.07	.06 (.04-.06)	.04-.07	NS[b]
Total snack foods: $\bar{x}$*(SE)*	.07 (.009)	.05-.09	.05 (.004)	.04-.05	.044[c] *

NS = Not significant (p > .05), *p < .05, **p < .01, ***p < .001

Log transformations and analysis excluding missing values

Log transformations did not reduce the skewness of RSL and RSS. Hence, the Mann-Whitney U test was conducted again, and similar results were obtained compared to those with raw data *(not shown).* As for missing values, data was incomplete in two stores located in higher SES sectors, which resulted in missing shelf length of frozen FV in one store and lack of food category for another store. The consequences of missing information in the first store is underestimation of total FV exposure for the remaining sequential space calculations (e.g. total shelf length and RSS) for all stores located in higher SES areas. The consequence of missing food category is underestimation of either total FV or snack foods. To test whether missing data influenced the results, statistical analyses were conducted without both stores for shelf space measures of total FV, and without the second store for shelf space measures of snack foods. All means and CI of shelf length and shelf surface slightly decreased, while the median and two CIs of ratios to floor area increased *(Table 11).* Nevertheless, the p-values remained similar except for shelf length of snack foods, for which the difference by SES area became insignificant. As there were no difference in results due to log transformation of the raw data, nor were there differences based on missing data, all findings presented in the remaining tables and figures were conducted on raw data on all stores.

Shelf space of canned and frozen FV

To verify if the greater shelf length and shelf surface of total FV was not simply due to greater shelf space of fresh FV, Mann-Whitney U tests and Independent samples *t* tests were carried out for shelf length and shelf surface of canned and frozen FV. Figure 9 illustrates the medians and means of these by lower and higher SES area. Results indicate that shelf length and shelf surface of canned and frozen FV were 1.61 to 1.86 times greater in higher SES areas.

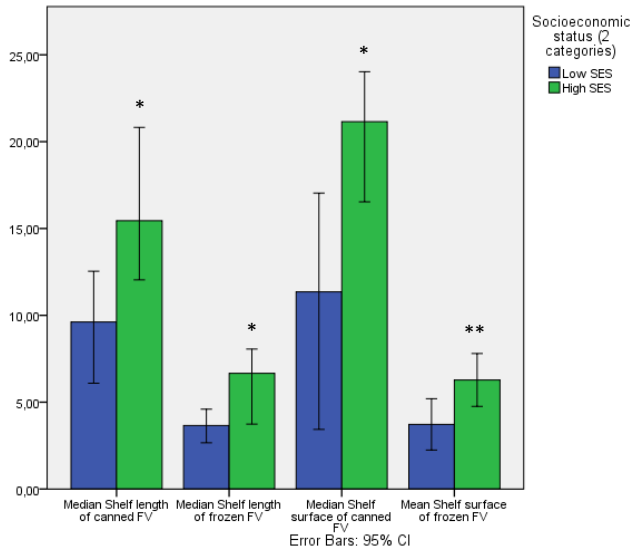


Figure 9: Clustered bar chart of medians and mean of shelf length and shelf surface of canned and frozen FV compared by SES area.

*p < .05, **p < .01

Table 11: Means and medians of shelf space measures according to SES area when excluding stores with missing data using the independent t-test [(a)] and the Mann-Whitney U test [(b)]

	Lower SES (n = 12)		Higher SES (n = 13 for FV, 14 for snacks)		
	$\bar{x}$(SE) or Median (IQR)	CI 95 %	$\bar{x}$(SE) or Median (IQR)	CI 95 %	p-value
Shelf length (m)	$\bar{x}$*(SE)*		$\bar{x}$*(SE)*		
Total FV	68.05 (11.02)	43.80–92.29	137.35 (13.11)	108.79-165.91	.001[a] **
Total snack foods	55.23 (9.26)	34.86–75.61	87.23 (12.76)	59.66-114.80	NS[a]
Shelf surface (length x height) (m^2)	$\bar{x}$*(SE)*		$\bar{x}$*(SE)*		
Total FV	58.02 (11.03)	33.75-82.30	118.22 (11.88)	92.34-144.10	.001[a] **
Total snack foods	66.15 (12.01)	39.71-92.59	114.04 (17.30)	76.68-151.41	.038[a] *
Ratio length / floor area	*Mdn (IQR)*		*Mdn (IQR)*		
Total FV	.07 (.06-.08)	.05-.11	.07 (.05-.08)	.05-.09	NS[b]
Total snack foods	.05 (.04-.09)	.05-.08	.04 (.03-.05)	.03-.05	.004[b] **
Ratio surface / floor area					
Total FV: *Mdn (IQR)*	.06 (.05-.06)	.05-.07	.06 (.04-.07)	.05-.07	NS[b]
Total snack foods: $\bar{x}$*(SE)*	.07 (.009)	.05-.09	.05 (.004)	.04-.06	.032[a] *

NS = Not significant (p > .05), *p < .05, **p < .01

Shelf space of categories of snack foods

To investigate further shelf space of snack foods, statistical tests of comparison were carried out on sweets (candies + chocolate), chips and soft drinks separately. Table 12 shows the means and medians of these by SES for shelf length, shelf surface, RSL and RSS. Shelf length and shelf surface of sweets and chips were on average about 2 and 1.75 times greater respectively in stores in higher SES areas (all p-values < .05). This corresponds to differences of about 13 m for shelf length of both sweets and chips, 16 m^2 for shelf surface of sweets, and 22 m^2 for shelf surface of chips. As for ratios to floor area, the contrary was observed. There was no difference by SES area for sweets and chips whereas for soft drinks, RSL and RSS were 1.83 and 1.6 times greater respectively in stores in lower SES areas (all p-values < .05).

Table 12: Means and medians of shelf space measures of chips, sweets and soft drinks compared by SES area using the Welch t test [(a)], the independent t test [(b)] and the Mann-Whitney U test [(c)]

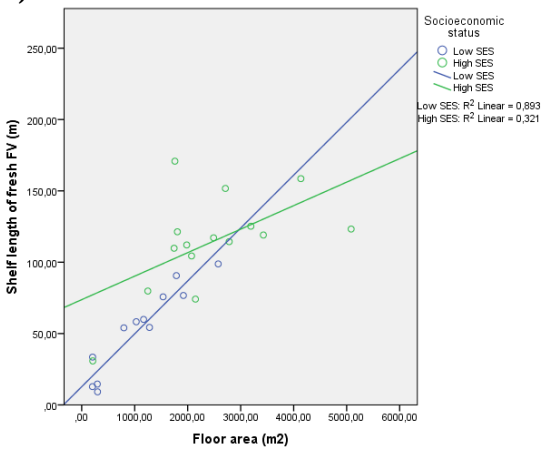
	Lower SES (n = 12)		Higher SES (n = 15)		
	$\bar{x}$ (SE) or Median (IQR)	CI 95 %	$\bar{x}$ (SE) or Median (IQR)	CI 95 %	p-value
Shelf length (m)					
Sweets: $\bar{x}$ *(SE)*	14.88 (3.15)	7.93-21.82	28.22 (4.58)	18.40-38.03	.025[a] *
Chips: $\bar{x}$ *(SE)*	19.01 (3.25)	11.85-26.17	32.50 (4.02)	23.89-41.12	.019[b] *
Soft drinks: *Mdn (IQR)*	18.63 (12.67-27.29)	12.54-30.16	28.83 (10.51-42.05)	19.00-39.24	NS[c]
Shelf surface (length x height) (m^2)	$\bar{x}$ *(SE)*		$\bar{x}$ *(SE)*		
Sweets	13.18 (2.48)	7.72-18.64	29.00 (5.51)	17.19-40.81	.017[a] *
Chips	26.65 (4.94)	15.77-37.53	48.43 (6.06)	35.42-61.43	.013[b] *
Soft drinks	26.32 (5.59)	14.01-38.63	39.23 (6.09)	26.16-52.30	NS[b]
Ratio length / floor area	*Mdn (IQR)*		*Mdn (IQR)*		
Sweets	.013 (.010-.021)	.011-.020	.012 (.007-.015)	.009-.016	NS[c]
Chips	.018 (.013-.029)	.014-.027	.013 (.011-.017)	.011-.018	NS[c]
Soft drinks	.022 (.013-.034)	.016-.037	.012 (.009-.014)	.009-.014	.003[c] **
Ratio surface / floor area					
Sweets: *Mdn (IQR)*	.013 (.011-.015)	.009-.017	.011 (.008-.015)	.009-.013	NS[c]
Chips: $\bar{x}$ *(SE)*	.026 (.003)	.019-.033	.021 (.002)	.017.024	NS[b]
Soft drinks: *Mdn (IQR)*	.024 (.015-.032)	.016-.043	.015 (.010-.018)	.011-.020	.021[c] *

