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SUPPLEMENT ARTICLE

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System mapping with adolescents: Using group model building to map the complexity of obesity

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Summary

Public health research and practice is increasingly employing systems thinking to help grapple with complex issues, from obesity to HIV treatment. At the same time, there is growing recognition that to address a given problem it is essential collaborate with those most at risk of or affected by it. Group model building (GMB), a process grounded in system dynamics, combines systems thinking and participatory methods to structure and address complex issues. As part of the CO-CREATE project we conducted GMB sessions with young people in six countries to create causal loop diagrams showing the factors that they believe drive obesity. This paper describes the background to GMB and the process we used to construct causal loop diagrams; it discusses how GMB contributed to generating noteworthy and useful findings, and the strengths and limitations of the method. Using GMB, we identified areas of concern to adolescents in relation to obesity that have so far had little attention in obesity research and policy: mental health and online activity. In using GMB, we also helped answer calls for a more participatory approach to youth involvement in research and policy development.

KEYWORDS
adolescents, complex systems, mapping

1 | INTRODUCTION

Participatory methods that aim to involve study participants actively are increasingly recognized as a fundamental part of any research process.[1] In particular, the participation of young people in research is considered integral to the validity of studies about them, as exemplified by the slogan "nothing about us without us."[2] A participatory method gaining traction is system mapping based on group model building (GMB), which uses techniques from system dynamics (SD) to examine complex problems.[3,4] GMB guides stakeholders to collectively map their perceived drivers of a complex issue[4–6]; it encompasses a group representing their collective ideas in a system map with the subsequent option of quantification and simulation modeling of systems behaviors. Here, we describe use of GMB to explore adolescents' views on the drivers of obesity among young people.[7]

Adolescent obesity is complex, persistent, and unequally distributed along a social gradient.[8,9] Given the potential for young people with obesity to experience physical, psychological, and social problems during adolescence and later in life,[10,11] it is essential to curb its prevalence. Known, modifiable, proximal causes of obesity are food intake and physical inactivity, but the drivers of these two are numerous and complex. Most interventions and campaigns to promote healthy diets and increase physical activity focus on individual-level behavior change, whereas it is known that broader, structural change to drivers impacting individuals' decisions across the whole system are more effective.[12] Both the complexity of adolescent obesity and the necessity of engaging with those affected by the problem make it imperative to partner with young people to identify appropriate responses.

A systems approach to obesity connects social, commercial, political, cultural, individual-level, and other contextual drivers and illustrates how these factors intersect within a system, accounting for their interdependence and relative strengths.[13,14] Contextualizing adolescent eating and physical activity within a wider system provides the potential to optimize interventions in ways that minimize their dependence on individual agency, thereby increasing the chances of both success and equity in outcomes.[12,15]

In spite of the need for a systems approach to obesity, GMB to engage young people is still uncommon, even though its potential for impact is increasingly recognised.[16] Recent examples of studies engaging young people in GMB include Gerritsen et al who included students in a predominantly adult group of participants exploring declining fruit and vegetable intake among children[17] and Frerichs et al who engaged adolescents in co-building a model about physical activity.[18] Other examples of using GMB for issues pertaining to children—such as their health—have not always included them directly as participants.[19]

The project "Confronting obesity: Co-creating policy with youth" (CO-CREATE) was designed to collaborate with adolescents in developing novel policy options that will contribute to overweight prevention and to reducing inequalities in obesity prevalence. To explore the drivers of adolescent obesity, as perceived by young people themselves, we conducted GMB workshops with young people in the Netherlands, Norway, Poland, Portugal, the United Kingdom, and South Africa.[7] Here, we describe the GMB process we used to engage the adolescents in identifying the factors important to them and discuss some of its unique value, as well as advantages and potential drawbacks of GMB as a tool in this setting.

