EDITORIAL

Systems Science for Obesity-Related Research Questions: An Introduction to the Theme Issue

As the prevalence of overweight and obesity has steadily increased over the past several decades, reversing the obesity epidemic has become of paramount importance in the United States and around the globe. How to do this has been the subject of much research and debate. What makes the problem so vexing is not only the enormity of the problem in terms of sheer numbers of affected individuals, but the complexity of multiple interacting forces that are working to drive the epidemic.[1,2] Given the complex, dynamic nature of the problem, systems science methods are well suited to addressing the public health challenges of obesity. Systems science refers to a range of methods, composed largely of mathematical or computational modeling and simulation, that enable the user to explore complex problems by addressing both interactions between components of a system and the behavior of the system over time.[3] These methods have only recently become embraced by the public health research community.[4,5]

COLLABORATIVE SYSTEMS SCIENCE FOR OBESITY RESEARCH

In recognition of the above, Envision was formed in 2010 (http://www.nccor.org/envision). Envision is a research network of 11 funded teams and a host of affiliate members who have worked together to address obesity-related research questions with systems science methods and advanced statistical techniques to identify the drivers of obesity and the leverage points and policies with greatest potential to reverse the tide. A key expectation of Envision is that teams using both similar and dissimilar approaches and addressing different research questions related to obesity will learn from one another and develop new collaborative projects. Envision is part of the National Collaborative on Childhood Obesity Research (NCCOR; http://www.nccor.org) and is led by the Guest Editors of this theme issue, Patricia Mabry and Regina Bures. This theme issue of *AJPH*, "Systems Science Applications in Childhood Obesity Research," was originated as a way to showcase some of the work that has been achieved by Envision members, as well as others who have entered this space, a space that barely existed at the inception of Envision, five years ago.[6] Three of the articles in this issue resulted from new collaborative work stimulated by Envision[7–9]; others have either already been published (see http://www.nccor.org/envision/publications.html) or are under development.

OVERVIEW OF THE THEME ISSUE

We were delighted by the response to the call for papers. The 58 manuscripts we received underwent the standard *AJPH* peer-review process. Among those accepted for publication by *AJPH*, we selected those that best represented the current research using systems science approaches to study obesity. The resulting theme issue contains 10 peer-reviewed articles that showcase a range of methodological approaches and research questions that demonstrate the utility of systems science approaches for addressing the public health challenges posed by obesity and related conditions.

The application of systems science approaches to public health problems is still a nascent field.[5] We gently remind readers that the development of any simulation model is an iterative process and that reporting standards for this type of work are underdeveloped. There may be several publications resulting from a single model, each describing the current state of the model. Some articles, including some in this volume, are early steps in the modeling process and do not include full validation information. For these reasons, we note that the articles contained in this special issue reflect the current state of the models presented. As the field matures, we expect that fully developed and validated models will be more routinely reported in the literature.

ANALYTIC ESSAY AND FRAMING HEALTH MATTERS

The analytic essay by Hall et al.[7] frames the study of obesity in the context of three separate, but interacting systems: (1) metabolic regulation of body weight (homeostatic system); (2) neurologically based reward learning, which is influenced by both the environment and genetics (hedonic system); and (3) a cognitive feedback system that includes conscious self-regulation, social influences on food intake and energy expenditure, and environmental feedback. The development of quantitative models that integrate these systems should be a priority, the authors argue. At the individual level, these models can yield a richer understanding of the complex, dynamic, obesogenic process; help determine the relative influence of each system; and inform the development of tailored or adaptive interventions. At the population level, such models could be used to inform policy development, including economic and environmentally based interventions.

Two articles appear in the Framing Health Matters section.[10,11] The first is an extension of a system dynamics model developed by the Centers for Disease Control and Prevention (CDC): PRISM.[12–14] Obesity interventions are among 22 community-level policy interventions modeled by PRISM for prevention of cardiovascular disease (CVD). The article details how PRISM was calibrated to a stylized, "less-advantaged county" with 22 interventions bundled into four categories: clinical, behavioral support, health promotion and access to services, and taxes and regulation. The resulting model and associated simulation exercise demonstrate how the "less-advantaged county" would compare with the rest of the United States with respect to the effectiveness of the intervention classes over a 30-year time horizon. Based on the model, the authors forecast the combination of interventions that would be required to close the CVD health gap between a less-advantaged county and the rest of the united States.

Yang et al.[11] extend previous work[15] using an agent-based model (ABM) to explore conditions under which a program designed to promote active transport to school (the walking school bus; WSB) would be most effective. Using a stylized model, they illustrate how arrival times at a WSB bus stop affect travel for the group. They also demonstrate how the model could help identify the best routes for the WSB. In addition, the model generated testable hypotheses such as that WSB would be more effective for places with lower population density. Lastly, they found a synergistic effect of WSB with educational campaigns that aim to increase positive attitudes toward the WSB.

RESEARCH ARTICLES

The seven research articles included in the theme issue illustrate the application of a range of systems science approaches (e.g., microsimulation, social network analysis, agent-based modeling, system dynamics modeling, optimization techniques) to a variety of obesity-related public health issues.

