Applications of Complex Systems Science in Obesity and Noncommunicable Chronic Disease Research[1–4]

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ABSTRACT

Interest in the application of systems science (SS) to obesity and noncommunicable chronic disease (NCD) research has been growing rapidly over the past decade as the epidemic of obesity and NCDs continues to grow globally. This article summarizes the key messages of the presentations made in the special symposium "Applications of Complex Systems Science in Obesity and Noncommunicable Chronic Disease Research," held during the ASN Scientific Sessions and Annual Meeting at Experimental Biology 2014. Invited leaders from various fields presented cutting-edge aspects of the applications of SS in public health research, with a focus on obesity and NCDs. In addition, the symposium was capped with a discussion on funding opportunities from the NIH. The speakers described the nature of SS, how it could be applied to biomedical and public health research, lessons from SS to inform obesity and NCD interventions, and the promises, challenges, and recommendations going forward. *Adv. Nutr. 5: 574–577, 2014.*

Introduction

Because complexity continues to challenge public health's ability to stem the epidemic of obesity and noncommunicable chronic diseases (NCDs)[10], interest has been growing in recent years in the potential of systems science (SS) to help cope with such complexity (1). The symposium "Applications of Complex Systems Science in Obesity and Noncommunicable Chronic Disease Research" included 5 invited presentations from leaders in various fields, who discussed cutting-edge aspects of the application of SS in public health research, with a particular focus on obesity and NCDs, as well as on funding opportunities from the NIH.

The symposium had 3 key learning objectives: *1*) to understand recent developments in the applications of SS to obesity and NCD-related research and interventions, *2*) to understand the key concepts and frameworks of SS, and *3*) to be informed about NIH research and training opportunities in the convergence of SS and public health.

Opportunities and Promises—SS and NCD Research (Youfa Wang)

SS and the promise. "Systems science" is a broad term referring to a family of analytic approaches that aim to elucidate the behavior of complex systems and to inform efforts to address ≥1 system problems. SS provides a good conceptual framework for interdisciplinary and transdisciplinary approaches (2). There have been an increasing number of articles on health-related issues using SS models since the 1960s. Wang's team searched published articles through 2013 and retrieved 2984 articles. More than half of the studies used network analysis methods, approximately

[1] This article is a summary of the symposium "Applications of Complex Systems Science in Obesity and Noncommunicable Chronic Disease Research" held 30 April 2014 at the ASN Scientific Sessions and Annual Meeting at Experimental Biology 2014 in San Diego, CA. The symposium was sponsored by the American Society for Nutrition (ASN).

[2] The organizer has indicated that related reviews of this symposium will be submitted for publication in an upcoming issue of Advances of Nutrition.

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[10] Abbreviations used: EPODE, Ensemble Prévenons L'Obésité des Enfants; FOA, funding opportunity announcement; NCD, noncommunicable chronic disease; OBSSR, Office of Behavioral and Social Sciences Research; SDM, system dynamics model; SS, systems science; SSB, sugar-sweetened beverages.

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one-sixth used system dynamics models (SDMs), and less than one-sixth used discrete event simulation or agent-based models.

Selected examples of using SS in public health problems. Approximately 15 y ago, the NIH–National Cancer Institute Tobacco Control Research Branch developed a transdisciplinary initiative to explore the application of systems approaches and methods to research, practice, and policy in tobacco prevention and control. The project set a precedent for NIH-funded SS research regarding other health outcomes such as obesity (3). Other examples include the NIH-funded MIDAS (Models of Infectious Disease Agent Study) project and a study that used SDMs to simulate the outcomes of different diabetes interventions (4).

Three recent childhood obesity–related projects that used SS methods. The UK Foresight Project "Tackling Obesities—Future Choices" is a good example of using SS in studying obesity. Its key findings and conclusions suggest that tackling obesity requires far greater change than anything tried so far, and at multiple levels: personal, family, community, and national. It requires partnership among government, science, business, and civil society.

The NIH funded a Systems-oriented Pediatric Obesity Research and Training (SPORT) Center of Excellence in 2011 based in The Johns Hopkins University with participation from other institutions via a U54 Center contractual agreement award sponsored by the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) and Office of Behavioral and Social Sciences Research (OBSSR) with Youfa Wang as the principal investigator. This initiative aimed to foster systems-oriented, innovative, interdisciplinary research to fight the growing global epidemic of childhood obesity and NCDs.