2 | GROUNDING THE WORK IN COMMUNITY-BASED SYSTEM DYNAMICS

Community-based system dynamics (CBSD)[4] actively engages stakeholders in the challenge being addressed, positioning them as "experts" in how the system works, before identifying potential actions that could be taken to improve it. GMB is a structured format used in CBSD that employs system mapping to create causal loop diagrams (CLDs), which provide a graphic representation of the complexity of a problem's drivers, from the stakeholders' perspective. Subsequently, the CLDs—or system maps—help inform responses to the issue. It is therefore well suited to participatory research.[20]

As the name *causal* loop diagram suggests, a CLD illustrates possible paths of cause and effect between the variables identified, often with an emphasis on circular relations of causality, or feedback.[21] GMB has been used for several decades in SD work aimed at understanding system behaviors in a wide range of subjects, from low-cost housing to childhood obesity to fossil-free city planning.[3,19,22] While there is a strong tradition in developing mathematical simulation models based on these initial insights, GMB also provides a qualitative tool that can be used to create CLDs for "group decision support."[23] Qualitative CLDs are part of an iterative process of examining a dynamic hypothesis, with a view to identifying postulated causal links and feedback, involving behaviors over time. The CLDs can subsequently help participants identify potential intervention points to move "system" behaviors toward achieving a more desirable state,[24] for example, to reduce the prevalence of adolescent obesity.

3 | GMB WORKSHOPS

Researchers in each of the six participating countries took part in a 5-day training course to learn how to recruit for, facilitate, and use results of GMB sessions to generate a causal loop diagram. CLDs were made using *Systems Thinking In Community Knowledge Exchange*

(STICKE, https://sticke.io and https://sticke.deakin.edu.au) software. Within the GMB sessions, the trained researchers took one of three main roles[25]: facilitator who introduces and manages the session; note-taker who makes a detailed account of the workshops and modeler operating STICKE (https://en.wikibooks.org/wiki/Scriptapedia/Roles_in_Group_Model_Building).

We recruited 319 young people aged 16–18 years, across 24 separate groups in the six countries: the Netherlands, Norway, Poland, Portugal, the Republic of South Africa, and the United Kingdom.

4 | ETHICS

Ethics approval was granted for this study by each participating institution (LSHTM Ethics Ref: 16153; University of Oslo: Norwegian Center for Research Data No. 122387; University of Amsterdam 2018-AISSR-9698; CEIDSS—through individual declarations for each school group, via the Directorate-General of Education; SWPS Ethics Committee approval: 02/P/12/2018; University of Cape Town HREC Ref 257/2019).

5 | METHODS: THE GMB SESSIONS

GMB is conducted using an evidence-based approach to the development of scripts that guide the process (https://en.wikibooks.org/wiki/Scriptapedia).[26] This allowed the workshops to be run in a standardized way across the countries, with variations on length and timing of sessions; with some groups, the whole process was conducted in one 3-h session with a short break in the middle, in others two separate session on different days. The full script for these sessions is described elsewhere.[5] There are two key phases to creating the CLD: The first involves eliciting the variables that drive the problem, and the second seeks to draw causal links between the variables; Table 1 sets out the process.

The first stage comprises exercises in which participants build "behavior-over-time graphs" (BOTG) depicting the dynamic factors that they believe drive the problem, which in this case was obesity. The "reference mode" for the BOTG provides a succinct description of the focus problem with an emphasis on how it has changed over time; we used the prevalence of adolescent obesity in each country. Each country tailored the wording of the reference mode in a way that would resonate with the group, such as putting the emphasis on behaviors (physical activity and healthy eating) or physical health more broadly.

Examples of the variables raised by group members in their BOTG include "screen time," "price of fast food" and "portion size," "social media advertising," and "stress" (see Figure 1). The participants, in small groups, then broadly prioritize the variables for which they have drawn BOTG, before sharing them, one by one, with the whole group until there is data saturation.

6 | BUILDING AND VALIDATING THE SYSTEM MAP

Variables from the BOTG exercise are shared with the group and entered by the modeler into STICKE, appearing initially on a circle,

TABLE 1 Group model building (GMB) session outline

Segment	Content	Tools/materials	Activity level
Introduction	Introduce team; explain process/logistics; outline of topic and systems approach		Whole group/presentation
Behavior-over-time graphs (BOTG)	Introduction and explanation		Whole group/presentation
	Making individual BOTG of variables driving problem	Individual BOTG templates	Individual/divergent
	Prioritizing variables, discarding duplicates	Group packs of completed BOTG sheets	Small group/evaluative
Factors circle	Small groups take turns to each call out variables	STICKE circle of variable diagram	Whole group, in turns/ convergent
Connection circle	Explanation of connecting variables activity		Whole group/presentation
	Preliminary connection identification	Note paper/in head	Individual/divergent
	Illustrating connections	STICKE connection circle diagram	Whole group, in turns/ convergent
Map creation	Convert connection circle to causal loop diagram	STICKE diagram function	
Map consolidation	"Tidying up" map and then validating with participants		Facilitation team then also participants
Action ideas	Generating potential points of "action" to shift system	Action Idea templates	Individual
Action idea placing	Locating action ideas on CLD		Whole group

