THE INTERVENTION LEVEL FRAMEWORK: USING SYSTEMS THINKING TO ADDRESS THE COMPLEXITY OF CHILDHOOD OBESITY PREVENTION

by

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ABSTRACT

Childhood obesity has generated a considerable response from policymakers in Canada and abroad, resulting in the production of numerous strategies containing recommendations for action. This abundance of proposed activity can be overwhelming for public health practitioners seeking to best invest resources. Complexity science has been proposed as a means to assist public health in moving forward on this issue. The Chronic Disease Systems Modeling Lab at SFU has developed the 5 level Intervention Level Framework (ILF), based on the work of Donella Meadows, as a means of sorting and analyzing recommendations to address complex health problems from a complex systems perspective. In this study the ILF is applied to a sub-set of childhood obesity recommendations in order to assess its strengths and weaknesses for a broader analysis. Finessing the ILF will contribute to the field of systems based methodological inquiry and will further the study of complex public health problems.

Keywords: Childhood obesity; Complexity science; Systems thinking; Intervention level framework.

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TABLE OF CONTENTS

INTRODUCTION

The past decade has witnessed a mobilization around the issue of childhood obesity, identified by many as one of the most serious health challenges of the 21st century (Veugelers & Fitzgerald, 2005; Wang, 2001; Willms, Tremblay & Katzmarzyk, 2003) and a potential cause of this generation of North American children having shorter life spans than their parents (Olshansky et al., 2005). While the rise in childhood obesity rates in high-income countries has been associated with the advances of industrialization and modern living, rates are also increasing in many low- and medium- income countries. The childhood obesity epidemic is increasingly a global one, presenting in a variety of social, economic and cultural contexts. The costs of this trend are wide-ranging as individuals, families and communities struggle with its associated physical and psychosocial burdens, and governments contend with the financial impact on a health care system challenged by the chronic conditions associated with obesity (Berenson & Horvath, 2003; Bodenheimer, Wagner & Grumbach, 2002; Hroscikoski et al., 2006).

The problem of childhood obesity has inspired a considerable response as organizations ranging from the level of the World Health Organization (WHO) to municipal governments have put forth prevention strategies and reports tackling this issue. The common approach taken is to attempt to engender improvements in healthy eating and physical activity – key variables in the energy balance equation which determines individual body weight. It has become clear, however, that addressing the obesity epidemic will demand a response that moves beyond individualized health promotion activities addressing energy imbalance. As policymakers engage with varying approaches, there is an increasing recognition that complexity science could be used to develop new ways of addressing complex public health issues like childhood obesity (Best et al., 2003; Finegood, 2006; Finegood, Karanfil & Matteson, 2008; Leischow & Milstein, 2006).

To this end the Chronic Disease Systems Modeling Lab of Simon Fraser University has developed the Intervention Level Framework (ILF), a 5 level framework that can be used to sort qualitative data by the leverage points in a complex system. The ILF was adapted from the work of Donella Meadows, a systems thinker who identified 12 places to intervene in a complex system. Meadows spent years working with systems and experiencing the ways in which actions taken to supposedly address problems could often result in influencing the system toward new, unanticipated and often unsustainable behaviours. Driven by her desire to find ways of changing “the structure of systems to produce more of what we want and less of what is undesirable,” she identified what she felt were the 12 points of intervention in complex systems, ranking them according to ease of implementation and potential for effectiveness. Malhi et al. have condensed these original levels into 5 mutually exclusive ones that still capture her original points of leverage, and have used that framework to sort data sets related to childhood obesity, chronic disease prevention and healthy and sustainable food systems (Malhi, 2009; Malhi et al., 2009). They have demonstrated that the ILF enables researchers to sort the ideas presented in a data set through a system lens and analyze them for potential leverage points. The ILF can also be employed to assess gaps in strategic planning according to a systems approach and discordance among the goals set out by different parts of the system (Malhi et al., 2009; Finegood, Merth & Rutter, 2010).

Purpose

Guided by the premise that childhood obesity is a complex problem that could benefit from solutions guided by complexity science, our research team is interested in applying the ILF to a large data set of recommendations drawn from Canadian strategies on the issue. Our aims are to both further the field of systems-based methodological enquiry with the refinement of the ILF, and to analyze the current state of Canadian strategizing on the issue of childhood obesity. The purpose of this paper is to investigate the potential usefulness of the ILF for this larger study by applying it to examples drawn from a sub-set of childhood obesity recommendations. I will begin my discussion with an overview of the childhood obesity epidemic and the challenges its complexity poses for policymakers, followed by a review of the basic tenants of complexity science as they relate to the study of childhood obesity. I will then review the underpinnings of the ILF and situate it among some other key developments in the application of systems thinking to complex public health issues. My analysis of the ILF in action will be grounded by the aforementioned examples drawn from childhood obesity strategies from British Columbia, the United States of America and England. I will conclude my discussion with an analysis of the strengths and limitations of the ILF as a tool for assessing the capacity of the public health response to childhood obesity, and consider how it might be paired with other methodological approaches to achieve this end.

1: CHILDHOOD OBESITY

1.1 Definition and Epidemiology

Obesity is defined as abnormal or excessive fat accumulation that presents a risk to health (WHO, 2009). *Childhood* obesity occurs in those between the ages of 2 and 17-19 years of age, depending on a population's definition of the end of adolescence. Measures of overweight and obesity in adults are often based on the body mass index (BMI), which calculates obesity as weight in kilograms over height squared in meters. BMI has been shown to be significantly correlated with body fat at a population level (NIH, 1998), but is less useful in assessing individuals due to its lack of consideration for body type, gender and ethno-cultural differences (Shields, 2006). This is particularly true of children, whose BMI ideals change substantially according to age and development. Children under 5 years of age are generally evaluated according to their weight for their height or length, and children aged from 5 to approximately 19 are evaluated according to BMI with age-appropriate cut-off points (WHO, 2009). It is estimated that globally, 1.6 billion adults and at least 20 million children under the age of five were overweight or obese in 2005. As of 2007 an estimated 26% of Canadians aged 2 to 17 years were estimated to be overweight or obese (Merrifield, 2007), with the overall financial cost of obesity estimated to be $1.6 billion in direct heath care costs (or 2.4% of total health care spending) and another $2.7 billion in indirect costs such as lost productivity, disability insurance, reduced quality of life and mental health problems related to stigmatization and self-esteem (Birmingham et al., 1999).