NS = Not significant (p > .05), *p < .05, **p < .01

6.2.2 Relationship between store size and shelf space of FV and snack foods

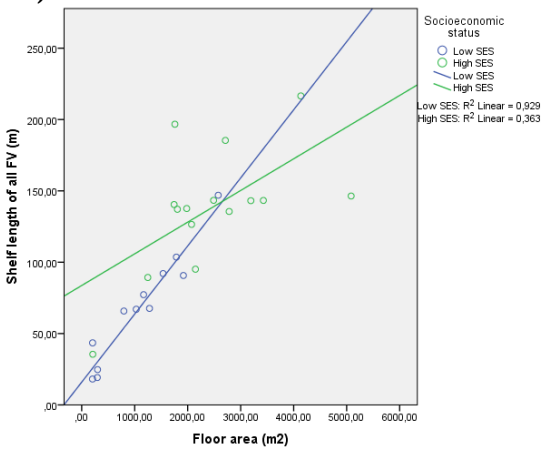
In order to illustrate the relationship between floor area and shelf space, scatter plots with fit lines were drawn by SES area for shelf length *(Figure 10)* and shelf surface *(Figure 11)* of fresh FV, total FV and total snack foods. These were all positively correlated to floor size, and R^2 values were all significantly different from 0 (all p-values < .05, *see bottom of figures*). A visual examination of the graphs and R^2 values show that for fresh and total FV, the relationship between shelf length or shelf surface and floor area was stronger in lower SES areas. Indeed, graphs a and b in both figures 10 and 11 show that floor area accounted for a range of 83-93 % of shelf space for lower SES areas, compared with 21-36 % in higher SES areas. As for snack foods, graphs c in figures 10 and 11 illustrate that floor area similarly accounted for a high proportion of shelf space (range 82-90 %) in both areas.

a)



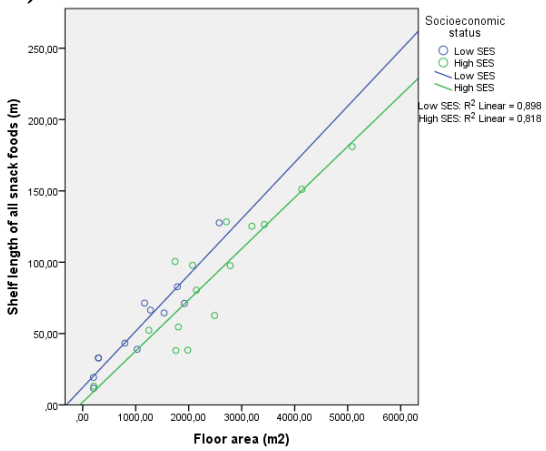
(p < .001 for lower SES, p < .05 for higher SES)

b)



(p < .001 for lower SES, p < .01 for higher SES)

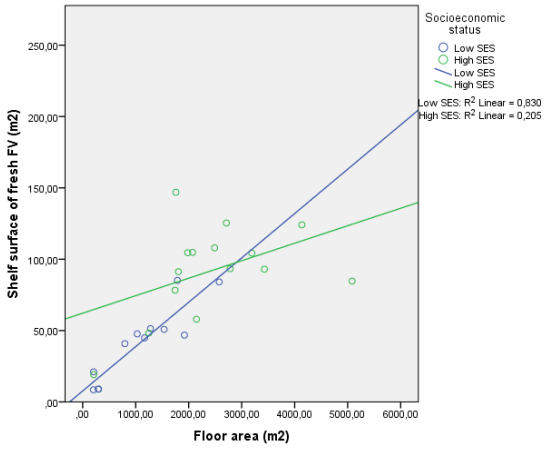
c)



(all p-values < .001)

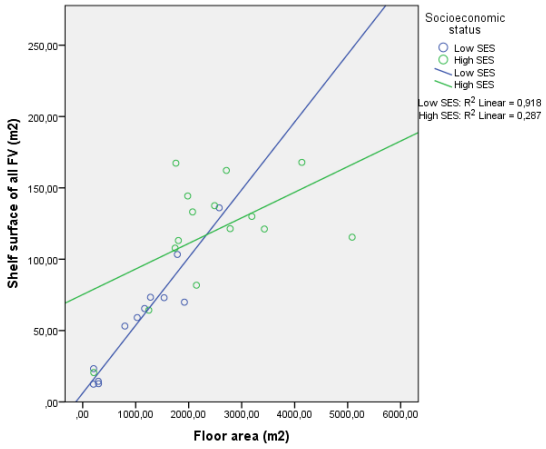
Figure 10: Scatter plots showing the relationship by SES area between floor area and shelf <u>length</u> of a) fresh FV, b) total FV, and c) total snack foods.

a)



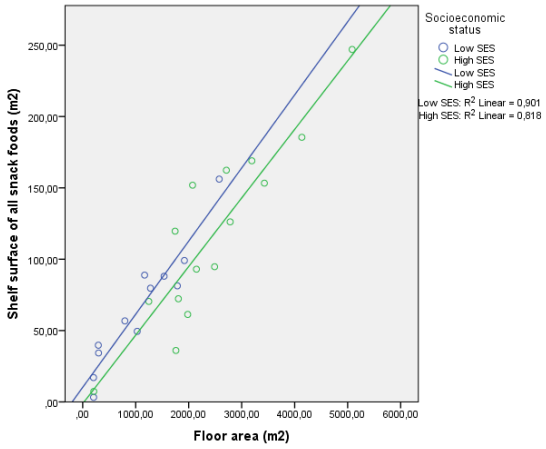
(p < .001 for lower SES, p < .05 for higher SES)

b)



(p < .001 for lower SES, p < .05 for higher SES)

c)



(all p-values < .001)

Figure 11: Scatter plots showing the relationship by SES between area floor area and shelf <u>surface</u> of a) fresh FV, b) total FV, and c) total snack foods

Additionally, Further examination of FV exposure in graphs a and b in both Figures 10 and 11 suggests a ceiling effect of shelf exposure according to floor area as there is a potential leveling of this relationship. Such a ceiling effect was not evident for snack food exposure. The curve for FV could not be tested with linear regressions due to the small size of the sample. Nevertheless, to test whether the differences (for FV) and similarities (for snack foods) between higher and lower SES areas shown on the scatter plots were adequate, Pearson correlation coefficients were calculated. A one-tailed test was used because the direction of the relationship was already known. Table 13 shows the correlation coefficients by SES area for shelf length and shelf surface of fresh FV, total FV and total snack foods, as well as the difference between the correlation coefficients for lower and higher SES areas. The differences between the correlation coefficients of lower and high SES areas were statistically significant for fresh and total FV only (all p-values [one-tailed] < .01), confirming the differences observed based on the visual examination of the scatter plots and the respective R^2 values.

Table 13: Pearson correlation coefficients by SES area and differences between the coefficients for lower and higher SES areas for shelf length and shelf surface in relation with floor area

	Floor area (m^2)	**Shelf length Fresh FV**	**Shelf length Total FV**	**Shelf length Total snack foods**	**Shelf surface Fresh FV**	**Shelf surface Total FV**	**Shelf surface Total snack foods**
Lower SES areas							
Floor area (m^2)							
Correlation coefficient	1.000	.945	.964	.948	.911	.958	.949
p-value (1-tailed)	.	.000***	.000***	.000***	.000***	.000***	.000***
N	12	12	12	12	12	12	12
Higher SES areas							
Floor area (m^2)							
Correlation coefficient	1.000	.567	.602	.904	.452	.536	.904
p-value (1-tailed)	.	.014*	.009**	.000***	.045*	.020*	.000***
N	15	15	15	15	15	15	15
Difference between lower and higher SES areas p-value (1-tailed)	.	.003**	.001**	NS	.005**	.001**	NS

NS = Not significant (p > .05), *p < .05, **p < .01, ***p < .001

6.2.3 Presence of food items on special displays

Table 14 presents the means for percentage of end-of aisle displays offering FV and snack foods by SES area, as well as the medians for percentage of cash register queues offering snack foods. On average, one end-of aisle display out of three contained snack foods in lower SES sectors compared to one out of five displays in higher SES sectors; a 15 % difference (p = .001). FV were present on average within 10 % of end-of aisle displays in both lower and higher SES areas (p > .05). As for cash register queues, in at least half of all stores located in lower SES sectors, 94 % of cash register queues displayed snack foods compared to 78 % in higher SES sectors. The difference by the neighborhood SES was insignificant.

Table 14: Means and medians of percentage of special displays with FV and snack foods by SES area using the independent t-test [(a)] and the Mann-Whitney U test [(b)]

	Lower SES (n = 12)		**Higher SES (n = 15)**		
	$\bar{x}$ *(SE) or Median (IQR)*	CI 95 %	$\bar{x}$ *(SE) or Median (IQR)*	CI 95 %	p-value
End-of aisle displays (%)	$\bar{x}$ *(SE)*		$\bar{x}$ *(SE)*		
With FV	10.54 (1.85)	6.47-14.61	9.75 (1.97)	5.52-13.98	NS[a]
With snack foods	33.79 (3.98)	25.03-42.56	18.54 (2.10)	14.03-23.05	.001[a] *
Cash register queues (%)	*Mdn (IQR)*		*Mdn (IQR)*		
With snack foods	94.44 (76.25-100.00)	72.49-97.79	77.78 (66.67-87.50)	68.47-85.49	NS [b]

NS = Not significant (p > .05), *p < .01

6.2.4 Checklists of fresh FV

Table 15 presents the medians of number of varieties of fresh FV by SES area when counting the FV included in the NEMS-S and when using the pilot audit tool. Both showed statistically more varieties of fresh FV in stores in higher SES sectors (p < .05 for the NEMS-S, and p < .001 for the pilot tool). However, for the FV included in the NEMS-S, there was a difference of only one variety. A much more marked difference (21 varieties, or 16 %) was observed with the pilot tool.