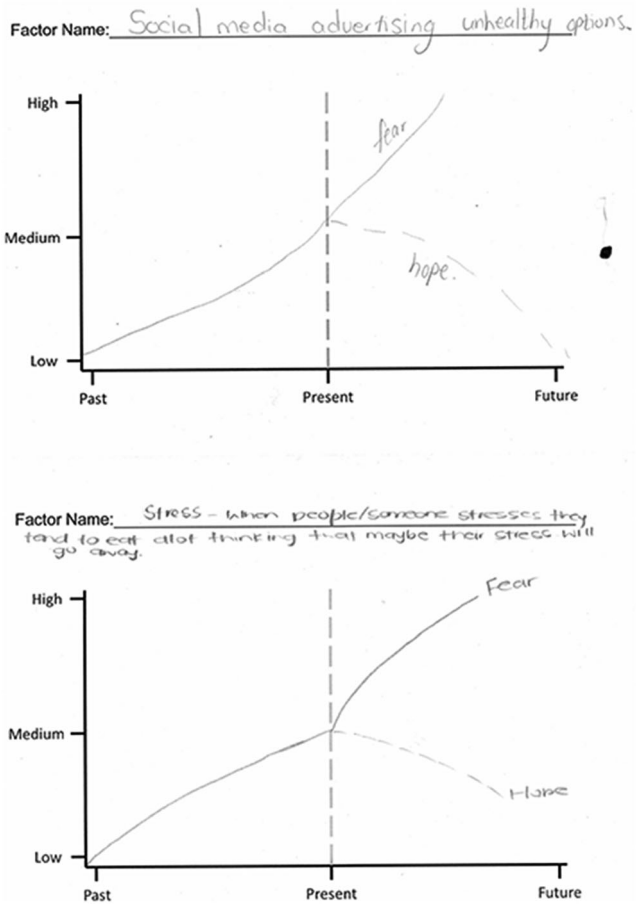

FIGURE 1 Sample behavior-over-time graphs by GMB participants (South Africa)

known as a "connection circle," projected on a screen visible to participants. Figure 2 shows the connection circle from one of the workshops.

Participants then work as a group to identify causal relationships between the variables on the circle, and these too are captured in STICKE (Figure 3) with the facilitator eliciting the direction (positive or negative) of the relationship between the two variables. A positive relationship means a change in one variable causes a change in the same direction in the other. For example, as fast food availability increases, fast food consumption increases. The positive polarity also means a decrease in one would lead to a decrease in the other. A negative relationship (or negative polarity) represents a change in one variable that causes a change in the opposite direction in the other. For example, an increase in screen time decreases time spent on physical activity.

As these pictures are developed, detailed notes are taken on the participants' descriptions of the factors and the connections, and any details not featured in the map are documented. A simple click function in STICKE transforms the "connection circle" into an initial version of a system map, representing the consensus views of the group resulting from the discussion, which can then be rearranged after the workshop by team members, based on the notes taken during the session. This includes ensuring the conversation and notes are represented in the map and moving the variables around to make them more legible. In the next session the revised map is presented to the participants for review and verification of the consensus that was reached. A sample map is shown in Figure S1.

Once the workshop participants have had the opportunity to review the CLD and ratify that it represents their views, they are guided through a process to identify points in the map where interventions may help mitigate the problem—here, adolescent obesity. They are asked to choose an area of the CLD that they think is particularly important or amenable to change or that interests them; they are told that areas where there are feedback loops may contain particularly strong leverage points for action. Participants are shown an "action idea" template and how to use it to represent their ideas (Figure 4), considering the following questions/instructions:

- "What could be done to make things better?"
- "Try brainstorming ideas for what action could be taken."
- "Draw an area you think is important in the template."
- "Write down an idea for an action we could take to improve things."