To understand the obesity epidemic among children, we need better estimates of obesity prevalence at the national level. Current nationally representative longitudinal surveys of children's height and weight statuses are few and rely on parents' reporting of these measures, which is known to be inaccurate. To understand and quantify this bias among two- to five-year-old children, Rendall et al.[16] developed a novel simulation method, in which they substituted parameters from the National Health and Nutrition Examination Survey (NHANES) for extreme values in data from the Panel Study of Income Dynamics and the National Longitudinal Survey of Youth. Their result show that these biases lead to dramatically inflated estimates of obesity in early childhood. The authors further demonstrate that by applying the correction to parent-reported children's heights in the first percentile alone may reduce the degree of overestimation of obesity by as much as half. The findings from this article have implications for population level obesity estimation as well as for those who use data from national obesity estimates for young children in their models.

Managing body weight in general is a challenge, in part because of the complexity of the phenomena—multiple interacting drivers and feedback loops between behavior and body weight (e.g., as body composition changes during weight loss, the energy balance equation changes).[17] Weight loss during pregnancy is even more complex and involves consideration for the health of the mother and the fetus. Savage et al.[18] employ an optimization technique from control systems engineering to tailor a behavioral intervention targeting obese pregnant women, and adapt that intervention according to the unique needs of the individual over the course of the intervention. A hypothetical case study is described to illustrate how the simulation model would adjust the intervention in near real-time to manage both gestational weight gain and achieve a healthy birth weight infant.

The Healthy People objective is to reduce obesity prevalence from 33.9% to 30.5% by 2020.[19] However, it is not clear what it will take to achieve that goal. Using NHANES data, Basu et al.[20] developed a metabolic–epidemiological microsimulation model to estimate the change in caloric intake at the individual level that would be required to achieve this goal. They found that only modest changes at the population level would be required (i.e., 8.5% reduction in daily caloric intake or 7.5% increase in minutes of moderate intensity physical activity per person per day). However, given the current disparities in obesity prevalence, any intervention would need to target specific subpopulations to prevent further widening of those disparities.

Social network analysis methods are used by Schaefer and Simpkins[21] to investigate how children's weight status affects friend selection, and in particular examined social marginalization of overweight youths and their tendency to select friends of similar weight status. Their analysis of Add Health data demonstrated that in the selected sample nonoverweight youths were 30% more likely to select a nonoverweight compared with an overweight friend. The large, nationally representative longitudinal sample adds generalizability to the findings, which underscore the importance of understanding of peer networks when studying and intervening with overweight and socially marginalized youths in general.

Zhang et al.[22] developed an agent-based model to investigate the "stable unit treatment value assumption," which assumes that there are no interactions between people that could differentially impact the effectiveness of a given intervention. The ABM, which explores the potential impact of obesity policy, was based on the district of downtown Pasadena, California, and was calibrated with data from the Food Attitudes and Behavior Survey and other empirical data. The model suggests that price-based strategies may not be as effective as interventions that promote healthy norms, which then propagate across the social network. The authors also suggest that improving transportation networks so that stores offering fresh fruits and vegetables are more accessible might also be a worthwhile strategy.

Given that approximately two thirds of the US population is overweight or obese, interventions aimed at the population seem to be in order. However, given the unequal distribution of obesity across different racial/ethnic groups and by gender, one size may not fit all. Fallah-Fini et al.[8] present a system dynamics model to quantify the energy imbalance gap responsible for the US adult obesity epidemic among different gender–race/ethnicity subpopulations. The article addresses the pervasive challenge of modeling in enough detail to capture meaningful heterogeneity across the population while keeping computational costs to a minimum and model transparency intact. The result is a model that not only helps inform population intervention development by quantifying the energy gap for various racial ethnic subpopulations, but also serves as an example of how to model parsimoniously.

Also using a systems dynamics model, Sabounchi et al.[9] explore the implications of the fact that half of all women of reproductive age are overweight or obese. The authors adapted a previously validated system dynamics model of energy balance by Hall et al.[7] to capture gestational weight gain and postpartum weight retention in obese women. The model shows that pregnancy contributes to greater obesity in previously obese women and illustrates the competing risks of age-related decline in fertility and risks associated with excessive body weight and aging. The authors demonstrate the utility of this system dynamics model for aiding clinicians in helping their obese female patients make reproductive decisions using a case example.

LOOKING AHEAD

The articles in this theme issue present a cross-sectional view of the application of systems science methods to obesity-related research questions. We recognize that while interest in and adoption of systems science methods by public health researchers has been growing for some time now, many readers will be new to these methods and others, while familiar, may not be well versed in some of the nuances. We hope that the breadth of this theme issue will encourage other public health researchers to apply systems science approaches to other research topics. ■

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Contributors

Both authors contributed equally to the conception and development of the theme issue. Together the authors conceptualized the content for this editorial. P. L. Mabry wrote the first draft, which was reviewed, edited, and finalized by R. M. Bures.

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