A Theory of Change for Community-Based Systems Interventions to Prevent Obesity

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Introduction: Applying systems science in public health trials is a recent innovation in childhood obesity prevention. This paper aims to use systems science conventions to propose a theory of change for community-based interventions aiming to build capacity and use exemplars from systems science for obesity prevention to describe how this approach works.

Methods: Participants were community-based researchers. A dynamic hypothesis was created in workshops conducted in 2020 and 2021 by identifying variables critical to building community capacity for systems thinking. These were used to develop stock and flow diagrams representing individual causal relationships, feedback loops, and the overall theory of change.

Results: The resultant model identified 9 stocks and 4 pairs of central balancing and reinforcing feedback loops. These represented building commitment through relationships, mutual learning, strengthening collaboration, and embedding capacity. The model is described using examples from 3 trials involving 25 communities across Victoria, Australia.

Conclusions: This nonlinear and practice-based model illustrates the process of community-based obesity prevention. The model integrates >20 years of community-based intervention implementation experience, providing an overarching theory of how such interventions work to create change and prevent obesity.

INTRODUCTION

Obesity is a preventable, global crisis, and worldwide obesity rates have tripled since 1975.1 Obesity prevention has experienced mixed success2,3 because of the mismatch of individual behavior focus against a disease with complex and multifactorial causes.2,3 The recognition of this complexity has led public health practitioners and researchers to experiment with techniques from systems science, shifting focus from individual behavior change to community, environmental, and policy interventions.3 Key strengths of systems approaches are their deliberate engagement with complexity, including capturing and understanding nonlinear relationships of cause and effect, differing time scales, and identification and management of unintended consequences.4 Several systems science methods,
such as community-based system dynamics (CBSD), make these techniques accessible to a broad range of stakeholders through a process of cocreation and codesign. CBSD involves a series of workshops that allow stakeholders to describe complex problems from their own perspective through development of qualitative causal diagrams, followed by identifying and leading corresponding action. CBSD also intentionally builds community capacity over time to apply system dynamics to identified complex problems independently from external researchers or consultants.

The potential benefit of systems methods was foregrounded by several effective community-based interventions (CBIs) among preschool, primary school, and secondary school children, each of which built capacity and ownership among community stakeholders to lead prevention activities. CBIs have high acceptability among government, industry, and the public and participatory systems science is suited to intervention design, implementation, and evaluation. These projects showed potential for understanding the complexity of obesity in a given context; potential for creating multifactorial, multilevel interventions reaching multiple parts of a community; and potential for interventions to be tailored and adapted to the local context. Indicators of success in CBSD often extend beyond the primary health outcome of interest and can also include building local capacity, increasing collaboration, building community ownership, collective learning, and the development of new insights.

A range of systems-informed approaches to address childhood obesity are emerging worldwide. A recent systematic review of these approaches highlighted a lack of consensus and formal definition of complex adaptive systems, a lack of ways in which these interventions create change, and a lack of ways in which implementation and evaluation should be conducted. The aim of this paper is to present a theory of change for CBIs to inform public health practitioners and community stakeholders on how to build community capacity in complex systems science interventions.

METHODS

Development of the Theory of Change Model
This theory of change builds on 20 years of experience working with >120 communities with illustrative examples from 3 community-based trials. Methods from system dynamics were used to create a model representing the theory of change for successful, sustained CBI over time. Known as stock and flow diagrams, these models identify the structures of cause and effect within a system that drive system behavior, with an emphasis on accumulation, time delays, and feedback loops. Models were developed in Vensim, version 9.0.0.

In 2 sessions, authors (ADB, JW, JH, SA, PF, KAB) with experience in system dynamics and CBIs research developed graphs over time to identify and describe the patterns of change in critical factors that affect the success or failure of CBIs to prevent obesity. The factors were first brainstormed by the researchers on the basis of their expertise with CBIs, discussed as a group, and then prioritized and collectively agreed on to form an initial set of stocks. Flows were added to explain how stocks accumulated or eroded over time and to clarify relationships between stocks using the script, Initiating and Elaborating a Causal Loop Diagram.