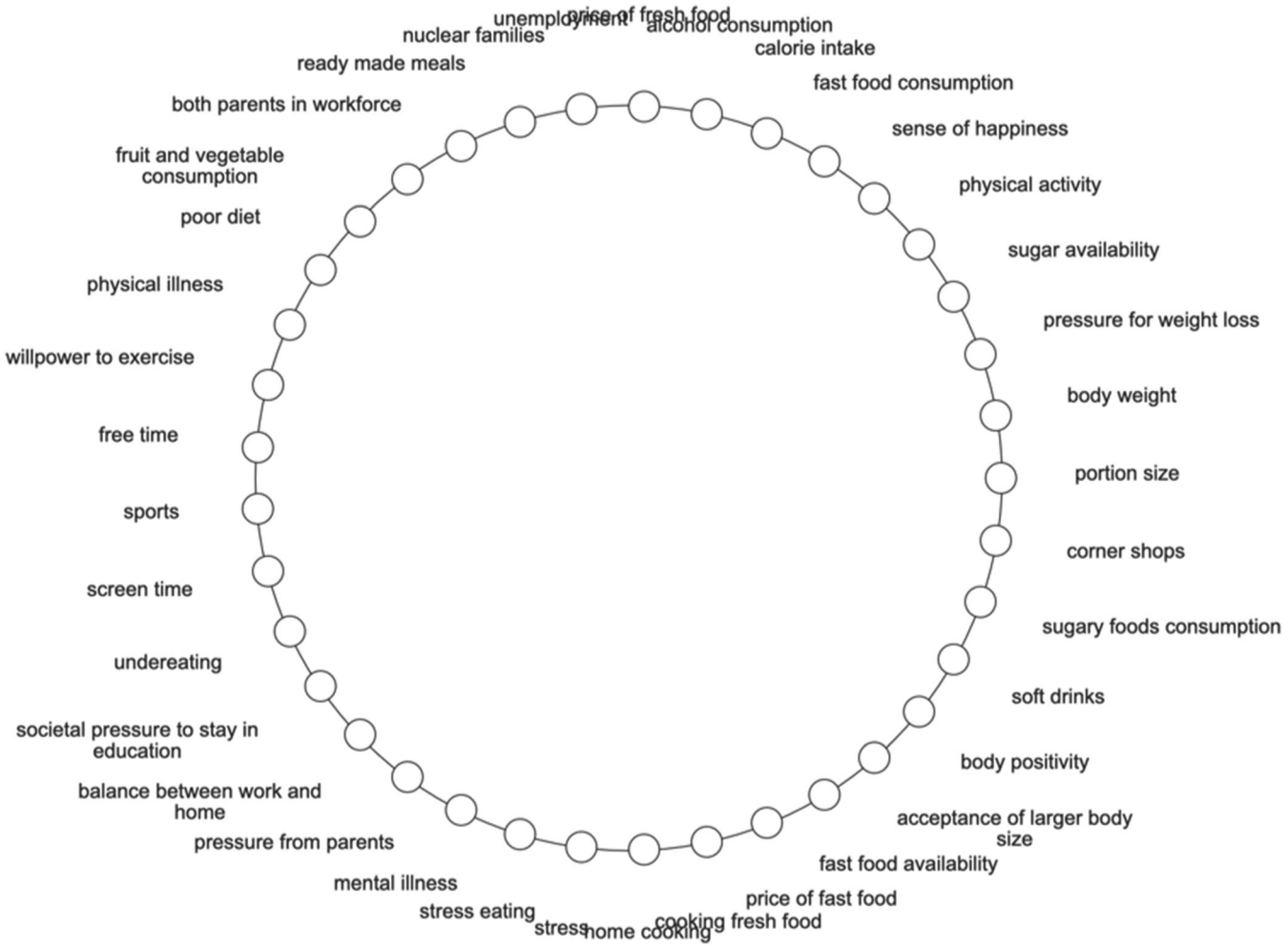

FIGURE 2 Connection circle stage 1

The participants are asked to spend some time coming up with action ideas and to write each down on a template sheet, focusing on detail rather than a larger number of ideas. The ideas are then shared around the room and can be placed on a projection of the CLD (Figure 5), and notes are taken to represent the discussions. These action ideas then form the basis for further work on intervention/policy development. In the case of CO-CREATE, the "action ideas" formed the basis of development with young people of adolescent obesity prevention policies.

7 | DISCUSSION: OBSERVATIONS FROM USING GMB

This article describes the use of GMB with adolescents in six countries to create CLDs of their observed drivers of the complex issue that is adolescent obesity. The resulting CLDs were co-produced by all the GMB workshop participants, with trained facilitators to guide the exercises, including the initial identification of potential areas for action.

