

Three Essays on Systems Thinking and Dynamic Modeling in Obesity Prevention Interventions

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ABSTRACT

Essay #1 - Parental Social Influence in Childhood Obesity Interventions: a Systematic Review

The objective of this study is to understand the pathways through which social influence at the family level moderates childhood obesity interventions. We conducted a systematic review of obesity interventions in which parents' behaviors are targeted to change children's obesity outcomes, due to the potential social and environmental influence of parents on the nutrition and physical activity behaviors of children. Results for existing mechanisms that moderate parents' influence on children's behavior are discussed and a causal pathway diagram is developed to map out social influence mechanisms that affect childhood obesity. We provide health professionals and researchers with recommendations to leverage family-based social influence mechanisms for increasing the efficacy of the obesity intervention programs.

Essay #2 - Dynamics of Obesity Interventions inside Organizations: a Case Study of Food Carry-Outs in Baltimore

A large number of obesity prevention interventions, from upstream (policy and environmental) to downstream (individual level), have been put forward to curb the obesity trend; however, not all those interventions have been successful. Overall effectiveness of obesity prevention interventions relies not only on the average efficacy of a generic intervention, but also on the successful Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) of that intervention. In this study, we aim to understand how effectiveness of organizational level obesity prevention interventions depends on dynamics of AIM. We focus on an obesity prevention intervention, implemented in food carry-outs in low-income urban areas of Baltimore city, which aims to improve dietary behavior for adults through better food access to healthier foods and point-of-purchase prompts. Building on data from interviews and the literature we

develop a dynamic model of the key processes of AIM. We first develop a contextualized map of causal relationships integral to the dynamics of AIM, and then quantify those mechanisms using a system dynamics simulation model. With simulation analysis, we show how as a result of several reinforcing loops that span stakeholder motivation, communications, and implementation quality and costs, small changes in the process of AIM can make a big difference in impact. We present how the dynamics surrounding communication, motivation, and depreciation of interventions can create tipping dynamics in AIM. Specifically, small changes in allocation of resources to an intervention could have a disproportionate long-term impact if those additional resources can turn stakeholders into allies of the intervention, reducing the depreciation rates and enhancing sustainability. We provide researchers with a set of recommendations to increase the sustainability of the interventions.

Essay #3 - Dynamics of Implementation and Maintenance of Organizational Health Interventions: Case Studies of Obesity Interventions

In this study, we present case studies to explore the dynamics of implementation and maintenance of obesity interventions. We analyze how specific obesity prevention interventions are built and eroded, how the building and erosion mechanisms are interconnected, and why we can see significantly different erosion rates across otherwise similar organizations. We use multiple comparative case studies to provide empirical information on the mechanisms of interest, and use qualitative systems modeling to integrate our evolving understanding into an internally consistent and transparent theory of the phenomenon. Our preliminary results identify reinforcing feedback mechanisms, including design of organizational processes, motivation of stakeholders, and communication among stakeholders, which influence implementation and maintenance of intervention components. Over time, these feedback mechanisms may drive a wedge between otherwise similar organizations, leading to distinct configurations of implementation and maintenance processes.

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only during the last year of my PhD program, but his technical expertise and policy-oriented thinking have been very helpful and I learned a lot from him during this short time. Working with my committee has been a pleasure and I look forward to continuing to do so in the future.

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Chapter 1 - Introduction

1.1 Problem context

Obesity has become a global epidemic, causing approximately 3.4 million deaths worldwide [1]. In the United States, more than 17% of the youth and one-third of the adults are obese [2], costing about \$147 billion annual medical costs [3]. To curb the obesity trend, a large number of interventions have been designed and implemented; however, complexity of the obesity crisis potentially challenges the effectiveness of the interventions [4]. We believe that systems science methods are well suited to addressing many of the challenges in obesity prevention interventions.

In essay one, we conduct a systematic review for social influence in family-based obesity interventions and enhance our review with a simple causal loop diagram. In essays two and three, we use system dynamics modeling to understand the dynamics of obesity interventions. We argue that, similar to quality and process improvement, community-level obesity prevention interventions have organizational characteristics forming many organizational dynamics. These organizational dynamics, associated with the success level of implementation and maintenance of interventions, have received little attention in the literature. Essay two aims to understand the dynamics of adoption, implementation, and maintenance of an intervention implemented in two food carry-out restaurants in Maryland. In a more aggregated study, essay three aims to study the dynamics of organizational interventions in two interventions implemented in the Carolinas. Building on interventions in two complex organizations, child daycare centers and hospitals, the model developed in the third essay extends that in the second essay, which helps increase the generalizability of the results. Research contributions in each study are presented in the next section.

1.2 Research contributions

1.2.1 Essay #1

In this study, we conducted a systematic review of obesity prevention interventions, published between January 2000 and end of 2013, in which parents' behaviors are targeted to change children's obesity outcomes, due to the potential social and environmental influence of parents

on the nutrition and physical activity behaviors of children. After reviewing 21 identified papers, we provided an in depth table of findings. Along with following protocols and best practices for systematic reviews, we extended the common reviewing toolbox and summarized the findings from 21 articles in an aggregated causal pathway diagram of the social influence mechanisms. The diagramming method, adopted from systems thinking and system dynamics, provides a graphical summary of the key mechanisms identified in the literature, highlights the areas in need of further empirical research, and sets the stage for statistical modeling as well as meta-analyses. Our analysis and discussions, mainly developed based on this diagram, have been enhanced by incorporating detailed feedback from several experts in family studies and obesity research.

We provide health professionals and researchers with recommendations to leverage family-based social influence mechanisms for increasing the efficacy of the obesity intervention programs. This essay, co-authored with Zahra Sharafi, Hazhir Rahmandad, and Alice Ammerman, is currently being revised for *Obesity Reviews*.

1.2.2 Essay #2

In this study, we aimed to understand the dynamics of implementation of obesity prevention interventions, focusing on an intervention in Baltimore city. The project started with field-work, conducting interviews with interventionists and other stakeholders involved in the intervention. Based on qualitative analysis of the interview data and the literature, we developed a dynamic model enabling us to study dynamic mechanisms of implementation of the intervention and various trade-offs in endogenous mechanisms. These trade-offs are particularly between designing and implementing intervention components vs. communicating with stakeholders to build confidence, increase motivation, and improve the quality of intervention.

1.2.3 Essay #3

In this study, we extend the second essay by focusing on two more intervention programs in child daycare centers and hospitals in the Carolinas. We extensively use interview data to develop a causal loop diagram and study various organizational processes, especially those affecting the erosion of intervention programs. While prior research has largely focused on intervention development processes as the source of differential outcomes, research on the

maintenance of interventions is in the early stages and promises to be a complementary avenue for understanding organizational performance.

We particularly focus on similar interventions across similar organizations to control for possible alternative explanations. We present how otherwise similar organizations may end up with very different paths to success due to small early differences, even when the elements of the interventions are relatively well-known. We also discuss how those small differences can be amplified and lead to very different erosion rates. Moreover, observing various rates for erosion of intervention components across child daycare centers and hospitals helps better elucidate how the underlying mechanisms may vary across various organizations. Overall, heterogeneity among the organizations presented in this essay and the second essay increases the generalizability of the results.

1.3 References

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Chapter 2 - Parental Social Influence in Childhood Obesity Interventions: a Systematic Review

2.1 Abstract

The objective of this study is to understand the pathways through which social influence at the family level moderates childhood obesity interventions. We conducted a systematic review of obesity interventions in which parents' behaviors are targeted to change children's obesity outcomes, due to the potential social and environmental influence of parents on the nutrition and physical activity behaviors of children. Results for existing mechanisms that moderate parents' influence on children's behavior are discussed and a causal pathway diagram is developed to map out social influence mechanisms that affect childhood obesity. We provide health professionals and researchers with recommendations to leverage family-based social influence mechanisms for increasing the efficacy of the obesity intervention programs.

Keywords: social influence, childhood obesity, weight-related behaviors, family-based intervention.

2.2 Introduction

Despite substantial efforts and much research, childhood obesity continues to be a significant public health concern. Beyond biological and genetic causes of obesity, a growing consensus among researchers (e.g., [1-5]) points to the significant role of social factors in weight-related behaviors. A variety of weight-related behaviors associated with eating patterns, sedentary life style and physical activity (e.g., [6-9]) can be influenced by social norms, family environments, and relationships [2]. Such influences have been shown to impact individuals' body weight [10, 11]. For instance, a study by Dowda et al. [12] suggests that youth between the age of 8 and 16 years who have at least one overweight parent are more likely to be overweight compared with youth who do not have an overweight parent. Christakis and Fowler [4] estimate that an obese sibling or spouse can increase the probability of becoming obese by 40% and 37% respectively. Reviewing studies on the role of social influence in the obesity epidemic, Hammond [2] concludes that social influence is an important area of continued research and is promising for informing intervention design.

Although some obesity interventions leverage social influences to enhance the effectiveness of the intervention, there is much room for designing interventions that better leverage social influence to impact weight-related behaviors. For example, Bahr, et al. [10] argue that inefficacy of obesity interventions is partially due to the fact that overweight and obese individuals are usually considered in isolation from their surrounding social context. However, teasing out the effect of social influence from other influences on behavior is complicated as the majority of obesity interventions that leverage social influence also have a direct effect on weight-related behavior.

In this study, we review parent-based social influence mechanisms in obesity interventions in the family setting. In this context, we focus on social influence that captures how children's weight-related opinions, emotions, and behaviors are influenced by parents. We specifically focus on the family setting because family relations represent psychologically close ties and have significant potential to influence obesity [13-15]. For instance, parents can significantly impact children's health behavior through modeling of behavior, rewarding desirable behaviors, providing concrete resources to support certain behaviors, among others [16]. The family setting is ripe for observing these mechanisms in action and their potential impact on weight-related behaviors. Moreover, to avoid confounding the mechanisms of social influence with other influence pathways in obesity interventions, we focus on studies that leverage a specific kind of family social influence, targeting parents to help with children's weight-related outcomes rather than intervening directly with the children.

2.3 Research methods

2.3.1 Search strategy

We conducted a systematic review to study the effects and potential mechanisms of parent-based influence in obesity interventions in the family setting. The studies should include an intervention that only includes parents and outcomes that include children's eating and physical activity behaviors. This design limits the review to studies that only capture social influence without confounding direct effect of intervention on children's behavior. We looked for relevant papers in public health and social science journals listed in PubMed and Web of Science. Search terms included: (family or family-based or parents or parent-focused or parent-led or family

members) and (weight or overweight or obesity) and (intervention or trial or treatment or prevention), and any variation of those key terms.

2.3.2 Inclusion/exclusion criteria

Peer-reviewed full-text papers written in English published between January 2000 and end of 2013 were included. The inclusion and exclusion criteria were fully specified in the review protocol before conducting the review. Papers had to include an obesity intervention (prevention or treatment) directly targeting parents to influence the weight outcomes of children (e.g., intervening with parents with the distal goal of influencing children's weight status). Papers were excluded if they did not report weight and/or weight-related behavior outcomes for children; were reviews or meta-analyses; did not target family interactions; involved medications or medical procedures, individuals with eating disorders, or individuals in institutional settings.

2.3.3 Review process and search results

The review process is illustrated in Figure 2-1. Using our keywords, we identified 1,021 papers from PubMed and 1,690 papers from Web of Science. After removing 462 duplicate papers, titles and abstracts of 2,249 papers were collected and screened by two reviewers. After excluding non-obesity interventions, review papers, and studies not implemented within the family setting (1,530 papers), 719 papers remained. We then focused on study purpose, design, and results; when compared with our inclusion criteria, 635 papers were subsequently excluded (e.g., studies in which the effect of social influence could not be traced to specific family members; studies that did not measure the effect of the intervention on targeted family members). Consequently, we reviewed the full text of 84 papers and excluded 58 papers that did not provide any measure of the effect of intervention on children, or were duplicate publication of the same intervention (Table 2-1). Finally, 21 papers satisfied our inclusion criteria; which presented the effects of parent-led interventions on children (mean child age equal to 8 years). Both treatment interventions (13 papers) and prevention (8 papers) are included. Eighteen studies targeted both parents, three studies focused on mothers, and no study on fathers. Seven studies are implemented in Australia, six in the United States, two in Israel, two in the United Kingdom, and four in Belgium, Germany, Switzerland, and the Netherlands. Summaries of the interventions are included in Table 2-3 and Table 2-4.

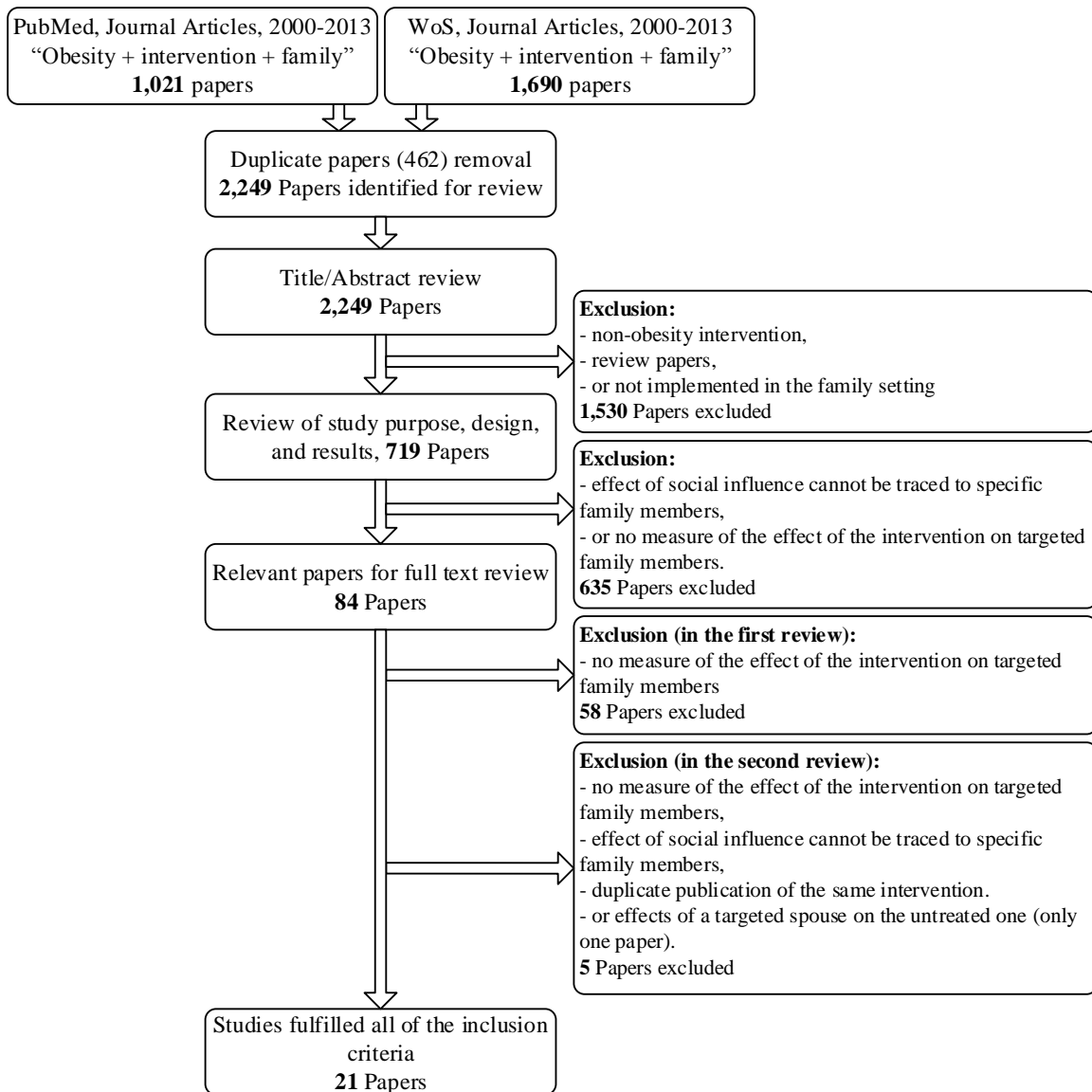


Figure 2-1. Study selection process

During the search process, we also looked for interventions that directly targeted any family member to influence the weight outcomes of another family member. We found only one paper [17] presented the effects of targeting a spouse on the untreated spouse’s behavior. We did not include this study in our review to avoid increasing the heterogeneity of our sample.

Table 2-1. Excluded studies in the second full text review

Study	Reasons for exclusion
MacGarvey <i>et al.</i> 2004 [18]	No measure of the effect of intervention on the targeted family members
Janicke <i>et al.</i> 2008 [19]	No weight-related behavior outcomes
Okely <i>et al.</i> 2010 [20]	Reported in Collins <i>et al.</i> 2011 [21].
Dalton <i>et al.</i> 2011 [22]	No measure of the effect of intervention on the targeted family members
Ostbye <i>et al.</i> 2012 [23]	Children directly engaged in some portions of the parent-focused intervention.

2.3.4 Data analysis

Data were extracted from each paper to provide a detailed understanding of the intervention and its impact. Study objectives, country of study, intervention type, duration, design, participants, family members directly/indirectly targeted, key findings and outcomes were extracted from each paper. We also coded for whether one or both parents were targeted, targeted behavior, and social influence mechanisms (see below).

After reviewing selected papers, we summarized the results using a causal pathway diagram of the social influence mechanisms (see Figure 2-2). Figure 2-2 captures the distinct causal mechanisms identified in the reviewed articles as potentially moderating the impact of parental interventions on childhood obesity. The diagram builds on the Social Ecological Models (SEM) for understanding childhood obesity [24, 25]. The causal pathway diagramming method is adopted from systems’ modeling toolbox [26-28] and has diverse applications, including literature reviews [29]. These diagrams provide a graphical summary of the key mechanisms identified in the literature, facilitate teasing out the empirical support for alternative pathways, highlight the areas in need for further empirical research, and set the stage for future quantitative statistical and systems modeling as well as meta-analyses. Due to the small sample size and high heterogeneity among the studies a quantitative aggregation of results using meta-regression was ruled out.

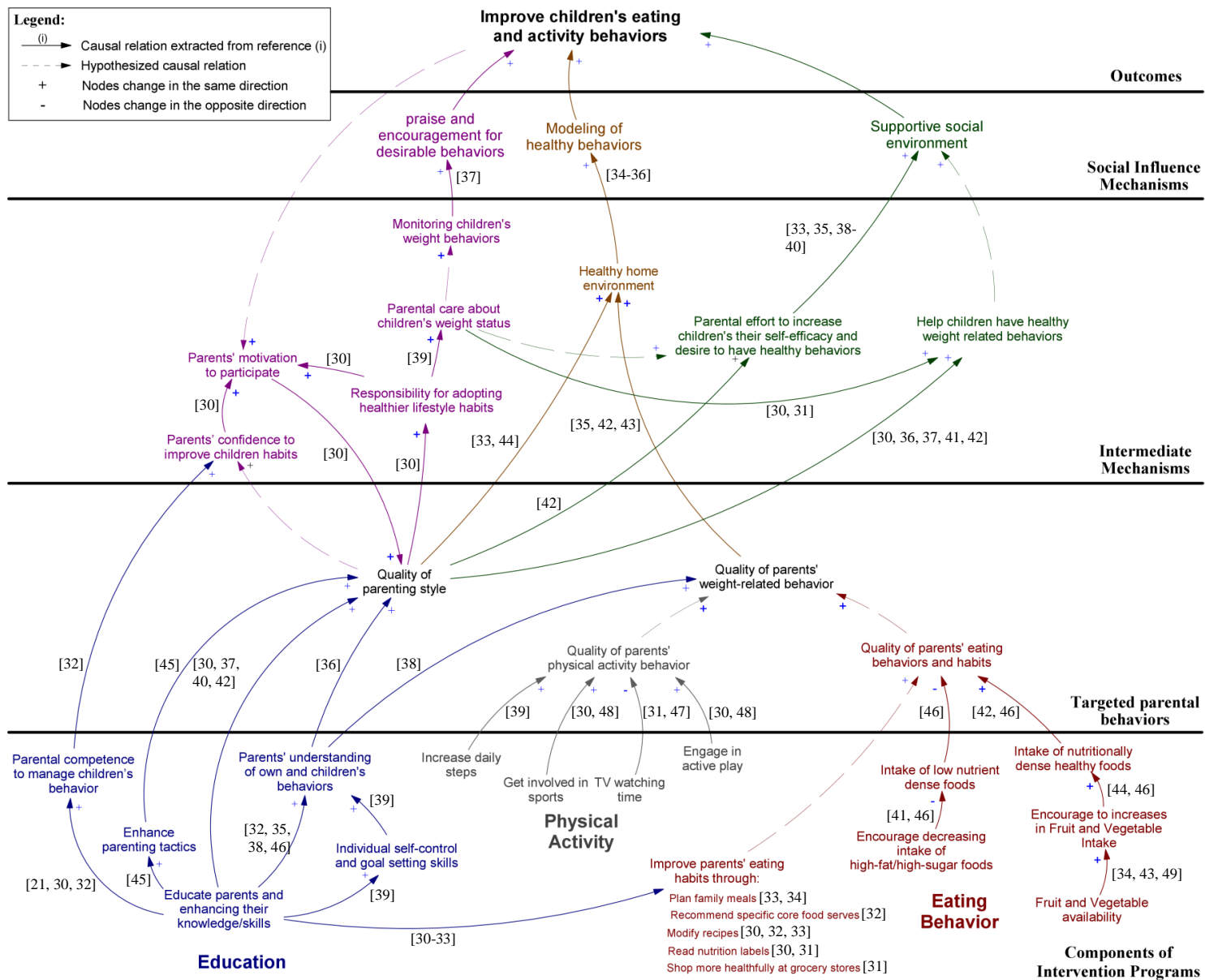


Figure 2-2. Causal loop relations

2.3.5 Social influence mechanisms

Different interventions leveraged diverse activities and behaviors, underlying the need for an organizing framework to categorize different social influence pathways used in each study. We therefore coded interventions for three core social influence mechanisms including: 1) a supportive social environment; 2) modeling healthy eating and activity patterns; and 3) praise and encouragement for desirable behaviors. Within each core mechanism, we identified specific behavior change techniques distilled from Abraham and Michie’s taxonomy [50]. For additional external validity, we mapped these techniques onto Kelman’s variants of social influence [51, 52] (see Table 2-2). For each intervention the behavior change techniques used and the targeted parent(s) are identified in Table 2-3.