Table 15: Medians of varieties of fresh FV compared by SES area using the Mann-Whitney U test

	Lower SES (n = 12)		Higher SES (n = 15)		
	Median (IQR)	CI 95 %	Median (IQR)	CI 95 %	p-value
N fresh FV using:					
FV included in the NEMS-S	18.00 (18.00-18.75)	16.89–18.61	19.00 (19.00-20.00)	18.53–19.47	.006*
Pilot audit tool	74.00 (45.00-78.50)	53.49–76.34	95.00 (78.00-101.00)	85.31–98.82	.000**

NS = Not significant (p > .05), *p < .01, **p < .001

To investigate the relationship between store size and the number of varieties of fresh FV, a scatter plot with fit lines was drawn showing the number of varieties measured with only the FV part of the NEMS-S (blue dots) and using the pilot tool (green dots) according to floor area *(Figure 12)*. R^2 values (0.175 for the NEMS-S and 0.491 for the pilot tool) show that there was no correlation between the number of varieties tallied when including only FV from the NEMS-S and floor area, whereas the number of varieties of FV using the pilot tool increased as floor area increased.

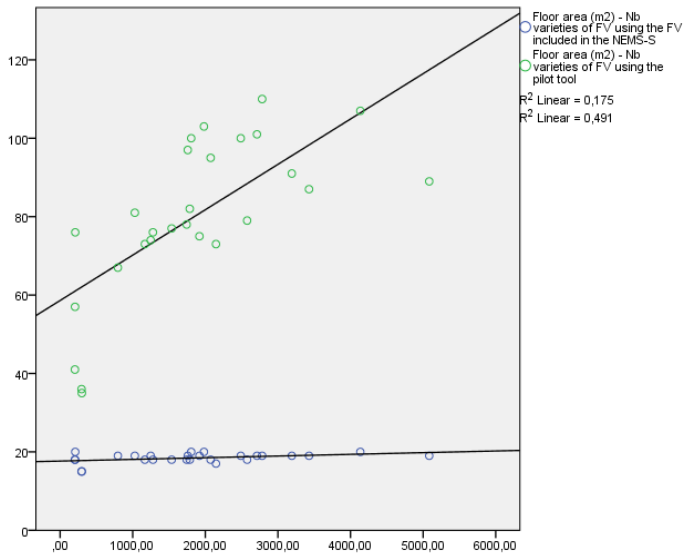


Figure 12: Scatter plots showing the relationship between floor area and the number of varieties of fresh FV measured: a) when including only those included in the NEMS-S (bottom line); and b) using the pilot tool

Finally, Kendall's tau correlations were conducted to see whether the relationship between floor area and the number of FV varieties differed by neighborhood SES. Table 16 shows the correlation coefficient for both checklists by SES area. The number of varieties of fresh FV was not significantly related to floor area except for the pilot tool in stores in higher SES areas ($\tau = .567$, $p < .01$).

Table 16: Kendall's tau correlations for floor area and the number of varieties of fresh FV by SES area

		Floor area (m^2)	N varieties using the FV included in the NEMS-S	N varieties using the pilot tool
Lower SES areas	Floor area (m^2)	1.000	2.11	.576
	Correlation coefficient	.	NS	.005*
	p-value (1-tailed)	12	12	12
	N			
Higher SES areas	Floor area (m^2)	1.000	.000	.268
	Correlation coefficient	.	NS	NS
	p-value (1-tailed)	15	15	15
	N			

NS = Not significant (p > .05), *p < .01, **p < .001

7. DISCUSSION

7.1 Summary of findings

This pilot study consisted of measuring the availability of FV and snack foods in 27 stores in socioeconomically contrasting areas of Montréal using four types of shelf space measurements, two checklists of fresh FV and a physical audit of presence of FV and snack foods within end-of aisle displays and cash register queues. Overall, FV tended to be more available in stores in higher SES sectors while snack foods tended to be more available in lower SES areas. This thesis will also highlight four other main findings.

First, the quantity and diversity of FV and snack foods varied depending on the measure or audit tool used. Indeed, the availability of FV was greater in higher SES sectors when measuring shelf length and shelf surface but there was no difference for RSL and RSS. Additionally, there were more varieties of fresh FV in stores in higher SES sectors when using the pilot audit tool but no difference (only one variety) when counting solely the varieties included in the NEMS-S. As for snack foods, shelf length and shelf surface were greater in higher SES sectors whereas RSL and RSS were greater in lower SES sectors. Second, both quantity and diversity of FV and snack foods were influenced by store size. This was particularly observed for snack foods. Third, measuring the presence of FV and snack foods within end-of aisle displays and cash register queues provided information on the use of strategic promotional displays. Results showed that a higher proportion of end-of aisle displays offered snack foods in lower SES sectors. In both lower and higher SES areas, few end-of aisle displays offered FV and a majority of cash register queues displayed snack foods. Finally, store density was greater in lower SES areas but stores in higher SES areas were larger.

7.2 Interpretation of results and agreement with previous literature

Our results are inconsistent with previous literature on in-store measurements of FV and snack foods according to the neighborhood SES. This section will discuss further the results and report on similarities and discrepancies with the literature regarding the four main findings: 1) the availability of FV and snack foods including shelf space measures and checklists of fresh FV; 2) the

relationship between availability of food items and store size; 3) exposure to FV and snack foods within special displays; and 4) store and density of stores.

7.2.1 The availability of FV and snack foods according to the neighborhood SES

This section will interpret results and compare them with previous literature regarding the use of: a) shelf space measures; and b) checklists of fresh FV.

a) Shelf space measures

Our results showed that shelf length and shelf surface of fresh, canned and frozen FV were 1.6 to 2.14 times greater in higher SES areas while there was no difference for RSL and RSS. Considering that stores in higher SES sectors were 2.25 larger than those in lower SES areas, shelf length and shelf surface of FV were therefore on average proportional to floor area. As for snack foods and particularly soft drinks, shelf length and shelf surface were 1.49 to 1.72 times greater in higher SES areas whereas RSL and RSS were greater in lower SES areas. Accordingly, although stores in lower SES areas were smaller, they allocated similar shelf length and shelf surface of snack foods (and soft drinks) as that in higher SES areas, which is of concern because the impact of exposure may be greater for residents of lower SES areas.

Among the studies published since 2007 on the availability of food items according to neighborhood SES, only three included shelf space measurements, two of which took place in Québec. In Montréal, Bertrand et al[23, 82] measured fresh FV surfaces in 501 stores and public markets offering fresh FV excluding pharmacies, kiosks, gas stations and some discount stores. They calculated access to fresh FV using an index that combined the proportion of households owning at least one car and total selling surface of FV within a radius of 500 m (walking distance) and 3 km (motorization distance) from the centroid of DAs. In the area of Québec City, Pouliot et al[27] assessed shelf space (length x width) of fresh FV using a proxy measure in 144 stores including convenience stores, grocery stores, supermarkets, superstores, greengrocers, natural food stores and delicatessen. Lastly, in Sydney, Australia, Vinkeles et al[50] measured shelf surface (length x height) of snack foods in proportion to the store's total shelf surface in nine chain supermarkets.

Contrary to our results, none of the three studies found a relationship between availability and neighborhood SES. This departure could be due to differences between countries as well as methodology such as use of store type, socioeconomic indicators and measurements methods. First, although the national context can obviously not explain the differences between our results and the studies in Quebec, it could partly account for those with Vinkeles et al. However, the latter also only included nine stores, which limits generalization to other stores and might not be powered enough to detect difference by SES area. Second, Bertrand et al[56] and Pouliot et al[27] included several types of stores in addition to supermarkets and grocery stores. While this may provide a more representative overview of fresh FV availability, the authors did not report exposure by socioeconomic level for each type of store, which makes comparisons between studies difficult. It is possible that greengrocers and ethnic shops in some deprived areas compensated for the lower availability of FV in supermarkets observed in our study. Consequently, Bertrand and Pouliot remind us the importance of examining the whole food store environment when describing overall availability of food items within a neighborhood. Although this was not our objective, we have to remember that supermarkets represent only 8.3 % of total food retailers in Montréal[71] and that 25 % of Montrealers purchase fresh FV in greengrocers.[83] Moreover, nontraditional food retailers including pharmacies, general merchandise stores (e.g. Wal-Mart) and wholesale retailers (e.g. Costco) now account for 23 % of food purchases in the province.

Third, while we used indicators of both material and social deprivation, Bertrand et al[56] only used income while Vinkeles et al[50] used income, education and occupation. As for Pouliot et al[27], although they used the same index as we did, they used the original matrix of nine levels of deprivation *(Figure 4)* whereas we only included the extreme levels and grouped them into two categories. The nine categories probably better reflect the actual SES, but dividing our 27 stores into nine would have resulted in a lack of statistical power. Furthermore, it was not clear which administrative level of deprivation Pouliot et al used within their study, which makes again comparisons difficult. Only 13 areas were included in their study, which is not much if these were representative of nine levels of SES. Table A in Appendix G lists the socioeconomic indicators that have been used in studies published since 2007 on in-store availability of FV and snack foods according to the neighborhood SES. All studies used income or poverty line as a poverty indicator. However this was the only indicator in US studies[5, 44, 48, 51-53, 55] while studies in Québec[25, 27, 56] and Australia[47, 50, 62] also used information on education and employment/occupation. Only Pouliot et al incorporated social deprivation. Consequently, while US studies can be more easily compared to

each other in terms of SES (though the administrative might differ), we need to be more careful in making comparisons with Québec and Australian studies given the range of socioeconomic indicators used. The impact of the choice of socioeconomic indicators on the selection of areas becomes an essential issue in ecological studies. It will be further discussed in the limitations of this study.