8 | GMB AND NOVEL FINDINGS

We conducted GMB workshops with young people in the Netherlands, Norway, Poland, Portugal, the United Kingdom, and South Africa.[7] In addition to being used in subsequent work with adolescents on obesity prevention, the CLDs provided some particularly notable findings in themselves. They demonstrated an appreciable mismatch between the published evidence based on obesity[8] and a consistent concern on the part of the adolescent participants about both mental health and the role of social media/online activity. Participants in South Africa also emphasized the impacts of fear of crime, and concerns about outdoor safety, on physical activity levels, and of domestic discord on stress and diet. Factors such as these that were emphasized by the participants warrant further investigation, especially given the paucity of other research linking obesity to them. These findings may have arisen in part, because the method helps elicit from participants the "causes of the causes" of the issue,[27] that is, in our case, the factors that drive or inhibit healthy eating and physical activity among young people. We argue, therefore, that it was the process of GMB, identifying not just drivers but also chains of

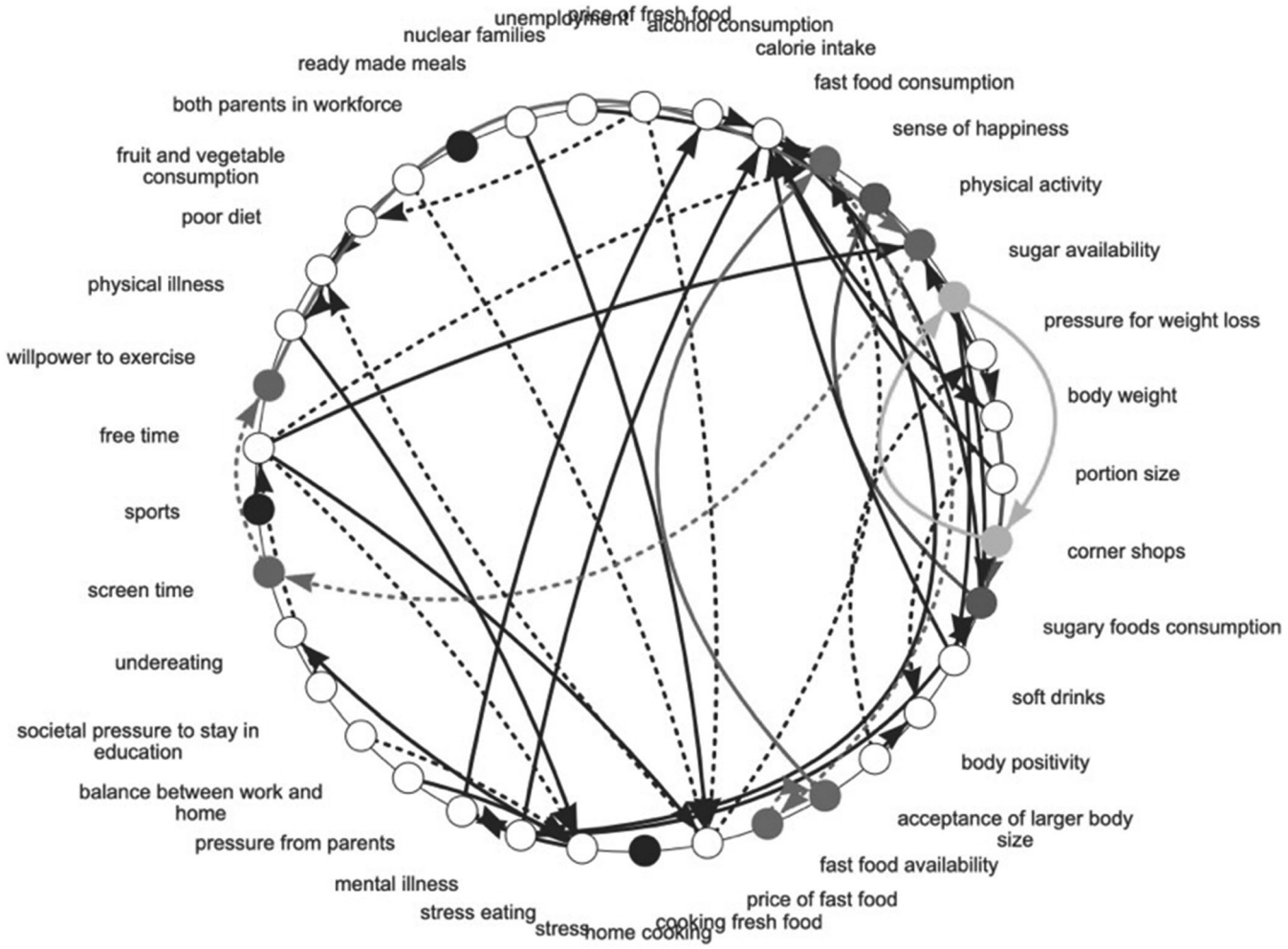

FIGURE 3 Connection circle stage 2, showing connections

causation, that contributed to the emergence of these factors that young people themselves associate with obesity prevalence, which have previously had little attention. The CLDs have therefore pointed to possible gaps in research and policies relevant to the subject matter and the demographic concerned, a process that could be usefully applied to different issues.