Childhood obesity is an attractive target for policymakers due in part to the perceived vulnerabilities of children and their inability to make responsible behavioural decisions for themselves (Robinson & Sirard, 2005). From a practical perspective, policies targeting youth are also attractive because children and adolescents spend much of their time as “captive audiences” in a relatively small number of settings (such as school, daycare and home) that are amenable to intervention (Robinson & Sirard, 2005). There are also strong physiological arguments to be made for targeting obesity prevention in children and youth. Obese and overweight children are more likely to be obese or overweight adults, and may be at risk of higher rates of hypertension, diabetes, and abnormal glucose tolerance (Dehghan, Akhtar-Danesh, & Merchant, 2005). Childhood obesity and overweight is also associated with premature death in adulthood, and there is evidence to suggest that weight gained in childhood will impact future health outcomes regardless of whether or not that weight is lost post-adolescence (Dehghan et al., 2005). Obesity among young people has also been correlated with a number of negative social and performance outcomes. Falkner et al. (2001) found that obese girls were less likely to spend time with friends, more likely to report serious emotional problems and hopelessness, more likely to report a suicide attempt in the past year and more likely to be held back at school. Obese adolescent girls were also likely to have completed less schooling and have lower household incomes than those who were not obese. Finally, prevention at the earliest stage possible is viewed as crucial due to the low yield of obesity treatments, which have proven difficult and costly (Caballero, 2004).

1.2 Causation

The difficulty in reversing obesity and overweight, in both individuals and in populations, is heightened by the multifactoral nature of their causes. At the most basic biological level overweight and obesity results when calories consumed exceed those expended on a regular basis (WHO, 2009). As concern over obesity has risen, so too has insight into the multiple causes of the disease, many of which are rooted in our obesogenic environment. An obesogenic environment is one in which maintenance of energy balance is especially difficult (Caballero, 2004), largely as a result of the conveniences associated with Western development and urban living. These include, but are not limited to: increased availability of inexpensive high-energy density foods; food marketing; increased portion sizes in restaurants and fast food establishments and an increasing reliance on them as food sources; reduced energy demands of daily activities due to the use of cars, elevators, escalators, etc.; and increasingly sedentary leisure time built around electronic devices (Caballero, 2004). Obesity has been associated with a number of other socio-ecological factors, including socio-economic status (Cecil et al., 2005), ethnicity (Kimm et al., 1996) and level of parental education (Willms et al., 2003). On a broader scale, it can also be linked to agricultural land use policy and global trade policies influencing food production. The breadth of factors influencing childhood obesity is represented in the causal web of obesity developed by the International Obesity Task Force

(IOTF) [Appendix 1]. This causal web links energy intake and expenditure with a range of determinants in multiple settings, demonstrating a multiplicity of causes. When the problem is viewed at this scale, the difficulty of addressing the causes of obesity becomes apparent.

If we accept that the determinants of obesity are plentiful, emanating from a myriad of sectors and domains, then we must also accept that proposed solutions should, taken together, address this multiplicity. This requires moving beyond traditional biomedical perspectives that seek to address the energy imbalance equation through individualized health promotion and clinical interventions. Critics suggest the failings of these interventions are attributable to their inattention to the social context within which individual decision making occurs (i.e. the obesogenic environment), which include multiple settings and interactions with a variety of actors and social influences (Dehghan et al., 2005). The ecological approach has been put forth as a means of addressing individuals in their environments and the ways in which the two influence one another (Lang & Rayner, 2007). It posits that "features of the social and built environment *above* and *before* the individual (at the familial, community, organizational, and societal levels), constrain, limit, reward, and induce the behavior of individuals" (Glass & McAtee, 2006, p.1652). Policymaking from an ecological approach therefore focuses on shifting the environment in order to make it more amenable to healthy decision-making.

In spite of attempts to shift the lens from health promotion activities targeting individuals to more ecological approaches, Alvaro et al. (2010) suggest that health promotion programs and policies are still “stuck” in promoting individual lifestyle change rather than the broader determinants of individual body weight. Even with best intentions to adopt a more ecologically based approach, policymakers are faced with a number of challenges that inhibit them from implementing system-wide changes that could impact childhood obesity. These include the difficulty of breaking down traditional silos between government ministries, the unpredictable nature of government funding allocations and public pressures to both proceed on the issue mixed with demands to respect individual rights. Lang and Rayner (2007) suggest that obesity policy is weighed down by complexity and “shrouded by ideological fears such as interventions being interpreted as ‘nanny-ish’ or restricting ‘personal’ choices in food and lifestyle” (p.166) and describe the many demands put on policymakers as resulting in *policy cacophony* – a preponderance of “noise drowning out symphony of effort”, clearly unhelpful to policymakers seeking “coherent directions on which they feel they can deliver” (p.166). Compounding this cacophony is the short time frame in which the political timetable demands results for a problem that was decades in the making.

This reliance on traditional means of addressing obesity could be reflective of the fact that biomedical and ecological models do not convey the *complexity* of childhood obesity, but rather present it as being relatively simple (in the case of a linear model of biological causality) or complicated (in the case of an ecological nested model of causation). This focus on individuals could also speak to a broader malaise in policy development on complex issues such as obesity, which require intersectoral and broad-reaching social changes. Lang and Rayner, for example, (2007) suggest that “a cross-society approach appears so big in conception that failure is assumed” (p.167). Bar-Yam (2004) similarly recognizes a trend of common responses to complex problems, some of which include retreat, belief that the problem is beyond hope, assigning blame, and putting forth simple solutions. New ways of thinking about – and responding to – complex problems may assist us in overcoming these reactions.