Lastly, shelf space measurements were carried out differently. Bertrand et al[56] measured selling surfaces with footstep estimation around FV displays and converted them into squared feet. Although this is less intrusive than using a measuring tape or wheel, it is also less accurate and it doesn't account for the height of displays. Furthermore, they did not compare availability of FV itself but combined with car ownership rates and geographic access. This is in a way more comprehensive than single measures of shelf space. Pouliot et al[27] did not measure the height of displays either nor did they provide details on their proxy measure. As for Vinkeles et al, they measured the height of all displays but what they did for flat surfaces is unclear since height was not relevant. Additionally, while the latter calculated ratios to total shelf surface, we calculated ratios to floor area. The first is likely to be more accurate since it accounts for all displays but pilot tests conducted in Montréal by the author showed that measuring it was not realistic since it required more than 3 hours per store. In addition to it being physically challenging, the author felt that it carried the generosity of store managers beyond the proper limit.

b) Checklists of fresh FV

This study tested the use of two lists of fresh FV: the 20 types of FV included in the NEMS-S and a pilot tool developed by the author that includes 135 varieties. Results showed a difference of only one variety (5 %) by SES area when using the first one, which is not significant from a practical perspective. On the other hand, the author recorded 21 more varieties in stores in higher SES sectors (16 %) using the pilot tool. This suggests that a large number of FV need to be examined to detect differences between lower and higher SES areas. As far as the author is aware, six other research groups[27, 47, 48, 51-53] used checklists to compare the availability of FV by SES area. Of these, one[48] used the NEMS-S, three[51-53] modified the latter (without changing the section on FV) and three[27, 47, 54] developed their own tool. Five[47, 48, 52-54] recorded a greater availability in stores in higher SES, one[51] observed the opposite and one[27] found no difference.

Four scholars, all from the US, used the NEMS-S or modified it. In Atlanta, Glanz et al[48] tested the NEMS-S in 24 grocery stores and 61 convenience stores. In Baltimore, Franco et al[52] used a modified version of the NEMS-S in 226 stores including supermarkets, grocery stores, convenience stores and food stores in which food is displayed behind bulletproof glass. In Florida, Leone et al[53] also modified the NEMS-S and tested it in 73 stores including supermarkets, grocery stores and convenience stores. While we detected no difference by SES area using the FV that are part of the NEMS-S, all three concluded that fresh FV were more available in higher income neighborhoods compared to lower ones. More specifically, while we observed a 5 % difference, which is very little, Glanz et al observed 22 % more fruit and 17 % more vegetables in high-income areas. This could however be due to the inclusion of convenience stores in Glanz's et al study , which accounted for 72 % of stores and offered 2.43 times less fruit and 28.0 times less vegetables than grocery stores. Availability of FV was also strongly associated with store type in Leone's et al study. These two studies are hence hardly comparable to ours due to the inclusion of more types of food outlets. However, similar to our findings, Franco et al did observe a greater availability of fresh FV in supermarkets in high-income areas compared to those in low-income areas. As for the fourth study, Andreyeva et al[51] used a modified version of the NEMS-S in 73 stores in Connecticut including supermarkets, grocery stores, convenience stores, drug stores and food marts. Surprisingly, they found a greater availability of FV in low-income neighborhoods. They explained this finding with the greater presence of drug stores and food marts in high-income neighborhoods, which did not generally offer fresh produce and therefore reduced the overall presence of fresh FV in these areas.

In addition, three groups developed checklists similar to our pilot tool. In Québec City, Pouliot et al[27] developed a list of 37 varieties of fruit and 38 varieties of vegetables. Contrary to our results, they did not detect a difference by SES area, which as previously discussed is incomparable due to differences in inclusion criteria and deprivation measure. In Australia, the Cancer Council of New South Wales examined the number of varieties of 30 types of fresh FV in 150 stores[54]. Similarly to our findings, a greater availability of FV was observed in higher SES areas. However, it is unclear if the stores included other types in addition to supermarkets. Lastly, another perspective developped by Ball et al[47] in Melbourne, Australia, was to examine FV availability at an area level. Using a list of 14 fruit and 23 vegetables in 50 FV stores and 71 supermarkets, they counted the number of varieties of each FV included in the list and compared total availability of each by the neigborhood SES. Although this study is not comparable to ours, they found that a third of FV tallied was more

prevalent in stores in higher SES areas compared to lower and mid ones.

7.2.2 The relationship between availability of food items and store size

Our study showed that shelf length and shelf surface of FV and snack foods were influenced by the size of the stores independently of the neighborhood SES. Indeed, in both lower and higher SES areas, shelf space of snack foods increased similarly and continually as floor area increased. As for FV, shelf space increased as floor space increased but to a certain limit, suggesting that contrary to snack foods, shelf space of FV is not indefinitely extensible. Thus, building extra large could increase the availability of snack foods but not FV. As for the number of varieties of fresh FV, only the ones recorded in higher SES areas using the pilot tool were associated with floor area. A potential explanation is that the 20 FV included in the NEMS-S are common ones. They were hence offered in almost all supermarkets and grocery stores. By including a larger number of varieties, the pilot tool might be more sensitive to the size of the stores and the neighborhood SES. The extra number of varieties in higher SES sectors could have made the difference between the relationship with floor area and the number of varieties in lower and higher SES sectors.

Numerous studies[5, 27, 42, 44, 48, 52, 53] have measured the availability of food products by store type. In general, availability is higher in supermarkets compared to convenience stores, which are normally smaller. Very few publications looked at the relationship between availability and store size. In 1986, Sallis et al[44] found a positive correlation between the number of low-fat and low-sodium items tallied using a checklist and the size of the stores. Recently, Krukowski et al[55] found no association between store size and the NEMS-S score for healthy food. Both researchers did not explain how they assessed store size. In addition, the NEMS-S includes not only information on availability but on price and quality as well. To our knowledge, no study looked specifically at the availability of FV and snack foods according to store size.

7.2.3 Presence of snack foods within special displays according to the neighborhood SES

Our study found that 15 % more end-of aisle displays offered snack foods in stores in lower SES sectors (Mdn : 34 %) compared to higher SES sectors (Mdn = 19 %). There was no difference for FV. A majority of cash register queues offered snack foods in most stores in lower and higher SES areas. As far as the author is aware, only one other study in Australia by Thornton et al[62] investigated the availability of snack foods within end-of aisle displays and cash registers. There is yet to be a similar one published on FV exposure. The presence of categories of snack foods that are similar to the ones we used was assessed in 35 supermarkets in socioeconomically contrasting urban areas in Melbourne. SES indicators included income, education, employment and car ownership. The researchers found for all stores a median of 38 % for front-of displays with snack foods (end-of aisle displays next to the cash registers) and a median of 33 % for back-of aisle displays. These are similar to those we calculated for stores in higher SES areas. However, contrary to our results, there was no difference by SES area. As for cash registers, similarly to our results, Thornton et al did not detect a difference by SES area. Nevertheless, snack foods were displayed at all cash registers in all stores but five, which is more than what we observed. The greater exposure to snack foods within these special displays and the absence of disparities by SES area for end-of aisle displays could potentially be explained by country difference. Additionally, while we measured exposure by cash register queue, Thornton et al examined displays by cash register, which may potentially underestimate exposure. This is a noticeable difference since displays around one cash register are part of two different queues *(see image in Appendix F)*. Finally, we only recorded food items representing at least one quarter of a display. It is unclear whether Thornton et al identified food items if there was only one unit or by proportion of space, and thus could have overestimated the availability of cash registers with snack foods compared to our study.

7.2.4 Density and size of stores according to the neighborhood SES

Our study illustrates differences in urban planning between lower and higher SES areas. Indeed, although a similar number of supermarkets were found in both lower and higher SES areas, store density was smaller in higher SES areas given the greater total land occupied by the latter. On the other hand, stores located in these areas were on average more than twice larger. Seven of the ten

largest stores were located in the West Island. Considering that the population density is 190 % greater in lower SES sectors, it is possible that land is scarcer and/or more expensive in the latter, which could explain the smaller size of the stores. Also worthy of note is the fact that sectors in the West Island are far from the city center and are generally newer. When the concept of large supermarkets and superstores was introduced in Montréal during the late-80's and the 90's[84], it is possible that more land was available in the West Island and thus more large stores were implemented there. Additionally, considering that large supermarkets are often located outside the main areas, the fact that more than 90 % of households in almost all neighborhoods of the West Island have at least one car compared to about 60 % to 70 % in lower SES areas might have influenced decisions regarding location of supermarkets.

Contrary to our results, two systematic reviews[21, 85] concluded that lower SES areas lacked supermarkets compared to higher SES areas. However, these results were mainly from the US, which have different zoning and city planning regulations than in Canada. Two Canadian studies found similar results to ours, which supports the idea that the food store environment is partly country specific. In Ontario, Latham et al[26] observed a greater number and density of stores in lower SES areas, and in Québec City, Drouin et al[25] found a slightly greater number of grocery stores and supermarkets in highly materially deprived areas. As for comparisons of store size by SES area, results are few and contradictory. Similarly to our results, Glanz et al[48] noted a greater presence of small grocery stores (1-2 cash registers) in low-income neighborhoods in Atlanta. On the other hand, in urban areas of Québec City, Drouin et al[25] observed no difference in the distribution of grocery stores (< 743 m^2), supermarkets (743-2.787 m^2) and superstores (2.787-9290 m^2) according to material deprivation. In Vermont and Arkansas, Krukowski et al[55] found no relationship between household median-income and store size, which was defined by the number of cash registers. None reported the mean size of stores.