Additionally, GMB helps expand the relations between the factors involved in an issue by explicitly "connecting the dots."[28] The young people we worked with emphasized the role of social and other media and emotional/mental health in driving eating and physical activity behaviors. Policies and interventions that merely function at the level of the individual or on the most proximal factors to the problem, for example, eating or exercising, without addressing the drivers of those behaviors—as illustrated in our CLDs—are likely to be of limited value in promoting healthy behaviors.

9 | GMB AS A PARTICIPATORY APPROACH

GMB engages participants in exposing the potential drivers of a complex problem and creating shared understanding,[4,23,29,30] providing a basis for policy/strategy consideration. In CBSD work, CLDs are generated in GMB sessions with stakeholders with the express purpose of identifying places to intervene to generate change in the system of interest. The process we used to work with the adolescent participants therefore goes beyond more traditional research methods such as focus groups. It does, similarly to the "Our Voice" approach to citizen engagement in research, empower residents to assess how their communities impact their well-being—taking the focus away from individual-level behaviors—and to identify actions for improving citizens' health.[31,32] It appears, from our findings, that not only did the integrated, participatory approach give rise to some unexpected results, but also those results provided a springboard for helping to identify points of action, as illustrated in Figures 4 and 5. This may be because GMB has been shown to be a particularly effective problem structuring method for complex problems such as obesity.[19,33] Another contrast with focus groups—in which the *interaction* between participants is of particular interest[34] —is that GMB is used expressly to facilitate *group* decision-making and problem structuring.[30,33] As such, our findings, as illustrated in the CLDs, represent a shared mental model of the way in which the participants perceived the challenge of adolescent obesity. The participatory, group-based nature of GMB

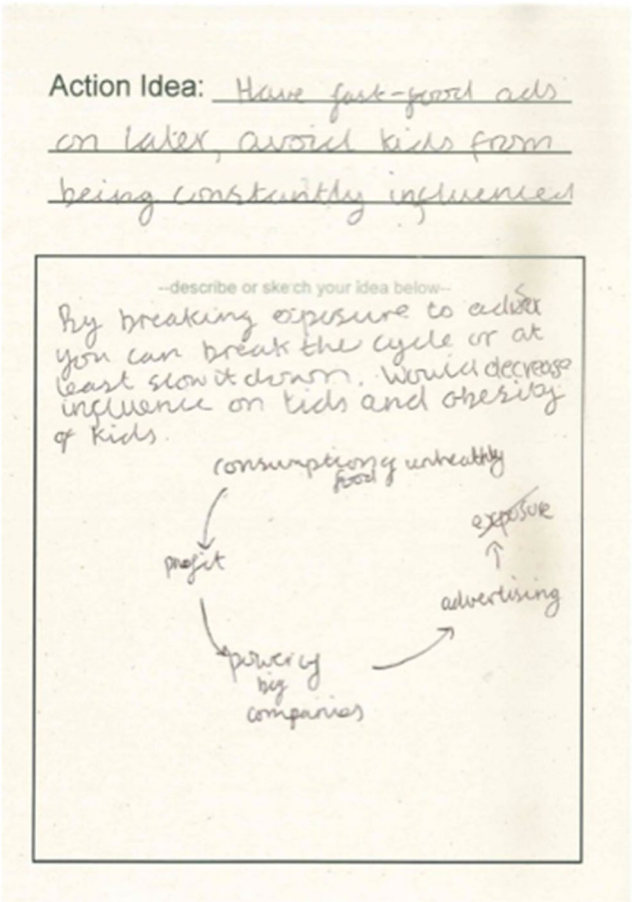

FIGURE 4 Action idea example

thereby provides a more inclusive approach to defining and addressing a complex problem such as obesity, with the demographic of concern.