Table 2-2. Behavior change through social influence

Core Social Influence Mechanisms	Behavior Change Techniques ¹	Observed in papers Table 2-3	Descriptions [50]	Kalman’s varieties of social influence [51, 52]
Supportive social environment	Plan social support or social change (I)	15 papers 71%	“Prompting consideration of how others could change their behavior to offer the person help or (instrumental) social support, including “buddy” systems and/or providing social support”	Internalization Compliance
	Provide instruction and guidance (II)	2 papers 10%	“Telling the person how to perform a behavior and/or preparatory behaviors”	-
	Provide feedback on performance (III)	3 papers 14%	“Providing data about recorded behavior or evaluating performance in relation to a set standard or others’ performance, i.e., the person received feedback on their behavior.”	-
	Prompt intention formation (IV)	4 papers 19%	“Encouraging the person to decide to act or set a general goal, for example, to make a behavioral resolution such as ‘I will take more exercise next week’”.	Internalization
Model healthy eating and activity patterns	Prompt identification as a role model (V)	13 papers 62%	“Indicating how the person may be an example to others and influence their behavior or provide an opportunity for the person to set a good example”.	Identification
Praise and encouragement for desirable behaviors	Provide contingent rewards (VI)	1 paper 5%	“Praise, encouragement, or material rewards that are explicitly linked to the achievement of specified behaviors”.	Compliance
	Provide general encouragement (VII)	6 papers 29%	“Praising or rewarding the person for effort or performance without this being contingent on specified behaviors or standards of performance”.	Compliance

¹The numbers associated with behavior change techniques are used in Table 2-3

Table 2-3. Characteristics of 21 reviewed studies

Paper	Type ¹	Age of child ²	Age of parent ³	Target behavior ⁴	Behavior change ⁵	Family composition
Epstein <i>et al.</i> 2001 [46]	T	IF&V: 8.8 (1.8) DF&S: 8.6 (1.9)	39.1 (4.1) 42.2 (4.8)	EB	I, III, VI	IF&V: 12 mothers and 1 father DF&S: 11 mothers and a father
Wardle <i>et al.</i> 2003 [40]	P	4.4 (0.8)	36.4 (4.7)	EB	VII	148 (95%) mothers and 8 (5%) fathers
Golan and Crow 2004 [35] ⁶	T	8.9 (0.3)	Mothers: 7.5(1.0) Fathers: 1.2(1.1)	PS	V	Both parents are included ⁷ .
Golan <i>et al.</i> 2006 [33]	T	PO: 8·7 (1.9) PC: 8·7 (2.0)	38.3 (4.7) 41.3 (5.6)	EB, PA	I, V, VII	PO (14 families): 13 fathers and 14 mothers PC (18 families): 18 mothers and 15 fathers
Golley <i>et al.</i> 2007 [32]	T	8.2 (1.1)	N/A ⁸	EB	II	Both parents are included.
Haire-Joshu <i>et al.</i> 2008 [43]	P	2.9	20 to 59	EB	IV	95% are mothers. Parents are more likely to be white, younger; less educated, and have lower income than control group parents. 70.4% of subjects in intervention group (n=605) and 74.6% of subjects in control group (n=701) are married or living with partner.
Janicke <i>et al.</i> 2008 [39]	T	PO: 11.0 FB: 11.4	41.0 40.4	EB, PA	I, V	Both parents are included.
Munsch <i>et al.</i> 2008 [41]	T	MO: 10.6 (1.5) MC: 10.3 (1.4)	38.8 (6.0) 40.9 (4.4)	EB, PA	I, V, VII	Only mothers are included. Four fathers eligible for the treatment are excluded.
Resnick <i>et al.</i> 2009 [31]	T	8.5	N/A	EB, PA	I, V	Both parents are included.
West <i>et al.</i> 2010 [30]	T	8.6 (1.7)	39.1 (5.2)	EB, PA, PS	I, V	Intervention group (n=52): Original biological parents: 42; One original, one step parent: 1; Sole parent: 9 Waitlist control (n=49): Original biological parents: 38; One original, one step parent: 1; Sole parent: 10
Boutelle <i>et al.</i> 2011 [37]	T	PO: 10.8 (1.3) PC: 10.1 (1.1)	44.6 (4.7) 41.0 (5.3)	EB, PA, PS	I, II	Both parents are included.
Collins <i>et al.</i> 2011 [21]	T	D: 8.2 (1.2) A: 8.3 (1.0) D+A: 8.1 (1.2)	N/A	EB, PA	I, V, VII	Both parents are included.

Paper	Type ¹	Age of child ²	Age of parent ³	Target behavior ⁴	Behavior change ⁵	Family composition
Golley <i>et al.</i> 2011 [47]	P	8.2 (1.1)	N/A	EB, PA, PS	I, V	Both parents are included.
Jansen <i>et al.</i> 2011 [45]	T	9.72 (1.6)	M: 40.31 (5.16) F: 43.18 (5.62)	EB, PA, PS	I, V	From 63 families, both parents participated in the study. In addition, 35 single parent families took part in the study (24 mothers and 11 fathers). In total, 87 mothers and 74 fathers participated.
Magarey <i>et al.</i> 2011 [36]	T	8.2 (1.2)	N/A	EB, PA, PS	I, VII	Most children (74%) are from dual-parent families.
Wyse <i>et al.</i> 2011 [49]	P	4.5 (0.8)	36.3 (5.2)	EB	I, III, IV, V	97% of parents (n=34) are female.
Moens and Braet 2012 [38]	P	S ₁ : 9.1 (1.3) S ₂ : 9.2 (1.4)	N/A	EB, PA	IV, V	Both parents are included.
De Bock <i>et al.</i> 2013 [48]	P	5.0 (0.2)	N/A	PA	I, V	Both parents along with grandparents are included.
Fletcher <i>et al.</i> 2013 [34]	P	4.3 (0.6)	35.2 (5.6)	EB	I, V, VII	Intervention group: mostly mothers (95.2%) Control group: mostly mothers (96.8%)
Janicke 2013 [42]	T	12	N/A	EB, PS	I, III, IV	A girl with her overweight mother
McGowan <i>et al.</i> 2013 [44]	P	3.4 (1.2)	35.7 (7.7)	EB	V	Most of the participants were biological mothers (91%), 5% were fathers, and 4% were step/adoptive parents.

¹T: Treatment, P: Prevention; ²Mean(standard deviation), IF&V: Increase Fruit and Vegetable Intake, DF&S: Decrease Fat and Sugar Intake, PO: Parent-only, PC: Parent-child, FB: Family-based, MO: Mother-only, MC: Mother-child, D: Diet, A: Activity, D+A: Diet+Activity, S₁: Study one, S₂: Study two; ³ Mean(standard deviation); ⁴ EB: Eating Behavior, PA: Physical Activity, PS: Parenting Style; ⁵ See Table 2-2; ⁶Ages and family composition are extracted from [53]. ⁷No further information is presented. ⁸Not available.

Table 2-4. Summary of 21 reviewed studies

Study, country	Objective, Type, Duration, Participants, Study design	Findings	Results summary / *** Quantitative results
Epstein <i>et al.</i> 2001 [46] United States	<p>Objective: Evaluate the effect of a parent-focused behavioral intervention on parent and child eating changes and on % overweight changes in families that contains at least one obese parent and a non-obese child.</p> <p>Intervention type: Treatment, randomized behavioral weight-control program</p> <p>Intervention duration: 6 months; follow-up at 6 and 12 months</p> <p>Participants: 30 families, one obese parent and a non-obese child (6-11 years)</p> <p>Study Design: Comprehensive behavioral weight-control program for parents; encourage increased fruit/vegetable intake <i>or</i> decreased intake of high-fat/high-sugar foods.</p>	<p>Focus on what can be eaten (versus what cannot) may increase adherence to caloric restrictions for weight control.</p> <p>Targeting fruit/vegetable intake in children increases intake of nutritionally dense foods AND decreases intake of low nutrient dense foods.</p> <p>Reduction in high-fat/high-sugar intake in children can be achieved by focusing on parent change.</p>	<p>Reduction in high-fat/high-sugar food intake in children of both groups; significant change in food patterns</p> <p>*** Group: Fruits and vegetables (Servings per day): Increase Fruit and Vegetable: 0.72 ± 1.11 Decrease Fat and Sugar: -0.55 ± 1.31 (significant between-group differences over time)</p> <p>Group: High-fat/high-sugar (Servings per day): Increase Fruit and Vegetable: -4.50 ± 7.97 Decrease Fat and Sugar: -8.50 ± 7.58 ($p < 0.001$)</p>
Wardle <i>et al.</i> 2003 [40] United Kingdom	<p>Objective: Evaluate effectiveness of in-home parent intervention to increase child preference for previously disliked vegetable.</p> <p>Intervention type: Prevention, exposure-based randomized controlled trial</p> <p>Intervention duration: 14 consecutive days taste test + 2- and 8-week follow up</p> <p>Participants: 156 parents of 2 to 6 years old children</p> <p>Study Design: Parents assigned to one of three groups: (a) training in ‘exposure’ feeding, (b) general nutritional information, or (c) no treatment. Target vegetable selected based on low ranking on preference test. Parents assigned to the exposure group given guidance on offering child a taste of target vegetable for 14 consecutive days.</p>	<p>Daily exposure to previously disliked vegetable increases child’s liking and consumption of target vegetable.</p> <p>The effect is strongest in the exposure group (showed a significant increase), weakest in the information group and intermediate in the control group.</p> <p>Anecdotally, parents and children enjoyed the ‘tasting games’ and frequently used the exposure technique for other foods after the study.</p>	<p>Increase children’s liking and consumption of that vegetable</p> <p>*** Means (SEM) of consumption of target vegetables: Exposure group: Pre-intervention: 4.1 (1.4) ; Post-intervention: 9.0 (1.7) Information group: Pre-intervention: 5.7 (2.1); Post-intervention: 7.3 (1.8) Control group: Pre-intervention: 5.7 (1.5); Post-intervention: 7.7 (1.6)</p> <p>Effects on preference ranking: Exposure group: 30% ranked their target vegetable as the most liked vs. Control group: 5% vs. Information group: 2%</p>
Golan and Crow 2004 [35] Israel	<p>Objective: Evaluate long-term change in child overweight in a parent-only vs. child only health-centered intervention.</p> <p>Intervention type: Treatment</p> <p>Intervention duration: 1 year + follow-up at years 1, 2, and 7</p> <p>Participants: 2 parent-only groups (15 families each), 2 child-only groups (15 children each). Children age 7-12 in original intervention</p> <p>Study Design: Parent-only Group: 14 1-hour support and educational group sessions. Topics included setting limits, nutrition education, eating and activity behavior modification, decreasing stimulus exposure, parental modeling, etc. Child-only Group: 30 1-hour group sessions. Topics included physical activity, eating behavior modification, stimulus control, self-monitoring, etc.</p>	<p>Over the long term, targeting parents improved child weight outcomes better than targeting children. Mean reduction in percent overweight is greater at all follow-up points in children of the parent-only group compared with those in the children-only group.</p>	<p>Reduction in percent overweight in children of the parent-only group after 7 years</p> <p>*** 7 years after the program terminated, mean reduction in children’s overweight: Parent-only group: 29% ($p < 0.05$) Children-only group: 20.2% ($p < 0.05$)</p>
Golan <i>et al.</i> 2006 [33] Israel	<p>Objective: Evaluate relative efficacy of targeting parents alone v. parents and obese children together to treat childhood obesity</p> <p>Intervention type: Treatment, randomized health-centered intervention</p> <p>Intervention duration: 6-month + follow-up at the 1-year</p> <p>Participants: 32 families, with at least one child age 6 to 11 years more than 20% overweight</p> <p>Study Design: Parents encouraged fostering authoritative parenting style. 16 1-hour support/education group sessions for each group. In addition, 40–50 min individual sessions once per month for each family (both groups), during the 6 month intervention.</p>	<p>Children (6–11 years) who attended intervention sessions with parents lost less weight than children whose parents were targeted alone. Parents-only produced significant reduction in the child % overweight at 6 and 12 months. Parents’ weight status does not change in either group.</p>	<p>Reduction in percent overweight of children in the parent-only group</p> <p>*** Parents-only group (BMI z): Baseline: 2.0 to termination (after 6 months): 1.6 (change: 0.4, $P < 0.05$); Overweight percentage: 47 ± 22.1 to 37.5 ± 22.0 (change: -9.5, $P < 0.05$) Parent and child group (BMI z): Baseline: 2.1 to termination: 2.0 (NS); Overweight percentage: 48.5 ± 18.1 to 46.1 ± 17.8 (change: -2.4, NS)</p>

Study, country	Objective, Type, Duration, Participants, Study design	Findings	Results summary / *** Quantitative results
Golley <i>et al.</i> 2007 [32] Australia	<p>Objective: Evaluate relative effectiveness of parenting-skills training as a key strategy for the treatment of overweight children.</p> <p>Intervention type: Treatment, assessor-blinded, randomized controlled trial</p> <p>Intervention duration: 5 month + follow-up at months 6 and 12</p> <p>Participants: 111 overweight, children age 6 to 9 years</p> <p>Study Design: 3 Parenting-skills training alone (P): parents participate in the Positive, Parenting Program (Triple P), 4 weekly 2-hour group sessions followed by 4 weekly, then 3 monthly, 15- to 20-minute individual telephone sessions. Parenting-skills training + intensive lifestyle education (P+DA): Complete the Triple P program described above plus an additional 7 intensive lifestyle support group sessions following completion of the 4 weekly parenting sessions (every 2 weeks at first, then monthly). Children in the P+DA group simultaneously attend structured activity sessions developed by physical activity experts. Three group design; third group is waitlist controls (WLC).</p>	<p>3 groups (P, P+DA, and control group) have a significant reduction in BMI z score over 12 months.</p> <p>Significant reductions in BMI seen in intervention boys, but not intervention girls or waitlisted controls. After 12 months, the BMI z score reduced by ~10% in P+DA versus ~5% P or waitlist controls</p>	<p>Reduction in BMI z score for both parenting-skills training groups (more reduction in P+DA)</p> <p>*** BMI z score change between 12 months and baseline: P+DA: -0.24 ± 0.43 P: -0.15 ± 0.47 Control group: -0.13 ± 0.40</p> <p>BMI z score decrease of children over 12 months: P+DA: 45% P group: 24% WLC group: 19%</p>
Haire-Joshu <i>et al.</i> 2008 [43] United States	<p>Objective: Test effectiveness of a home-based intervention for parents to foster a positive fruit–vegetable (FV) environment for their preschool child; examine whether changes in parent behavior are associated with improvements in child intake.</p> <p>Intervention type: Prevention, group randomized nested cohort</p> <p>Intervention duration: 7 months (range of 6 to 11 months)</p> <p>Participants: 1306 parents and children (ages 2 to 5 years)</p> <p>Study Design: High 5 for Kids (H5-KIDS) developed in partnership with Parents As Teachers (PAT). Parent educators deliver a standardized curriculum (social cognitive theory-based) via at least five home visits, on-site group activities, and a tailored newsletters and materials for families.</p>	<p>H5-KIDS parents and normal weight children increased FV intake.</p> <p>Overweight children more likely to consume high calorie snack foods or sweetened drinks which may limit intake and preference for FV.</p>	<p>Increase of FV servings in normal weight children but not overweight children</p> <p>*** Mean change of daily FV intake (parents): Both overweight and normal weight, Control group: 0.06 (p=0.05); Intervention group: 0.24 (p=0.05)</p> <p>Mean change of daily FV intake (children): Both overweight and normal weight Control group: -0.05 (p=0.2); Intervention group: 0.01 (p=0.2)</p> <p>Mean change of FV intake: Overweight children only, Control group: 0.09 (p=0.48); Intervention group: -0.07 (p=0.48)</p> <p>Mean change of FV intake: Normal weight children only, Control group: -0.11 (p=0.02); Intervention group: 0.23 (p=0.02)</p>
Janicke <i>et al.</i> 2008 [39] United States	<p>Objective: Assess effectiveness of parent-only vs. family-based interventions for pediatric weight management in underserved rural setting.</p> <p>Intervention type: Treatment, three-arm randomized controlled clinical trial</p> <p>Intervention duration: 4 month + follow up at 10 months</p> <p>Participants: 64 families with overweight/obese 8 to 14 years old children</p> <p>Study Design: Study arms: (1) a behavioral family-based (FB) intervention: Parent and child dyads participated in simultaneous but separate groups, (2) a behavioral parent-only (PO) intervention: Only the participating parent(s) attended group meetings, or (3) a waitlist control.</p>	<p>Both PO and FB interventions demonstrated improvement in weight status compared with control. Children <11 years, those in the PO had about 50% greater decrease in weight status at follow-up relative to those in FB.</p>	<p>Decrease in BMI z score of children in PO group; Not significant difference in weight status change between PO and FB</p> <p>*** An overall mean decrease of BMI z score: Children in the PO intervention: 0.090 (0.039) Children in the FB intervention: 0.115 (0.046)</p>

Study, country	Objective, Type, Duration, Participants, Study design	Findings	Results summary / *** Quantitative results
Munsch <i>et al.</i> 2008 [41] Switzerland	<p>Objective: Investigate whether treatment of mothers only is as effective as a mother-child treatment in a randomized controlled clinical trial to reduce child overweight.</p> <p>Intervention type: Treatment, Cognitive behavioral therapy (CBT) randomized controlled trial.</p> <p>Intervention duration: 10 weekly 120-min sessions and 6 monthly sessions</p> <p>Participants: 31 families in the mother-child (MC) group and 25 families in the mother-only (MO) group (child age 8 to 12 years)</p> <p>Study Design: In both conditions mothers receive CBT. Children in MO attend relaxation training of equal frequency/duration to the child CBT training in MC. Mothers encouraged to follow basic food rules for family meals, model physical activity, and focus on coping with social stigmatization of obesity for their child.</p>	<p>Overweight percentage between baseline and 6-month follow-up is reduced by 1.9% (MC) and 4.5% (MO) based on a linear mixed model.</p> <p>Both treatments are efficacious with respect to the reduction of overweight in children between baseline and 6-month follow-up and that these reductions are similar between the two treatments.</p>	<p>Reduction in child percent overweight; no difference between the parent-only and parent-child interventions</p> <p>*** Child BMI (MC): Baseline: 29.64; End of treatment: 29.60; End of follow-up: 29.70</p> <p>Child BMI (MO): Baseline: 27.34 (SE=1.69); End of treatment: 27.40 (SE=1.69); End of follow-up: 27.21(SE=.70)</p>
Resnick <i>et al.</i> 2009 [31] United States	<p>Objective: Pilot an easy-to-use parent outreach model that could ultimately be used by school nurses, pediatricians, community health agencies, and community health workers to reduce child overweight/obesity.</p> <p>Intervention type: Treatment, pilot parent-directed trial</p> <p>Intervention duration: 36-hr training program over 6 days, 1-year follow-up</p> <p>Participants: 46 parents of overweight/obese elementary school students (mean age 8.5 years)</p> <p>Study Design: Parents from two schools randomly assigned to either Materials Group (M) or Materials plus Personal Encounters Group (M + PE). M receives mailed educational materials and P+PE receive educational materials through interactions with community health workers. Parents in both groups receive identical materials.</p>	<p>~50% parents reported confidence in knowing ways to improve child's nutritional habits, and ~66% reported confidence in knowing/ talking about ways to increase child's activity at baseline. Modest reductions in BMI found for children who watched <2 hr TV/day after study completion compared with children who watched >2 hr TV/day at baseline.</p>	<p>Reduction in BMI for children</p> <p>*** Post-Intervention Overall: child BMI percentile: 90.6 ± 10.0 (p = .005)</p> <p>Baseline Overall: child BMI percentile: 94.1 ± 4.3</p> <p>There are no significant between-group differences in the reduction of BMI (between M and M + PE groups).</p>
West <i>et al.</i> 2010 [30] Australia	<p>Objective: Evaluate the effects on child weight of a parent-only parenting and child weight-related behavior intervention, relative to a waitlist control.</p> <p>Intervention type: Treatment, randomized clinical trial</p> <p>Intervention duration: 12-week + 1 year follow-up</p> <p>Participants: 101 families with overweight/obese children age 4 to 11</p> <p>Study Design: The lifestyle-specific parenting program consists of nine 90-min group sessions to enhance parents' commitment to change and three 20-min telephone sessions to review parents' implementation of strategies, and address challenges. All sessions use an active skills training process within a self-regulation framework (e.g., goals and progress evaluation). Parents receive a workbook summarizing session content and suggested between-session tasks.</p>	<p>The intervention has significant effects on child body size, weight-related problem behavior, parenting self-efficacy, and ineffective parenting. 25% of parents report reductions in child weight-related problem behavior. 33% of families show significant decreases in ineffective parenting, and 14% children show clinically significant decreases in weight. 10% of children move from obese to overweight.</p>	<p>Reductions in children BMI z score and weight-related problem behavior</p> <p>*** Intervention group: child BMI z-score: 2.15 (pre) to 2.04 (post) and 1.96 (after 1 year)</p> <p>Control group: child BMI z-score: 2.11(pre) to 2.10 (post)</p>
Boutelle <i>et al.</i> 2011 [37] United States	<p>Objective: Determine whether a Parent-only (PO) intervention is not inferior to a parent and child (PC) treatment for childhood obesity.</p> <p>Intervention type: Treatment, randomized clinical trial</p> <p>Intervention duration: 5-month + 6-month follow-up</p> <p>Participants: 80 parent-child dyads (overweight/obese children age 8 to 12 year) (40 pairs PO; 40 pairs PC)</p> <p>Study Design: 60-min separate child and parent sessions. Parents in the PO group coached on how to assist children in weight monitoring and behavior change. Program included dietary modification (traffic-light diet), increased physical activity, behavioral change skills, and parenting skills specific for children who are overweight.</p>	<p>Child weight loss and physical activity in PO group not inferior to PC group. PO potentially more cost-effective and easier to disseminate.</p>	<p>Decrease in BMI-z score of children in PO and PC groups; PO child weight loss, parent weight loss and child physical activity not inferior to the PC.</p> <p>*** Child BMI-Z score in Parent-only: Pre-treatment: 2.29 (0.38); Post-treatment: 2.16 (0.54); Follow-up: 2.10 (0.68),</p> <p>Child BMI-Z score in Parent-child: Pre-treatment: 2.25 (0.34); Post-treatment: 2.06 (0.40), n=28; Follow-up: 2.08 (0.41), n=28</p>

Study, country	Objective, Type, Duration, Participants, Study design	Findings	Results summary / *** Quantitative results
Collins <i>et al.</i> 2011 [21] Australia	<p>Objective: Evaluate the impact of a child-centered physical-activity plus parent-centered dietary-modification program on child BMI-z score</p> <p>Intervention type: Treatment, three-arm assessor-blinded randomized control trial</p> <p>Intervention duration: 6-month + 6-, 12-, and 24-month follow-up</p> <p>Participants: 165 overweight prepubertal children (68 boys) age 5.5 - 9.9 years</p> <p>Study Design: 3 arm intervention (1) parent-centered dietary-modification program (Diet), (2) child-centered physical-activity skill-development program (Activity), and a combination of programs (Activity + Diet). Each arm: 1) 10 weekly 2-hour face-to-face session with homework activities; 2) 3-monthly relapse-prevention telephone sessions to review parent goals.</p>	<p>All groups achieved clinically significant reductions in BMI z score and waist circumference at 24 months.</p> <p>Parent Diet program is more efficacious than child Activity program, although not different from Activity + Diet suggesting childhood obesity treatment could focus exclusively on parental modification of child dietary intake.</p>	<p>All groups reduction BMI z score (greatest effects through inclusion of a parent-centered diet program)</p> <p>*** BMI z score, adjusted for gender, 24-month difference from baseline by treatment group (P<0.001): the diet-only group: -0.35 (-0.48 to -0.22) activity-only group: -0.19 (-0.30 to -0.07) the activity and diet group: -0.24 (-0.35 to -0.13) all groups -0.26 (-0.33 to -0.19)</p> <p>BMI z score, adjusted for gender, between-group differences from baseline (P=0.04): the diet-only group: -0.17 (-0.34 to 0.01) activity-only group: -0.05 (-0.21 to 0.11) the activity and diet group: 0.11 (-0.06 to 0.28)</p>
Golley <i>et al.</i> 2011 [47] Australia	<p>Objective: To describe the impact of a parent-led, family-focused child weight management program on the food intake and activity patterns of pre-pubertal children</p> <p>Intervention type: Prevention, an assessor-blinded, randomized controlled trial</p> <p>Intervention duration: 6 month + 6 month follow-up</p> <p>Participants: 11 (64% female) overweight, pre-pubertal children age 6 to 9 years</p> <p>Study Design: The parenting-skills training alone (P) and P + activity education (DA) groups attended an eight-week standardized general parenting program. Parents in the P + DA arm attended additional seven lifestyle education sessions based on the Australian food selection guide. Parents in the P and wait list control groups (WLC) received a 'lifestyle recommendations' pamphlet.</p>	<p>Intake of extra foods (i.e., energy-dense nutrient-poor foods) was lower in both intervention groups at 6 and 12 months. Intervention achieved a reduction in children's intake of extra foods without compromising intake of nutrient-rich foods.</p>	<p>Reduction in children's intake of energy-dense, nutrient-poor foods and an increase in the time reported spent in active play</p> <p>*** Reducing children's intake of extra foods: P + DA: Baseline: 3.5 (2.5-4.5); 6 months: 2.0 (1.5-2.5); 12 months: 2.0 (2.0-3.0) P: Baseline: 3.0 (2.4-3.4); 6 months: 1.5 (1.5-2.0); 12 months: 2.3 (1.5-3.0) WLC: Baseline: 3.0 (2.0-3.5); 12 months: 2.5 (1.9-4.0)</p>
Jansen <i>et al.</i> 2011 [45] Netherlands	<p>Objective: Evaluate whether a treatment aimed solely at obese children's parents results in positive effects on the children's weight status</p> <p>Intervention type: Treatment, a randomized controlled trial</p> <p>Intervention duration: 10 weeks + 3 month</p> <p>Participants: Parents of 98 overweight or obese children, age 7 to 13 years</p> <p>Study Design: Parents attended eight sessions spread over 10 weeks. The purpose of the sessions was to teach parents to think of alternatives and possible solutions, rather than to purely present information. A substantial part was devoted to enhancing parenting tactics.</p>	<p>Child BMI percentile decreased 2.4% in the treatment group, whereas there was no change in the waiting-list control group.</p>	<p>The parents' treatment had significant effects on child and parent BMI.</p> <p>*** BMI percentile child: Treatment group (n = 59): Pre-treatment: 96.8±2.93; Post-treatment: 94.5±6.52; 3 Month follow-up: 94.7±6.58 WLC group (n = 39): Pre-treatment: 95.9 ±3.38; Post-treatment: 96.0 ±3.64; 3 Month follow-up: 95.7±3.90</p>