A total of 4 further sessions engaged 6 additional researchers with insight into specific parts of the model, including epidemiology, health economics, and community-based health promotion. The final modeling group included 3 researchers who also live and work in the communities where CBIs had been conducted by the group. The group refined the stocks and flows, causal relationships between stocks, and key feedback loops. The final 2 sessions comprised focused discussions in 3 subgroups relevant to topic expertise (community engagement and collaboration, capacity building, and health behaviors and outcomes). The subgroups confirmed the wording of the variables, the most important connections, and finally, 1 key reinforcing loop (R) and 1 key balancing loop (B) that could explain the key drivers of change in that area and the potential limits to that change. The groups presented the proposed pairs of feedback loops to the wider group, and the group came to a consensus on the 3 pairs of feedback loops to hypothesize the drivers of success or failure of CBIs. The group identified any final gaps in the proposed theory to come up with a final set of feedback loops. To further build confidence in the pairs of feedback loops, case studies were written to connect the theory in the model with actual practice.

Case Studies
Vignettes were drawn from community-based trials of systems thinking to preventing obesity in Victoria, Australia. These were Whole of Systems Trial of Prevention Strategies for Childhood Obesity (WHOSTOPS), Reflexive Evidence & Systems interventions to Prevent Obesity & Non-communicable Disease (RESPOND), and Yarriambiack—Creating, Healthy, Active Nourished Generations. Vignettes were chosen to illustrate the theory of change model.

RESULTS
The theory of change model comprised 9 key stocks and 4 pairs of balancing and reinforcing feedback loops. These loops together form 1 system (Figure 1) and are described in this study as separate feedback loops. In the diagrams, factors that accumulate over time (stocks) are represented by boxes, the processes that cause stocks to change (flows) are represented as valves, and the curved arrows connecting stocks and flows are causal arrows, representing a change in the same direction with a + sign at the end and change in the opposite direction with a − sign at the end.
R1 (Figure 2) describes the initial dynamics in obesity prevention initiatives. When people in leadership positions (stock) identify a community public health need, one path taken is to partner with researchers, leading to an increase (flow) in research support (stock). The strength of the relationship between researchers and community (stock) often changes slowly over time (flow). As it builds, opportunities for community involvement (stock) in the CBI increase, leading to a higher quality of action28,29 (stock) because of greater community buy-in and tailoring of actions to the local context. As higher quality actions are built, there is a greater level of community exposure to actions, ultimately leading to positive change (flow) in community health behaviors29 (stock), creating evidence of CBSD effectiveness. This growing evidence increases leadership (flow), describing greater commitment from leaders already involved and new leaders joining. In turn, this improves the credibility and acceptability of the CBI and CBSD, creating new opportunities for research support and continuing the cycle.29,30

B1 (Figure 2) shows that as researcher support grows, the number of communities engaged in CBSD can grow faster than the supply of researcher support, and the strength of the relationship between researchers and community will weaken. When the relationship weakens before the community effort has become self-sustaining, the effectiveness of CBIs is reduced.31

A core element of researcher support is capacity building. R2 (Figure 3) shows how researcher support builds CBSD capacity focused on obesity through effective training but also how the CBSD capacity feeds back and builds researcher support as researchers learn from the community. B2 (Figure 3) shows how researcher support being spread too thin across too many communities results in less effective support.

In R3 (Figure 4), enhanced collaboration leads to increased healthy action implementation because greater community exposure to action creates additional partners.29,32 Greater improvement in community health behaviors leads to further leadership as described in R1. B3 (Figure 4) shows that as community health behaviors
improve, the overall perceived need for action may decline, lowering the political acceptability of the approach relative to competing priorities. This can lead to a loss in leadership and collaboration, undermining initial positive gains.