2: COMPLEXITY AND CHILDHOOD OBESITY POLICY

2.1 Complexity Science and Complex Adaptive Systems

Complexity science is a relatively new school of thought concerning how the relationships between the parts of a *system* give rise to the collective behaviors of a system, and how the system interacts and forms relationships with its environment (Bar-Yam, 2004). Begun, Zimmerman & Dooley (2003) suggest that complexity science does not consist of a single theory, but rather encompasses a collective of theories and constructs that have “conceptual integrity” among them. It is a highly multi- and inter-disciplinary field and has been employed by biologists, chemists, anthropologists, sociologists, physicists and others. What all complex systems theorists have in common is their interest in answering “fundamental questions about living, changeable systems” (Begun et al., 2003, p.258). Meadows (2008) recommends that in considering systems, we focus on three central characteristics they have in common: the parts of the system, the interconnections between those parts and the function or the purpose of the overall system.

Childhood obesity has itself been identified as a *complex adaptive system* (CAS) (Hammond, 2008) or as a property emerging from a CAS (Finegood, 2010). A complex adaptive system is a “system composed of many diverse pieces, interacting with each other in subtle or nonlinear ways that strongly influence the overall behavior of the system” (Hammond, 2008, p.5). There is a wide range of literature on what characterizes CASs and distinguishes them from simpler systems (Bar-Yam, 2004; Begun et al., 2003; Hammond, 2008;). For the purposes of my discussion I will review only the most pertinent characteristics of CASs using examples from the Foresight Obesity System Map [Appendix 2]. Meadows argues that pictures are more effective than words in conveying information about systems, in part because systems "happen all at once, in all directions." The causal loop model developed by Foresight Programme of the UK Government Office for Science provides a nice example of this. Driven by the overarching aim of producing a long term vision for a sustainable response to obesity in the UK, the developers hoped the map would help the viewer understand the complex systemic structures of obesity – to give them "insight into the underlying structure of a messy, complex situation" (Vandenbroeck, Goossens, & Clemens, 2007). The Foresight map therefore makes visible what many practitioners already intuitively know about complex public health problems like childhood obesity.

Many characteristics of CASs like childhood obesity are evidenced in the Foresight map. CASs have, for example, a high degree of *heterogeneity* (or *diversity*) among the system's actors and the goals and rules by which the various actors and sub-systems operate (Hammond, 2008). The Foresight map contains 108 variables, all interconnected to some degree, clustered in seven sub-systems centering around the map's "engine" of energy balance: social psychology, individual psychology, individual physical activity, the physical activity environment, physiology, food consumption and food production. The variables within these systems include such diverse factors as “level of satiety”, “food literacy”, “resting metabolic rate”, “smoking cessation” and “safety of transport.” Each of these sub-systems further involves a diverse range of agents, many of whom act in the decentralized, local interactions that drive CASs from the bottom up (Hammond, 2008). The agents at play in the Foresight map include patients, clinicians, engineers and city planners responsible for the built environment, employers, bartenders, parents, siblings, and a multitude of others. And of course each of these agents can occupy multiple roles, sometimes simultaneously. Hammond (2008) notes that each of these actors has different goals, motivations, modes of decision-making, and relationships to other actors and levels above and below them in the hierarchy of levels. They will all be affected differently by policy shifts or other interventions, and will in turn affect others differently depending on their sphere of potential influence as an agent of change (Hammond, 2008). Public health can be viewed as one sub-system within the Foresight map, and it itself is a complex system with a diverse range of actors, including governmental bodies at the international, regional and local levels, practitioners, advocacy and special interest groups, coalitions and partnerships, academics and academic institutions, and the public at large (Trochim, Cabrera, Milstein, Gallagher, & Leischow, 2006).

Contributing to the complexity of a CAS is the high level of *interdependence* between the actors in the system and between different levels of the system, and the ways in which that interdependence enables them to exert influence on one another, in a variety of directions. This interdependence is signified in the Foresight map by arrows between the system variables, which represent their positive and negative influences on each other. Some of these arrows represent a key characteristic of CASs – the presence of *feedback loops*. Feedback loops are closed chains of connections from one element to another and back to the original (Meadows, 2008). Feedback loops allow a system to regulate itself by providing outcomes of different actions back to the source of the actions, thereby informing future activity. Feedback loops can drive change (positive feedback) or lock in a system behaviour and stifle change (negative feedback) (Alvaro et al., 2010). An example of a feedback loop existing at the level of the individual is that of energy balance: a drop in an individual's physical level of energy sends feedback to their body triggering them to acquire and/or preserve energy in response. A positive feedback loop associated with other variables (e.g. stress) can drive this activity in the absence of real physical need (Vandenbroeck et al., 2007). The addition of a balancing loop could counter this push toward unsustainable activity, an example of which might be working with an individual to identify how stress triggers them to eat when they are not hungry.

One of the strengths of complexity science is that it turns our attention toward the relationships between variables in a system, encouraging us to think about ways in which changes in one area might affect outcomes in another. Systems thinkers such as Meadows and Bar-Yam note that we have a tendency to examine the parts of a system in depth, but in doing so we may lose sight of the forest for the trees, so to speak. Meadows (2008) suggests we instead "stop dissecting out elements and to start looking for the *interconnections*, the relationships that hold the elements together" (p. 13, emph. original). This argument was mirrored in a review process of the pilot Initiative on the Study of Implementation of Systems (ISIS), a project funded by the National Cancer Institute. The key findings from the review were that understanding and implementing complex systems is at its core about "the relationships among people, collections of information and even concepts", and that these relationships "work or do not work as a function of information and how it is communicated" (Leischow et al., 2008).

This interconnectedness in a system can result in *emergent*, or unexpected, phenomena. Emergent phenomena result from patterns of collective behaviour that form in the system; they cannot necessarily be foreseen from understanding the individual elements of a system (Hammond, 2008). In other words, the sum of a system may be greater than its parts in ways that are difficult to grapple with. An example of this from the natural world is that of the hurricane (Burbeck, 2010): taken independently, changes in temperature, air pressure and other meteorological activity might not seem like much on their own. Combined together in a weather system, however, they can result in emergent and unpredictable phenomena. Emergence and the nonlinearity of CASs lend to their unpredictability, further challenging policymakers. Hammond (2008) notes that impacts caused by small changes in one part of the system can seem out of proportion with the action taken, and have the potential to tip the system from a relatively stable state into an unstable one. Finegood (2010) notes that obesity itself can be viewed as an emergent property of a complex system – a system in which a variety of confluences have resulted in runaway system growth. Considered on their own, for example, changes in variables such as TV viewing or deskilling in food preparation might not have been predicted to result in a population level obesity epidemic. Considered in the context of a system however, it becomes apparent that a host of such variables that have resulted from changes in daily living, combined with our innate biological tendency to preserve energy, have set the stage for just such a phenomenon. The interdependence that exists in CASs ensures that complex problems are difficult to solve using traditional approaches because cause and effect are not always obviously related. As Bar-Yam notes, pushing on part of a system *here* can affect the system *over there* in unanticipated ways. The late biologist Lewis Thomas observed that, under these circumstances, intervening can be a way of causing trouble.