Study, country	Objective, Type, Duration, Participants, Study design	Findings	Results summary / *** Quantitative results
Magarey <i>et al.</i> 2011 [36] Australia	<p>Objective: Evaluate a healthy lifestyle (HL) intervention to reduce adiposity in children aged 5 to 9 years; assess effect of added parenting skills training.</p> <p>Intervention type: Treatment, single-blinded randomized controlled trial</p> <p>Intervention duration: 6-month + 6, 12, 18, 24 months</p> <p>Participants: 169 pre-pubertal moderately obese children, age 5 to 9 years</p> <p>Study Design: Both arms parent-only: 12 (P+HL group) or 8 (HL group) 90- to 120-minute group sessions (and 4 telephone sessions, delivered over 6 months with tapered frequency (weekly, bimonthly, then monthly). The Positive Parenting Program (Triple P) was delivered in 4 sessions to P+HL parents before the lifestyle (HL) component (to encourage parents to anticipate and manage high-risk situations with respect to a positive energy balance). HL sessions focused on information only.</p>	10% reduction in BMI z scores from baseline to 6 months (maintained at 24 months with no additional intervention.)	<p>Reduction in BMI scores in pre-pubertal children</p> <p>*** Mean BMI z Score:</p> <p>P+HL: Baseline (n=85): 2.77±0.58 After 24 month (n=52): 2.38 ±0.67</p> <p>HL: Baseline (n=84): 2.68±0.65 After 24 month (n=54): 2.26±0.84</p>
Wyse <i>et al.</i> 2011 [49] Australia	<p>Objective: Examine efficacy of a brief telephone-based parent intervention to increase fruit/vegetable consumption in children aged 3–5 years' examine feasibility of intervention delivery and parent acceptability.</p> <p>Intervention type: Prevention, pre–post study design with no comparison group.</p> <p>Intervention duration: 4 weeks + 1 week follow-up</p> <p>Participants: 34 parents of children age 3 to 5 years</p> <p>Study Design: Four 30 minute weekly telephone calls plus instructional resources. Three focus areas: availability and accessibility of foods within the home, role modeling fruit/vegetable consumption, and supportive family eating routines.</p>	Variety and/or frequency of children's fruit/vegetable consumption significantly increased. Increased vegetable/fruit consumption corresponded with non-significant decrease in the variety and frequency of children's consumption of non-core foods. Parents willing to receive and continue with an intervention.	<p>Increase of variety and/or frequency of children's fruit and vegetable consumption</p> <p>*** CDQ, Children's dietary questionnaire, fruit and vegetable subscale (P=0.027): Pre-intervention: 15.5 (5.1) Post-intervention: 18.1 (4.1)</p>
Moens, Braet 2012 [38] Belgium	<p>Objective: Evaluate a parent-led intervention to reduce child BMI.</p> <p>Intervention type: Treatment, a cluster-randomized controlled trial</p> <p>Intervention duration: 6 month + 12-month</p> <p>Participants: 50 families with overweight children, age 6 to 12 years</p> <p>Study Design: Six 2-hour group sessions over 5-months. Dietician and a psychologist provide lifestyle education behavior.</p>	<p>Children in the intervention group: decrease in adjusted BMI of 7% post-intervention; weight loss maintained at the one-year follow-up.</p> <p>For the obese children more intensive treatment is required.</p>	<p>Positive changes in children's eating behavior and positive increase in familial health principles</p> <p>*** The decrease in adjusted BMI from baseline to the 6-month measurement was comparable in both groups Intervention group: M1 = 147.57% and M2 = 142.55%; Waitlist group: M1 = 139.45% and M2 = 135.92%) (Only significant in the intervention group, t(30) = 2.44, p = .021).</p>
De Boek <i>et al.</i> 2013 [48] Germany	<p>Objective: To assess whether a participatory parent-focused approach using parents as agents of behavioral change enhances the efficacy of a preschool physical activity (PA) intervention</p> <p>Intervention type: Prevention, a cluster randomized controlled trial</p> <p>Intervention duration: 6 months (but continued for a total of up to 9 months) + 12 months follow-up</p> <p>Participants: parents of 433 preschool children age 4 to 6 years</p> <p>Study Design: In control group, parents received a state-sponsored program consisting of twice-weekly 1-hour gym classes over 6 months. In intervention group, parents are motivated to develop and implement their own project ideas for promoting children's PA. The external gym trainers in intervention group received additional training and served as intervention facilitators helping to coordinate parent activities, encouraging participation, and documenting the intervention implementation.</p>	<p>Compared to children enrolled in the standard, expert-driven program alone, children who received a combination of the participatory intervention and the expert-driven non-participatory program were significantly less sedentary and more physically active after 12 months. Half a year after program termination, children in the participatory arm had 4% more accelerometry counts and spent 11 (1.7%) fewer minutes in sedentary behavior during wake times.</p>	<p>Promote PA and reduce sedentary behavior in preschoolers</p> <p>*** Sedentary behavior, minutes/day Intervention Group: Baseline: 631.3±68.3; 6 months: 629.9±62.6; 12 months: 623.9±66.8 Control Group: Baseline: 631.4±63.2; 6 months: 633.3±63.5; 12 months: 628.1±67.1</p> <p>Mean accelerometry, counts/15 seconds/day Intervention Group: Baseline: 31.4±8.1; 6 months: 32.2±8.7; 12 months: 32.95±10.78 Control Group: Baseline: 31.8±9.7; 6 months: 31.8±9.4; 12 months: 32.6±11.6</p>

Study, country	Objective, Type, Duration, Participants, Study design	Findings	Results summary / *** Quantitative results
Fletcher <i>et al.</i> 2013 [34] Australia	<p>Objective: To assess the effectiveness of a telephone-based intervention in reducing child consumption of non-core foods, and to examine parent and home food environment mediators of change in child consumption</p> <p>Intervention type: Prevention, a clustered randomized controlled trial</p> <p>Intervention duration: 2 months + 6 months follow-up</p> <p>Participants: 394 parents of preschool-aged children, age 3 to 5 years</p> <p>Study Design: Parents in the intervention group received four telephone contacts and print materials targeting parent and home food environment characteristics, while parents in the control group received generic print materials only.</p>	Child consumption of non-core foods was reduced at 2 months, however this was not maintained at 6 months. Child access to non-core foods in the home, and child feeding strategies are significant mediators, which representing the primary causal pathways by which the intervention influenced the consumption of non-core foods.	<p>Improve short-term dietary behavior in preschool age children</p> <p>*** Child non-core food consumption:</p> <p>Intervention Group: Baseline: 2.48±0.08; 2 months: 2.24±0.07; 6 months: 2.29±0.09</p> <p>Control Group: Baseline: 2.59±0.08; 2 months: 2.57±0.11; 6 months: 2.47±0.10</p>
Janicke 2013 [42] United States	<p>Objective: To describe behavioral parent-only intervention to promote healthier lifestyle habits and reduce weight status in an obese 12-year-old female participant.</p> <p>Intervention type: Treatment, case example of a randomized controlled trial</p> <p>Intervention duration: 4 month + 10 month follow-up</p> <p>Participants: A 12-year-old girl with her mother</p> <p>Study Design: The intervention included 12 group sessions over 4 months. Behavioral strategies such as including self-monitoring, goal setting, performance feedback, reinforcement, stimulus control, and instruction in behavioral parenting strategies were applied.</p>	The child lost 17 pounds and grew 1.7 inches in height. Her quality of dietary intake was improved. She also experienced a drop in the number of self-reported unhealthy weight control behaviors.	<p>Improvement in the child's quality of dietary intake and a drop in the number of self-reported unhealthy weight control behaviors</p> <p>***BMI z-score decrease: At 6-month follow-up: 0.6</p> <p>Mean daily caloric intake: Baseline: 2,066; At 6-month follow-up: 1,664</p>
McGowan <i>et al.</i> 2013 [44] United Kingdom	<p>Objective: To promote habit formation for three parental feeding behaviors: serving fruit/ vegetables, serving healthy snacks, and serving non-sweetened drinks</p> <p>Intervention type: Prevention, a cluster-randomized, controlled exploratory trial</p> <p>Intervention duration: 8 week (follow-up measures were completed at the final home visit)</p> <p>Participants: 126 parents of children age 2 to 6 years</p> <p>Study Design: The intervention was delivered over the course of 4 visits to the family in home. Researchers worked through an intervention booklet in each visit, lasting about an hour. The booklet introduced the concept of habit formation along with tips for habit formation.</p>	Significant effects on children's intake of vegetables, healthy snacks and water were reported. Changes in parental automaticity of feeding behaviors correlated with children's food intake.	<p>Modification in parental feeding behaviors, change children's diets positively, and well acceptance by parents</p> <p>*** Change in children's serving of vegetables per day: Intervention Group: +0.8±1.3; Control Group: +0.1±0.8</p> <p>Change in Healthy snack occasions per day: Intervention Group: +1.0±2.1; Control Group: -0.2±2.1</p> <p>Change in Water occasions per day: Intervention Group: +0.6±1.0; Control Group: +0.1±0.9</p>

2.4 Analysis

The analysis focuses on teasing out the components of interventions, mechanisms of impact, and the outcomes to inform social influence processes and future intervention designs. Table 2-4 provides a detailed review of these studies, including their design, findings, and quantitative outcomes. Given the level of detail in Table 2-4, Figure 2-2 is developed to help illustrate the findings in this section. Insights gained from these studies are summarized as potential causal mechanisms that connect different interventions to outcomes of interest, improving eating and activity behaviors (Figure 2-2). We relied both on the explicit reports of mechanisms in the original studies (solid lines in Figure 2-2) and our judgment about likely additional pathways (dashed lines). Figure 2-2 is divided into five layers that span conceptual steps involved in these mechanisms: 1) *Components of intervention programs*, 2) *Targeted parental behaviors*, 3) *Intermediate mechanisms* (actions that transfer the effects of intervention programs from the parents to the indirectly targeted family member, i.e., children), 4) *Social influence mechanisms* which include the psychological consequences of the intermediate mechanisms, and 5) *Outcomes* (e.g., improved child's eating and activity behaviors). Below we discuss these five layers in more detail, noting that the causal pathways span across these layers and thus they are easier to follow along with the Figure 2-2 diagram.

2.4.1 Components of intervention programs

Three distinct components, *education*, *physical activity*, and *eating behavior*, can be identified as part of the interventions we reviewed (the bottom layer in Figure 2-2). Some interventions focus more on one component than others, yet they all include these three elements to some extent. These components each activate several additional mechanisms relevant to understanding how social interventions work. We first summarize the intervention components and then discuss the pathways through which they impact children's obesity outcomes.

Parental Education

Parental education is a significant element in many of the interventions, though it is often accompanied by other components [54]. Parental education aims to improve parents' own weight-related behavior as well as their feeding style. For example, changes in parental responsibility for child feeding [55] encouraging nutritional variety and balance, and modeling

[56] have been reported. In the reviewed interventions, some educational components enhance parents' understanding of their own and children's behaviors [32, 35, 38, 46], parenting tactics (e.g., teaching parents to ignore undesirable behaviors and reward desirable behaviors) [45], and improve parents' competence in managing children's behavior [21, 30, 32]. Moreover, some interventions include components related to individual self-control and goal setting to enhance parenting skills [39].

Physical Activity and Eating Behavior

Many interventions also aimed to change parents' weight-related behaviors. Interventions with *physical activity* components attempted to: increase daily steps [39], get parents involved in sports [30, 48], reduce TV watching time [31, 47], and engage parents in active play [30, 48]. Interventions with *eating behavior* components targeted improving parents' eating habits through planned family meals [33, 34], recommending core food servings [32], modifying recipes [30, 32, 33], reading nutrition labels [30, 31], shopping for more healthful foods at grocery stores [31], encouraging decreased intake of high-fat and high-sugar foods [41, 46], increasing fruit and vegetable availability at home [34, 43, 49], and increasing intake of nutritionally dense healthy foods [44, 46].

2.4.2 Targeted parental behaviors and intermediate mechanisms

The capabilities, routines, and knowledge resulting from the above components enhance a set of parental behaviors in relationship with children [30, 36], which together we call quality of parenting style. These include taking responsibility for adopting healthier lifestyle habits at home [30], caring about a healthy home environment [33, 44], parental effort to instill a desire for healthy behavior in children [42], and support for children's attempts to adopt healthy behaviors [30, 36, 37, 41, 42].

By taking responsibility for adoption of healthy lifestyle habits parents may become more motivated to participate in intervention components [30]. That responsibility also enhances parents' caring about children's weight status [39], leading to better monitoring and feedback to change children's behavior, one of the social influence mechanisms relevant to children's outcomes. Moreover, increased quality of parenting may lead to children's enhanced self-efficacy and increased desire to have healthy behaviors [42] and ultimately result in creating a supportive social environment at home [33, 35, 38-40].

Parental education can increase parents' competency to manage children's behavior, improving parents' confidence in helping children change their habits [32] and enhancing parents' own motivation to continue participation in the intervention [30]. Motivated parents also show higher quality of parenting style [30]. In fact, there is a potential virtuous cycle (reinforcing feedback loop) in which parents gain confidence, become more committed to the intervention, and therefore perform better in their parenting style, paving the way for further successes and confidence building.

Changing parents' own weight-related behaviors moderates home environment, access, and children's modeling of behaviors. Different studies have targeted different subsets of parents' activities, from reducing TV watching hours to increasing fruits and vegetable availability. Parental education also reinforces parental weight-related behavior change as parents learn more about the importance of their own and the children's behaviors [38]. Once actively pursued, these parent's healthy eating and activity behaviors, together with improved parenting style, lead to healthier home environments [33, 35, 42-44]. Home environment, as a psychosocial antecedent for children's obesity [57], has the potential to change children's attitude toward different foods and activity level [58, 59]. Through modeling effects as well as access, healthy home environment could also regulate children's "obesogenic" behaviors such as regularity of participation in family meals, television viewing habits, and healthy food consumption [33].

2.4.3 Social influence mechanisms

In the preceding section, we identified three core social influence mechanisms that moderate how parental interventions influence children's behaviors. We discuss these mechanisms below.

Praising and encouraging desirable behaviors

As parental attention increases monitoring of children's weight-related behaviors, parents can provide praise and encouragement for desirable behaviors (and potentially punish undesirable ones). This type of social influence, also referred as *compliance* [51] (see Table 2-2), is not typically associated with enduring changes; in the absence of other influences, compliance often requires continued rewards and punishments to sustain the target behavior [60]. Ultimately, children must develop the ability to follow healthy eating and physical activity behaviors without much external feedback.

Modeling of healthy eating and activity patterns

Modeling is one of the main mechanisms in which behaviors transfer through social relations, and has been strongly recommended for obesity interventions [61, 62]. Social modeling occurs because people, often unconsciously, adjust their behaviors to match their valued social ties. This type of social influence (modeling) is also called *identification* [51, 60] (see Table 2-2), and provides a pathway to more sustained change in children's behavior. The key to activating this pathway is parental behavior change which provides a healthy home environment and opportunities for children to imitate parents' healthy behaviors [63]. Given the reduction in the amount of time children spend with their parents and the adoption of role models outside of home as children age, identification is likely strongest for younger children [60], leading to the recommendation of using social influence for younger children [60]. However long-term follow up studies are needed to track if the modeled behaviors among younger children last into adulthood and whether this mechanism includes an age effect separate from the amount of time children spend with parents.

Supportive social environment

Providing a social environment supportive of healthy behaviors provides a third pathway to social influence. This mechanism is partially encouraged by the healthy home environment. Moreover, in a supportive environment parents would help children form their values and beliefs so that they actively choose healthy behaviors. This mechanism allows for the *internalization* (see Table 2-2) of the target behaviors, and is hypothesized to be the longest lasting type of social influence and best suited for older children [60].

In our sample parent interventions most frequently targeted building supportive environments (see letters I-IV in Table 2-2 and Table 2-3) to promote healthy child weight, followed by providing general encouragement as positive reinforcement. Parent interventions were least likely to target contingent rewards (such as offering a toy in exchange for making healthier food choices) as positive reinforcement.

2.4.4 Outcomes

Our main outcomes of interest are children's eating and physical activity behaviors, which directly influence obesity outcomes. The reviewed studies showed various levels of impact on

children's obesity outcomes and weight-related behaviors. Eight papers [21, 30, 32, 33, 36, 37, 39, 42] reported reductions in BMI z-score (mean [range] of -0.25 [-0.6,-0.1]), two papers reported reductions in BMI percentile by 3.5% (P=0.005) [31] and 2.4% (P<0.001) [45], and one paper reported 7% (P=0.001) decrease in adjusted BMI (actual BMI/percentile 50 of BMI for age and gender x 100) [38]. Reductions in percentage overweight were reported as 4% (P<0.001) [41] and 14% (P<0.05) after one year (29% (P<0.05) after seven years) [35]; however, one study reported no change in the percentage of overweight over one year [46]. Moreover, several papers report changes in food consumption patterns including an increase in the frequency and variety of fruit and vegetable consumption (P=0.03) [49], increases in intake of vegetables (P=0.003), healthy snacks (P=0.009) and water (P=0.03) [44], increase in the willingness to eat vegetable (P<0.01) [40], decrease in the consumption of non-core foods at two months (P<0.01, however not maintained at six months) [34], and a decrease in the intake of energy-dense, nutrient-poor foods (P=0.02) [47]. One study reported positive effects of parents' fruit and vegetable intake (P=0.001) and availability of fruit and vegetable (P=0.01) on children's fruit and vegetable intake [43]. Reported physical activity outcomes included a decrease in sedentary behavior (11 min/day, P=0.01) and an increase in the accelerometry counts (1.4 counts/15 seconds, P=0.02) [48].

2.4.5 Alternative behavior change techniques

Seven of the behavior change techniques summarized in Table 2-2 include social influence mechanisms and were utilized to varying degrees in the studies we reviewed (see Table 2-2 for descriptions of these techniques and their associations with the core social influence mechanisms). Among the techniques that targeted supportive social environments, the behavior change technique of *plan social support or social change* was most prevalent, being observed in 71% of the interventions (15 papers). Three other techniques were not widely utilized: *provide instruction and guidance* (10%, two papers), *provide feedback on performance* (14%, three papers), and *prompt intention formation* (19%, four papers). It should also be noted that a supportive social environment needs proper and effective parenting style (see [64-66] for more discussion), while only 27% of the interventions (4 papers) focused specifically on the parenting style (see Table 2-3). Among the rest of the behavior change techniques, the potential technique of *prompt identification as a role model* was observed frequently (62%; 13 papers). Lastly,

provide contingent rewards and *provide general encouragement* were observed in 5% (one paper) and 29% (six papers) of interventions, respectively.

2.5 Discussion and conclusion

The choice of direct and indirect change agents within the family has recently received some attention in obesity research, e.g., see [57, 67-71]. A few family based interventions target parents aiming to induce behavioral change in children. We provided a simple graphical summary (Figure 2-2) of the key social influence mechanisms identified in the 21 reviewed papers in which children are targeted indirectly. We also mapped out three core social mechanisms to seven behavior change techniques and their use in the interventions (Table 2-2 and Table 2-3). Analyzing these mechanisms, we identified the provision of a supportive social environment for children as potentially the most beneficial social influence mechanism for older children, and the modeling of healthy behavior as especially useful for younger children [60]. The choice of existing intervention designs, however, is not explicitly connected to these recommendations, and may be better explained by feasibility constraints and other goals the studies have pursued. Therefore, significant diversity can be observed in the current designs and outcomes. The limited number of studies and heterogeneity in the designs and reported outcomes did not allow for insights from quantitative assessment of specific pathways. The reports on these interventions also did not provide enough detail to enable comparative cost-benefits analysis, an important need for designing cost-effective interventions.

In addition to the social influence mechanisms and the causal relations discussed in the analysis section, findings from the included studies provide insights on how to improve the efficacy of interventions. Specific recommendations adopted from the reviewed studies include targeting families with young children, (children younger than 11 years) [33, 36, 39]; starting treatment from early stages of obesity [38, 43] as more intensive interventions are usually required for obese children; focusing on what can be eaten versus what cannot be eaten [46]; and focusing on health-centered rather than weight-centered approaches [35, 46]. These recommendations are in line with focusing on providing a supportive social environment that leads to internalization of healthy behaviors in the family, rather than more narrowly defined obesity treatment goal.

Moreover, additional benefits are observed in treating parents as the direct agents of change in the family setting rather than treating the children directly (for more discussions on the roles of mother and father, see [72, 73] and [74], respectively). These benefits relate more to the logistics and sustainability of interventions than to social influence mechanisms. First, focusing on parents reduces children's perception of having a health problem and the stigmatization that goes with being "an overweight patient" [35]. As a result, children are less likely to resist the lifestyle changes that accompany the intervention [39]. Moreover, parents usually have an easier time attending the intervention sessions without the children [39, 40], and the sessions are more productive in terms of problem solving and discussion time among participating parents [39]. In addition, including fewer change agents reduces the costs of the intervention [30, 31, 37] and makes the intervention more feasible for some, especially among underserved rural communities [33]. The logistical benefits also enhance parents' motivation to participate, increasing intervention's sustainability and parents' commitment. Nevertheless, the current literature provides limited cost data to enable a systematic comparison of cost-benefits against alternative interventions.

There is considerable interest among obesity researchers in understanding the influence of systems on nutrition and physical activity behaviors. This goes more "upstream" from the family and addresses the outer levels of the socio-ecologic model including community and organizational (e.g., school, faith-based organizations, and community recreation programs) factors as well as policy and environmental change at the local, state, and national level [25, 75]. However, one can also consider systems change within the family, where parental training/education could lead to structuring the home environment so that the "healthy choice is the easy choice". Here the influence on a child's behavior is likely a combination of reinforcement, modeling and internalization as well as a more direct impact of having access to healthy food and equipment/space promoting physical activity, and not having access to tempting foods and sedentary behavior promoting devices (TV, computer games). One can even make the argument that families can have organizational "policies" that create health promoting environments. Children benefit both from directly experiencing this environment as well as learning how to structure one for themselves when they are able to make their own decisions.

During the search process, we did not limit our review to studies in which only children are targeted indirectly, but we considered any combination of family members. Interestingly, we

found only one paper that presents the effects of a targeted spouse on the untreated partner, and we did not find any other combinations (within our inclusion criteria). This shows a potential research need for exploring the targeting of other combinations of family members, e.g., between spouses, among siblings, extended family members (e.g., grandparents), or even targeting children to change parents' outcomes.