What is striking is the range of definitions of stores that have been used, which makes comparisons difficult between studies. Table B in Appendix G shows examples of definitions of supermarkets and grocery stores that have been used in studies on the in-store food environment. Criteria included various cut-off values of floor area (m^2) and number of cash registers, as well as information on ownership (independent or chain), presence of specific food items and sales data. Only two studies[27, 53] used definitions from governmental sources. The use of different selection criteria can potentially act as a selection bias since the same store can be classified into different categories. For

instance, while a store with a floor area of 300 m^2 would be considered as medium or large by Farley et al[42] depending on the number of cash registers, it would be too small to be included by Pouliot et al[27]. Furthermore, using data from our study, a scatter plot of floor area by the number of cash registers showed that these measures are positively correlated but not replaceable by each other (R^2 = .68).

7.3 Strengths and limitations of this study

7.3.1 Strengths

As far as the author is aware, this study is the first to depict in-store food exposure using shelf space measurements, checklists of FV and audits of special displays. Its main strength is that it quantified public health knowledge on disparities in access to food by using not only measures on quantity, diversity and location within the stores but also multiple measures of each of the latter, which required a significant amount of work. It showed that the use of multiple methods to assess in-store food availability is necessary. Additionally, this study is also the first to fully audit food items placed within end-of aisle displays and cash register queues in supermarkets and grocery stores in North America.

Three strengths also worthy of note are the use of well-defined food categories, standard definitions of stores and well-established socioeconomic indicators. Food categories were based on health recommendations, nutrient composition and data on consumption. For each category, the items that were included and/or excluded were specified. Snack foods for which the classification of being "healthy" or "unhealthy" is inconsistent were excluded. Given that the author still faced some hesitation for some products, the food categories could even be defined more precisely. As for the socioeconomic indicators, the selection of areas was based on the Deprivation index for health in Canada, which has been developed by the Québec National Public Health Institute[66]. The index is also used by the Canadian Institute for Health Information and it has been used in two studies on the in-store food environment in Montréal and Québec City[25, 27, 57].

7.3.2 Limitations

This study has also several limitations regarding: a) the selection of areas, stores and shelf space measures; b) the measurements; c) the study design; and d) the literature search.

a) Selection biases

There were important selection biases regarding the choosing of the neighborhood areas, stores and shelf space measures. Biases concerning the selection of the areas include the assumption according to which people shop within their area of residence and the use of socioeconomic indicators that might not be associated with food purchase and intake. Biases in the selection of supermarkets and grocery stores include the possibility of having missed some stores, the over-representation of chain stores and the inclusion of small stores. Lastly, other dimensions of shelf space could have been measured.

First, sectors were used as proxies for area with the assumption that people buy food within their sector of residence. This might be not an adequate reflection of one's food purchasing environment. For instance, in a US study, only 51 % of households bought milk within the zip code where they lived.[33] Second, a few lower and higher SES sectors were located next to each other, making it possible for residents within higher SES sectors to purchase food in stores in lower SES sectors and vice-versa. Third, stores located in deprived DAs within higher SES sectors were excluded as well as those located in advantaged DAs within lower SES sectors. While this aimed at controlling for the range of SES within each sector, it could be inappropriate since stores that were excluded this way can be visited by people living in the same sector. Similarly, stores on the other side of a sector boundary were excluded although they were accessible to residents of the sector. To account for this, Andreyeva et al included not only all stores within the selected areas but also within a half-mile or one-mile buffer around the boundaries.[51] Lastly, few sectors were included, which limits the generalization of results to the whole island of Montréal. On the other hand, selecting more sectors would have reduced the socioeconomic contrasts between these. Two lower SES sectors were particularly not well represented due to high rates of refusals. This might have improved or worsened overall exposure to FV and snack foods in lower SES areas.

Second, although the Deprivation index for health in Canada is used by the Québec health sector, it does not measure deprivation at the individual level. Moreover, the inclusion of social deprivation is ambivalent. Indeed, it has been argued that deprivation is both material and social.[68] However, material deprivation might have a stronger impact on food purchase compared to social deprivation. In Québec, of the studies on the in-store environment of which the author is aware, one only used income[56], one used material deprivation[25] and one used both material and social deprivation[27]. Although it is not possible to say if one is more appropriate than another, the choice of indicators strongly influences the selection of areas. For example, if sectors would have been chosen according to material deprivation, then only five out of each of the respective study sectors would have been eligible.

Third, the sample of stores chosen for the study might not represent all supermarkets and grocery stores located in the selected sectors. Although these were identified using Internet resources and verified by on-site observations, there might have been false negatives illustrating that some stores could have been present in the field but absent via the Internet. Stores that were observed in the field were taken into consideration but others could have been missed since sectors were not systematically driven or walked. In addition, independent stores might have been under represented since there were only two (7 %) in the samples but in reality, they represent 46 % of supermarkets and grocery stores in Montréal.[71] Nonetheless, a study conducted in Montréal showed that Internet tools are quite reliable to identify grocery stores and supermarkets.[86] As for the independent stores, it is possible that many have a floor area < 200 m^2, making them not eligible for the study according to inclusion criteria.

Fourth, according to the Food and Agriculture Organization of the United Nations (FAO), supermarkets are defined as having a floor area of 400-2.500 m^2 and at least 70% of floor space for food products. Hypermarkets have a floor space ≥ 2.500 m^2 and at least 35% of floor space for food products. Following this, the five smaller stores that were audited were too small to be categorized as supermarkets and seven stores were too large although they offered mainly food products. The author decided to include them anyway to represent the diversity of supermarkets and grocery stores in Québec. Furthermore, independent *t* tests and Mann-U Whitney tests carried out excluding the five smallest stores provided similar results compared to analyses including all stores. The only exception was the presence of snack foods within end-of aisle displays that became insignificant

when excluding the small stores. Nevertheless, the author believes that the five small grocery stores should be included since they exist and contribute to the local food availability.

Finally, shelf depth and the number of shelves were not considered for this study. Shelf depth had been considered by Vinkeles et al[50] but ignored since it had the same value in all stores. The omission of measuring shelf depth and the number of shelves has also been identified as a limitation of studies[27, 42]. Nevertheless, after having conducted a pilot test, the author came to the conclusion that both measures would be inappropriate because they misrepresent food exposure. First, the consumer is only exposed to the first row of products. Considering shelf depth would thus overestimate the availability of some food items and underestimate the availability of others. As for the number of shelves, it is only reflective of product height, which does not contribute to overall exposure. Indeed, two similar sections of an aisle (same length and height) but containing a different number of shelves would have different values for exposure yet surface exposure would be the same. Lastly, food displayed at the entrance of the stores before the selling area were not included, which might have underestimated exposure of snack foods and FV.

b) Measurement biases

Measurement biases include the use of measures and tools that were not validated as well as the possibility of under- or overestimating shelf space, the number of varieties of fresh FV, the proportion of special displays offering FV and snack foods and floor area. First, the second recorder was minimally trained and no inter-reliability test was conducted. This might have resulted in a lack of consistency in the measures and a low internal reliability. Nevertheless, the supervision of all shelf space measures by the author, the performance of audits of special displays by the latter alone and the double-checking of the pilot tool of fresh FV should have limited the impacts of a lower internal reliability on results. Second, food items might have been omitted when measuring shelf space, the number of varieties of FV and exposure at special displays. Moreover, the presence of non-food items within food products and the presence of empty spaces between shelves when measuring height could have overestimated shelf space of FV and snack foods. Finally, floor area was measured with the assumption that it was squared, which was often not exact. More sophisticated techniques such as laser measurers (e.g. Stanley FatMax Tru Laser) could provide a better estimate of store size.

c) Study design

The ecological and cross-sectional study design cannot address causality, does not provide information at the individual level and captures information at a single point in time. Nevertheless, test-retest reliability assessments carried out within four weeks suggest that food availability is stable over time.[5, 48] Moreover, tests on end-of aisle displays showed that the presence of total snack foods remains stable despite the dynamic nature of these displays.[62]

d) Literature search

The literature search was restricted to one database (PUBMED) and reference tracking of studies published from 2007. Older articles, additional databases such as Cochrane, CINHAL and AGRICOLA, as well as other search strategies including handsearching key journals, citation tracking and searching the grey literature would have increased the representativeness of the existent literature and thus provided a more comprehensive view of the methodology used and improved the accuracy of comparisons between previous studies and ours.

7.4 Futures studies and implications for public health practice

7.4.1 Recommendations for future studies

Recommendations for future studies include conducting multi-level studies, using better definitions of study areas and stores, using combined measures to examine in-store food availability, selecting appropriate socioeconomic indicators, developing time efficient tools, undertaking cost-effectiveness analysis, and examining consumer behaviors and decisions taken by store managers.

First, multi-level studies combining ecological studies with information at the individual level enable the examination of the interaction between these two. Information needed on consumers include age, sex, ethnicity, deprivation level, food preferences, proximity to stores, reasons for choosing a store and mean of transportation. As for the food environment, combinations of

geographic access studies with information on in-store food availability, quality and price would give a better picture of food access. Food price is particularly relevant since in 2007-2008, in the greater Montréal, 9 % of persons in households were food insecure, meaning that they compromised food quality and/or quantity because of unavailability or uncertainty of having sufficient funds.[87]

Second, to determine the effect of the selection of an area on results, food availability could be compared using various administrative levels of areas. Moreover, the use of buffer zones around boundaries could partially account for the fact that people can shop nearby their area of residence. As for stores, although definitions are likely to be country specific, standardized sources such as NAICS[70], FAO/WHO[72] or MAPAQ (for Québec)[88] should be prioritized. Additionally, to improve representation of the overall food retailer environment, traditional and nontraditional retailers should be included. Results should be reported by SES area for all stores as well as by store type.