While overwhelming in their entirety, the strength of models such as the Foresight obesity map lies in their presentation of complex issues in a grand scale, while still capturing their finer elements. Applying the metaphor of “not seeing the forest for the trees” to the field of health promotion, one can argue that the myriad of health promotion programs targeting childhood obesity, and emanating from various silos, are trees, and that we have few means of ensuring we can envision the forest. Models such as the Foresight map help us to do so. Hammond (2008) also sees possibility in the nonlinearity of complex systems, in that relatively small, focused policies can create large scale change, and that complex systems do in fact have that significant structure and organization which can be managed or directed through careful intervention. Policymakers have also taken strength from the fact that we seem to be at a societal *tipping point* (or critical point) in regard to the obesity problem. Alvaro et al. (2010) identify this transitional phase, at which point a "seemingly ordered system is on the verge of (or coexists with) disorder," as a pivotal opportunity for achieving change in the system. They further suggest the Canadian government 'system' may have reached critical point with respect to obesity epidemic, in that the system is in a state of readiness for change. This could be due in part to the estimated costs of the problem, which threatens a system that Canadians hold dear – the health care system.

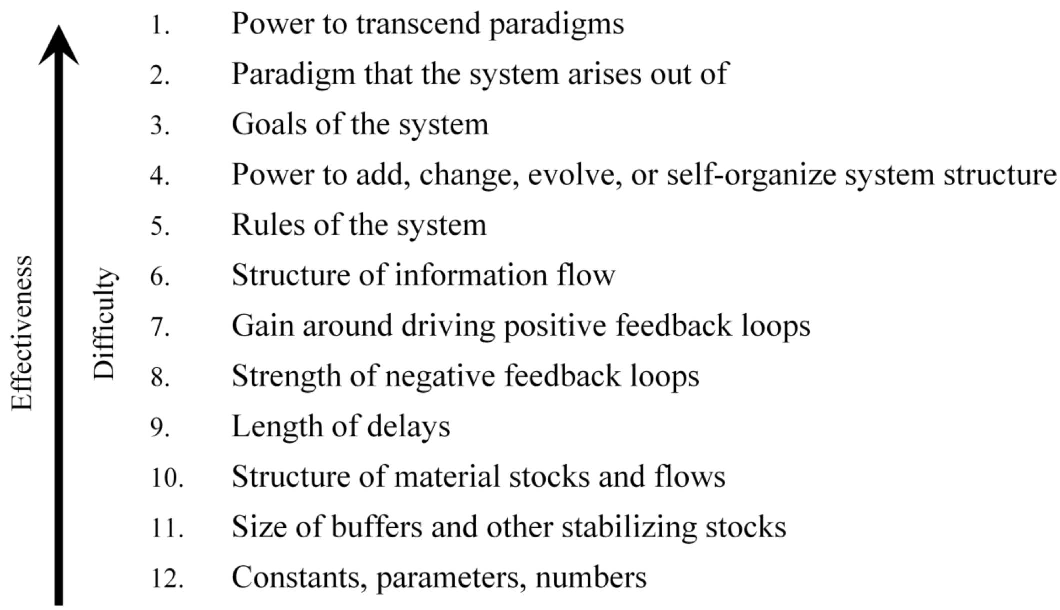
The work of ISIS and the Foresight group is intended to help policymakers integrate systems thinking into their work. The exploration of how best to go about this, and what is best practice in doing so, is just beginning. Finegood et al. (2010) suggest that complex systems methods should be applied to data collection, research, knowledge synthesis and knowledge exchange in order to accelerate the pace of progress in adopting system wide patterns of intervention. In the following section I will overview the ILF and demonstrate how it operationalizes many of the concepts that I have just discussed using examples drawn from childhood obesity prevention strategies.

3: APPLICATION OF THE ILF TO CHILDHOOD OBESITY RECOMMENDATIONS

3.1 Methodology

The ILF is built upon the work of Donella Meadows, an accomplished systems scientist and environmentalist whose work addresses themes of sustainability. Meadows' most famous work was *The Limits to Growth*, a book that arose from her experience working on the Club of Rome world modelling project in the early 1970s. It was there that she became frustrated with the group's identification of growth as a key leverage point for addressing major global problems. Recognizing the unpredictability inherent in complex systems, Meadows worried about the potential unintended consequences that pushing on this particular point of leverage could result in. Inspired to engage with leverage in a more thorough manner, Meadows identified a list of 12 *leverage points* common to complex systems – "places in the system where a small change could lead to a large shift in behavior" (p.145). Meadows listed these leverage points in order of their potential for impact and their difficulty of implementation, with changes at the top generally being the hardest to implement but having the greatest impact, and those at the bottom generally being the easiest to implement but having the smallest relative impact on changing the path of the system (there are exceptions to this rule).

Figure 1: Meadows' Places to Intervene in a Complex System



Meadows' places to intervene were based on her considerable expertise in systems thinking, and on her intuition of how complex systems operate. She also considered them to be a work in progress; they would likely have undergone further development had she had more time to work on them before she died. As such they present not so much a firmly established framework as a jumping off point from which she expected others to engage with systems thinking in attempting to solve complex problems. Malhi (2009) and her peers felt that Meadows' places to intervene provided guidance for engendering change in complex systems and sought to operationalize the 12 leverage points into a practical framework tool. They attempted to sort action statements drawn from the McGill 2007 Health Challenge Think Tank survey data according to her 12 points, but found the process too cumbersome, and the levels too specific to be useful in doing so. Malhi notes that, as the stakeholder suggestions were retrieved through survey tools, most of the respondents “were not thinking in terms of systems or leverage points so it was very difficult, and essentially impractical, to force their suggestions into a very specific framework which was designed to elucidate leverage points” (Malhi, 2009).