Funded by the NIH, Wang's research team is testing potential intervention options using SS models for fighting the childhood obesity epidemic in the United States and other countries. As an example, using SDMs, his team found that imposing taxes on sugar-sweetened beverages (SSBs) might not necessarily result in reduced SSB consumption in the long run when demand system dynamics and supply-demand interactions were considered.

Challenges of using SS in obesity- and NCD-related research. Several challenges confront the integration of SS into public health research. Data limitations often make it challenging to fit and calibrate SS models, and reconciling SS with the heavily data-driven tradition of epidemiology sometimes leads to skepticism. These challenges make it harder at times to publish SS-based articles. Research funding also remains limited for SS work in public health, particularly regarding NCDs.

In summary, SS offers many good promises for studying and addressing the complexity of public health problems. However, there are also major challenges and uncertainties regarding future applications and support for using SS in obesity and NCD research.

Complex SS and Selected Methods (Yaneer Bar-Yam)

Dr. Bar-Yam discussed complex SS, focusing on multiscale complex systems analysis and its applications to obesity and NCD research. He started with an introduction to complex systems: the idea that correlations are not sufficient and that we need to study patterns and collective behaviors of components (5). Cells, neural networks, and social communities are all examples of complex systems. Complex SS has been used in many areas including the following: the food system, the health system, and the social-environmental system. For example, multiscale complex analysis has been used in health care to reduce costs, improve prevention, enhance patient care, and reduce medical errors (6). It has been used in the social context to advance our understanding of food riots, revolutions, ethnic violence, and urban dynamics, among other phenomena.

The complex nature of many of the problems humankind faces, including obesity, requires systems-oriented solutions. An individual has a regulatory system that should be preventing obesity. This regulatory system should cause people to stop eating when they are satiated. The reason this regulatory system is not working is that society is overriding individual regulation. In particular, the food system is making money from promoting more food consumption; and low cost, variety, palatability, and advertisement of high-energy-dense foods are all overriding the individual regulatory process. A key question is whether it is possible for government or public pressure to modify the profit model of the industry.

With regard to individual regulation, research should be conducted to understand the dynamic instability: for example, how different foods make people eat more or less, what controls the desire for more food, and the role of taste and hunger in the dynamics of eating. Bar-Yam presented a simple SDM to demonstrate that the eat-satiate balance is broken by the profit-pursuing behaviors of the food industry, which promotes overeating, and suggested a systematic future research direction: to understand the combined individual-societal regulatory systems.

Applications of SS in Childhood Obesity Research and Interventions (Terry Huang)

Dr. Huang focused on the application of SS to childhood obesity research and interventions. He highlighted 3 examples where interventions were designed to target these systems issues specifically. First, SaludableOmaha is a grassroots community mobilization initiative whose aim is to increase the level of community readiness among Latino residents in South Omaha, Nebraska, so that this community can better respond to health promotion interventions. The initiative relies on the synergy of 3 pillars: a strong social marketing and social media platform, institutionalization of SaludableOmaha as a service learning activity in schools, and community and business engagement. Youth activism and cross-sectoral

partnerships are strategies that cut across these pillars. Over the course of 2 y, community readiness was increased by 67%.

The second example was Ensemble Prévenons L'Obésité des Enfants (EPODE), the world's best scaled-up primary intervention for childhood obesity. EPODE entails a community-based approach to aligning community interests and creating a coordinated and mutually reinforcing set of strategies to tackle healthy eating, active living, access to preventive care, and health-promoting policies. EPODE has led to a decrease of 10–22% in the prevalence of childhood obesity in communities in France and Belgium in recent years. The key to EPODE's success at both the community level and at scaling up can be tied to the strategic emphasis on vertical (throughout levels of government/societal institutions) and horizontal (across the community) coordination, effective and well-managed public-private partnerships, and continuous communication with the central coordinating team and across sites.

The third example relates to the recently launched Access to Nutrition Index, which rates and ranks the world's top food and beverage manufacturers in terms of their contribution to healthy nutrition at the population level. The Access to Nutrition Index creates a new competitive playing field for food and beverage producers, which, in turn, spurs innovation and change.

In summary, an SS approach to childhood obesity is more than multilevel or multicomponent interventions. The approach focuses specifically on the interconnections across levels and components that lead to structural changes underlying the behavior of the system. Insights from systems thinking applied in other fields such as management and engineering can potentially be translated into the next generation of obesity interventions.