Third, examination of the in-store environment should be conducted using measures on quantity (shelf space), diversity (number of varieties), location (special displays) and floor area. Shelf space and the number of varieties are not replaceable by each other. Indeed, using data from our study, a scatter plot illustrating the relationship between the number of varieties of fresh FV (pilot tool) and shelf length and shelf surface of fresh FV showed that shelf space does not explain all variation in the number of varieties (R^2 = .78 for both shelf length and shelf surface). In addition, scholars need to be aware of the type of information the tools provide as well as their limitations. For instance, shelf length is the most common and simple shelf space measure but only represents one dimension of displays. By adding information on shelf height or shelf width, the author believed that shelf surface would be more accurate. Nevertheless, shelf length and shelf surface constantly provided similar results, as well as RSL and RSS. The extra time and effort spent on measuring height and width are therefore not justified. As for choosing between shelf length/surface and RSL/RSS, the constant differences between these suggest that they provide complementary information. Indeed, while shelf length provide information on absolute exposure (total exposure in a store), RSL and RSS give information on availability relatively to floor area (the chance that a costumer might be exposed to a food product considering the size of the store). Thus, both absolute and relative measures are necessary to depict accurately shelf space of products.

As for checklists of fresh FV, the NEMS-S is suitable for Québec since the most consumed and sold FV in the province are almost the same as the ones that are included in the NEMS-S.[13, 89] Nevertheless, the inclusion of only very common FV might not be sufficient to detect differences by

SES area. Results with our pilot tool suggest that more varieties are needed. Moreover, further work is required to improve the pilot tool and validate it. Researchers need to be aware that including all varieties of FV would be demanding and time-consuming. Furthermore, trials without using a checklist showed that checklists are essentials. Indeed, for the benefit of Thornton et al, the author counted all varieties of fresh FV including different colors, companies and if they were organic or not, which could exceed 300 in a single store. Given that some FV were displayed at various locations, it was almost impossible to remember which one had been previously counted, which overestimated FV diversity. Lastly, measuring the proportion of end-of aisle displays and cash register queues offering FV and snack foods only takes a few minutes and provides information on the presence of food items at strategic locations.

Fourth, socioeconomic indicators should be selected according to the study population and the specific activities that are under study. To examine their effect on results, various indicators should be tested including median household income, indicators of material deprivation and indicators of both material and social deprivation.

Fifth, one of the main barriers of this type of study is that it is time-consuming. Indeed, in addition to travelling time, conducting the audits required more than two hours in most of the stores. Thus, there is a need to develop tools that do not only include various measures but that are also time efficient. Furthermore, a cost effectiveness analysis would provide information on the feasibility of similar studies regarding material and human resources.

Finally, one question this study underlies is whether food availability is influenced by customer demand or food retailers. While costumers can have a powerful impact on stocking decisions, retailers are also strongly influenced by profitability, space maximization (highest profits for minimal space) and supplier recommendations.[90, 91] Besides, Hawkes[92] argues that supermarkets simply want costumers to buy more no matter the food. The greater exposure to snack foods and the relative limited availability of FV might influence food preferences and consumption habits of residents from deprived areas. More research is needed to understand the impact of availability on consumers and interviews with food stores managers and chain head offices could give insights on stocking decisions and the perception these have of their role in health promotion.

7.4.2 Implications for public health practice

Recommendations for public health practice include modifying the store content, conducting education interventions and distributing vouchers to encourage the purchase of healthy foods.

First, to encourage a healthier diet, especially in deprived areas, a potential solution is to increase shelf space and the number of varieties of fresh FV and to reduce shelf space of snack foods. Moreover, given the strong presence of snack foods and the limited presence of FV within cash register queues and end-of aisle displays, changes must be done in both SES areas. This requires the support of research, store managers, costumers, public health practitioners and government bodies. Managers and chain offices need to be convinced of their role in public health and be involved in public health decisions bearing in mind that interventions need to be profitable to them as well. The removal of candies from cash registers in some food retailers in the UK has shown that actions in this direction are possible[91]. Furthermore, increasing the availability of healthy fresh produce in small stores and/or promoting them in or outside the stores can increase sales and frequency purchase as well as consumers' knowledge about food and health.[93]

Second, though not new, education interventions such as informative sessions, cooking classes, in-store activities and mass campaigns to residents of deprived areas and to the general population can improve self-efficacy in buying FV, increase demand for the latter and increase pressure to reduce exposure to snack foods in supermarkets and grocery stores. Additionally, teaching shopping tips such as using a shopping list, shopping more frequently, avoiding the unnecessary aisles, limiting the amount of time in stores and paying cash could help consumers resisting to snack foods since all these behaviors are associated with a smaller likelihood of making unplanned purchases[60].

Lastly, a system of vouchers for lower SES populations such as the WIC vouchers in the US can increase the demand for healthy products. The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC)[94] distributes coupons and vouchers every month for the purchase of specific healthy foods including FV. Receivers are people at nutritional risk of which many are from deprived areas. A before-after study in corner stores showed that demand for FV, low-fat milk as well as whole grain bread and cereals increased when vouchers became accepted in the latter.[90]

8. CONCLUSION

This study examined the availability of FV and snack foods in supermarkets and grocery stores in socioeconomically contrasting areas of Montréal using measures on quantity, diversity and special displays. It highlights the presence of disparities in the availability of FV and snack foods between lower and higher SES areas as well as the necessity of assessing availability using a comprehensive set of measures. There is also a need to improve the selection of areas, stores and socioeconomic indicators as well as the audit tools themselves. Moreover, multi-level research that combines information on consumers, geographic access to stores and the in-store environment is required to understand further the interaction between these.

Creating supportive environments across the social gradient is essential to change social norms, give access to adequate food to all, facilitate healthier choices, and empower individuals and communities to adopt a healthy diet.[6, 95, 96] This includes the building of healthier food store environments, which requires support from costumers, food retailers, public health practitioners, government bodies and research. The involvement of store managers and chain head offices in public health decisions is particularly important as well as costumer demand and pressure. The latter could be stimulated through education interventions and the distribution of vouchers for healthy food products. Finally, to examine further the underlying causes of diet inequalities and to conduct appropriate initiatives in the field, the overall food store environment needs to be taken into consideration including traditional and nontraditional food retailers.

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APPENDIX A

Literature search

MEDLINE via Ovid on 21 April 2012 for the period 2007 to present (21/04/2012):

1. (((supermarket$) OR grocery) OR food store) AND („2007“[Date – Publication] : „3000“[Date – Publication]) → 1.136 results

2. ((((availab$) OR shelf) OR variet$) OR market basket$) AND („2007“[Date – Publication] : „3000“[Date – Publication]) → 3.021 results

3. (((((food access) OR food security) OR socioeconomic) OR deprivation) OR income) AND („2007“[Date – Publication] : „3000“[Date – Publication]) → 7.064 results

4. ((((((fruit) OR vegetable$) OR snack food$) OR healthy food$) OR unhealthy food$) OR unhealthy snack$) AND („2007“[Date – Publication] : „3000“[Date – Publication]) → 54.405 results

5. (#2) OR #3 → 79.026 results

6. ((#1) AND #4) AND #5 → 189 results

APPENDIX B

Consent letter in French and in English

LETTRE DE CONSENTEMENT

Participation à une étude dans des épiceries à Montréal

<u>À l'attention du gestionnaire du commerce ou d'un employé responsable</u>

Bonjour,

Vous êtes invité à participer à un projet de recherche sur la disponibilité des aliments dans les épiceries à Montréal. Cette étude est entreprise par Laurence Blanchard, étudiante à la maîtrise en santé publique à l'Université de Copenhague, Danemark.

AUCUNE PHOTO NI EXTRAIT VIDÉO NE SERONT PRIS. De plus, l'adresse et le nom des épiceries ne seront pas identifiés dans les résultats.

Le but de cette étude est de comparer la disponibilité de certains aliments entre différents quartiers de Montréal. En acceptant de participer, vous nous permettez de mesurer à l'aide d'une roue et d'un ruban à mesurer l'espace dans votre magasin qui est alloué aux fruits, légumes, boissons gazeuses, chocolat, croustilles et bonbons. Le nombre de variétés de ces derniers sera également compté, et leur présence aux extrémités des allées et aux caisses sera notée.

Toutes les informations recueillies demeureront confidentielles et anonymes. Votre participation est volontaire et ne demande aucune implication de votre part ainsi que de celle de vos clients. Les chercheurs responsables ne reçoivent aucun bénéfice financier. Les résultats pourraient être publiés dans un journal scientifique, mais sans identifier les épiceries. Finalement, certaines informations seront partagées avec une équipe de recherche Australienne dans le cadre d'un projet international.

Vous pouvez refuser de participer à tout moment. Si vous avez des questions, contactez :

Laurence Blanchard : zdh315@alumni.ku.dk

Chalida Svastisalee, PhD, Institut national de santé publique (Danemark) / Statens Institut for Folkesundhed) : chsv@niph.dk; Tél : +45 6550 7847.

Signature au verso ➔

Votre signature sur cette lettre de consentement indique que vous acceptez de participer à cette étude. Une copie de cette lettre vous sera remise que vous acceptiez de participer ou non. La copie signée sera conservée par la chercheure.