A team therefore adapted the 12 points into the 5 level ILF in order to create a generalizable framework. Three sets of data were used throughout the process: the McGill data; the Public Health Advocacy Institute’s 2008 Policy Recommendations from their 5th Conference on Public Health, Law and Obesity; and the Coalitions Linking Action and Science for Prevention’s action statements collected from an expert group survey. The coding and sorting of the data were done using the computer software Nvivo 8 and Excel 2007. Sorting was standardized into the framework through an iterative process: members of the research team first sorted the statements independently, then came together to discuss differences in results, create rules for sorting and re-sort the statements to test for inter-coder reliability. The 5 levels retain all of the elements of Meadows original leverage points and the ILF has been demonstrated to have a high inter-rater reliability. The ILF has since been used to examine the background material provided to participants in a Food Systems and Public Health Conference. Data was sorted according to the conference themes of healthy, green, fair and affordable to assess compatibility of stakeholder goals at various points of intervention in the complex food system (Malhi et al., 2009).

Figure 2: The Intervention Level Framework

INTERVENTION LEVEL	DEFINITION
Paradigm	System's deepest held beliefs. System goals, rules and structure arise out of the paradigm.
Goals	The aim/priorities of the system.
System Structure	All of the elements that make up the system as a whole including the subsystems, actors and interconnections between these elements.
Feedbacks and Delays	Loops that cause an action by one element of the system to in turn affect the flows into or out of that same element.
Structural Elements	Subsystems, actors and the physical elements of the system.

In the following section I will review the levels of the ILF in more detail, using examples from childhood obesity strategies to ground the theory behind their development and demonstrate their potential application in a larger analysis of recommendations. The recommendations are pulled from the following strategies: 1) Healthy Weight, Healthy Lives: A Cross Government Strategy for England (2008); 2) Solving the Problem of Childhood Obesity within a Generation: White House Task Force on Childhood Obesity Report to the President (2010); 3) A Strategy for Combatting Childhood Obesity and Physical Activity in British Columbia (2006). Each of these strategies was of interest for different reasons: the BC report because it is local; the England report because it is informed by the Foresight analysis; and the US report because it was most recent and part of a high-profile movement being led by First Lady Michelle Obama. However, they make up only a small sample of the hundreds of strategies and reports recommending actions on childhood obesity and related health promotion activities, and as such are not intended to constitute a representative sample of current childhood obesity strategies. Myself and another researcher familiar with the ILF and the theory behind it coded each of the recommendations discussed. In total 132 recommendations were coded; inter-coder agreement was high (94%). While I will discuss the levels of the system from the "lowest level" of structural elements and work my way up, it should be noted that my use of the terms "higher" and "lower" in this context is not intended to convey an evaluative judgment of the levels or their relative importance. This would be counterintuitive to systems thinking, which informs us that the activities at each point of leverage are not only essential in their own right, but interdependent with one another.

3.2 Results

Structural Elements

The majority of recommendations coded (n=132, 83%) were identified as being at the level of structural elements, which consist of the subsystems, actors and the physical elements of the system. Structural elements include constants and parameters, such as taxes and subsidies. Meadows (2008) uses the example of a bath tub to elucidate how stocks and flows work within a system. The tub is full of water – a stock – that is influenced by the flow created by the faucet delivering water into the tub and the drain taking water away. Lessening the rate of flow into or out of the stock will create change, but the rate of change will be buffered by the relative stability of the water in the tub. She notes that subsidies and taxes are popular examples of numbers that are variable and therefore popular intervention points. This is reflected in recommendations such as: “Investigate the feasibility of new junk food taxes on non-nutritive foods and beverages” (BC) or “Invest £75 million in an evidence-based marketing programme which will inform, support and empower parents in making changes to their children’s diet and levels of physical activity” (ENG). Recommendations such as “Schools should consider upgrading their cafeteria equipment to support the provision of healthier foods, for example, by swapping out deep fryers for salad bars” (USA) exemplify the approach of addressing the physical elements contained within one sub-system, in this case the public school system.

Feedback and Delays

The importance of feedback loops has already been noted, in that they are key in feeding information about the results of intervention in the system back to the source of that intervention and activity, thereby informing future activity. Only 9 of the recommendations were coded at this level. Examples of feedback from the field of public health include program and intervention evaluation, reflected in the recommendations such as “the health care sector, ActNow BC, and other key stakeholders engage in a coordinated effort to further develop, monitor and assess the effectiveness of obesity prevention programs for early childhood” (BC) and “Analyze the effect of state and local sales taxes on less healthy, energy-dense foods” (US). The majority of recommendations coded at this level were specifically geared toward clinical feedback at the level of the individual in order to improve their care, such as “launch a number of pilots of well-being assessments throughout the National Health Service (NHS) in spring 2008, where individual staff are offered personalised health advice and lifestyle management programmes linked to personal assessments of their health status" (ENG).

System Structure

The next leverage point, system structure, encapsulates all of the elements that make up the system as a whole including the subsystems, actors and interconnections between these elements. It includes the rules that govern the system and the structure of information flows. These are all potentially powerful leverage points, as is echoed in Bar-Yam's (2004) claim that the solution to a problem has to be related to the type or structure of the particular problem, a structure that is established in the relationships among the system's actors. Examples of the 5 recommendations coded at this level include: "reporting to the minister responsible for ActNow BC, the government create a Nutrition and Exercise Council, composed of senior representatives of different levels of government, healthy living advocates and stakeholders, and food and beverage industry officials to examine and report out annually on progress made" (BC). The level of structural elements includes changes aimed at establishing linkages across sectors in a system, as in the recommendation that the "USDA should work to connect school meals programs to local growers, and use farm-to-school programs, where possible, to incorporate more fresh, appealing food in school meals" (US). Actions such as these can institute and leverage demand (from the school system, for example) with agricultural policy. These actions are in turn supported by activities taking place at the lower levels of the system, such as the previously mentioned health promotion efforts to have individuals increase their vegetable consumption.