Our review may be limited in selecting only the peer-reviewed studies published in English and focusing on a narrowly defined category of interventions. Nevertheless, the current review suggests the interventions that mainly utilize social influence pathways are potentially promising and offers a template for their mechanisms of impact. Much remains to be understood about the relative impact of such interventions in comparison with alternatives, and their best study designs.

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Chapter 3 - Dynamics of Obesity Interventions inside Organizations: a Case Study of Food Carry-Outs in Baltimore

3.1 Abstract

A large number of obesity prevention interventions, from upstream (policy and environmental) to downstream (individual level), have been put forward to curb the obesity trend; however, not all those interventions have been successful. Overall effectiveness of obesity prevention interventions relies not only on the average efficacy of a generic intervention, but also on the successful Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) of that intervention. In this study, we aim to understand how effectiveness of organizational level obesity prevention interventions depends on dynamics of AIM. We focus on an obesity prevention intervention, implemented in food carry-outs in low-income urban areas of Baltimore city, which aims to improve dietary behavior for adults through better food access to healthier foods and point-of-purchase prompts. Building on data from interviews and the literature we develop a dynamic model of the key processes of AIM. We first develop a contextualized map of causal relationships integral to the dynamics of AIM, and then quantify those mechanisms using a system dynamics simulation model. With simulation analysis, we show how as a result of several reinforcing loops that span stakeholder motivation, communications, and implementation quality and costs, small changes in the process of AIM can make a big difference in impact. We present how the dynamics surrounding communication, motivation, and depreciation of interventions can create tipping dynamics in AIM. Specifically, small changes in allocation of resources to an intervention could have a disproportionate long-term impact if those additional resources can turn stakeholders into allies of the intervention, reducing the depreciation rates and enhancing sustainability. We provide researchers with a set of recommendations to increase the sustainability of the interventions.

Keywords: Obesity prevention interventions, dissemination and implementation, motivation, communication

3.2 Background

In the United States, obesity has been recognized as a major public health challenge for over two decades. Two-thirds of the adults and one third of the children are either overweight or obese [1, 2]. Excess weight is associated with many leading causes of morbidity and mortality, including increased risk for type II diabetes, hypertension, stroke, arthritis, and certain cancers, as well as all-cause mortality [3, 4].

At its core, obesity is the result of imbalance of energy intake and energy expenditure in the body, yet multiple factors, from individual biology [5], to built environment [6-8], social environment [9, 10], and economics [11, 12] interact to determine individual energy intake and expenditure. Consistent with this socio-ecologic framework [13], a large number of interventions, from upstream (policy) to downstream (individual level), have been put forward to curb the trend (e.g., see [14-16]). However complexity of the obesity problem makes it challenging to design and the implement successful prevention interventions [17].

Although there is a large and growing literature documenting potentially effective interventions, this literature often focuses on well-supported and thus more successful instances of various interventions. Yet, in assessing the potential real-world impact of an intervention much depends on the fraction of instances where the implementation is successful, and sustained. The variation in the successful implementation and maintenance of interventions depends, partly, on the organizational dynamics unfolding during and after the implementation of an intervention [18]. The overall goal of this paper is to enhance our understanding of organizational dynamics that impact the effectiveness of obesity prevention interventions. Through case-based modelling this study contributes to our understanding of the dynamics of program adoption, implementation, and maintenance and thus helps explain why some instances of an obesity prevention and treatment program prove more effective than others. Specifically, we show how small changes in an intervention can make the difference between failure and success and make the interventions sustainable.

3.2.1 Obesity prevention interventions

Interventions translate theoretical research findings into practical procedures to improve health outcomes based on known causal mechanisms related to the outcome of interest [19]. Obesity is largely the result of life styles that promote unhealthy eating and limited physical activity.

Therefore, intervention strategies are moving upstream, with an aim to modify the organizational/community settings in which individuals live, study, and work, in order to limit individuals' exposure to obesogenic environments and facilitate healthier choices [20-22].

Obesity prevention interventions vary in the populations they target, the organizations they involve, the resources they require, and their mechanisms of impact; yet many of them share the need to bring together multiple stakeholders to implement new processes and routines within specific organizational and community contexts. The multi-stakeholder, organizationally complex nature of these organizational interventions distinguishes them from individual-level interventions. The real-world effectiveness of organizational interventions depends not only on the "Efficacy" of the intervention in an idealized setting, but also on how well each instance of the intervention (i.e., each program) "Reaches" the right population, is "Adopted" by the relevant stakeholders, is "Implemented" in the organizational setting, and is "Maintained" over time to maximize the overall program effectiveness (the RE-AIM framework [23]). In fact, a review of the published literature from 1999 to 2010 [24] finds that obesity and physical activity interventions are among the most frequent users of the RE-AIM framework.

3.2.2 Dynamics of adoption, implementation, and maintenance

A key feature of the RE-AIM framework is the shift from short term efficacy to longer-term effectiveness [25-27]. Efficacy is a measure of how the intervention performs under ideal conditions, while effectiveness is a measure of how an intervention performs under real-world conditions [25]. The efficacy of many lifestyle interventions aimed at obesity and related chronic diseases such as diabetes is well established [28]. Overall effectiveness of these interventions, however, relies not only on the average efficacy of the intervention, but also on the successful Adoption, Implementation, and Maintenance (AIM) of each instance of that intervention (i.e., each program or organizational level policy change) within the responsible organizational and community context [29]. In practice, much variability in overall effectiveness of interventions arises from variations in AIM. Evidence from a few controlled trials of multiple programs of the same intervention suggests significant variations across programs are common [30, 31].

Figure 3-1 reflects how multiple instances of the same intervention (i.e., same inherent efficacy) applied to similar population groups (i.e., similar reach) can show different trajectories of overall effectiveness due to their varying levels of AIM.

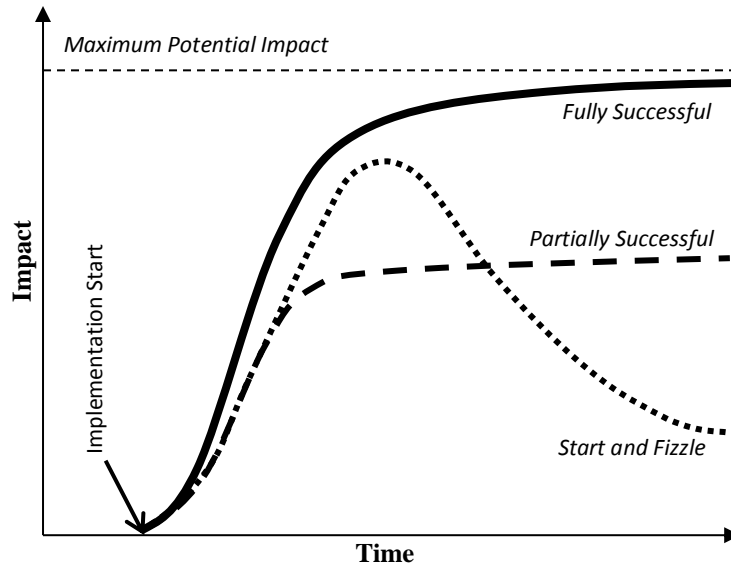


Figure 3-1. Potential program impact trajectories

For example, one can imagine differences in the implementation process that lead one organization to receive early technical assistance while the other receives none. In the absence of that support, the second program fails to develop the required knowledge and capabilities, does not receive any positive feedback from its effort, and thus builds little motivation to be maintained by organizational stakeholders. Such mechanisms could lead to significantly diverse results across different instances of AIM for the same intervention. Understanding the sources of variation in AIM is therefore central to enhancing the effectiveness of existing interventions and designing more effective new interventions.

Common effectiveness research methods, such as randomized controlled trials (RCTs), usually focus on measuring efficacy and therefore try to minimize the program variations across AIM by selecting motivated, resource rich, and well-trained organizational participants. Therefore, by design, RCTs may indeed exclude from analysis the very factors that explain important variations in actual effectiveness of different programs [32-34]. These shortcomings have motivated recent interest in more holistic frameworks to evaluate interventions on dimensions other than efficacy alone (e.g., see [35-39]). Even though there have been several models and frameworks for implementation of obesity prevention interventions, existing research does not capture the feedback loops between key variables in the system and does not attempt to quantify the key mechanisms of AIM.

AIM is a dynamic process that engages multiple stakeholders with different motivations and perspectives in an interactive process of decision making, action, and learning [40]. Variations in effectiveness could partly be explained by how these dynamics unfold differently across multiple programs due to different institutional arrangements, resources, and path dependencies. This may be part of the explanation why the multitude of policies and interventions aimed at reducing obesity have so far failed to curb the increasing trends [41].

3.2.3 Building on the organization behavior and strategy literature

One innovative feature of this study is that it draws on theories in organization behavior and strategy to study the effectiveness of chronic disease interventions. Strategy literature has found the differences in configurations of organizational resources as what explains much heterogeneity in organizational performance [42-44]. Getting to successful configurations of resources is a complex process fraught with many pitfalls, in which some organizations succeed while others fail [45-47]. Building on strategy literature, we look for organizational resources and capabilities which are instrumental in AIM processes of obesity prevention interventions.

A second insight from the organizational literature involves the dynamic trade-offs in building alternative resources. These trade-offs increase the failure risk in many settings [48]. For example, organizations are susceptible to focusing on doing what they know best and ignoring new emerging opportunities [49, 50]. They also routinely under-value investments with long-term payoffs [51, 52]. For instance, empirical studies provide strong support for many of quality and process improvement programs [53, 54], yet organizations often fail to fully realize these benefits because resources are withdrawn from the program before full results are observed, initial enthusiasm overwhelms the training capacity to keep the program effective, or seeking short-term gains the system is overloaded with demand and is pushed into a firefighting mode of operation [55-58]. Similar to quality and process improvement initiatives, many health care interventions may be beneficial over long run, but require initial investments and delays before benefits materialize. Therefore, here we ask: What are the mechanisms for building and sustaining the resources central to an intervention's effectiveness? What are the common failure modes that derail successful development and maintenance of those resources? What are the main leverage points to increase success chances in a program's life-cycle?

Third, by explicitly considering the AIM of programs, this study builds on the current public health intervention assessment methods such as RE-AIM [23, 59-61], yet goes beyond those by using dynamic modelling to study dynamics of program success and failure. This perspective, combined with model-based experimentation, allows us to develop more holistic theory, evaluate existing and new programs and provide more operational recommendations.

3.2.4 Dynamic modelling and endogenous perspective

We develop a dynamic model to understand how effectiveness of organizational level obesity prevention interventions depends on the endogenous dynamics of AIM. Dynamic modeling and simulation is a potential tool to understand the complexity of a system and is increasingly used in the public health in general and obesity literature in particular [62-69]. Dynamic simulation models often take an endogenous perspective: they focus on the interactions among concepts within the boundary of the system that lead to behaviors we are interested to understand. This focus does not negate the importance of exogenous drivers of behavior, but is motivated by three considerations [70]: First, endogenous perspective often provides a richer understanding of the phenomenon, because it does not pass down the explanation to external factors. Second, endogenous perspective brings to the forefront the interactions among various stakeholders that relate to success and failure of AIM, and thus informs modifications that should be sought in response to various signals in the process of implementing and sustaining an intervention. Finally, endogenous dynamics allow us to tease out how otherwise similar organizations can move to different outcomes, a major focus in our study of AIM. In our context, the value of simulation is not to produce specific predictions, but to provide a range of likely scenarios and insights into what dynamics drive those scenarios [18]. Simulation modeling enforces internal consistency in the resulting explanations and allows for quantitative analysis of various trade-offs. In fact, such models could be used as training micro-worlds [71] to enhance stakeholders' mutual understanding, commitment, and skills in successfully implementing and maintaining an intervention. We develop a dynamic model based on a pilot environmental intervention, Baltimore Healthy Carry-outs (BHC) which is described next.

3.2.5 Case study, a food environment intervention

The BHC intervention was designed and conducted in food carry-outs in low-income neighbourhoods of Baltimore (median household income about \$20,000 [72]), where fast food

and carry-out restaurants are the main prepared food sources [73, 74]. The carry-outs are similar to fast-food restaurants but have different physical layouts. They often store, cook, and sell foods behind floor-to-ceiling glass partitions. Many owners may speak English as a second language. Consequently, customers do not interact much with the storeowner or the seller. Storeowners usually know what foods are popular and adjust their menu accordingly. Customers often do not have many healthy options or the choice to request a customized healthier meal [72].

The scope of the BHC intervention was to design the following strategies: improving menu boards and labelling to promote healthier items, promoting healthy sides and beverages, introducing new items, and introducing healthier combo meals [75]. It was implemented by researchers from Johns Hopkins University in a controlled trial across four carry-outs which were compared against four matching control carry-outs.

3.3 Methods

In this section we discuss the data collection, data analysis and modelling that are the main components of our research method. Progress on these steps was iterative in nature, as, for example, preliminary analysis exposed new data needs. We present the model and simulation analysis in the Results section.

3.3.1 Data collection

Data was collected through interviews with the key stakeholders in two of the intervention carry-outs after the original intervention implementation had ended. We selected two carry-outs with different levels of success with implementing the BHC intervention. Variations across the cases offer useful insights into how AIM processes can diverge.

We interviewed the lead interventionist and two of the carry-out owners in Baltimore city that had participated in the intervention. We also interviewed two experts from the Baltimore City Planning Department (the two experts were familiar with the food environment in Baltimore and the BHC intervention). Some stakeholders were interviewed more than once. Interviewers began with four key questions and probed further [76, 77]: Did the intervention work? Under what circumstances did the intervention work (or did not work)? How did the intervention work? For whom did the intervention work? Additional questions covered various related categories including program history, initial steps in implementation, communication among stakeholders,

trust, motivation, post-implementation processes, outputs, financial matters, and success and failure instances. Interview data was augmented by archival data and reports from the original implementation of the intervention.

3.3.2 Data analysis and modelling

The goal of analysis was to weave together the case study data into a dynamic model that provides a picture of dynamics relevant to AIM of interventions in the BHC and beyond. All interviews were coded to extract 1) key concepts related to perceived intervention effectiveness; 2) mechanisms of AIM; 3) time-line of events within a program; and 4) quantitative metrics where available.

The coded interviews were then combined and synthesized with the archival and observational data based on their common themes to identify the causal mechanisms likely relevant to the dynamics of AIM. This synthesis generated a set of dynamic hypotheses, also called a causal loop diagram, that provides a qualitative overview of the potentially relevant mechanisms. Next, these dynamic hypotheses were refined through additional data collection and building of a simulation model. First, we conducted four interviews with an interventionist, the lead interventionist, and the two Baltimore city experts to get their feedback on the qualitative model draft and elicit further insights and estimates for some of the parameters needed for quantifying the model.

The next step of analysis entailed quantifying these mechanisms into a detailed simulation model. Quantification of the causal loop diagrams into a simulation model provides a few concrete benefits. First, it enforced internal consistency in conclusions drawn from a complex web of causal pathways, a task our brains are not well-equipped to do without the assistance of computational tools [78-81]. Moreover, quantification allows us to assess the plausibility of various dynamic hypotheses, narrowing down a more complex set of hypotheses to the ones more likely to play a role in actual case histories. Building of the simulation model was also assisted by the previous literature on the intervention as well as broader literature on modelling organizational dynamics (e.g., [56, 82, 83]). These sources are especially useful for quantifying key metrics such as efficacy and organizational decision making parameters, as well as process and timeline of interventions. The modelling process included iterations between refining the mechanisms captured qualitatively and quantifying and simulating those mechanisms.

In this study, we focus on the sustainability of the intervention components as the main measure of success, while we acknowledge other aspects (e.g., effectiveness and costs-benefits) are relevant to defining success. We note that the BHC intervention components had a positive impact on the healthy food sales and as a result the intervention should be considered potentially efficacious [84]. Our focus on AIM dynamics allows us to better understand the mechanisms that would impact the ultimate effectiveness of the BHC and similar programs.

3.4 Results

In this section, we present the core mechanisms of the model developed based on the data gathered from the interviews and other data sources. Given the limited space, we first provide a brief overview of the two cases, specifying the basic modes of behavior our modelling work elaborates on. We then demonstrate the feedback loops relevant to modelling AIM that were explicated in the analysis process. These feedback loops were identified as the most important mechanisms after simulating a larger set of hypotheses in our computational model. Next, we show simulation results that demonstrate the key outcomes of the hypothesized mechanisms and offer insights into the sources of variation in AIM. Additional details including the full simulation model are provided in an online appendix. In presenting the mechanisms, we draw on the BHC examples, but provide a more generic terminology and discussion to highlight the transferability of the insights to other interventions that include multiple stakeholders. After discussing the key feedbacks we present some simulation analysis.

3.4.1 Key feedback mechanisms

Intervention components, implementation and motivation- An interventions can be seen as a project with a deadline, comprised of various components. Execution of these components, such as designing and installing a new menu board, informs the progress of implementation phase and depends on the time allocated to implementation by the interventionists, the quality of their effort, and the motivation of carry-out owners to actively contribute to the intervention. In fact, in the absence of any cooperation by carry-out owners, no implementation is feasible. Figure 3-2 summarizes these mechanisms, showing in a box the *stock*¹ of “Implemented Components” that grows with the valve-like *flow* variable “Implementation rate”. In the BHC intervention,

¹ A stock variable represents accumulations and sources of inertia in a system.

interventionists emphasized building rapport with carry-out owners and making changes that place minimal burden on the staff to maintain the motivation of stakeholders when implementing the intervention.

The first feedback loops in our setting emerge when we consider the impact of implemented components on the carry-out operations. Some components may lead to new costs, e.g., for acquiring healthier ingredients and finding new suppliers. Benefits may also ensue, including financial benefits due to increased sales or incentives for participation in the study, reputational benefits, and the personal satisfaction of making a contribution to community health. One carry-out owner elaborates:

“There was some personal satisfaction, since some customers could’ve thought that our carry-out is a pretty clean/good carry-out, seeing that we were participating in a research study. So that was beneficial for me.”

An increase in motivation due to observation of such benefits can lead to further implementation of components, and thus even more benefits, in a reinforcing process (Figure 3-2, reinforcing loop 1 (R1)). On the other hand, if the carry-out owner perceives the costs to exceed those benefits, then a balancing loop may dominate which reduces motivation in response to progress, and slows down further implementation (Figure 3-2, balancing loop 1 (B1)). An intervention that, in net, does not benefit the carry-out owner, has little chance of successful implementation, let alone maintenance. Yet, even objectively beneficial interventions may not succeed. When it comes to the relative strength of these two loops, perception is more important than facts. For example, in one of the carry-outs, we noticed that the perception of the owner did not match the analysis of sales data: sales data tracked by the interventionist showed significant benefits as a result of the intervention but the owner had come to believe the opposite.

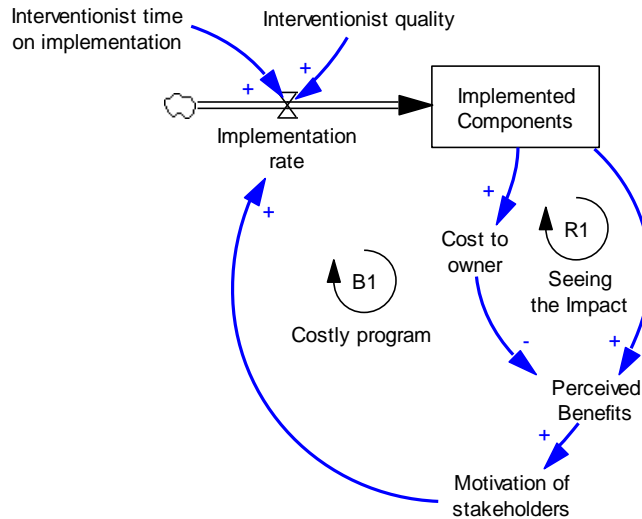


Figure 3-2. Effect of costs and benefits on motivation.

Successful implementation depends on the competition between a reinforcing loop (R1: Seeing the Impact) and a balancing loop (B1: Costly Program). If R1 dominates, successful implementation is possible.

Design quality and communication among stakeholders- Design quality is an important aspect of any intervention. A well-designed intervention is less costly to carry-out owners, may include more benefits, and would be easier to implement and maintain. The quality of design partially depends on the skills and knowledge of the interventionist, which was high in the BHC case. Moreover, the intervention should be customized based on the characteristics of each program, and that requires ample communication between the interventionist and the carry-out owner. Carry-out owner’s motivation was a major determinant of their availability for communication, and in the BHC case the owners started with high-levels of motivation. For example, initially the BHC interventionists wanted to refer to new items on the menu as “Healthy”, yet carry-out owner feedback suggested that the term Healthy is not appealing in the community, and “Fresh” was chosen instead. On the other hand, design problems that are not fixed can lead to various issues in implementation and hurt the motivation of stakeholders. For instance, adding watermelons to the menu during the summer was one of the intervention components and sales data suggested it was profitable [84]; however, it resulted in trash removal problems for the carry-out owner which led to the scrapping of this component: *“in the case of the watermelons, during the summer time, even if we wanted to sell those, a lot of garbage would come out of it. Here in [this area of] Baltimore City, there isn’t a place to throw garbage. You can’t put a garbage can outside.”*

Taken together, communication and design quality create another reinforcing loop (Communication Helps Design, (R2), in Figure 3-3): increased motivation facilitates better communication, which improves design and keeps the stakeholders motivated. Reinforcing loops can amplify small differences between two programs: if one, by chance, faces an early design problem, that can reduce motivation and communication, and saw the seeds of future problems.

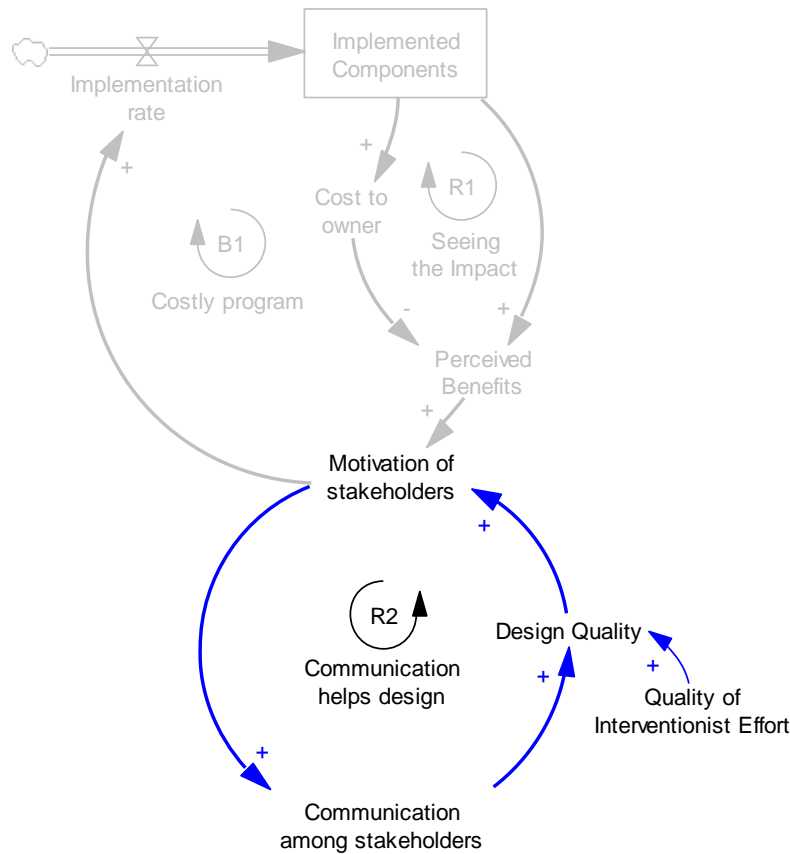


Figure 3-3. Effect of motivation of stakeholders and communication among stakeholders on design quality.

Small problems in design can lead to loss of motivation, reduced communication, and more design problems as implementation progresses.

Note that motivation is also impacted by other factors such as individual knowledge and beliefs about the intervention and self-efficacy to carry out the intervention [85]. While such characteristics have a potential impact on motivation, we do not explicitly include them in our discussion of endogenous mechanisms because they usually do not dynamically change as part of the AIM processes.