J'ai lu cette lettre de consentement et j'ai obtenu des réponses à toutes mes questions. J'accepte de participer à ce projet de recherche.

Nom en lettres moulées : _____

Signature: _____

Date: _____

CONSENT LETTER

Supermarket Audit Study in Montréal

Dear manager or employee,

You are invited to participate in a study about food availability in supermarkets in Montréal. This project is conducted by Laurence Blanchard, student in a Public Health Master program at the University of Copenhagen, Denmark.

Participation in this study is voluntary and does not require time nor contact with any employee or costumer. NO photographs or videos of the store will be taken.

If you agree to participate, you would allow us to take measurements of shelf space using a measuring wheel and a measuring tape. The availability and the number of varieties of fruit and vegetables, soft drinks, chocolate, chips and confectionary would also be noted. All information about your store will be anonymous and confidential.

There is no extra risk for your store and you to participate in this study. Moreover, this study could help Montrealers to improve their diet. The researchers will receive no financial benefit. Results are likely to be published in scientific journals, but without identifying the stores. Finally, some data will be shared with a research group in Australia for an international research project and will be kept anonymous and confidential again.

You have the right to refuse participation at any time. If you have any questions, please contact:

Laurence Blanchard : zdh315@alumni.ku.dk

Chalida Svastisalee, PhD, National Public Health Institute in Denmark/ Statens Institut for Folkesundhed): chsv@niph.dk; Tel: +45 6550 7847.

Your signature on this consent form indicates your agreement to participate in this study. You will be given a copy of this form to keep, whether you agree to participate or not. The second signed consent form will be kept by the researcher.

I have read the consent form and all my questions about the study have been answered.

I agree to participate in this study.

Print name: _____

Signature: _____

Date: _____

APPENDIX C

Student declaration for the School of Health and Related Research Research Ethics Review, University of Sheffield

School of Health and Related Research

Research Ethics Review
for Postgraduate-Taught Students

Form 1B: Student Declaration (for research that does not involve human participation or analysis of secondary data)

To be included in Appendices of dissertation

Research Project Title: Access to fruit, vegetables and snack foods in grocery stores and supermarkets in Montréal, Canada

In signing this Student Declaration I am confirming that:

My proposed project will **not** i**nvolve people participating in research either directly** (e.g. interviews, questionnaires) **and/or indirectly** (e.g. people permitting access to data).

My proposed project does not therefore require an ethics review and I have not submitted a Research Ethics Application Form.

Name of student: Laurence Blanchard

Signature of student:

Name of supervisor: Chalida Svastisalee, University of Copenhagen

Signature of Supervisor:

APPENDIX D

Description of shelf space measurements

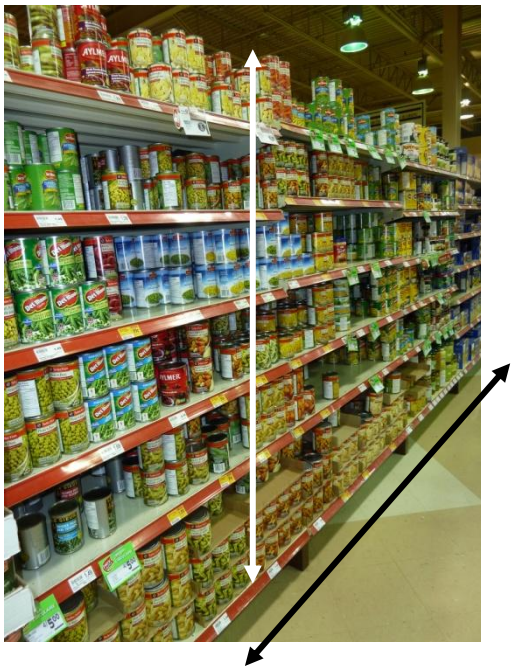


Figure 1: Measurement of shelf length and shelf surface for an aisle.

- Shelf length = Black arrow.
- Shelf surface = Length x height = Black arrow x white arrow.

Figure 2: Measurement of shelf length and shelf surface for any other vertical display.

It is measured for every side of the display containing FV or snack foods.

- Shelf length = Black arrow 1 + black arrow 2 + Black arrow 3.
- Shelf surface = Length x height of each section = Black arrow x white arrow of section 1+2+3.

Figure 3: Measurement of shelf length and shelf surface for approximately flat surfaces.

- Shelf length = for all sides of a display (white arrows added up).
- Shelf surface = Length of one side x width of another side = Dotted black x dotted black arrow.

APPENDIX E

Audit tool used to measure shelf space

Pilot tool to count the number of varieties of fresh FV (in French and in English)

Supermarket: _____ Date:_____ Auditor(s):_____

Audit tool to measure shelf space in grocery stores and supermarkets

Floor length: _____ m Floor width: _____ m

Food category:

A. Fresh FV
B. Canned FV
C. Frozen FV
D. Candy and chocolate
E. Chips
F. Soft drinks

A: Aisle B: Island vertical C: Island horizontal	Length/ Circumference (m)	Height/ Width (m)	Total length (m)	Food category

A. Fresh FV
B. Canned FV
C. Frozen FV
D. Candy and chocolate
E. Chips
F. Soft drinks

A: Aisle B: Island vertical C: Island horizontal	Length/ Circumference (m)	Height/ Width (m)	Total length (m)	Food category

A. Fresh FV
B. Canned FV
C. Frozen FV
D. Candy and chocolate
E. Chips
F. Soft drinks

A: Aisle B: Island vertical C: Island horizontal	Length/ Circumference (m)	Height/ Width (m)	Total length (m)	Food category

Liste de fruits et légumes frais

Fruits

Avocat		Citron-mandarine		Litchi		Pêches	
Abricot		Clémentine		Longane		Poire	
Ananas		Coing		Mandarine		Poire asiatique	
Banane		Datte fraîche		Mangouste		Poire cactus	
Banane plantain		Figue fraîche		Mangue		Pomelo	
Banane-mini		Fraises		Melon d'eau		Pomme	
Bleuets		Framboises		Melon miel		Pomme grenade	
Canneberges		Fruit de la passion		Melons – autres*		Prunes	
Cantaloup		Fruit-Dragon (Pitahaya)		Mûres		Raisins	
Carambole		Goyave		Nectarine		Ramboutan	
Cerise		Grenadille		Noix de coco		Rhubarbe	
Cerise de terre		Kaki		Orange		Tamarillo	
Châtaignes		Kiwi		Oroblanco		Tangelo	
Cherimoya		Kumquat		Pamplemousse		Tangerine	
Citron		Lime		Papaye		Inconnu*	

Légumes

Ail		Chou chinois/nappa		Fèves germées		Pois mange-tout	
Artichaut		Chou fleur		Gombo		Poivron	
Asperge		Chou rave		Gourgane		Pomme de terre	
Aubergine		Collard vert/chou cava.		Haricot plat		Pousses asperge	
Bette à carde		Concombre		Laitue		Pousses pois	
Betterave		Concombre libanais		Luzerne		Pous. Pois mangetout	
Bok Choy		Courge buttercup		Mâche		Pousses tournesol	
Borecole		Courge musquée		Maïs		Radis	
Broco-fleur		Courge poivrée		Maïs – mini		Radichio	
Brocoli		Courge spaghetti		Navet		Rapini	
Brocolinni		Courges – autres*		Oignon		Roquette	
Cardon		Courgette		Oignon vert		Rutabaga	
Carotte		Cresson		Oignons – petits		Salsifis	
Céleri		Daikon		Pak-choi		Tomate	
Céleri-Rave		Échalotte française		Panais		Tomate cerise	
Champignons		Endive		Patate douce		Topinambour	
Chayotte		Épinards		Piment fort		Inconnu*	
Chicorée		Escarole		Pissenlit (Dandelion)			
Chou		Fenouil		Poireau			
Chou Bruxelles		Fève		Pois sucré			

* Inscrire le nombre de variétés excluant celles présentes dans la liste

List of fresh fruit and vegetables *(English translation – not used)*

Fruit

Apple		Fig (fresh)		Mango		Plum	
Avocado		Grapes		Mangosteen		Pomelo	
Abricot		Grapefruit		Melon – others *		Pomegrenate	
Banana		Grenadille		Nectarin		Prickly pear	
Banana – tiny		Groundcherry		Orange		Quince	
Blackberry		Guava		Oroblanco		Rambutan	
Blueberry		Honeydew melon		Papaya		Raspberry	
Cantaloupe		Kiwi		Passion fruit		Rhubarb	
Cherimoya		Kumquat		Peach		Star fruit	
Cherry		Lemon		Pear		Strawberry	
Chestnut		Lemon-mandarin		Pear – Asian		Tamarillo	
Clementine		Lime		Persimmon		Tangelo	
Coconut		Longan		Pineapple		Tangerine	
Cranberry		Lychee		Pitahaya		Water melon	
Date (fresh)		Mandarin		Plantain		Unknown*	

Vegetables

Acorn squash		Celery		Green onion		Rutabaga	
Alfalfa		Chard		Hot pepper		Salsify	
Artichoke		Chayote		Jerusalem artichoke		Scarole	
Aspargus		Cherry tomato		Kale		Snow peas	
Bean		Chicory		Leek		Spaghetti squash	
Bean – flat green		Chinese cabbage		Kohlrabi		Sprouts – aspargus	
Beet		Collard greens		Lamb's lettuce		Sprouts – bean	
Buttercup squash		Corn		Lettuce		Sprouts – pea	
Butternut squash		Corn – tiny		Mushroom		Sprouts – snow peas	
Bok Choy		Cress		Okra		Sprouts – sunflower	
Brocoli		Cucumber		Onion		Spinach	
Brocolinni		Cucumber – lebanese		Onions – tiny		Squash – others *	
Brussel sprouts		Daikon radish		Parsnip		Sweet potato	
Cabbage		Dandelion		Peas		Tomato	
Cabbage – nappa		Endive		Pepper		Turnip	
Cardoon		Eggplant		Potato		Zucchini	
Carrot		Escarole		Radish		Unknown *	
Cauliflower		Fennel		Radicchio			
Cauliflower romanesco		French shallot		Rapini			
Celeriac		Garlic		Rucola			

* Enter the number of varieties excluding the ones already listed

APPENDIX F

Audit tool from Thornton et al to measure exposure to FV and snack foods within special displays

- End-of aisle displays (question 3)
- Cash registers (question 8)
- Example of a filled audit for question 8 from this study with drawings indicating to which cash register displays costumers were exposed to while queuing.