R4 (Figure 3) describes that how and when the research group becomes less central over time, leaving behind tangible skills and positive change in the community, the CBSD capacity focused on obesity transitions to the application of CBSD across broader health and social issues. The delay mark on this connection highlights that it can take a long time over the course of a CBI for this transition to occur. Once it does, the application of CBSD feeds back, strengthening the obesity prevention work.

Over the time span required to see truly embedded CBSD capacity, the biggest risk described in B4 (Figure 3) is stakeholder turnover. If the built-up CBSD capacity focused on obesity is concentrated in a small number of people (as is often the case in prevention teams) and they leave their positions, progress is negatively impacted.

In Yarriambiack—Creating, Healthy, Active Nourished Generations, a whole-of-community systems approach to obesity prevention in adults and children prioritized, among other actions, the establishment of a health-promoting café in the local health service. This process commenced with leadership from the health service and the local disability service improving the level of collaboration in the community with inputs from the researchers (researcher support). Collaboration between local leadership and researcher support led to a strengthened relationship between researchers and community. This relationship increased community involvement and resulted in a system-level change of a healthier food
environment (healthy action implementation) within the system boundary of the local community and increased community exposure to purchase healthier food from the café (healthy behavior change). Evaluation of the café showed improvements in health behaviors (purchase and consumption of healthier food) creating evidence of CBSD effectiveness in developing this healthier food environment, which further built support from leadership to sustain this change.

Southern Grampians Glenelg Primary Care Partnership (SGGPCP) was the backbone organization for the GenR8 Change initiative within WHOSTOPS. As part of WHOSTOPS, a high level of researcher support was provided early in the GenR8 Change initiative, allowing stakeholders to receive effective training and mentoring in CBSD and systems thinking. Having developed CBSD capacity focused on obesity, SGGPCP went on to build generalized capacity across a broader group of stakeholders (e.g., in local government and schools) to use CBSD for other complex problems (e.g., family violence prevention). Because stakeholders integrated their new capacity of CBSD, coupled with community enthusiasm, SGGPCP was able to build a workforce of community stakeholders who thought and worked using CBSD. The application of CBSD across health and social issues included local government health planning and collaboration on many health and social issues. Building generalized capacity resulted, creating a feedback loop with an application of CBSD across health and social issues. More than 250 actions have been implemented in the community as part of the GenR8 Change initiative. The outcomes of GenR8 Change as part of WHOSTOPS have been evaluated with significant intervention effects on child takeaway food consumption and health-related quality of life.12

In RESPOND, stakeholders underwent extensive in-person and online training to use CBSD to address childhood obesity. RESPOND utilized expertise within the University (researcher support) to undertake effective training with identified community stakeholders to build expertise in CBSD focused on obesity. As expertise developed among stakeholders, there was less reliance on researchers (a decrease in research support). This facilitates a changing relationship with stakeholders as they enhance their knowledge as local experts. This facilitated enhanced engagement and community involvement and increased community involvement, which continued to reinforce this changing relationship among researchers, local stakeholders, and community.

DISCUSSION

This theory of change model shows how key elements of systems approaches to community-based obesity prevention interact and work to prevent obesity. The model

![Feedback loop pair—mutual learning and embedding capacity.](image-url)
integrates >20 years of CBI implementation experience, providing an overarching theory of change of how these interventions work rather than a step-by-step approach demonstrating what to do. The model locates research support relative to other stocks that drive change, including community involvement, collaboration, quality of action, feedback about intervention success, and how leadership interacts with community health behaviors and outcomes. Nonlinear relationships and feedback loops show how each element both influences and is influenced by CBI implementation.