Intervention maintenance - Intervention maintenance is possibly the most challenging but least measured dimension of the AIM [25]. Long term impact of many interventions cannot be fully assessed due to limited follow up horizons for collecting maintenance data, especially in community-based interventions [86]. Interventions are not maintained when their components deteriorate, depreciate, or are otherwise scrapped, and are not renewed. From wear and tear of signs and menus, to changes in prices that may reduce the attractiveness of “fresh” items, these depreciation processes continually reduce the number of ‘Implemented Components’. Yet, the depreciation rate is also endogenous, as it depends on motivation, communication, and design problem (Figure 3-4). Communication can help remind the stakeholders about the need for sustaining changes and fixing emerging problems. High quality of designs foresees, and corrects for, the most common modes of failure and thus includes lower baseline depreciation rates. Finally, we find that motivated stakeholders are more likely to sustain the changes without external prompts. These mechanisms create three additional reinforcing loops, as successful implementation raises motivations, improves communication, and design, and thus allows for sustaining the gains more effectively.

The feedback loops we discussed summarize the key endogenous mechanisms we found relevant in understanding the dynamics of AIM in our case study. However, a fully operational simulation model of the AIM dynamics required us to include additional detail in specifying each mechanism quantitatively and include various exogenous drivers, such as the amount of interventionist time available to the intervention. Given the limited space here, in an online supplement we provide a fully documented model that follows a set of minimum reporting requirements [87].

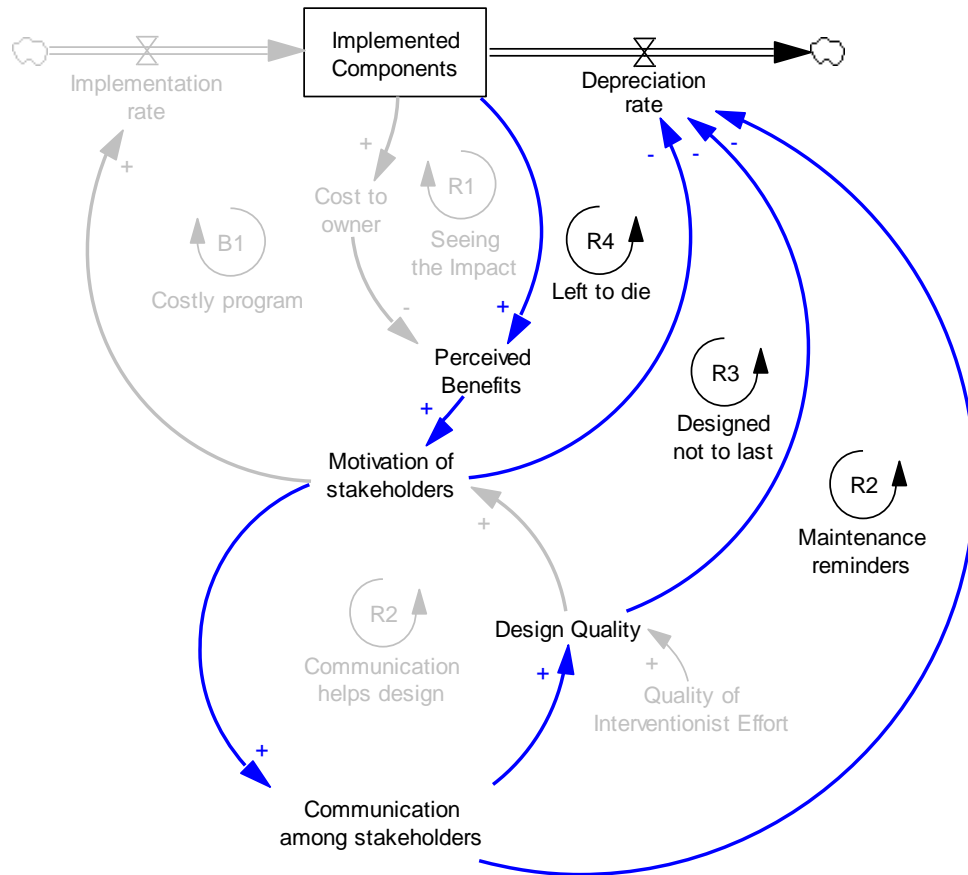


Figure 3-4. Mechanisms affecting the maintenance of interventions.

The depreciation rate is influenced by motivation, design quality, and communication, creating three additional reinforcing loops that can drive a wedge between successful and unsuccessful maintenance of programs.

3.4.2 Building confidence in the model

Any model is a simplification of reality, and as such it should be tested for its usefulness for the purpose of the modelling project. We conduct various tests to build confidence in the usefulness of our model in understanding the endogenous dynamics of AIM. First, structure and behavior validity tests were conducted [88]. Mechanisms represented in the model were confirmed in interviews with the stakeholders including interventionists and experts from the Baltimore City Planning Department. In formulating each equation, we test it against different input values to ensure it represents the logic portrayed in the data [89], and is robust in extreme conditions. Unit consistency was also enforced in model equations. Extreme condition tests were then conducted to reveal subtle flaws which are not easy to capture by direct inspection or baseline behavior [70]. These tests specify expected model behaviors under extreme conditions not seen in the field

data, e.g., if motivation of stakeholders is zero, no intervention components should be implemented, or if the quality of effort of interventionists is at the maximum possible level and communication among stakeholders is sufficient, there should be few design problems. Behavior reproduction tests were used to assess model's ability to reproduce the key reference modes observed in various cases and helped build further confidence in model's usefulness [90]. While these tests provide some confidence in the qualitative insights generated from our cases, the purpose of this study is building theory. Therefore, in the absence of detailed quantitative data for a larger number of cases, one should be cautious about generalizing the findings or seeking operational advice from our model.

3.4.3 Simulation analysis

Our simulation results point to a nonlinear dynamic with potentially important implications for understanding variations in AIM. Specifically, we find that small differences in allocation of interventionist resources to design, implementation, or communication can lead to significant differences in AIM outcomes. To demonstrate, consider two identical organizations with identical interventions, composed of various components (e.g., improving menu boards, introducing healthier combo meals, and identifying fresh items on the menu). The only difference between the two simulated organizations is the amount of interventionist time allocated to each, which is 8% higher in one case. The project's adoption, implementation, and maintenance unfold over multiple months: during the first year the focus is on the design of the intervention, the next seven months are mostly focused on implementation, and then the sustainability of the intervention is measured once the interventionists largely leave the scene, offering only some follow up time afterwards. Figure 3-5 (A) shows our main outcome variable, the number of intervention components effectively at work in the simulated organizations. This number is zero for the first months as much of the effort goes into designing the intervention. Implementation starts after about 10 months and speeds up to completely unroll the intervention (i.e., implement its 20 components²) by month 19. By this time, both simulated organizations show a solid implementation, and if they were actual organizations, they would likely be considered success stories for this intervention. However, what happens afterwards, i.e.,

² The number of components can vary to scale the size of the intervention against resources and other constraints, the number 20 is somewhat arbitrary, and is only chosen to be consistent with the overall timeline of the cases.

maintenance, is key to the long-term effectiveness of each program, and here a small difference in the resources allocated by the interventionist makes a huge difference. One organization keeps most of the components in place, while the other gradually loses most of the components. Why would a small difference (allocation of 8% more interventionist during implementation and maintenance phases) have such a major impact?

Early on, the design and implementation processes unfold almost identically for both organizations, and both have enough resources and support to complete the tasks on schedule. The differences become visible only in the maintenance phase. Once implemented, the components are subject to depreciation, for example, menu boards may fall and not be replaced and healthy items may be dropped from the offering. The rate at which such deterioration happens, and the speed with which the required fixes are applied (or ignored) distinguish between organizations that maintain the intervention in the long-run and those that revert back to the old ways of doing things.

A few reinforcing loops are essential for explaining the observed differences in depreciation and re-implementation rates. First, “R2-Maintenance Reminders” highlights the importance of continued communication between interventionists and organizational stakeholders. While the effort needed for keeping this communication is modest, it does provide reminders and support for keeping the depreciation rates low, e.g., by fixing any emerging problems before they lead to complete loss of a component. Low depreciation, in return, allows for keeping the intervention at its most efficacious state. The intervention thus shows more benefits to the organization, motivates the stakeholders (e.g., carryout owners) to keep the communication up with the interventionists, and thus maintains the program in a desired state. On the other hand, a shortfall in communication early after the end of implementation phase can increase the depreciation rate, reduce the components standing, cause disillusionment with the program, and further cut down on communication. A similar mechanism unfolds in “R4-Left to die”, as lost motivation increases depreciation, reduces the success of the program, and thus further erodes the motivation of organizational stakeholders. The third feedback loop connects motivation and communication: a shortfall in communication erodes motivation; that will then require even more communication for fixing task-related issues as well as rebuilding the interpersonal trust and collaborative atmosphere. As a result, the current communication levels fall even further behind what is required, completing a vicious cycle. As these loops take over the dynamics, the

unlucky organization falls behind, requires even more time from the interventionist for fixing the problems, which leaves even less time for communication, further strengthening the feedback loops that are affected by the sufficiency of communication. After a few months, the gap between the two otherwise similar organizations becomes very wide and the chances of reviving the intervention in the unsuccessful program remote.

In our simulation experiment the initial shortfall in communication is triggered by slightly less interventionist time available after implementation is complete (4.8 vs. 5.2 hours per month). However, this small shortfall is amplified through the feedback loops above, leading to the widely different outcomes at the end. Interestingly, for a little while after the completion of implementation phase, the organization with lower interventionist time seems to do even better, because lower communication translates into less cost for the organization, making the intervention even more appealing as long as little depreciation has happened. The real costs are only revealed once the depreciation requires more interventionist time for fixes and thus reduces the sufficiency of communication below acceptable levels.

Note that the exact numbers generated in our simulations are not consequential for the main qualitative finding, that dynamics of AIM include a tipping point which leads to widely different outcomes for small changes. Lack of attention to the underlying dynamics can lead to erosion of an intervention after it was implemented in a vicious cycle of lower motivation and communication, faster erosion, and thus less beneficial intervention. For the intervention to work, a minimum level of communication should be maintained throughout, so that motivation is above a threshold that allows for active support of the implemented components by the owner. Such support will then slow down the erosion of the existing components after the active implementation phase is over, thus significantly reducing the ongoing costs of restoring the implemented components. This allows the owner and the interventionists to sustain the intervention with limited investment, while keeping up the beneficial impacts, maintaining motivation, and thus locking the system in a fortunate alternative equilibrium (see Figure 3-5).

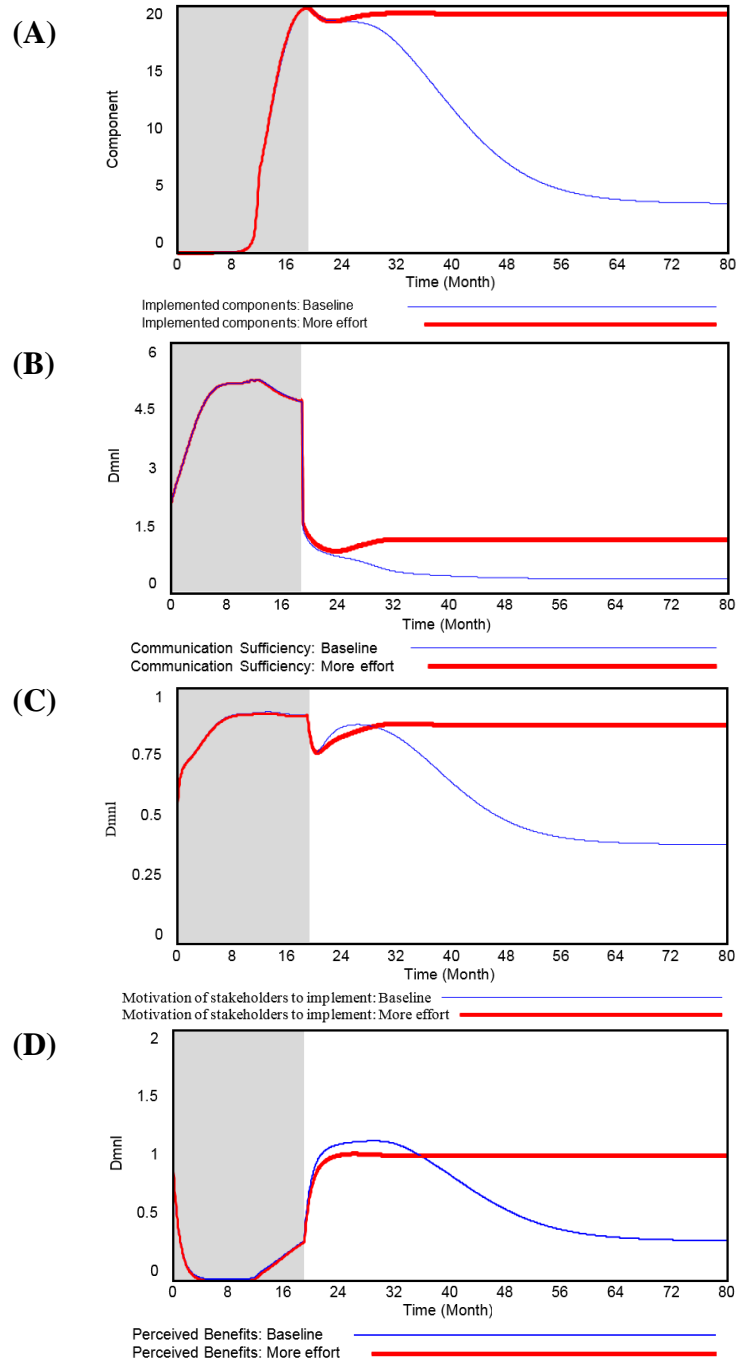


Figure 3-5. Implemented components (A), communication sufficiency (B), motivation of stakeholders to implement (C), and perceived benefits (D).

Baseline (blue line) is based on 24 hours effort of interventionists per month. More effort (red line) is based on 26 hours effort of interventionists per month. The big difference between the outputs of these two scenarios relates to the tipping threshold, e.g., a level of interventionists' efforts that once exceeded causes a sustained intervention. Dmnl: Dimensionless.

3.5 Discussion

Overall, transporting interventions from laboratory settings to community settings is challenging. When the implementation of interventions fails, it is important to know whether the failure occurred because the intervention was not successfully implemented or if it was ineffective [91]. In many cases, in fact, intervention is theoretically effective but not properly implemented and maintained. In this study, we developed a system dynamics model of the BHC intervention showing how the dynamics surrounding communication, motivation, and depreciation of interventions can create tipping dynamics in AIM. Specifically, small changes in allocation of resources to an intervention could have a disproportionate long-term impact if those additional resources can turn stakeholders into allies of the intervention, reducing the depreciation rates and enhancing sustainability.

The model we develop is stylistic and simple. Real world interventions include many subtle variations and building a fully calibrated model may not be feasible due to data limitations, or may only be viable after the intervention has fully unfolded and the opportunity to improve the situation is lost. Yet our simple model provides a few ideas to help monitor and improve the design and implementation of interventions in order to avoid the dynamics that lead to poor long term maintenance of interventions. Specifically, we found that the quality of the intervention design plays a key role throughout the process. Reviews of research show that health interventions that are designed based on theory or theoretical constructs are more effective than those lacking such foundation [92]. Lack of theoretical and practical bases (or poor choice of theory [93]) in the design process leads not only to the ineffectiveness of the innovations in the intervention but also to the ineffectiveness of the implementation process [94, 95]. We showed that a well-designed intervention sustains stakeholder motivation and limits later deterioration; therefore, changes that increase the quality of original design are critical for the long-term success of AIM. Those changes could include the use of more skilled and situationally informed interventionists. They could also include more communication early in the design process with key stakeholders to iterate on the elements of the intervention and to foresee and fix potential problems and gain stakeholder buy in.

Another area for improvement is monitoring of stakeholder motivation. This variable plays a key role in the tipping dynamics we identify, if it goes below a threshold, the intervention will

become exceedingly costly to maintain. Interventionists should be as sensitive to this motivation level as to the design and implementation of tasks. Intervention design steps may also need to include components that explicitly boost motivation. Again, communication plays an important role in enhancing stakeholder motivation, and thus needs to be prioritized.

Interventionists need to be sensitive to financial or other incentives that stakeholders value, and incorporate them in the design of the intervention to increase the chances that once implemented, the intervention can cross the self-sustaining threshold. For example, in the BHC intervention, certificate from the mayor and the city of the Baltimore was a successful practice. One of the carry-out owners mentioned: *“According to them [interventionists], the certificate was for my contribution to the community with my food. Food that was fresh and good for the community. That made me feel good when I didn’t feel like I wasn’t doing that well. It’s not really about the money to me. I get a lot out of just spending time for a lot of people, finding jobs for people. I like to provide. This is right up my alley. To be recognized for my contribution to the community was really good.”*

In addition, finding different mechanisms to motivate stakeholders, especially in the middle of the process (after early honey-moon and before they see the actual benefits) can help. These mechanisms can be frequent site visits by interventionists, asking about ongoing problems and coming up with solutions before tasks are abandoned, and providing data on the benefits (and setting up measurement procedures to track benefits from early on).

A third leverage point is how the design influences intervention depreciation rates. Intervention components that can easily become part of the daily routines in an organization (such as the menu board in the BHC intervention which require limited attention for the maintenance) are much easier to sustain than those that will require conscious and constant attention (such as restocking of baked chips). If organizational routines are to be changed as part of the intervention, structures such as physical layout, supply chains, and decision making processes should be thought through and explicitly designed so that they are consistent with the changes in the core organizational routines. Inconsistencies in those arrangements are likely to increase the speed of depreciation of implemented components and diminish motivation over time. The implementation process should also focus on training and empowering organizational stakeholders so that they will appreciate and maintain the components in the absence of the

interventionist. Only when the new routines are fully integrated in the organizational culture and processes, can one expect long term sustainment of new interventions.

A common trade-off that our model highlights is the trade-off between designing and implementing intervention components vs. communicating with stakeholders to help build confidence and improve the quality of the intervention. Given that many interventionists are more familiar with the former, there may be a built in bias in the AIM processes against adequate investment in the communication processes central to AIM dynamics. Overcoming that bias and tuning communication levels to address both the motivation and the quality considerations is an important leverage point for training successful interventionists.

This research provides preliminary evidence on tipping dynamics in health intervention design, implementation and maintenance. The research can be extended in several directions. Closer integration of quantitative data with the model will enhance confidence in the results. Findings could also be expanded by creating a clear set of recommendations to enhance interventions similar to the BHC intervention. More specific monitoring and performance evaluation metrics could be developed and integrated into protocols for design and implementation of interventions so that corrective action can be taken based on signals observed in each case. Dissemination of a successful intervention design in different organizations may include some interesting dynamics that go beyond the scope of the current paper but are important for overall effectiveness of health interventions. Future case studies could also explore these dynamics in other interventions and organizational settings, expanding the empirical basis for the dynamics, introducing new mechanisms, and offering testing grounds for implications of this research. Large scale studies may also use data from larger intervention programs to assess outcomes based on more nuance models that capture the dynamics we discuss explicitly. Despite these limitations, we hope the current study provides a first step towards better understanding organizational interventions that target the prevention of obesity and other chronic conditions.

3.6 List of abbreviations

RE-AIM: reach, effectiveness, adoption, implementation, and maintenance. AIM: adoption, implementation, and maintenance. RCTs: randomized controlled trials. BHC: Baltimore healthy carry-outs. R loop: reinforcing loop. B loop: balancing loop.

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Chapter 4 - Dynamics of Implementation and Maintenance of Organizational Health Interventions: Case Studies of Obesity Interventions

4.1 Abstract

In this study, we present case studies to explore the dynamics of implementation and maintenance of obesity interventions. We analyze how specific obesity prevention interventions are built and eroded, how the building and erosion mechanisms are interconnected, and why we can see significantly different erosion rates across otherwise similar organizations. We use multiple comparative case studies to provide empirical information on the mechanisms of interest, and use qualitative systems modeling to integrate our evolving understanding into an internally consistent and transparent theory of the phenomenon. Our preliminary results identify reinforcing feedback mechanisms, including design of organizational processes, motivation of stakeholders, and communication among stakeholders, which influence implementation and maintenance of intervention components. Over time, these feedback mechanisms may drive a wedge between otherwise similar organizations, leading to distinct configurations of implementation and maintenance processes.

Keywords: implementation and maintenance, health interventions, obesity prevention interventions, system dynamics, endogenous dynamics, system dynamics, qualitative modeling, case studies

4.2 Introduction

One of the biggest health challenges in the U.S. is obesity; two-thirds of adults and one-third of children are overweight or obese [1, 2]. Despite extensive public health efforts to control and reduce obesity, it still remains a critical crisis in the U.S. One of the main efforts has been the development and implementation of obesity prevention interventions in local communities and businesses. These organizational interventions are often successful in the short term; however,

their sustainability over the long term has been questioned. There are three distinct reasons for the importance and complexity of understanding the sustainability of obesity interventions:

- 1) **Health consequences of obesity:** Excess weight is associated with many leading causes of morbidity and mortality, including increased risk of type 2 diabetes, hypertension, stroke, arthritis, and certain cancers, among others [3, 4].
- 2) **Economic impact of obesity:** The obesity epidemic has a potential economic impact in the U.S. Overall health expenditures in the U.S. from 2009 to 2012 were 17.7% of the GDP, the highest rate among 221 countries and more than twice the average for all countries (6.9%) [5]. The economic impacts associated with the obesity epidemic include medical, productivity, transportation, and human capital costs, which makes obesity-linked costs a noticeable portion of total national health expenditures [6].
- 3) **Complexity of organizational health interventions:** Social systems are complex and implementing health related interventions within organizations is specifically complex [7]. Such interventions require changes in work processes that are often in a complex zone where uncertainty and lack of agreement are common [8]. We particularly select interventions involving multiple stakeholders, and this selection further increases the organizational complexity of implementation and maintenance of interventions.

Given the motivations of the study, we provide qualitative evidence for understanding the dynamics of implementation and maintenance of organizational obesity prevention interventions. The studies were conducted in three different settings including hospitals and child daycare centers in the Carolinas, and food carry-out restaurants in Maryland. These projects included design and development, along with deployment and implementation of the interventions.

To increase the generalizability of this study, we selected three organizations with different levels of complexity, where complexity is highest in hospitals, moderate in child daycare centers, and lowest in food carry-out restaurants. We particularly focus on: 1) endogenous dynamics of implementation and maintenance of obesity interventions, 2) organizational interventions with multiple stakeholders, 3) trade-offs in building alternative resources within each organization. They are further discussed below.

- 1) **Endogenous dynamics:** The selected intervention programs provide health organizations with capabilities that have the potential to tackle obesity in a target population and

provide additional benefits. A general belief is that the level of these capabilities (e.g., capabilities achieved by installing an outdoor playground in a child daycare center) is degraded over time and irrespective of other factors, but recent theories in the strategic management literature present the idea that such erosion could also be a result of systematic and endogenous dynamics within the organization [9]. These theories contend that, in addition to exogenous factors, capabilities can erode based on endogenous dynamics, which can take an organization from efficient to inferior capabilities. These endogenous dynamics could result from unfavorable temporal trade-offs between performance and robustness and long delays between the ‘better’ and ‘worse’ parts of temporal trade-offs [9].