3) Supermarket layout audit – length of aisle and end of aisle displays

Please record the product at the front (near register) and back of each aisle, plus aisle length.

Aisle Number If aisle is split, renumber as 1a, 1b, 2a, 2b, etc.	**Aisle length (m)** 3 same as previous	**Product: Front** **a)** reg soft drink **b)** diet soft drink **c)** chips **d)** chocolate **e)** confectionery **f)** fruit/veg **g)** non-snack item **h)** no end-of-aisle display	**Product: Back** **a)** reg soft drink **b)** diet soft drink **c)** chips **d)** chocolate **e)** confectionery **f)** fruit/veg **g)** non-snack item **h)** no end-of-aisle display
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

If store is non-standard in terms of shape/ setup draw a picture below to help indicate how you measured store size (e.g. total store length x width) and which side of the aisle you considered as the front and the back of store (if the aisles run parallel with the checkouts).

Aisle Number	Aisle length (m) **a)** same as previous **b)** last aisle	Product: Front **a)** reg soft drink **b)** diet soft drink **c)** chips **d)** chocolate **e)** confectionery **f)** fruit/veg **g)** non-snack item	Product: Back **a)** reg soft drink **b)** diet soft drink **c)** chips **d)** chocolate **e)** confectionery **f)** fruit/veg **g)** non-snack item
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			

8) Cash Register audit

Record the variety of products at each cash register display (note, one record per display, not per cash register)

Cash register display	Product **a)** reg soft drink **b)** diet soft drink **c)** chips **d)** chocolate **e)** confectionery **f)** kids toys
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Cash register display	Product **a)** reg soft drink **b)** diet soft drink **c)** chips **d)** chocolate **e)** confectionery **f)** kids toys
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

Cash register display	Product **a)** reg soft drink **b)** diet soft drink **c)** chips **d)** chocolate **e)** confectionery **f)** kids toys
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	

Example of a filled audit with drawings indicating to which cash register displays costumers are exposed to while queuing.

n.s = non snacic foods

8) Cash Register audit

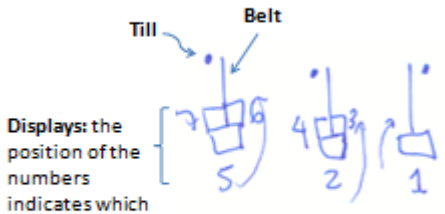
Record the variety of products at each cash register display (note, one record per display, not per cash register)

Cash register display	Product a) reg soft drink b) diet soft drink c) chips d) chocolate e) confectionery f) kids toys
1	n.s
2	n.s
3	n.s
4	d
5	n.s
6	n.s
7	n.s
8	n.s
9	n.s
10	n.s

Cash register display	Product a) reg soft drink b) diet soft drink c) chips d) chocolate e) confectionery f) kids toys
11	n.s
12	n.s
13	d
14	n.s
15	n.s
16	d
17	n.s
18	n.s
19	d
20	n.s

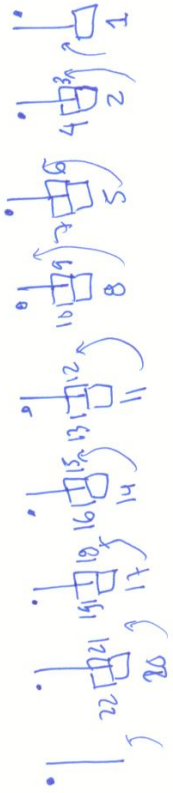
Cash register display	Product a) reg soft drink b) diet soft drink c) chips d) chocolate e) confectionery f) kids toys
21	n.s
22	d
23	
24	
25	
26	
27	
28	
29	
30	

Legend



Middle of the arrow: trajectory of a queue. The displays on the sides of an arrow belong to this queue.

E.g. of interpretation:
- *Arrow at the left (queue nb 1): includes displays 5, 6 and 4*
- *Arrow in the middle (queue nb 2): includes displays 2 and 3*
- *Arrow at the right (queue nb 3): includes display 1.*



APPENDIX G

Extra tables for the discussion section

Table A: Socioeconomic indicators used in studies published from 2007 on the in-store availability of FV and snack foods according to the neighborhood SES

Authors, year	Country	Income	% Living below poverty line	Education	Employ-ment	Others
Sallis et al, 1986[44]	USA	X				
Glanz et al, 2007[48]	USA	X				
CCNSW, 2007[54]	Australia	X		X	X	Occupation, car ownership, housing expenditure
Ball et al, 2008	Australia	X		X	X	Occupation, car ownership
Bertrand et al, 2008[56]	Canada (Montréal)	X				
Franco et al, 2008[52]	USA	X				
Pouliot et al, 2009[27]	Canada (Québec City)	X		X	X	% of population a) living alone; b) separated, divorced or widow; and c) single-parent families
Vinkeles et al, 2009[50]	Australia	X		X	X	Occupation, car ownership, housing expenditure
Krukowski et al, 2010[55]	USA	X	X			
Gloria et al, 2010[5]	USA	X				
Leone et al, 2011[53]	USA		X			
Andreyeva et al, 2012[51]	USA	X				
Thornton et al, 2012[62]	Australia	X		X	X	Occupation, car ownership, housing expenditure

Table B. Examples of definitions of grocery store and supermarket in studies on the in-store environment

Authors, year	Country	Definitions of grocery store or/and supermarket	Floor area	N cash registers	Owner -ship	Presence of certain food items
Sallis et al, 1986[44]	USA	2 categories: Supermarkets and neighborhood groceries, no definition.				
Cheadle et al, 1990[45]	USA	Grocery stores with ≥ 2 cash registers and carrying fresh produce and fresh meats.		X		X
Glanz et al, 2007[48]	USA	Small grocery store: 1 or 2 cash registers. No definition for grocery store.		X		
CCNSW, 2007[54]	Australia	Not defined				
Franco et al, 2008[52]	USA	4 categories adapted from the Standard Industrial Classification (SIC) - Supermarket: SIC codes + chain + annual payroll of > 50 employees. - Grocery stores: remaining of SIC codes for supermarkets - Convenience stores: SIC codes - Stores where food items are displayed behind bullet-proof glass and sold through a revolving window.	X		X	X
Farley et al, 2009[42]	USA	3 categories: - Small food store: Independent (non-chain) where primary items sold are foods and beverages + sales space < 200 m^2. - Medium-sized food store: Independent or chain where primary items sold are foods and beverages. + sales space ≥ 200 m^2 and ≤ 3 cash registers. - Supermarket: Independent or chain where primary items sold are foods and beverages and ≥ 4 cash registers.	X	X	X	X
Pouliot et al, 2009[27]	Canada (Québec City)	3 categories defined by Québec Ministry of Agriculture, Fisheries and Food[88]: - Grocery store: Average surface area < 743 m^2, designed to accommodate basic food needs for the area. * - Supermarket: Average surface area between 743-2.787 m^2. * - Superstore: Average surface area between 2.787-9290 m^2, offers food in self-service aisles and competitive low prices. A large amount of food supplies, general products and complementary services are available. *	X			X

Authors, year	Country	Definitions of grocery store or/and supermarket	Floor area	N cash registers	Owner -ship	Presence of certain food items
Rose et al, 2009[49]	USA	3 categories of full-time groceries (grocery sales ≥ 60% of total gross sales): - Small food stores: Sales < $1 million/year - Medium food stores: Sales of $1–$5 million/year - Supermarkets: Sales > $5 million/year				
Vinkeles et al, 2009[50]	Australia	Supermarkets in shopping centers belonging to the chains Woolworths or Coles (2 main chains in Australia)			X	
Krukowski et al, 2010[55]	USA	2 categories according to Morland et al[97]: - Supermarket: Large corporate chain store - Grocery store: Smaller, local and independent No definition for store size			X	
Gloria et al, 2010[5]	USA	Offers a full range of items from all food categories including fresh/raw products which require preparation for cooking (e.g. FV, raw meat)				X
Leone et al, 2011[53]	USA	3 categories defined by the Department of Agriculture and Consumer Services Florida Administrative Code[98]: - Supermarket: ≥ 5 cash registers and ≥ 1.394 m^2 * - Grocery store: ≤ 4 cash registers and < 1.394 m^2 *	X	X		
Andreyeva et al, 2012[51]	USA	Supermarkets and small stores with < 3 cash registers (so any number of cash register) that are not convenience stores, drug stores and food marts				

* Squared feet were converted into squared meters.