Goals

The goals of a system are significant drivers of the activities taking place in its lower leverage points. Meadows (2008) argues that, once a goal is established, “everything further down the list, physical stocks and flows, feedback loops, information flows, even self-organizing behavior, will be twisted to conform to that goal” (p.161). I have previously noted how different actors and sub-systems within a larger system operate by their own goals – when these goals come into conflict with one another the result can be *policy resistance*, resistance to change arising when “goals of subsystems are different from and inconsistent with one another” (Meadows, 2008, p.113). Meadows offers the example of the “war on drugs,” in which the competing aims of the government, drug suppliers, drug users and the general public ensure an ongoing problem in spite of considerable investment of resources. A society’s decision to achieve the goal of eradicating drug use as opposed to achieving “safe” drug use (or reduced harm) will shape the activities of many of the system’s actors.

In this data set, goals were not explicitly mentioned in the recommendations or actions sections. They were found in the text of the documents. The UK strategy, for example is guided by the overarching target of being “the first major nation to reverse the rising tide of obesity in overweight in the population by ensuring that everyone is able to achieve and maintain a healthy body weight”; it initially focuses on children, aiming to reduce the proportion of overweight and obese children back to 2000 levels by 2020. While such markers are useful in their own right, Finegood (2010) has argued that goals that set targets for emergent properties such as the level of obesity or physical activity are not very helpful in guiding system change, suggesting instead that goals should set targets for system function and speak to changes at the level of system structure, feedback loops and delays, or structural elements. Examples of such *functional* goals include increasing neighbourhood walkability and increasing access to healthy, affordable food. A goal pulled from the BC strategy for example, recommends that "the province adopt 'active living in walkable communities' as a goal for all British Columbians". This kind of functional goal lends itself more to shaping a system at a variety of levels, and necessitates the engagement of a variety of actors across subsystems. Similarly, goals aimed at increasing the accessibility of healthy food options will necessarily drive activities at lower intervention points.

Paradigm

The top level of *paradigm* represents the deepest held beliefs that govern the actors in the system; it can also be thought of as the ideology that drives the system, or its values. These values may be instituted from above, from those in control of the system, but are also shaped by the actions and beliefs of the general population. Paradigm shifts do not occur frequently but are extremely effective in changing the system when they do occur (Meadows, 2008). One paradigm shift that has occurred relatively recently in North America is that of attitudes about tobacco use. Once a more prevalent and more easily accessible activity, tobacco use is now looked upon much less favourably (Bayer, 2008). This shift in public attitude toward smoking did not occur in a vacuum; rather, it was supported by numerous activities taking place at the lower points of leverage, including a range of social marketing, taxation and policy interventions, among others. It is difficult, if not impossible, to implement a paradigm shift through legislation or policymaking. Unsurprisingly, there were no recommendations for paradigm-centered activity in the data set analyzed. However, analysis of recommendations at lower leverage points presents a means by which we can better understand how strategies might contribute to a paradigm shift, or the beginning of one. Consider for example, the recommendation that "the government…develop annual awards for developers and urban and rural communities to recognize best practices in residential development, in terms of densification, recreation, and zoning practices that encourage physical activity" (BC). While the immediate action is to reward "good" residential development, as it is defined from an obesity-reduction perspective, this recommendation speaks to the broader issue of how communities might integrate physical movement into everyday living. This could include shifting cultural norms about physical activity in general from an emphasis on exercising in purposeful bursts (i.e. at the gym, with its associated barriers) to one where less structured activity dispersed throughout our everyday lives is sought out and made accessible. Such a shift is supported by evidence that unstructured activity, or non-exercise activity thermogenesis (Levine, Eberhardt & Jensen, 1999) plays a significant role in health and obesity (Levine et al., 2005). In strategizing around complex issues, policymakers might benefit from knowing what paradigm shift they would like to have occur and then organizing activities at the lower levels in order to support that shift. The goals of a system are especially indicative of its operating paradigm, and they should be considered in tandem.

3.3 Discussion

Applying the ILF to a sub-set of data proved to be a very informative exercise in preparing for a larger analysis of recommendations to prevent and address childhood obesity, in terms of both content and process. The distribution of recommendations according to leverage points was similar to that of previous applications of the ILF. Activities at the level of *structural elements*, for example, formed the bulk of the recommendations. Activities undertaken at this level can contribute greatly to change in local subsystems and provide essential services to specific populations, but are less likely to impact on the *behaviour of the system* overall than activities undertaken at higher levels (Meadows, 2008). This is due in part to the fact that activities at this level do little to affect the information flows and relationships between different areas of the obesity system. An effective health promotion activity encouraging an individual to increase their vegetable consumption may improve the health of that individual, but will not change the availability of fresh produce to that person, which might instead be better leveraged with activities occurring at the levels of structural elements or goals.

As noted previously, activities as the levels of *feedback* and *structural elements* have more influence on the system as a whole. The fact that relatively few recommendations were coded as feedback was also similar to previous application of the ILF (Malhi, 2009). A dearth of data geared toward the feedback level could present missed opportunities for ensuring systems of self-correction exist in a system (Malhi, 2009), an analysis that will be familiar to public health practitioners who have identified the need for more program and intervention evaluation in order to inform progress. The ILF is useful here for parsing out where feedback is being built into a strategy to address a complex issue. For example, the next stage of this project could involve a deeper analysis in which those feedbacks are mapped out according to the Foresight map to gain a picture of where gaps exist, and where opportunities to leverage feedback into the system might exist. Similar analyses could be conducted at the level of *structural elements*, where information flow in a broader system is also developed and/or hindered. For example, an ILF analysis could be applied to map out the ways in which these activities occurring at various systemic levels might support each other. Increasing linkages among the structural elements is also part of the broader trust building exercises necessary to progress on complex issues that are far-reaching in their scope. The extent to which these activities will be feasible and/or successful in changing the nature of the system's direction will be dictated in large part by the goals by which various actors are operating.