- 2) **Multiple stakeholders:** Health organizations often have multiple stakeholders, making it difficult to trace the shortcomings of dynamics of implementation and maintenance of obesity interventions and tease out the sources of those shortcomings. Multiple stakeholders not only have different goals and perceptions, but their goals and perceptions may also change dynamically over time [10]. The organizational sciences literature also shows that there is often no agreement in perceptions of success factors among stakeholders, e.g., see Davis [11]. In addition, research shows that the allocation of clear stakeholder responsibilities is often problematic [e.g., 12]. We contend that even if stakeholder roles and responsibilities are clearly defined in the development of interventions, other pitfalls in organizational processes driven by endogenous dynamics may turn cooperative or complementary interactions into conflicting interactions, which can potentially cause the erosion of intervention components. The organizational literature also stresses the importance of interactions and communication among stakeholders, but without an understanding of the underlying dynamics of such interactions, it would be hard to assess the consequences of insufficient interactions. In fact, the literature shows that even simple organizational systems, if they include time delays and multiple feedback relationships, can create complicated outcomes, which therefore become hard to anticipate via intuition [13].
- 3) **Trade-offs in building alternative resources:** There are usually trade-offs in building alternative resources that increase the complexity of managers’ decisions for allocating effort to those resource investment [14]. For example, organizations are susceptible to

focusing on doing what they know best and ignoring emerging opportunities [15, 16]. They also routinely undervalue investments with long-term payoffs [17, 18]. Empirical studies provide strong support for many quality and process improvement programs [19, 20]. Yet organizations often fail to fully realize these benefits because: Resources are withdrawn from programs before complete results are observed; initial enthusiasm overwhelms the training capacity for keeping the programs effective; or seeking short-term gains overloads the system with demand and the organizations are pushed into a firefighting mode of operation [21-24]. Similar to quality and process improvement initiatives, many organizational health interventions may be beneficial over the long haul, but require initial investments and delays before the benefits materialize.

To address the concerns discussed above, we develop a causal loop diagram, building on organizational processes from case study evidence, to study the dynamics of implementation and maintenance of obesity interventions. The rest of this section is organized as follows. Study design and empirical setting is discussed in Section 4.3; Section 4.4 discusses data collection and research methods; Section 4.5 presents modeling, including the main mechanisms of the model; and Section 4.6 explains the heterogeneities across the case studies based on the endogenous dynamics in the developed model. The discussion is presented in Section 4.7.

4.3 Study Design and Empirical Setting

Studying the microfoundations and sources of variations in implementation and erosion of interventions calls for a few design characteristics. First, a focus on similar interventions across similar organizations is needed to control for possible alternative explanations. Second, observing various rates of erosion of intervention components across these cases may better elucidate how the underlying mechanisms vary across organizations. Finally, heterogeneity among the organizations under study would increase the generalizability of the results.

We used a polar case study design with three pairs of organizations. Each pair includes two similar organizations and the same intervention. In one of the two cases in each pair, the organization has been successful in implementing and maintaining the intervention; in the other, the organization has been less successful in sustaining the intervention. The three pairs of organizations vary in size and complexity. Moreover, we focus on well-defined interventions that require coordination among different stakeholders for their implementation, a common feature of

most complex organizational processes. Additional comparability was achieved by focusing on interventions that are all related to health outcomes at the organization and community levels.

4.3.1 Baltimore Healthy Carry-Outs (BHC)

The first pair of cases comes from the adoption and maintenance of the Baltimore Healthy Carry-Outs (BHC) initiative [25]. This initiative provided a random sample of small food carry-out vendors in a poor Baltimore neighborhood with assistance and incentives to implement healthier menu options and eating opportunities for the local community. The carry-out vendors were interested in this initiative because it distinguished them from the competition and also benefited the local community. Researchers from Johns Hopkins Bloomberg School of Public Health worked with the carry-out vendors to design and implement the intervention, which included changes in menu items, raw material suppliers, marketing and presentation of stores, and pricing of items. The BHC case was thoroughly discussed in Chapter 3.

4.3.2 Shape North Carolina (Shape NC)

The second pair of cases looks at the Shape North Carolina (Shape NC) program, an initiative to introduce healthier food and more physical activity into child daycare organizations in the state. Changes in food provision, physical layout, and activity planning for children are designed in collaboration with Shape NC partners and provide the participating child daycare centers with improved market position, parental support, and local government support [26]. The intervention brings together previously developed programs in the state and integrates them with new research-based models. There are several major stakeholders involved in the Shape NC project, including Smart Start and Blue Shield of NC Foundation, NC Partnership for Children, Blue Cross, and researchers from UNC-Chapel Hill. The implementation approach aims to be both top-down and bottom-up. It is a community-based program and local experts in each community (at the county level) provide technical assistance in adopting, implementing, and maintaining the intervention. After multiple meetings with the project managers, we selected two child daycare centers from two counties with different levels of success in implementation and maintenance of the intervention—we call the successful center S1 and the less successful one S2.

4.3.3 North Carolina Prevention Partners (NCP)

Finally, larger organizations are targeted in the third pair of cases, where hospitals partner up with North Carolina Prevention Partners (NCP), a nonprofit that focuses on implementing healthier cafeteria food, more physical activity, and smoking policies in large organizations, among others. The implementation of these changes requires adjusting various vendors and organizational regulations, and introducing new layouts and incentives for various participants [27]. In return, the hospitals expect reductions in employee health costs, improved morale, and better experiences for patients, which all contribute to long-term competitiveness. The NCP conducts assessments for food establishments such as restaurants and cafés in hospitals and issues “Apple” certificates representing healthy organizations. There are three different Apple certificates: Red (indicating that the place provides ‘healthy and delicious’ foods), Yellow (working towards Red), and Green (getting started). Particularly for hospitals, it is an excellence award showing that they provide healthy food choices and a healthy environment, not only to employees but also to patients and visitors. For this project, we selected two hospitals. Hospital one (N1), with over 600 beds, is a nonprofit general hospital, recognized as one of the top 50 hospitals in the U.S. It was the first hospital in the state to achieve the Red Apple. Hospital two (N2), with over 50 beds, is also a nonprofit general hospital with no Apple certificate.

While the cases vary significantly in the size of the organizations involved, they share a focus on interventions that require collaboration among internal and external stakeholders and focus on processes that enhance health outcomes. These similarities allow us to compare and contrast the processes of implementation and erosion of intervention components.

4.4 Data and Methods

We selected the cases in consultation with the external stakeholders involved in implementing these interventions (i.e., Johns Hopkins researchers working on BHC, the Blue Cross and Blue Shield of NC Foundation and the NC Partnership for Children, Inc. on Shape NC, and the nonprofit NC Prevention Partners on NCP; from here on we will call these external stakeholders). Cases were selected such that enough time had passed since inception of the programs to allow for observation of erosion mechanisms in action. In each case, we conducted interviews (mostly in person and a few on the phone) with the main stakeholders involved in the implementation and day-to-day enactment of the intervention components. Interviews focused on

understanding the components, how they were adopted and implemented, the parts that had been institutionalized, and challenges in maintaining them. Where available, archival data on the history of the cases were used to augment the interviews. Table 4-5 provides a summary of the interviews conducted to date.

Table 4-5. Summary of the interviews

Organization	Interviewees	Number of interviews	Interviews length (min)
Baltimore Healthy Carry-outs (BHC)	Consultants	5	225
	Internal stakeholders – case 1	1	50
	Internal stakeholders – case 2	1	60
Shape North Carolina (Shape NC)	Consultants	11	695
	Internal stakeholders – case 1 (S1)*	8	230
	Internal stakeholders – case 2 (S2)**	4	190
North Carolina Prevention Partners (NCP)	Consultants	5	400
	Internal stakeholders – case 1 (N1)*	3	140
	Internal stakeholders – case 2 (N2)**	6	170
Total		44	2,160

*S1 and N1: successful cases; **S2 and N2: unsuccessful cases

Interviews for BHC were conducted by the author, and interviews for Shape NC and NCP were conducted by the author and a joint researcher (PhD student) from the University of North Carolina at Chapel Hill. The research protocol was fully approved by the Virginia Tech Institutional Review Board (IRB number: 11-947). Interviewees included: 1) Interventionists as external stakeholders who designed and implemented the interventions; 2) internal stakeholders engaged in the implementation of the interventions—store owners for BHC, center owners, CEOs, or department directors and their key staff for Shape NC and NCP. All interviewees were informed of the purpose and procedures of the research, and assured that the information would be confidential. They signed a consent form and received compensation of \$35 per hour of interview for their time. A spreadsheet tracked interview information, including name, gender, ethnicity, and organizational role of interviewees, as well as date, duration, and location of the interviews. Interviews were recorded and transcribed into text. All transcriptions were then saved in MAXQDA 11³ for qualitative data analysis.

³ MAXQDA, software for qualitative data analysis, 1989-2015, VERBI Software – Consult – Sozialforschung GmbH, Berlin, Germany.

Data analysis began with coding the interviews for common themes related to implementation and maintenance of the interventions [28], following standards for qualitative research [29]. Coding of interviews was conducted by the two authors; any disagreements or concerns about the extracted data were discussed until consensus was reached. Coding helped in learning the mechanisms of implementation and maintenance through identifying key variables and relationships among the variables. For example, ‘financial benefits’ (earned from implemented components) and ‘motivation of internal stakeholders to implement’ are two variables extracted from the interviews, and the relationship between these two variables was that ‘financial benefits’ had a positive effect on ‘motivation of internal stakeholders to implement.’ More variables and mechanisms that have an impact on implementation and maintenance are discussed in the following sections. The emerging relationships among the extracted variables were then integrated into an evolving causal loop diagram [30]. The resulting causal loop diagrams embedded the key relevant mechanisms important for understanding how the interventions were implemented and how they eroded.

4.5 Modeling

Similar to any project, an intervention includes several components that need to be implemented. However, not all implemented components are sustainable, and they may deteriorate over time. We assume that the intervention components are effective, in the sense that if properly implemented and maintained, they have a positive health impact. Therefore, it is the role of adoption, implementation and maintenance to make the intervention successful and sustainable. Figure 4-1 simply shows the basic stock and flow of the implemented components. We review the interview codes and capture the dynamic mechanisms affecting both the inflow and outflow of the stock, implementation rate and depreciation rate. In this section on modeling, most examples come from successful cases. In the following section on analysis, unsuccessful cases are discussed more.

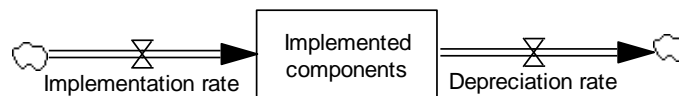


Figure 4-1. Basic stock and flow structure of implemented components

4.5.1 Resources and motivation

Sufficient resources and motivated stakeholders are two necessary factors for implementation. The effects of resources and motivation on implementation are discussed as follows—examples are presented from each case study.

Shape NC:

Unlike the BHC, implementation of Shape NC is expensive. For example, building an outdoor playground requires financial resources. Both Shape NC centers (successful case S1 and unsuccessful case S2) received the same initial grant to implement the intervention (\$3,000). The initial grant was crucial and helped the centers involved in the project. The grant was not enough to support the implementation of all components, but it helped the centers get started. One of the staff at S1 elaborates:

Financially, the first grant was \$3,000 which helped us get started. We won't have been able to get started if we didn't have that little push.

Another necessary resource for implementation is interventionists who help the centers implement the intervention. Without the effort and knowledge of the interventionists, the implementation would not be feasible. We consider financial resources and the efforts of interventionists to be key resources needed for implementation.

Resources are essential to implementing the intervention components; however, motivation is another needed element, without which ample resources are not of much help in kicking off and continuing the implementation. In Shape NC, competition was a key motivator for the center owners to join the project. The director of S1 discusses:

Forever we have always tried to get a leg up on other centers, because we felt like in order to get the children, we needed to be something a little different.

One of the staff at the local hub, an external stakeholder, says of the director of S1:

Sometimes it comes from—not because she knew about it but because she came to a meeting and someone else said this is what we are doing. So then she'll go out and figure out how to get that done in her center, so it is kind of that competitive. Her competitiveness is motivating her to do more... She is competitive. That is the first thing that comes to my mind when I think of Ms. [A.].

She was lower stars and she didn't care about increasing her stars [an assessment measure for the centers], because she knew she already had quality, she didn't care about the star rating system, but when that NC pre-k program came, she was like, what!? And sure enough she got it together. They had to apply to be the model early learning site—she made sure she had every piece that had to be in it. So she competed with 5 or 6 centers that applied and she made sure she had everything above what they could do so she could be that model learning center. So that competitive nature.

Furthermore, leadership support and involvement in the project is key to facilitating implementation. The level of support of organizational leaders goes back to their motivation. If leaders do not see the intervention as impactful, not only might they not support the project, but they even might be against it. This dynamic mechanism is already captured in the effect of motivation on implementation. We observed two completely different approaches to leadership support at S1 and S2. The director of S1 runs the child daycare center as a business center, so she potentially cares about competition with other centers in the community. In contrast, S2 was a center owned by a church and competition was not a big factor in motivation there. These different approaches by the leaders define the different initial motivation level of internal stakeholders.

NCPP:

Interventionists from NCPP were also the key agents in helping the hospitals implement the intervention. One of the staff at the successful hospital (N1) elaborates:

I think they [interventionists] have been pretty helpful. There are a lot of things that we've done on our own. But we've used them as just an extra piece. I think we will continue to use it a lot more, because I know they built the toolkit, they've built a lot more resources, they have lots of webinars that they provide, and I think just continuing to communicate that to the rest of our staff internally so they know it's there. I think it's going to be helpful, because you don't have to reinvent the wheel every time.

In addition to the efforts of interventionists, competitive advantage served as a driver of motivation in the NCPP intervention as well. One of the staff at hospital N1 mentions:

...we all felt it was the right thing to do. And I think quite frankly you don't want to be the hospital that is not on the map, because they have a map of North Carolina that shows

the hospitals that are and that aren't [involved in the wellness program, the intervention]. I think if you were the leadership of the hospitals that aren't, I think it might put some pressure on you to be the ones that are. Does that make sense? Because one of the things I learned about healthcare, I got into healthcare about ten year ago. I never realized really how competitive it is. It is very competitive. So you don't want to be the hospital that's in the market that doesn't promote wellness because the one down the street is.

Along with competitive advantage, contribution to the health of community was a strong driver of motivation at NCPP; it was mentioned by several interviewees. One of the staff at N1 says:

...one thing that we are doing now more than in the early days, and this is part of our attempt or work to move from just the hospital, to expand from the hospital sector to other sectors. So now we are working to bring the program to whole communities. We look at the hospital to become an anchor for that community.

Another staff at N1 elaborates, particularly on community leadership:

I think we had a real commitment. As a community hospital, we very much want to represent to our community a healthy way of living, and we thought it is important to I guess be a mirror to our community. So it was important to our CEO, it was important to our wellness leadership that we partner with NC Prevention Partners to make a statement and to give us a pathway to becoming a healthier organization and being healthier for our customers.

The impact of leadership support was strong enough to distinguish the successful hospital N1 from the unsuccessful hospital N2. We further discuss this difference in the analysis section (Section 4.6.2). One of the staff members at hospital N2 says:

...getting the directors on board with the staff and saying, 'Hey, look, this is gonna launch. This is gonna benefit you.' I think that's the only way we can upscale it, because if you just email people, 'Oh, this is happening, such and such.' Okay, they most of the time just delete it...

One of the staff at the local hub of S2 believes that the commitment of directors is the factor that makes some child daycare centers more successful than others:

...having a strong leader who is willing to do what it takes and be inspirational and motivating and facilitating into the roadblocks that they run into and of course staff who buys into that vision.

Therefore, the two key factors affecting implementation are resources and motivation. As discussed earlier, we consider resources to be interventionists' efforts and financial resources. We also particularly focus on motivation, capture it as a stock variable, and study possible mechanisms that change it. Figure 4-2 presents the effects of motivation and resources on implementation.

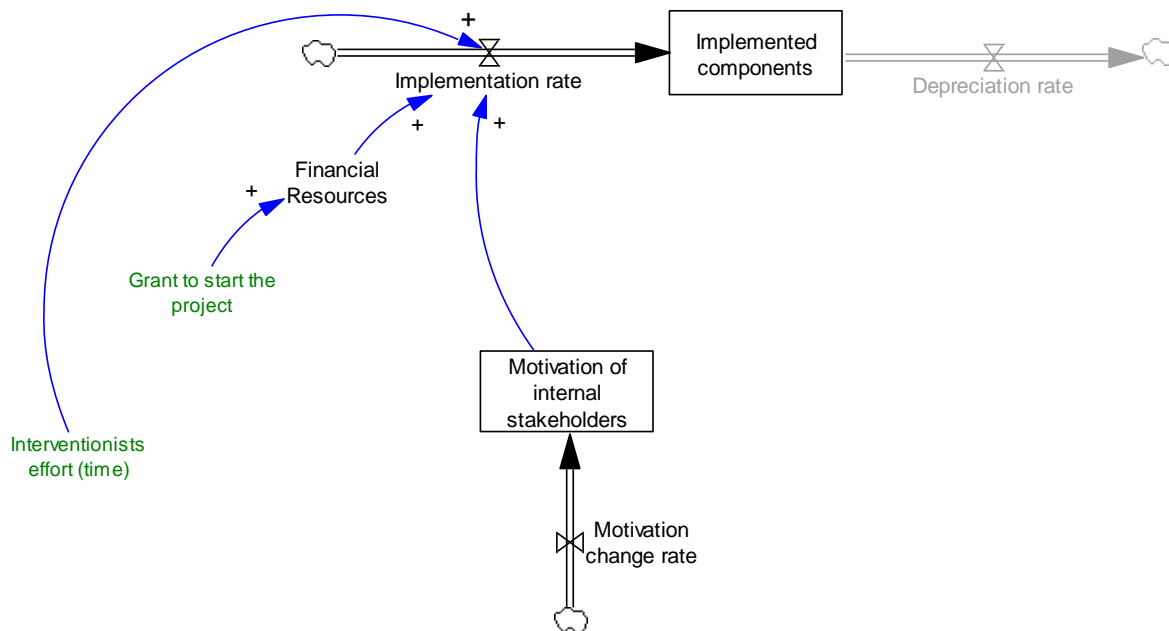


Figure 4-2. Effects of motivation and resources on implementation

It should be noted that we focus on motivation of internal stakeholders and assume that external stakeholders stay motivated. In fact, we observed highly motivated interventionists. However, we acknowledge that in other settings external stakeholders might become less motivated about the intervention over time. For the sake of simplicity, we only discuss the motivation of internal stakeholders in the model.

4.5.2 Communication and design quality

To keep the internal stakeholders motivated, a proper level of communication is needed between them and the interventionists. It helps not only to build trust among the stakeholders but also to

address some of the issues in the design and adoption of the intervention—the design process requires sufficient communication among the stakeholders. Another important component that affects the quality of design and adoption of the intervention is the quality of effort of interventionists. If sufficient resources are available and internal stakeholders are excited about the program, yet the efforts of interventionists are of poor quality, the implementation process will face potential challenges. Thus, communication among stakeholders and the quality of effort of interventionists affect design quality. Examples to support these mechanisms are presented below.

Shape NC:

One of the staff at S1 mentions:

It [our relationship with the technical assistants—interventionists] has been like a glove, we work very closely together. A lot of times they push me, because sometimes I get busy doing other things and [Ms.] R. [the key interventionist] gets me back on track; we should be doing this, change this, etc. She has been very instrumental with that and probably one of the key components to the whole program being successful is the partnership office.

As discussed earlier, communication also helps improve implementation by reducing errors and facilitating implementation processes. Staff and interventionists at both centers highlight the need for sufficient communication. The director of center S1 elaborates:

Of course [Ms.] R. [the key interventionist] is phenomenal; she's worth her weight in gold! She has come out and sits down with me for a few minutes and I am thinking, you know I can't go this next step. I just really don't want to go out and beg for more money or more help. She will say, Ms. A., you just have to... By the time she gets through, I'm thinking this is going to be a piece of cake! I go do whatever we need to do and I don't always make the best decisions with the people that we hire, but we look pretty good out there and kids love it. That is name of the game.

In a more explicit example, one of the interventionists of S1 explains a design issue in serving healthy meals:

Actually really the biggest killers are the teachers. If they say, eww... I'm not going to try that. Then the kids react the same... The little bit of stuff you hear from the kids is the

food, but mostly it's because they heard a teacher say they didn't want to eat something. If you get the teachers on board and get them to introduce it and be excited about it and have taste testing parties.

This design issue was raised and solved through the communication between the interventionists and internal stakeholders—training sessions for teachers were accordingly planned. Moreover, quality of efforts of interventionists affects the adoption and later the implementation of the intervention. If the quality level is low, more problems are encountered later in the intervention implementation process. Quality is rarely perfect, so the implementation of some intervention components can often be problematic. In Shape NC, technical assistants (TAs) who were the key interventionists directly in touch with the center owners and staff were highly trained, so we can expect that the quality of their efforts was at a good level. One of the staff at the local hub mentions:

...in the beginning, we really focused on the working and training and as the hours grew I think we put a little more of a hands off rule specially this last year, because I think they [TAs] feel more confident in their field compared to the previous years and they had a lot more experience behind them.

Another staff member also elaborates:

They [the TAs] have learned to believe in the program so strongly... I've done this training for every employee that I've had.

Also, the culture of sharing is noticeable among the interventionists, which helps improve the quality of their efforts. Another staff member at the local hub says:

Everyone is very willing to share resources. If you need something that you don't know, you can just email them and if they don't have it they will find it. So, I think we have a good system for sharing resources and I try to come back and share it with all of the TA girls, so it can spread throughout the county.

NCPP:

One of the staff at hospital N1 elaborates:

...they [interventionists] are great at answering as soon we have questions. I think we get an e-mail every week or two with maybe an upcoming webinar or anything that may be of interest to us. So, I'd say maybe once a week, once every two weeks we're in contact with

them... We communicate a little more often around the times that we take the assessments, because we're gathering information, preparing slides and getting things ready to show that we've met certain requirements to earn an A in those areas.

Given the large organizational size of NCPP compared with Shape NC, there was a higher demand for communication among the internal stakeholders. One of the staff at N1 explains:

We have the e-mail blasts that go out every week, weekly reminding people that you have the opportunity to earn points, don't forget to go in and track your exercise, bulletin boards, [and] staff meetings.

One of the interventionists at N2 explains how they communicated with their upper level stakeholders—state-level stakeholders who funded the program—in the design of the intervention.

When we were first designing the intervention, we've always had a very open, qualitative approach, where we read the science, we write it down, but then we spend a lot of time with our stakeholders, saying, really, what do you need? Like what are your stresses, what are your frustrations, what are your pain points? And then put the two together, so that it's a little bit more user-friendly, and it really meets their interests, instead of just our goals.

However, there was not much communication between the interventionists and internal stakeholders at hospital N2. This lack of communication can potentially reduce the quality of intervention component, which later reduces the motivation of internal stakeholders. We observed several design issues mostly for physical activity components at hospital N2. One of the staff members says:

I think for our program here, you can either participate here at the gym, or you can do it at home and be part of the wellness program... You don't have to be linked in here, but that seems like the biggest issue. Concern-wise, I think, the few people that I've mentioned, like insurance benefits and stuff like that [incentives for the wellness program]... [but] I think some people feel like it kind of steps into their personal lives too much.

Another staff member also adds:

I think the biggest challenge I could see... as far as I enjoy exercising, but the biggest challenge for me, and motivational factor for me is the transition with the weather or the seasons to still keep people motivated... So you just incorporate it into your daily routine, [but] I could see [it] as a really big challenge, because they drew people in at the first part of the year, but then with the warm weather, it's kind of like, how do you keep them engaged? So I think that's been one piece that hasn't quite been figured out yet.

These two design issues were not discussed with the interventionists and they remained unsolved. The director of the wellness program at N2 mentions another design issue in a physical activity component, which was raised and discussed with the interventionists and they could plan for other alternatives:

Like the first year, we started something called Walking Wednesdays, which was supposed to be, the idea was, that every Wednesday employees would gather and walk during their break time. Complete flop...! You know, it became too difficult to coordinate that sort of things, so we pretty quickly found out. This is not effective; this is not a good use of time for our staff. Let's pull back and put in something else that'll work a little bit better.