Previous research with adolescents on obesity has argued that they should be "creative contributors" to exploring potential interventions.[35] Given that youth voices remain underrepresented, by choosing the GMB approach we used a systematized method to initiate and sustain collaboration with young people as contributors, rather than merely as the objects of policy development or research, as has often been raised in criticism of youth involvement.[36–38] This collaboration was enhanced by continuing to involve adolescents within and across all countries as partners in further workstreams of the CO-CREATE project, where they used the CLDs to develop potential policy ideas for obesity prevention and discuss the feasibility of the ideas with a range of stakeholders.

10 | STRENGTHS OF GMB

The GMB process yielded novel results about the perceived drivers of adolescent obesity and the group process created shared learning and collaborative development of the way the problem is conceptualized[3,23] and can be addressed. Working with adolescents on such a multilayered topic produced results that concur with reviews of GMB which show its value in fostering systems thinking, in improving understanding of, and collaboratively developing responses to, complex problems; additionally, the resulting CLDs have—as in other work—been useful for continuing to examine problems over time, with further interrogation and adaptation as a project progress.[4,39] The GMB process we used and resulting CLDs thereby facilitated hypothesis generation using the maps to explore potential causal mechanisms driving adolescent obesity and how they may be disrupted. It is a method that goes beyond more traditional ways of conducting health research with specific populations, in terms of addressing complexity and collaborating with participants in identifying responses to the problem.

GMB is also a method that lends itself well to potentially sensitive topics; participants express their views on a *generalized* situation—what *they* perceive to be the drivers of the issue. This can help foster openness to share views that they may not necessarily reveal if they were asked about their individual experiences; though we did not have the scope to expressly check with participants that this was the case, our experience was that the GMB sessions ran smoothly and openly, with no sense of stigma or awkwardness around the topic of body weight and little dropout between GMB sessions. With skilled facilitation, GMB can provide opportunities for open discussion on delicate topics such as body weight and has been used to map subjects such as HIV testing, family violence, and community violence.[4,40,41] Indeed, CBSD was originally designed and tested in the context of working with high school students.[4,42] Additionally, because the resulting CLD represents the views of the group, the specific contributions of individuals are not identifiable from the map, and this relative anonymity may foster more openness in participation.

GMB workshops keep participants engaged with exercises to generate graphs and diagrams.[25] The sessions switch throughout between exercises that are "convergent" and "divergent," that is, working as individuals then as a group, then as individuals, through the different phases of creating the CLD (see Table 1). This ensures that even people who may be disinclined to speak out in a group setting are still ultimately represented on the CLD; the process builds a sense of shared vision and a group product in the diagram; it also helps incorporate and smooth out any disagreement that may arise. Again, we found that our adolescent participants were engaged, with high repeat attendance at second sessions.

11 | LIMITATIONS OF GMB

Using GMB requires considerable commitment to the process from participants/stakeholders; creating a well-crafted, useful CLD takes time and experienced facilitation.[39,43] This can present recruitment challenges and did so for us: resistance to the amount of time we were asking adolescents to commit to building the CLDs, with, their varied—especially educational—commitments; demands on already stretched organizations and schools, which have other priorities, to support recruitment; navigating the administrative and ethical hurdles.[44] That said, it is less demanding than other "citizen science"-type