The ILF enables one to isolate the data related to a particular point of leverage and understand them in relation to one another. Understanding how stakeholder influence comes into play in shaping the goals and paradigm (and therefore lower level activities) of the system, however, requires a deeper critical analysis (depending, of course, on the specific objectives of the project at hand). Take, for example, the goals driving current obesity strategizing to achieve particular population levels of body weight. Critics of the anti-obesity movement have questioned the potential these goals have to stigmatize already vulnerable children, and to possibly promote eating disorders (Robison, 2007). They have countered the anti-obesity mantra with models that promote “health at any size” and approaches that instil all obesity planning with information from the eating disorder literature. This dilemma is noted in the English strategy, which states that the system approach modelled in the Foresight map suggests a fundamental shift in approach may be necessary, one that moves policymakers away “from a focus solely on obesity to one of promoting healthy weight and so healthy lives” and offers support to “individuals who are underweight and so also at a higher risk of health problems, to maintain a healthy weight.” In the short term, however, they feel compelled to focus initially on the obese and overweight. The questions inherent in these debates can be furthered by the inclusion of a critical systems or an equity lens in the analysis of data extracted by the ILF, one that more closely examines the roles of power dynamics in systems.

Methodologically speaking, this process brought to light some logistical issues that will inform future research. For example, while there were very few items coded as goals in our data set it was found upon review that this did not reflect an absence of goals being present in the strategies (which would be antithetical to the nature of strategizing and planning in general) but rather that these goals were not listed “actions” or “recommendations.” This serves as a reminder that in future applications of the ILF the nature of the documents at hand must be reviewed and understood thoroughly before data is extracted. Based on my review of the three documents at hand, this will prove to be a challenge given the diversity of formats in which childhood obesity strategies are produced. The US strategy, for example, clearly lays out 70 specific recommendations to be acted upon and designates that many will have to be undertaken by federal agencies; the English strategy, on the other hand, contains recommendations for actions throughout the text of the strategy, some of which are in bold font, some of which are bulleted, and some not clear as to whether they are explicit recommendations or rather ideas for possible follow-up.

In order to be effectively undertaken, the ILF demands a high degree of coding competency on the part of the researchers involved. I was able to familiarize myself quickly with this process due in part to extensive background work in qualitative content analysis and data extraction from texts. Less experienced researchers, however, may require more training and familiarization with the principles of systems thinking. The depth to which instruction will be required for future coding warrants further examination. While I am confident that basic data extraction, coding and sorting are teachable to less experienced researchers, the in-depth analysis of data should be undertaken by those with a familiarity of the system at hand (i.e. the obesity system). In analyzing the data on goals, for example, an understanding of the players involved in the system – their ideals, objectives and scale of power in the system – will be extremely helpful. These concerns are in keeping, however, with the general principles of rigor in qualitative analysis, and are not specific to the ILF.

SUMMARY AND CONCLUSION

The preceding overview of the ILF and its levels was intended to demonstrate its usefulness in getting us to think about complex issues through a complex systems lens. Most of its components will be familiar to anyone who has worked in strategic planning or has an understanding of elements such as system hierarchies, goals and demands for multi-sectoral action on pressing public health concerns. As a heuristic, however, the ILF turns our examination away from a dissection of the parts in detail, and moves us toward examining how they interact with one another. With a larger sample and a refined data extraction template the ILF could also be used to provide an immediate representation of the ways in which recommendations are distributed according to their potential leverage within the overall system. One could quickly determine if the data under analysis is focused mainly at the lower end of the leverage spectrum (i.e. structural elements), and how much attention has been paid to issues of information flow throughout the system (feedbacks and delays) and forging relationships between sub-systems (structural elements). This overview is useful in helping us become familiar with a system, for in attempting to shift the system we had best understand it in its current incarnation (Meadows, 2008).

The ILF can also be used to organize large quantities of data for more in-depth qualitative examination. When we extract recommendations for our larger analysis, our data extraction template will code for the content of the recommendations themselves, so that we are able to run comparisons between actions recommended in the various clusters of the obesity system as defined by the Foresight map. For example, goal statements can be separated out for further examination and to determine where goals from various actors and subsystems are in alignment or discord with one another – such as those of the food industry and those of the health care system. The ILF can thus be used to help stakeholders understand how to effect meaningful change in a complex system, by identifying gaps in the attention being paid to certain parts of the system, and to determine whether stakeholder's beliefs about how to intervene in the obesity system are consistent with their actions.

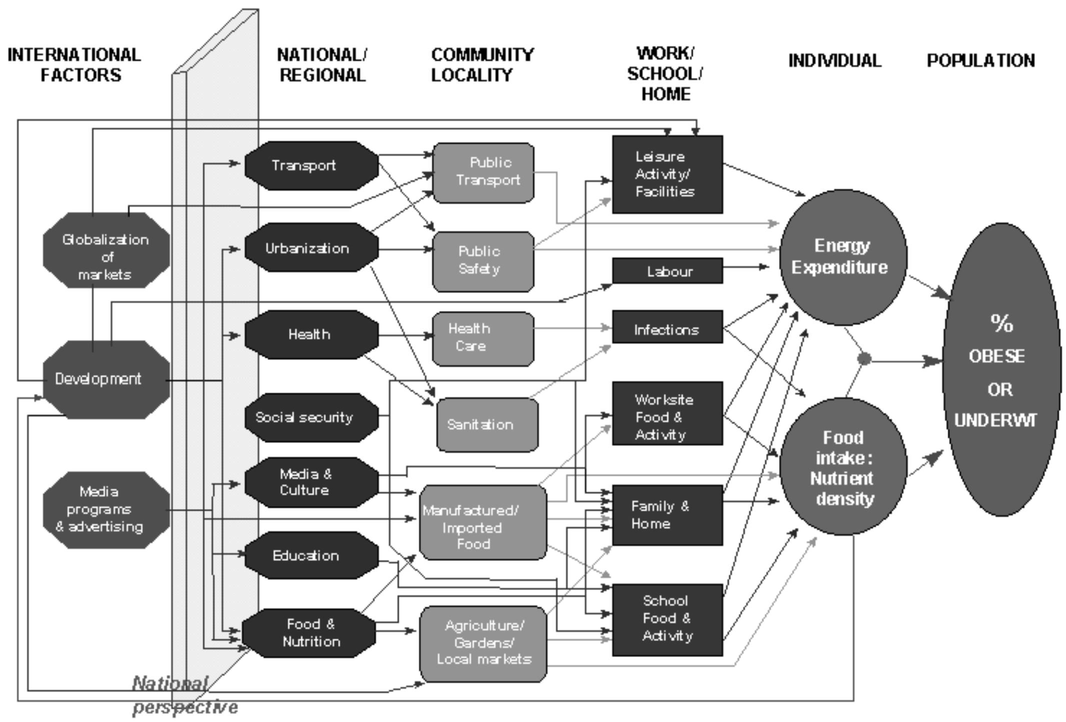
One of the factors that makes complexity science appealing is its ability to account for the temporal element of problems. Alvaro et al. (2010) suggest that understanding how systems remain static or evolve into new systems over time, and how these changes are a function of a system's various components, is a hallmark of complexity science. An analysis contrasting the leverage point distribution of strategies with the actual evolution of the systems in which they are based over a period of time would therefore be useful. Follow-up on strategy implementation would elucidate this discussion, and provide valuable insight into how the goals of the system in action align or diverge from the goals set out in priority-setting documents.