One of the first child obesity prevention CBIs, Be Active Eat Well, introduced both individual and population mediators in a linear logic model. This and subsequent community interventions (Romp & Chomp, It’s Your Move!) were based on the hypothesis that building community capacity and supportive policy led to more supportive environments and more health-oriented knowledge, attitudes, and behaviors of individuals, in turn impacting BMI. Similarly, the 2013 Ensemble Prévenons l’Obésité De Enfants logic model both identify the essential elements of leadership, capacity building, and local organizations engaging in successful health-promoting activities. These models were ahead of their time in identifying the importance of building local capacity as a key part of successful interventions but did not explicitly include a dynamic logic. This paper builds on the previous work by showing the nonlinear relationships that influence other parts of the system, emphasizing the dynamic nature of the stocks and flows inherent in the proposed theory.

More analogous to the model presented in this study is the recent Shape Up Under 5 (SUU5) conceptual framework. The SUU5 model depicted the multiple feedback loops hypothesized to underpin obesity prevention action, while still predominantly focusing on a left-to-right linear flow from committee formation to downstream reductions in overweight. The core premise of SUU5 was that the knowledge of and engagement from people with positions of leadership in obesity prevention were central to the success of the initiative. By contrast, the theory of change proposed in this paper places leadership as central to success, not as an input but rather as one of many interacting factors.
contributing to effectiveness in CBSD approaches. Another recent project retrospectively analyzed stakeholder interviews to understand the dynamics of a single successful obesity CBI, but it did not make use of stock and flow conventions to highlight accumulations. The cocreated, nonlinear nature of the model provides a more comprehensive picture of how community interventions work than earlier logic models. Most notably, the model details the placement of the researcher as one element of this system and shows the interaction of other elements of community interventions that are critical to achieving outcomes. The role of researcher was inadequately documented in previous models that reflect the life of an intervention. The cocreation of this model between academics and practitioners builds confidence that the model reflects reality and strengthens the utility of the model. The vignettes provide examples of the model working in practical, real-world interventions.

Each of these advances set a firmer stage to allow for measurement across all phases of a project and most notably provides new directions for implementation science by providing a model of what to measure at a process level to understand intervention outcomes. Furthermore, it presents a dynamic hypothesis to quantitatively evaluate the interactions and impacts of currently poorly understood concepts such as engagement, and capacity. This model is more about the theory of change using systems approaches in CBI than the prevention of obesity as a complex problem per se. The model presented in this study could be useful for a wider range of actors in preventative public health beyond those working in obesity prevention.

This theory of change model represents one group’s intervention process, and although all models are wrong, some are useful. This model is based on the experience of researchers and practitioners working in >120 communities to capture their understanding of what makes CBIs prevention of obesity work. The need to be adaptive and tailored to context is inherent in this model and cannot reflect a fully generalizable model. Rather, it provides the basis to consider a more thorough conception of CBIs, further informed by practitioner views and the nonlinearity of existing systems. It is crucial to understand the boundary of models as well to understand their utility. In this case, the model specifically applies to community—academic partnerships. Research is needed to test and enhance its utility for CBIs.

The model offers public health practitioners and community stakeholders a nuanced framework to facilitate the implementation of new or established community—academic partnerships. The model could be used to help build, maintain, or erode the characteristics likely to be critical to effective and sustainable community interventions. Greater political support for CBIs may also result because the model highlights clear processes to actively address political palatability. These potential gains will require more emphasis on communication and dissemination than traditional health promotion and that evaluators be cognizant of the needs of those they hope to influence.

The qualitative model in this paper represents a hypothesis of the relationships that drive successful CBIs over time. However, system dynamics offers the opportunity to quantify the proposed model, which would deepen the understanding of how changing stocks and flows in this model interact with implementation and subsequent obesity outcomes. This may be especially important if, for example, future increases in the number and size of initiatives limit the amount of support research staff are able to provide. A quantitative model may identify alternative approaches or inputs that could offset the effect of this change to maintain effectiveness.

CONCLUSIONS

Because the complex causes of obesity and other health issues increasingly have been recognized, CBIs have adapted to address this complexity. Models such as this demonstrate changes in interventions as they are happening and are needed as part of an evaluation to learn more about how community-based system approaches operate and to enhance effectiveness.

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