He further explains how these design issues, along with an issue in the design of incentives for the wellness program, can reduce the motivation of internal stakeholders and hospital staff members:

I think some of the wellness challenges, as I mentioned, have been a little bit flops. Not a little bit, they've been flops! I do think some different incentives will be a big help, even if they're not directly tied to insurance premiums, if we made the incentives a little more relatable to insurance cost, I think that would be a big step in the right direction as far as incentives go. The incentives we have now just frankly do not motivate everybody. They'll only be motivators for some people, which I guess is true of any incentive, but I think having some more incentives will just give a broader spectrum of people to incentivize or to motivate.

It should be noted that to keep the communication at a desirable level, stakeholders need to be motivated enough to communicate, otherwise communication decreases. This completes loop R1, Figure 4-3.

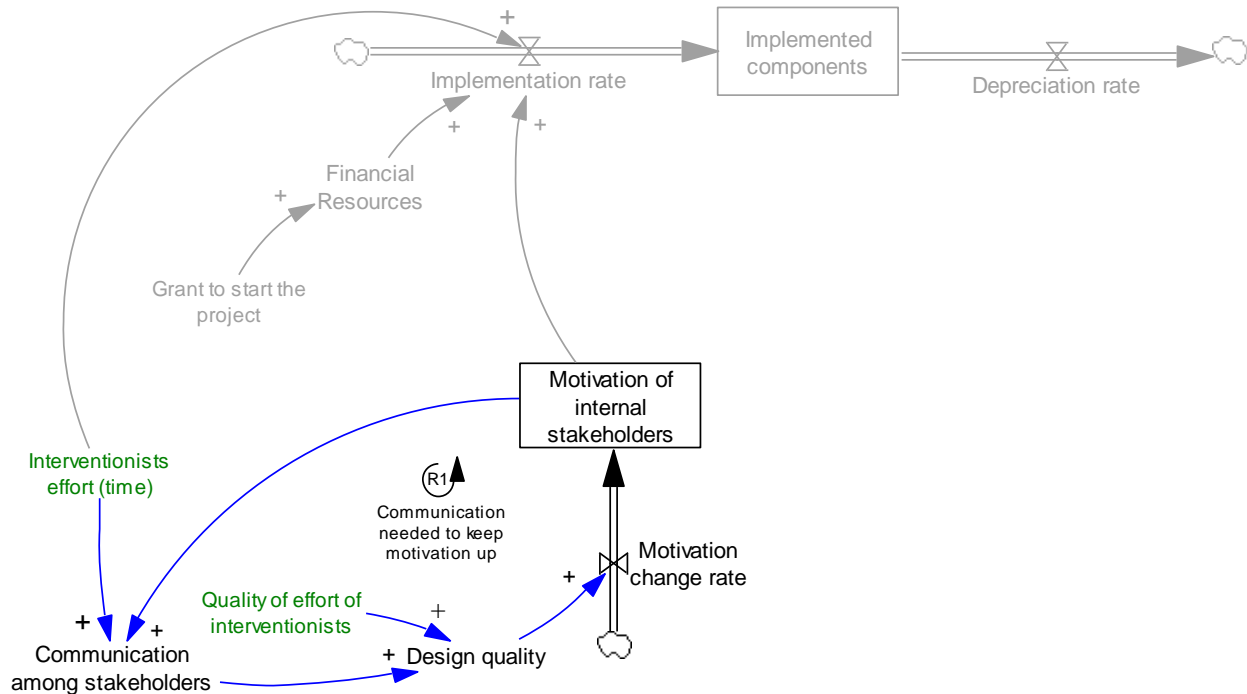


Figure 4-3. Effect of communication on motivation

4.5.3 Stakeholder alignment

Shape NC:

Stakeholder alignment is another component that helps reduce errors in the adoption and implementation of the intervention. A staff member at the local hub elaborates:

The owner may say they want it but the director may not be fulfilling the extent of the intentions made. And the owners aren't in the loop; it is the directors [who] are in charge. The directors are the ones on [the] go but the owners are the ones who can put a brake on the project. The owner may switch the bandwagon—we have seen that a lot.

Another staff member at the local hub explains:

I think motivation was high but it dipped when it came to how to implement the project, because they weren't quite sure what was going on and what happened. So, potentially, I think the motivation varied but now everybody seems pretty motivated. They were pretty

jazzed and excited and had really good positive stories to share. I think motivation is back up top.

Once the motivation dipped down because of conflict among stakeholders, communication helped them raise and deal with the issues. Hence, communication among stakeholders increases stakeholder alignment, which eventually results in increased motivation of internal stakeholders. This mechanism is presented in loop R2, Figure 4-4.

NCPP:

In NCPP, stakeholder alignment was not a major issue—there were some differences in perceptions and intentions of the wellness program director and the CEO at hospital N2, and we discuss this in more detail in Section 4.6.2.

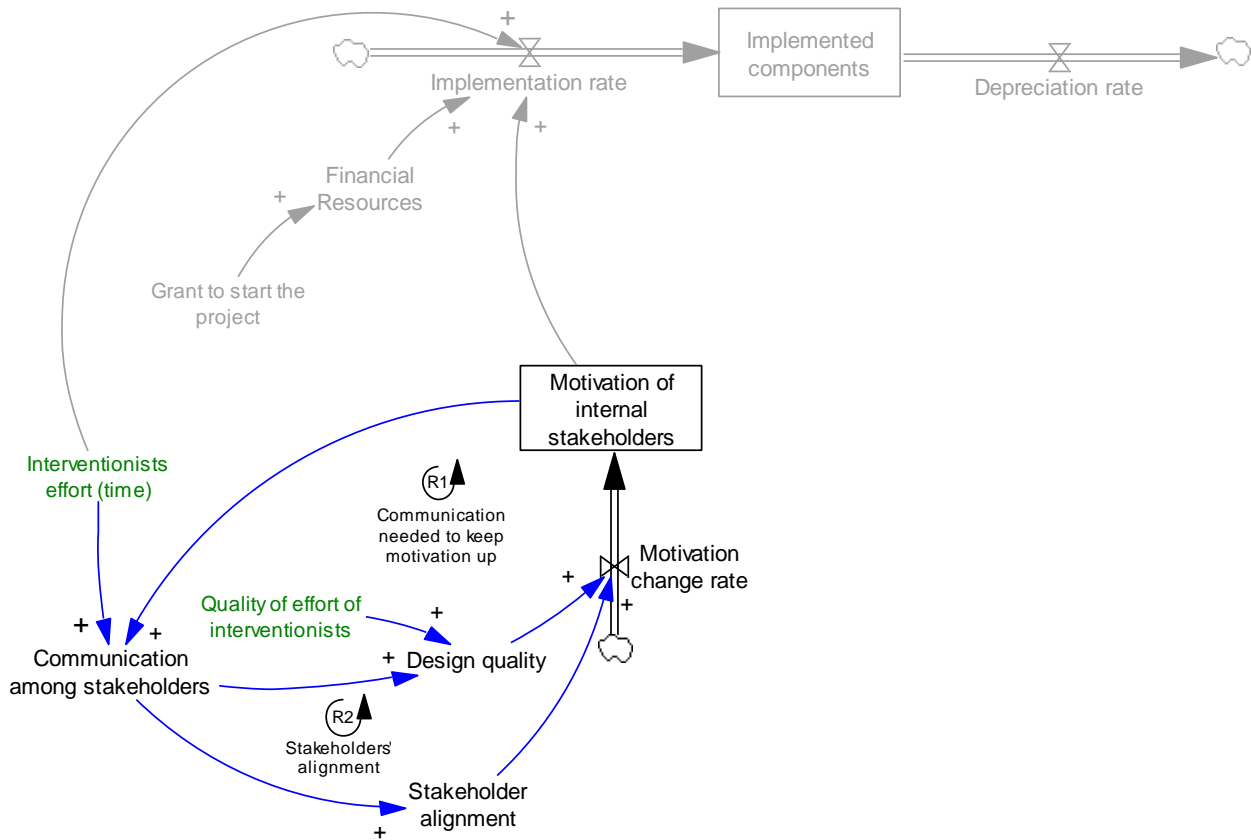


Figure 4-4. Effect of communication on stakeholder alignment

4.5.4 Effects of costs and benefits on motivation

As a result of the intervention implementation, internal stakeholders might observe new costs and benefits. A major benefit for the organization was competitive advantage as well as having an impact on the health of the community. There were also major costs of implementation of the intervention components, such as installing an outdoor playground in Shape NC.

Shape NC:

The director of S1 discusses this:

I would like to do what [Ms.] R. [the key interventionist] has suggested. It seems like we'll have a cook for a while and then they are gone, but what I'd really like to do is have a tasting on a Friday afternoon and do some new recipe and let parents have a taste. Have parents come and taste the new recipes and ask them if they think their kid would like it and give them the recipe to make at home... That would be good advertisement.

NCPP:

The implementation of the intervention imposed significant costs on the hospitals. Not only was the implementation costly, but also the projection of the consequences of some of the components did not seem beneficial to some staff. The program director at hospital N1 elaborates:

Everybody told me we were going to lose money, that the sales were going to hurt, because people want French fries; I said don't worry about that. We actually increased revenue. It's been pretty good.... We looked at it after six months and we were up about 18% on our growth. Overall since we took over five years ago we've been up to around \$2,000,000 revenue of the year. And that's just [for] serving better food, and brought in a whole new customer base. If you looked at the snapshot of the customers who were eating six years ago, it was heavy environmental services maintenance guys who want fried food, fried chicken, that kind of crowd. And when we introduced healthier food, we started seeing more doctors, more nurses, [and] more outside people who were eating, because it was a healthy way to go. So we brought in a new customer-base by adding healthier foods.

Another staff member at hospital N1 mentions:

We did a whole renovation, and we were going to invest that money to get rid of the fried food, we certainly needed to be able to support that. [When] it comes down to money, you don't want to do something that will really hurt your business and you're just left hanging out there if this wasn't a good idea. And we wanted to make sure that the idea we were doing was a good idea, both financially and nutritionally and all those things.

Therefore, the internal stakeholders compare the costs and benefits (we added the variable 'net benefits' in the model, $\text{net benefits} = \text{benefits} - \text{costs}$), and if they observe more benefits than costs (when net benefit is positive and loop R3 dominates loop B1 in Figure 4-5), they will be more motivated and consequently will collaborate in implementing remaining components and maintaining those previously implemented. However, this mechanism is dynamic and might change over time. For example, if implementation gets more and more expensive such that the costs are not worth the outcomes, the perception of the owners tends towards being against the program, making them less motivated to contribute. It should be also noted that the perception of the net benefits does not change motivation immediately—this delay itself can be another complexity in the model. Figure 4-5 presents these mechanisms:

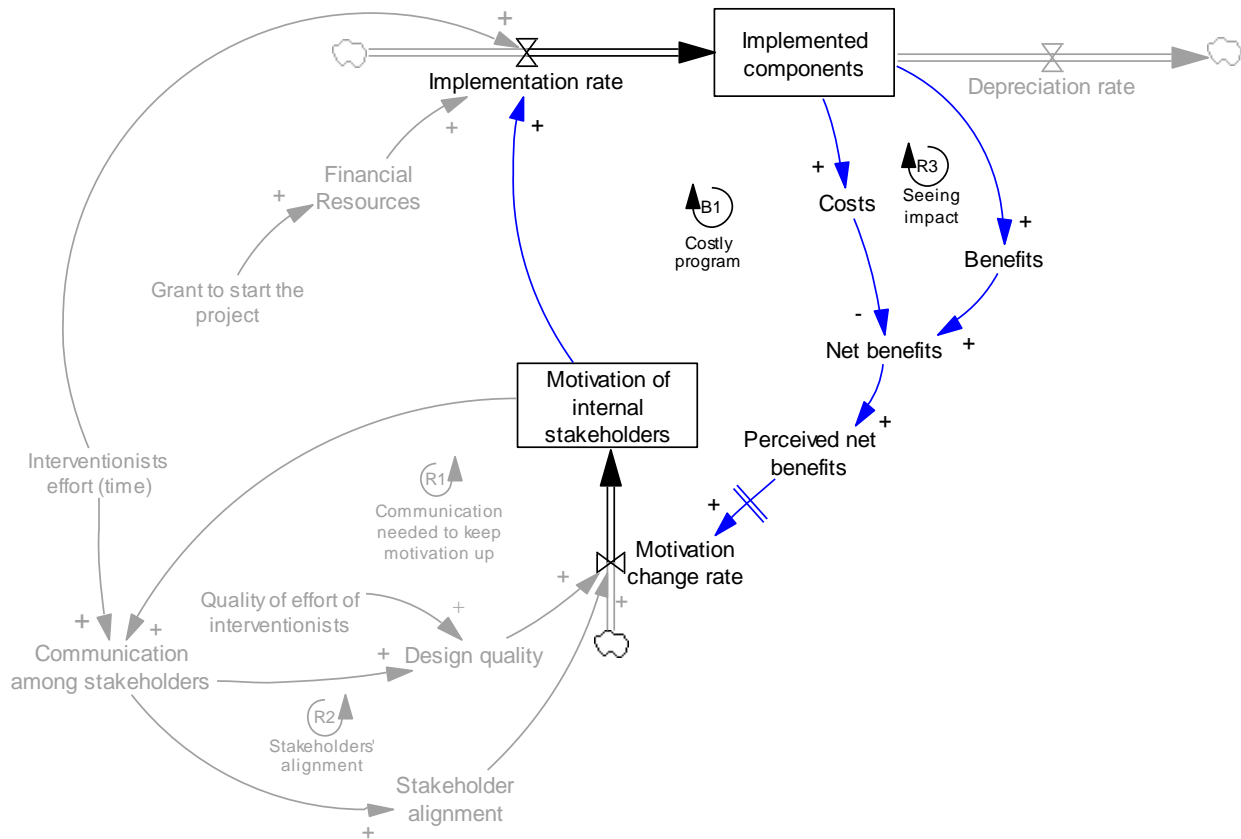


Figure 4-5. Effects of costs and benefits on motivation

4.5.5 Self-funding

As already discussed, implementation is costly, and both child daycare centers and hospitals need sufficient financial resources to move forward and implement the intervention components. This requires that internal stakeholders invest in the intervention and self-fund the implementation—in addition to grants from external stakeholders, if any.

Shape NC:

By seeing the impact of the intervention, center owners become more motivated to implement, and may be willing to provide financial resources if the initial grant does not cover all implementation costs. The director of S1 elaborates:

A lot more money should be put into this than what is being put in now. I've always liked to break new ground, which is what I've done. But I've spent way more money than I received, but it has been well worth it to this point.

I've put my own personal funds in and move money to this out of the budget. Not everybody can do that. But the more you put into a program the more you get out of it. They also need checks and balances—you need to make sure that the money that you are putting in is really doing what it needs to do. In some instances it is not, and that is a waste.

I would say that I have spent probably three times the amount of my own money of the scholarship that we've received.

One of the staff at S1 adds:

Ms. A. [the director] went way above and beyond that as far as spending. She built a well just to water the plants—it takes away from her water bill, but by the time you figure out how much she spent on that vs. the cost of the well, it was probably no comparison. But it is out there and it is wonderful. It is great the kids can turn it on and we don't get excited if the water is running a little longer than it should. They've learned to water their plants. So that little bit of a financial thing [initial grant] was like the carrot out there. Just kind of got us started. By no means did it support everything that we did.

NCPP:

The initial grant at Shape NC helped the centers get started, but NCPP did not offer any financial support to the hospitals. This highlights the importance of the effect of motivation, such that if internal stakeholders, particularly hospital administrators, are not motivated enough to fund the project, implementation of the resource-based intervention components (such as renewing the hospital restaurant) may not be feasible. While motivated administration at N1 provided financial resources for the implementation of the intervention components, less motivated administration at N2 did not provide any financial support. The program director at N2 elaborates:

We really have had no resources to allocate. We don't have a budget for wellness per se. Now, of course our department has a budget, but there never has been a particular amount set aside for employee wellness specifically. So all of the things that we have tried to do since the beginning have been low to really no cost movements.

The self-funding mechanism is presented in Figure 4-6, loop R4.

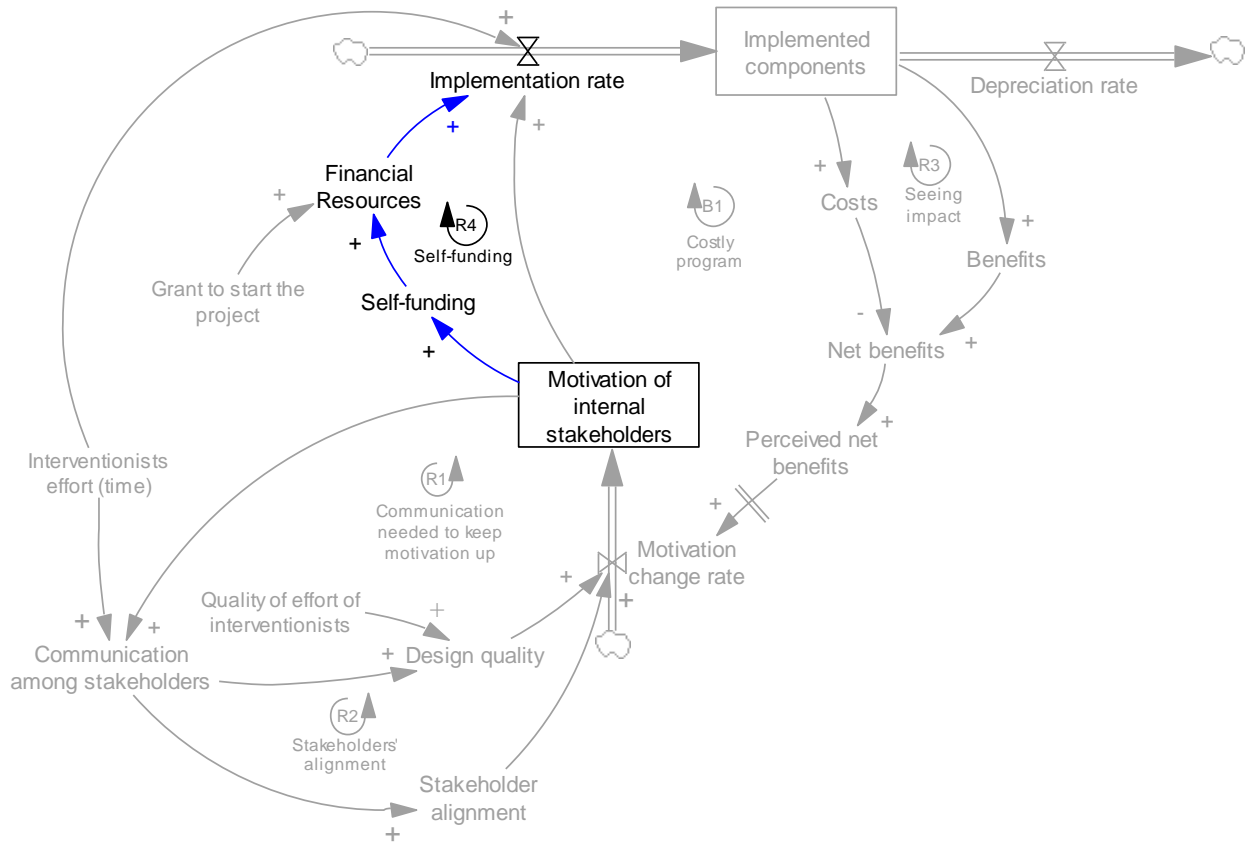


Figure 4-6. Self-funding mechanism

4.5.6 Non-dynamic factors affecting motivation

Motivation is also impacted by other factors, such as individual knowledge and beliefs about capability and self-efficacy for carrying out the new processes [31]. Other factors affecting the motivation of internal stakeholders could be novelty and the curiosity of leaders (owners/admins) about implementation results and their concern about the health of the community—examples presented for motivation (Section 4.5.1) and self-funding (Section 4.5.5) mechanisms support these two factors. While such characteristics have a potential impact on motivation, we do not explicitly include them in our discussion of endogenous mechanisms because they usually do not change dynamically during the evolution of an intervention. These parameters are added in Figure 4-7.

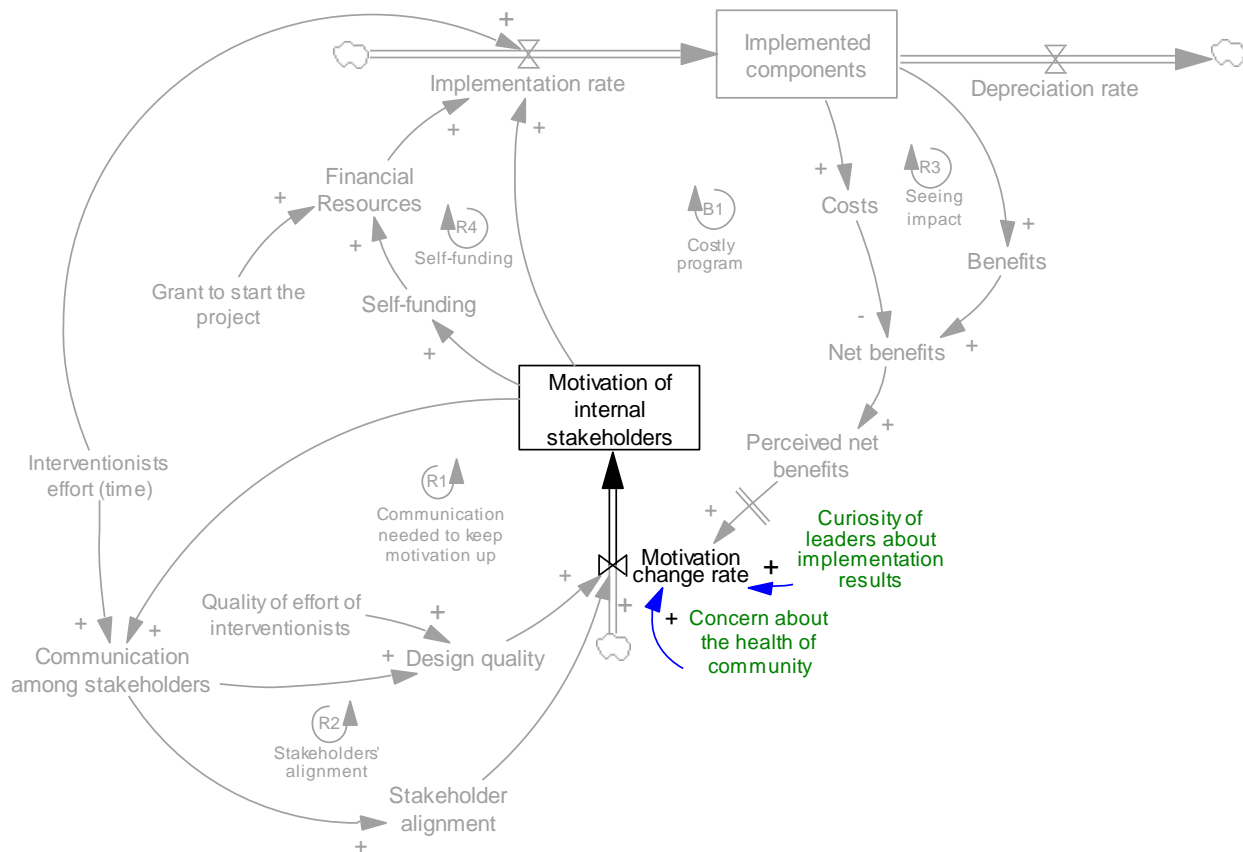


Figure 4-7. Examples of non-dynamic factors (green parameters) affecting motivation

4.5.7 Depreciation and Maintenance

Up to this point, all the mechanisms presented affect the implementation of interventions. Intervention maintenance emerged as another critical factor. Implemented components erode when they deteriorate, depreciate, or are otherwise scrapped, and are not renewed—these processes continually reduce the number of implemented components. Yet the depreciation rate is also endogenous, as it depends on other factors. Through the interview data from internal stakeholders and interventionists, we learned of three key factors: motivation, communication among stakeholders, and design problems. We find that motivated internal stakeholders are more likely to internalize and sustain changes without external prompts (R5, Figure 4-8). Communication can help remind internal stakeholders of the need to sustain changes and fix emerging problems (loop R6, Figure 4-8). Finally, high-quality designs foresee and correct for

the most common modes of failure and thus include lower baseline depreciation rates (R7, Figure 4-8).