As previously noted, the ILF could be made more relevant to public health practitioners interested in health equity through the addition of a critical theory lens through which we might examine power dynamics related to policy development and implementation. Critical theory “draws our attention to power struggles within the policy implementation process, and to the role of dominant interest in ideologies in maintaining particular policies, as well as the possibilities for change through internal contradictions in the ‘system’” (Alvaro et al., 2010, p.2). A critical analysis of the policymaking system as it relates to childhood obesity would elucidate some of the ways in which system goals are in conflict with one another, and continue the work of finding ways of bringing various sub-system goals into alignment. A necessary step in this movement is a re-evaluation of the central goals driving childhood obesity prevention, and a discussion about what paradigm shifts policymakers would like to support with lower leverage activities. As noted, critics have pointed to the dangers of setting BMI targets as goals for obesity reduction, and of the problematic nature of making *childhood obesity* prevention a goal in and of itself, considering what that might to do stigmatize body weight and eating behaviours among young people. Obesity speaks not only to our disordered food and physical activity systems, but to a host of cultural and social issues. Lang and Rayner (2007) succinctly note that “obesity has to be seen as not just a technical, food, physical activity or healthcare problem but a challenge for what sort of society is being built” (p.167). A complex systems analysis will further our effort to holistically examine what obesity tells us about the society we wish to build in the future.

APPENDICES

Appendix 1

The IOTF Causal Web of Obesity. Retrieved November 1 2010 from http://www.iotf.org/groups/phapo/causal.htm

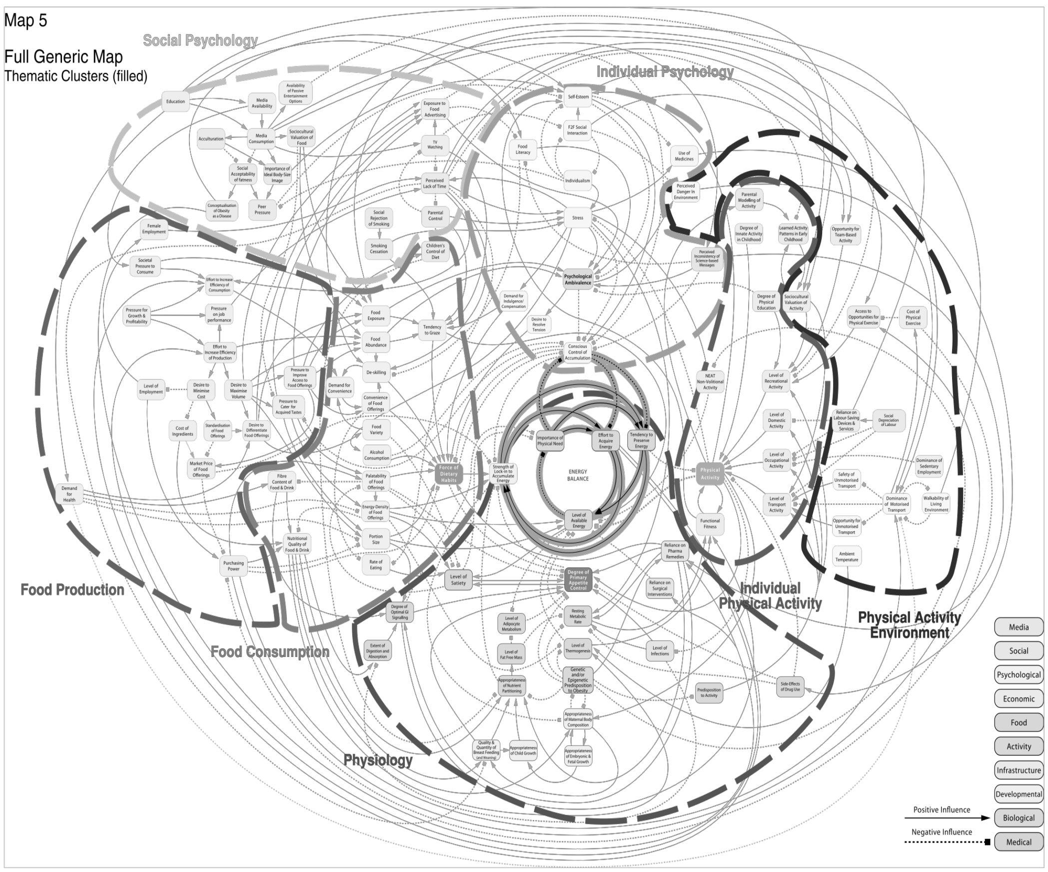


Modified from Ritenbaugh C, Kumanyika S, Morabia A, Jefferey R, Antipatis V. IOTF website 1999:

Appendix 2

The Foresight Obesity System Map
Retrieved September 1 2010 from http://www.bis.gov.uk/foresight/our-work/projects/current-projects/tackling-obesities

Figure 5.2: The full obesity system map with thematic clusters (see main text 5.1.2 for discussion)[17,18] Variables are represented by boxes, positive causal relationships are represented by solid arrows and negative relationships by dotted lines. The central engine is highlighted in orange at the centre of the map.



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