A Physiologist Thinks About the Obesity Epidemic (Michael J. Joyner)

When an integrative physiologist looks at the obesity epidemic, it is hard to find a simple biologic explanation for it. The failure of the pharmaceutical industry to develop a "magic bullet" drug that safely promotes weight loss is also evidence that a reductionist "single (or simple) biologic mechanism" is unlikely to account for the obesity epidemic.

Public health challenges are multifactorial—causes? The determinants of most NCDs are dominated by behavioral and environmental factors. Access to medical care and "biologic" factors including genes probably account for only a small fraction of the incidence and prevalence of chronic conditions, including obesity.

In addition to a much fatter world, so-called developed countries have also experienced a vast reduction in occupational physical activity. The loss of occupational physical activity is amplified by the fact that a large fraction of the population gets no or minimal leisure-time physical activity.

Starting in approximately 1980, there has also been evidence of an increase in macronutrient consumption (e.g., more calories) in the population. This has been ascribed to a variety of causes including increased consumption of SSBs and the ubiquitous presence of high-fructose corn sweeteners in the diet. In addition, more fast food is being consumed, and most individuals underestimate the energy they consume in fast-food venues.

Public health challenges are multifactorial—solutions? The built environment matters. For example, the fraction of individuals participating in active commuting is inversely related to diabetes rates in a number of locales. The built environment also provides barriers to physical activity among individuals living in selected urban areas or those living in distant suburbs where extensive automobile use is obligatory for many activities. High amounts of screen time are a risk factor for obesity. One potential solution is the adoption of walking meetings or the use of office furniture such as treadmill desks so that low-level physical activity can be performed during routine tasks that are normally sedentary in most cubicle-ized environments.

Linking insurance premiums to risk factors with a strong behavioral component works. The Safeway supermarket chain has a program that links health insurance premiums to BMI, smoking, lipids, and hypertension. If employees are successful in controlling these risk factors, they receive an insurance premium rebate. This program has shown success in lowering BMI in individuals deemed to be obese. However, polling data indicate that such insurance schemes are not popular.

Another solution to the obesity epidemic is the enactment of "sin" taxes, including taxes on either high-fat foods or SSBs. There is limited evidence on the efficacy of such taxes, but experiences based on tobacco control efforts and data on alcohol consumption indicate that taxes are effective in changing behavior and consumption.

When combatting obesity, the social contagion theory should be considered, which posits that positive or negative health behaviors and habits travel in social networks much like infectious disease can spread among individuals in close contact with each other. Is it possible to identify people in various social networks who can both change their behavior and influence the behavior of others?

Another solution to the obesity epidemic is medicalizing the problem. Currently, it is difficult for the medical community to refer patients to what might be described as "metabolic rehab" focusing on diet and exercise. If such long-term advice and interventions were possible, would it make a difference and would the long-term efficacy of diet and exercise interventions increase?

In summary, reductionist explanations for the obesity epidemic are inadequate. Comprehensive interventions such as those outlined above are therefore needed to address this problem.

NIH Support for SS-Related Research (Layla Esposito)

NIH support for SS-related research. The NIH is the world's largest supporter of biomedical, behavioral, and

social science research and training. There are various NIH funding mechanisms to support research, such as the R01 (research project grants awarded for up to 5 y), R03 (small grants for 2-y projects), R21 (2-y exploratory/developmental grants), and R15 (academic research enhancement award) grants. Several NIH institutes and centers support SS-related research through specific program announcements (e.g., PAR-13-374–Modeling social behavior), requests for applications, and investigator-initiated mechanisms.

The NIH grant guide can be searched to determine which funding opportunity announcements (FOAs) are currently accepting applications. The NIH Obesity Research Task Force page also has a list of all active FOAs in obesity research; many of these are open to SS methods. The NIH OBSSR has a Web site dedicated to SS resources, including videocasts and slide presentations, opportunities for training, relevant FOAs, information on the Institute on Systems Science and Health, and an SS listserv. Prospective applicants may contact an NIH program officer to discuss their proposal and fit with the institute or center before submission.

Examples of NIH-funded SS and childhood obesity–related research projects. The NICHD with cofunding from the OBSSR has funded several large SS initiatives in recent years, including the Envision Project, which funded 7 teams to develop SS, statistical, and computational models to study the impact of policies and interventions on childhood obesity. Another example is the Johns Hopkins Global Center on Childhood Obesity, a U54 cooperative agreement grant aimed at using SS methodologies across multiple innovative research projects (both domestic and international) and small rapid-response pilot studies conducted in various countries (see above). The center also focuses on SS training. Both the Envision Project and the NIH U54 Center are affiliated with the National Collaborative on Childhood Obesity Research.

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