Shape NC:

To keep the program successful, intervention components must not only be properly implemented but also maintained, otherwise they will deteriorate over time. We already indicated that communication is needed to identify implementation errors and consequently results in more progress in implementation. Lack of communication not only makes implementation problematic, but also increases depreciation of those components already implemented. One of the interventionists says:

...the frustration and the motivation at the beginning and the lack of communication just sour it all and it never recovered. And when we select folks, there is this criterion but you have got centers, directors or owners who may not be that good at communicating.

In fact, communication can help remind internal stakeholders of the need to sustain changes and fix emerging problems until intervention components are fully institutionalized and transformed into organizational routines. Moreover, motivated owners are more likely to sustain the changes without external prompts, and the quality of implementation influences the baseline depreciation rates.

An example from S1 shows how a small design problem was about to deteriorate an intervention component, where the implementation of a garden for kids focused only on children and not on teachers. However, with more communication through training, the issue was resolved. One of the interventionist further elaborates the story:

Now with the garden, there's some enthusiasm, there's motivation from the teachers. Whereas some time back, I was not seeing much motivation from the teachers. After the training, now I'm seeing teachers like little bees running around outside with the kids. They are playing soccer and it is kind of weird how it happened. I saw a big shift when they opened up the fencing and allowed more space, more free spaces for kids and teachers to move.

NCPP:

The three mechanisms affecting the depreciation of implemented components were more noticeable in Shape NC than in NCPP. NCPP interventionists paid close attention to the

maintenance while designing the intervention components. One of the key interventionists elaborates:

We've designed the program in order for them to easily maintain things over time, because one of the things that we encourage is that they continue to take the assessments to make sure that they're maintaining that high level once they've achieved it.

Hospital N1 had not noticed as much depreciation by the time of the interviews, and hospital N2 was not able to implement many of the intervention components. The program director at N1 was fairly aware of the effect of motivation on maintenance. He elaborates:

[The main challenges to maintain the program is] just to keep people interested and excited. You want to do something that is different enough each year to keep them engaged, but you don't want to change it so much that they go, 'Uh, here we go again', but something new, something completely different. We just learnt this one, now we're starting something new.

One of the staff at N1 nicely summarizes the effect of motivation:

[To be successful] I think you've got to have buy-in in that. I think that goes back to the culture, but I think you need to understand why you're doing this, what's the benefit of doing it, in that you stick with it, dig your heels in the ground, this is it, this is what we're doing, this is our program, and then eventually it will become a culture thing.

Another staff member at N1 answers the question, “Was there any part of the program which was not maintained well”:

Not really! Honestly, it's just continued to grow bigger and bigger and bigger, and haven't seen it backslide at all.

The preceding two examples support the hypothesis that once new practices, intervention components, are institutionalized and transformed into organizational routines, they will sustain and emerging problems will be fixed. The three factors affecting depreciation rate are presented in Figure 4-8.

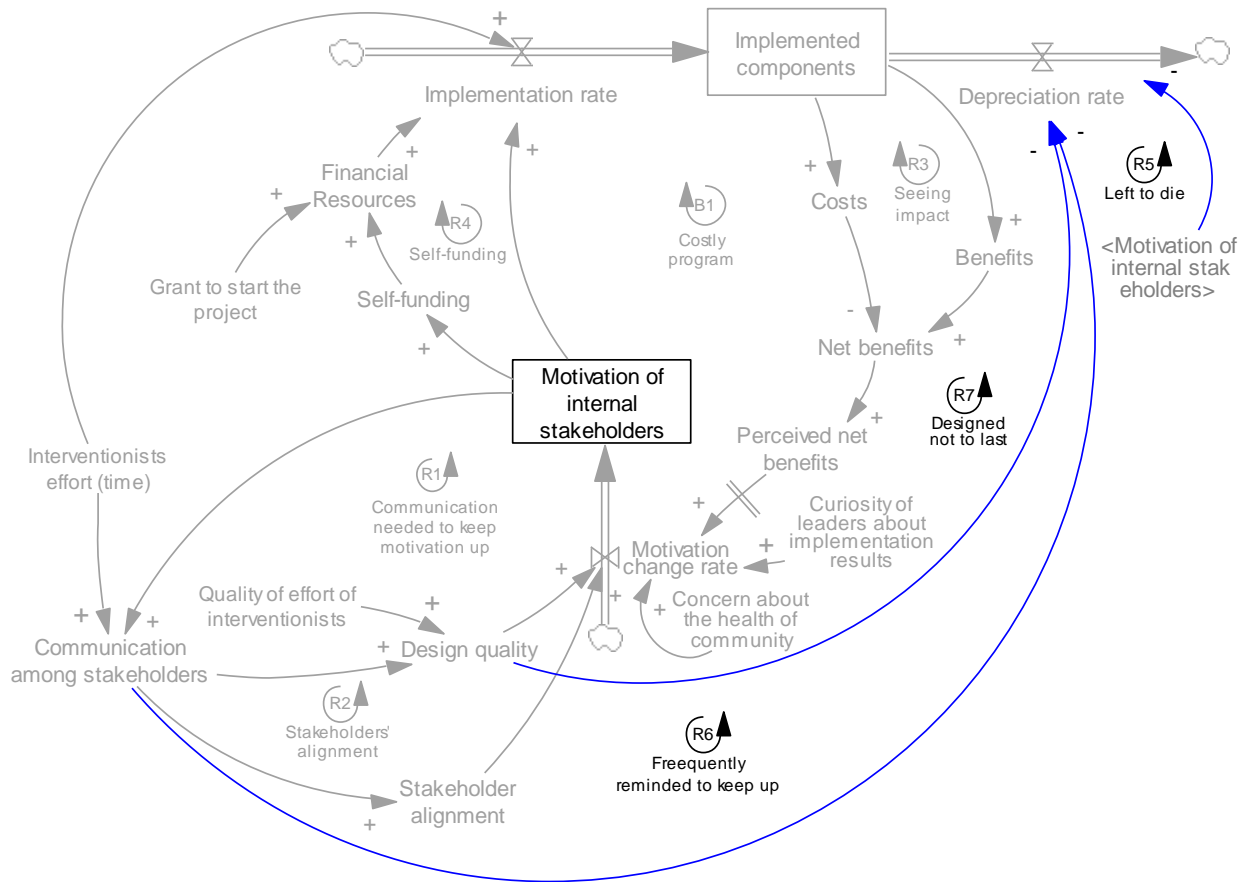


Figure 4-8. Effects of motivation, communication, and design quality on maintenance of intervention

4.6 Analysis

The focus in Section 4.5 was on the relationship between the key variables to develop the casual loop diagram. In this section, we explain how the dynamic mechanisms in the model and trade-offs in the endogenous mechanisms can distinguish successful cases (child daycare center S1 and hospital N1) from the unsuccessful ones (child daycare center S2 and hospital N2).

4.6.1 Shape NC

In a nutshell, high motivation of internal stakeholders was the key to success at S1 because it encouraged original implementation and reduced future depreciation, allowing for sustainability and growth of the intervention and its financial benefits to materialize. Here we describe the mechanisms that helped increase and maintain the level of motivation of internal stakeholders.

Expanding on examples discussed in Sections 4.5.1, personal characteristics of the center owner (competitiveness and leadership interest) and situational factors (facility attractiveness and leadership role in the community) created a desirable initial level of motivation. Over the course of implementation, internal staff realized the impacts of the implemented components. In fact, comparing the perceived benefits (e.g., making center S1 the leader in the child daycare business in the community) with the costs of the intervention, their overall perception of the intervention was that it was a beneficial program (where loop R3 dominates loop B1 in the model, Figure 4-5). Therefore, the initial high motivation of the internal stakeholders, particularly the center owner, was maintained. With her and the staff motivated and excited about the program, they were willing to communicate with the interventionists, receive advice from them and solve possible issues throughout the implementation processes (loop R1, Figure 4-3).

Motivated internal stakeholders at S1 helped customize the intervention components, which facilitated further maintenance. This required more communication between the internal stakeholders and interventionists to fix the issues and plan for additional implementation of modifications, which eventually transformed the intervention components into organizational routines.

Once the intervention components were institutionalized, the internal stakeholders continued to maintain the intervention with or without the help of interventionists. A staff member at S1 mentions:

We re-hauled the entire playground, added the trike path, planted fruit trees and other trees, [and] had parent work days. We come out on Saturdays some days. Just want needs to be done, step by step. We've had about four work days where we built things out here without the children... We try to keep the staff motivated, because at first they didn't really get it, but now they are adding it to their lesson plans and thinking about it all the time. They picking books that have fruits and vegetables and fresh foods in them—farm books and things like that, instead of your typical fantasy princess stuff.

The initial motivation of internal stakeholders in center S2 was not as high as in center S1. If the center directors are not motivated enough about the intervention, they may affect the perceptions of the staff and eventually they will not commit to better implementation and maintenance of the implemented components. One of the staff at the local hub of S2 elaborates

on the commitment of directors and how it can make some child daycare centers more successful than others:

...if you have a director X and center Y, and church you probably know this but [the] church based child care doesn't have high requirements for profit and they give them a pass on certain things. So it's different to see where the center director gets it and gets on board with it to where you have had a good relationship with the local partnership and they are prompt to do these kinds of things.

4.6.2 NCPP

Similar to child daycare center S1 in Shape NC, internal stakeholders at hospital N1 joined the project with high initial motivation. Their motivation was then maintained over time by communication with interventionists, fixing the issues, and seeing the impact of the intervention. In section 4.5.1, we noted some examples of benefits to hospital from implementing the intervention, such as competitiveness and community leadership.

Consequently, with motivated internal stakeholders at N1 the intervention was maintained well and the internal stakeholders implemented further practices. Moreover, the motivation of internal stakeholders accompanied by hospital administrative support enhanced implementation and maintenance of the intervention. The motivation of administration is an essential factor, particularly in large, complex organizations like hospitals. For example, given that there was no initial grant to start the intervention, self-funding was a necessary factor to cover program costs. Without the support of hospital administration, funding would not have been secured.

Overall in the NCPP project, external stakeholders were faced with lack of leadership support in several hospitals, so much so that they tried to get verbal confirmation of administration support for the program. One of the interventionists mentions:

Something that we require hospitals to do before they start working with us is to sign a CEO commitment form. That form basically says: 'Yes, personally I support this but also I am going to put in my strategic plan, we're going to work on this as an organization, and there are the people that want to work on it from my hospital.' Having that leadership support is just so important, and as we go out and we visit hospitals and see what they're doing on the ground, and seeing the CEO support, we definitely see those

hospitals as moving forward more quickly than hospitals that have just mediocre or no support for the wellness program.

Chief executive officers or directors may have different leadership skills and strategies, yet their support is tied to their motivation and affected by endogenous organizational mechanisms, i.e., the feedback loops affecting motivation in the model. With motivated internal stakeholders along with the support of administration, the hospital practices intervention components and gradually such components integrate with organizational processes and are routinely maintained. The wellness program at hospital N1 experienced the transformation of new practices into organizational routines. One of the internal stakeholders elaborates:

The wellness program is just a part of our life here. People are used to it, they're very committed to completing their preventive items, and that is still a part of the wellness program with vitality, there is a prevention component to that.

This transformation facilitates the maintenance so much that interventionists, along with internal stakeholders, believed that maintenance was not as hard as implementation. One of the internal stakeholders says:

I think it's pretty easy to maintain [the program] once you get there. Getting there could be challenging for some people.

While high motivation reinforces several dynamic mechanisms in the model that lead to better implementation and eventually better maintenance of the intervention, low motivation can act in the opposite manner. Stakeholders who are not motivated might not communicate with the interventionists as often as needed, causing them to face more challenges along the way to implementation, which eventually decreases their motivation. Consequently, reduction in financial and leadership support for implementation results in not fully or properly implementing the intervention components. Internal stakeholders then perceive the program as a whole as not beneficial, and such negative perceptions of the program feeds back to their motivation and makes the situation even worse. This was the situation in hospital N2. The director of the intervention at hospital N2 answers to the question, "Why did the hospital decide to join the program at the beginning":

I really don't know! I've never been able to find out the actual answer. I think it was just because somebody had brought it up in a meeting, and the CEO at that time was like,

'Okay!' and didn't really know anything about it, because I actually went back to my HR director... maybe two years ago, around the end of the first year of the program, when I had been trying to offer a lot of proposals for things to do, and was not really getting anywhere, and she said, I'm talking about the CEO, said, 'he doesn't care. He doesn't know what's going on. He doesn't have any interest in it.'... She was being nice to me, telling me that information. She just said, 'You know, you do with it what you feel like you need to do.'

Hospital N2 tries the best they can to save money, even by laying off employees. Employees are also so busy with their daily tasks that they do not have any additional time to spend, e.g., on attending wellness programs. In fact, since the implementation was not properly done, the intervention components never turned into organizational routines.

4.7 Discussion

In each case, the introduction of a new practice entails designing and implementing various components, such as physical components (e.g., playground) and incentives (e.g., for employees to exercise or quitting smoking). The design and implementation in each case can be seen as a project comprised of various components. Execution of these components informs the progress of the implementation phase and depends on the time allocated to implementation by the interventionists, the quality of their efforts, and more importantly the motivation of internal stakeholders to actively contribute to the project. Besides implementation, the maintenance of newly implemented components is key to the long-term value of the intervention: the new practices only have the potential for impacting organizational performance if they last. Our qualitative modeling work elucidates a few exogenous factors (such as quality of efforts of interventionists and the existence of program grants), as well as some endogenous mechanisms, that moderate implementation and erosion rates.

Based on several endogenous reinforcing mechanisms, we present that early differences in the implementation of interventions can end up with very different paths to success. For instance, initial high motivation of internal stakeholders makes the organization become more motivated to communicate with the interventionists, provide financial support for implementation, and institutionalize the new practices, and thus see lower costs for maintaining them, further increasing the perceived benefits, compared to another organization that started off on the wrong foot. Also, for one organization, lack of initial motivation may limit the bandwidth of

communication, reduce the quality of design, reduce the stakeholder alignment, and lead to much rework and wasted resources in the implementation phase, while another organization thrives. In addition to making implementation problematic, these early differences can also be amplified and lead to very different erosion rates. For instance, internal stakeholders who are less motivated will be less likely to communicate with the interventionists (e.g., to raise emerging issues) and hardly internalize and sustain changes without external prompts.

Furthermore, design quality emerged as an important aspect of the studied interventions because a well-designed intervention matches the requirements for the organization at hand and thus is less costly to organizations, may include more benefits, and is easier to implement and maintain (see examples in Sections 4.5.2 and 4.5.7). The quality of design partially depends on the skills and knowledge of the designers (in our cases, the interventionists), but more importantly on the communication between designers and internal stakeholders. In fact, the customization of the intervention based on the characteristics of each organization requires ample communication between the interventionists and internal stakeholders. Communication between internal stakeholders and interventionists sets the tone for whether new practices are taken up and modified to best fit the organization's internal and external environment, or are ignored or even actively resisted. Taken together, communication and design quality create potential reinforcing loops: increased motivation facilitates better communication, which improves design, enhances perceived benefits, and keeps the internal stakeholders motivated.

In all our cases, motivation of internal stakeholders emerged as a critical part of explaining performance heterogeneity across similar organizations. As discussed earlier, reinforcing loops can amplify differences between two programs, if one faces initial lack of leadership support that reduces motivation and communication and sows the seeds of future problems. Variations in the development of each intervention were observed, but much of the difference in longer-term performance levels could be better explained by the motivation of internal stakeholders. We present several endogenous mechanisms which change the motivation dynamically over the course of implementation, i.e., communication between internal stakeholders and interventionists, intervention design quality, stakeholder alignment, and impact of implemented components.

Our analysis points to a few reinforcing mechanisms, moderated by motivation, communication, and design quality, which impact both initial implementation and erosion of

intervention components. We suggest that these reinforcing mechanisms can create path dependencies in capability evolution trajectories (capabilities achieved due to the implemented interventions) across organizations, leading to heterogeneity in performance, even when the elements of the intervention are relatively well-known. Similar dynamic mechanisms were presented for the BHC case in Chapter 3. The basic design, implementation, and maintenance of new organizational processes are shared in developing many health interventions. In fact, there is much variability in the three interventions and organizational contexts explored here. Therefore, qualitatively, the dynamics discussed will be relevant to many settings. Yet the quantitative analysis will be more dependent on the organizational context and indicates which loops will dominate the dynamics in which organizational settings.

Finally, the endogenous perspective we employed offers a distinct way of interpreting organizational performance and change. In this perspective, organizations may diverge into different performance trajectories, not because the actual payoff landscape is very rugged [32] and finding the best configuration is computationally intractable [33], but because actions taken by organizational members and results observed complement each other in endogenous feedback processes. While the strategic importance of some reinforcing processes, such as learning curves [34] and network effects [35], are well established, we think this explanatory engine can be fruitful in understanding a much wider set of phenomena in strategy, particularly in the health literature. The feedback processes among communication, motivation, and design are just a few examples. Using this perspective, researchers can identify and quantify the various feedback processes relevant to each health organization setting, and managers can seek to activate specific feedback loops in their favor and leverage those to distinguish their organization from the competition.

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Chapter 5 – Conclusion

Obesity has been recognized as a major public health challenge for over two decades in the U.S. Despite Much research and substantial efforts to control and reduce obesity, it continues to be a critical issue. Over the last two decades, public health research institutes have designed and implemented many obesity prevention programs, with great attention to family- and community-based initiatives; however, the effectiveness of these programs over the long run has been questioned. In this dissertation, we took advantage of systems science methods to address some of the challenges in this area of obesity research.

The complexity of the problems under study in this dissertation is beyond the understanding of the human brain. In fact, research already shows that our brains are not well-equipped to infer a complex web of causal pathways accurately without the assistance of computational tools [1-4]. From this complexity emerges the use of systems science, which not only helps provide a simplified version of reality, but also helps understand the consequences of any changes in baselines. Systems science approaches can potentially help identify and quantify nonlinear relationships among system components, feedback loops between component parts, and time-delayed effects, among others [5]. The use of systems science as a branch of industrial and systems engineering and management sciences in health research is not at all new. However, its use in obesity prevention interventions is relatively new, particularly in understanding the dynamics of organizational health interventions. We provide preliminary evidence on the dynamics of the implementation and maintenance of such interventions. We also discuss study limitations and areas for future research in each essay, but in a nutshell, closer integration of quantitative data with our models can enhance confidence in our results.

For the first essay (Chapter 2), we conducted a systematic review of parent-based social influence mechanisms in obesity interventions in the family setting. We not only followed the best practices for systematic reviews, but also extended the common reviewing toolbox and summarized the findings from 21 articles in a causal pathway diagram. The diagram, adopted from systems thinking and system dynamics, offers a structured graphical summary of the key mechanisms identified in the literature. We coded the reviewed interventions for three core social

influence mechanisms: 1) a supportive social environment; 2) modeling healthy eating and activity patterns; and 3) praise and encouragement for desirable behaviors. We then focused on teasing out the components of interventions, mechanisms of impact, and outcomes to inform social influence mechanisms and future intervention designs; these mechanisms are summarized in the causal loop diagram. The diagram helps identify how intervention components pass through the three core social influence mechanisms. Given our discussion of the durability of the three social influence mechanisms, intervention developers can target those components to pass through the most durable social influences. The diagram also provides a big picture of the current contributions in the literature and can help highlight the areas in need of further empirical research. In addition to the causal diagram and the review of social influence mechanisms, we provide insights from the reviewed articles to improve the efficacy of interventions, such as targeting families with young children, starting treatment from the early stages of obesity, focusing on what can be eaten vs. what cannot be eaten [6], and focusing on health-centered rather than weight-centered approaches [6, 7]. Moreover, treating parents as the direct agents of change in the family setting has additional benefits that can help in the following ways: dealing with children's stigmatization about being "overweight patients" [7]; making attending the intervention sessions without the children easier for parents [8, 9]; increasing the productivity of sessions in terms of problem solving and discussion time [9]; and decreasing costs of interventions with fewer change agents [10-12]. These benefits increase the motivation of parents to participate, which further helps increase the sustainability of interventions and parents' commitment. Overall, our review suggests that interventions that mainly utilize social influence pathways are potentially promising, and we offer a template for their mechanisms of impact. However, much remains to be understood about the best study designs and the relative impact of such interventions in comparison with alternatives.

In the second essay (Chapter 3), we discuss the great heterogeneity in the impact of implementation of obesity prevention interventions in communities. To understand this heterogeneity, we focused on an obesity prevention intervention, implemented in food carry-outs in low-income urban areas of Baltimore, that aims to improve the dietary behavior of adults through better access to healthier foods and point-of-purchase prompts. Based on qualitative analysis of interview data and the literature, we developed a dynamic model enabling us to study the dynamic mechanisms of implementation of the intervention and various trade-offs in

endogenous mechanisms. We present how the dynamics surrounding communication, motivation, and depreciation of interventions can create tipping dynamics in the Adoption, Implementation, and Maintenance (AIM) process. Specifically, small changes in allocation of resources to an intervention could have a disproportionate long-term impact, if those additional resources can turn stakeholders into allies of the intervention, reducing the depreciation rates and enhancing sustainability. For example, in our simulation analysis, the dynamics mechanisms create non-linearities in the model and a tipping point on the level of interventionists' efforts, which leads to widely different outcomes of small changes; once the level of interventionists' efforts exceeds the tipping threshold, the intervention is sustainable. We also discuss how quality of the intervention design, communication among stakeholders, and stakeholder motivation can affect intervention depreciation. A well-designed intervention sustains stakeholder motivation and limits later deterioration; therefore, changes that increase the quality of the original design are critical for the long-term success of AIM. Moreover, our model highlights the common trade-off between designing and implementing intervention components and communicating with stakeholders to help build confidence and improve the quality of the intervention. Given that many interventionists are more familiar with the former, there may be a built-in bias in the AIM process against adequate investment in the communication processes central to AIM dynamics. Overcoming that bias and tuning communication levels to address both motivation and quality considerations is an important leverage point for training successful interventionists.

In the third essay (Chapter 4), we presented two additional case studies to understand the dynamics of implementation and maintenance of organization health interventions, particularly obesity prevention interventions. We used interview data extensively to develop a causal loop diagram and outlined how endogenous mechanisms can affect the implementation and sustainability of intervention programs. In our analysis based on the dynamic mechanisms in the diagram, high motivation of internal stakeholders is the key to success, because it encourages the original implementation and reduces future depreciation, allowing for sustainability and growth of the intervention and materialization of financial benefits. Moreover, initial high motivation of internal stakeholders makes the organization more motivated to communicate with the interventionists, provide financial support for implementation, and institutionalize the new practices, and thus see lower costs for maintaining them, further increasing the perceived benefits, compared to another organization that starts off on the wrong foot. Furthermore, lack of

initial motivation for one organization may limit the bandwidth of communication, reduce the quality of design, reduce the stakeholder alignment, and lead to much rework and wasted resources in the implementation phase, while another organization thrives. In addition to making implementation problematic, these early differences (e.g., differences in motivation of stakeholders) can also be amplified and lead to very different erosion rates. For instance, internal stakeholders who are not much motivated will be less likely to communicate with the interventionists (e.g., to raise emerging issues) and will hardly internalize and sustain changes without external prompts. Our analysis points to a few reinforcing mechanisms—moderated by motivation, communication, and design quality—that impact both initial implementation and erosion of intervention components. These reinforcing loops can amplify differences between two intervention programs, if one faces initial lack of leadership support that reduces motivation and communication and sows the seeds of future problems. Overall, heterogeneity among the case studies presented in the second and third essays increases the generalizability of the results; however, in the absence of detailed quantitative data for a larger number of cases, one should be cautious about generalizing the findings or seeking operational advice from our model.

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