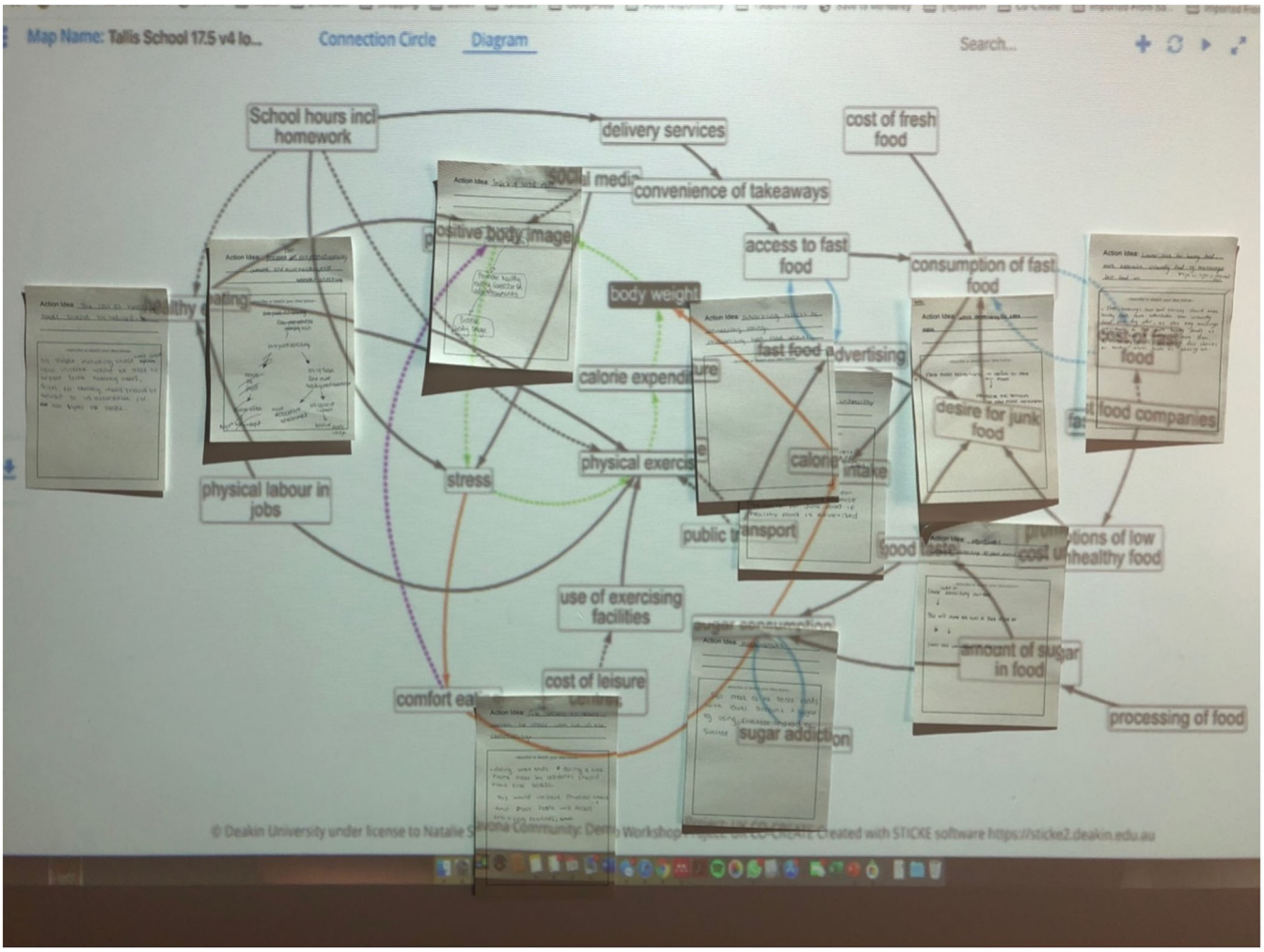

FIGURE 5 Action ideas on projected CLD

approaches such as "One Voice,"[45] which—though potentially very effective—require participants to commit to a prolonged process. Additionally, functional and representative CLDs are best produced with experienced facilitators. These issues—time required, commitment from adolescents/schools, experienced session leaders—combine to create lessons about what is required for the generation of robust CLDs with young people: Ideally, we would have had more time with the participants, including subsequent sessions to help "tidy up" the maps and confirm that they were accurate representations of their views. Overall, as a project, we had in place experienced systems thinkers and the time to consolidate the findings, but these are nontrivial issues that require prior consideration.

12 | CONCLUSION

A causal loop diagram is a tool that illustrates not only the structure of the system as viewed by people who experience or work within it but also the interwoven factors involved; it acts as a starting point for considering how to shift the way the system operates and a potential benchmark as a project unfolds. It is, therefore, an especially valid way of examining and addressing complex problems, such as obesity. We have added to the evidence that GMB offers a productive way of conceptualizing a complex challenge with its pertinent stakeholders to make sense of the "mess" and the many factors and interactions that constitute the problem under scrutiny. Our work using GMB with adolescents investigating drivers of adolescent obesity and potential responses to it, has provided fruitful outputs, and we endorse it as a method that warrants wider application to other topics. GMB also appears to provide several advantages for helping identify the deeply held beliefs of the population of interest and collaborating with them: in our case, adolescents who revealed factors related to obesity—mental health and online activity—that have not yet had sufficient attention in research and policy. Such insights are essential for the development and implementation of high leverage interventions that can mitigate complex problems such as obesity.

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CONFLICT OF INTEREST

None declared.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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