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Making the Case for Systems Science Approaches in Public Health

Context for Systems Science

Systems science methods comprise an array of predictive and system-based simulation modeling methods, including (but not limited to) microsimulation, agent-based modeling (ABM), system dynamics, discrete event simulation (DES), and network analysis. Systems science conceptualizes a system as being composed of interrelated component parts, in which the relationships between the component parts are viewed as critical to the system, which should be resonant to public health professionals familiar with ecological models. Systems science goes beyond these models by formalizing the system and the relationships between its component parts into mathematical models. These models can then be used as virtual laboratories, where hypothetical scenarios (such as a new policy or intervention) can be evaluated and variables (such as the social environment or the population studied) can be manipulated to study the performance of various scenarios under different conditions. Systems science is thus uniquely positioned to address the challenging task of designing interventions and policies to improve population health while optimizing resource allocation. In the field of public health, it is widely recognized that there are complex interactions between interdependent factors—e.g., social, economic, environmental, genetic, behavioral and health services—that shape individual and population health.[1] These complex relationships create challenges for stakeholders trying to determine policies that would optimize population health in the long-run, within a complex public health system where different stakeholders can have conflicting goals and there are competing risks. Systems science methodologies can be used to construct models of this complex system, and the models can then be used as virtual laboratories to systematically evaluate the intended and unintended consequences and the time-delayed effects of a policy or intervention in advance of its implementation, and to study how these effects would differ under various specified conditions (e.g., different population, social, or environmental conditions).

Opportunities for the Application of Systems Science in Public Health

Several prominent organizations have emphatically acknowledged the utility of systems science to address the complex public health challenges. For example, the National Institutes of Health (NIH) has several funding opportunity announcements orientated towards the use of systems science methodologies[2,3] and has supported several major initiatives utilizing systems science in the past such as Cancer Intervention and Surveillance Modeling Network (CISNET) and Models of Infectious Disease Agents Study (MIDAS). In particular, the Office of Behavioral and Social Sciences Research (OBSSR) of the NIH has been specifically vocal about the issue, calling for the use of systems science approaches to health among the four programmatic directions in its 2007 strategic prospectus.[4] More recently, in its 2012 report "For the Public's Health: Investing in a Healthier Future", the Institute of Medicine (IOM) called for the current research paradigm "to be expanded to include other empirical study designs and the use of modeling and microsimulation."[5]

Despite these recognitions, public health still lags behind other fields, like economics and health care, in using systems science to inform policy decisions.[1] There is significant untapped potential in using systems science methodologies to advance our progress through the many burgeoning and intractable problems in public health – such as childhood obesity, pandemic influenza, and gun violence.

As practical examples, systems science has been used to evaluate the long-term effects of various tobacco control policies such as: raising taxes; on smoking prevalence and long-term health;[6,7,8,9] the impact of various possible interventions in responding to the H1N1 epidemic;[10,11,12] the potential impact of reducing sodium intake in the population,[13,14] and many more. There are also many other promising purposes to use systems science in public health, for instance as exploratory models to understand mechanisms in a complex system (such as the emergent behavior of a crowd in a disease outbreak) that will help elucidate the design of policies that address such systems, and to synthesize existing data from disparate disciplines into a 'big picture' model.

Moving the Field Forward

Systems science models can be valuable tools in informing policy decisions and resource allocations to optimize public health impact. To increase and facilitate its adoption in the public health domain, systems science should complement, not supplant, traditional public health methods. For instance, within the context of a Health Impact Assessment (HIA), systems science methods could be used to project the potential impact or to determine the scalability of the policy under consideration. Systems science methods can also play an important role in mixed methods studies, where they could synthesize results of the quantitative and qualitative studies into a holistic model and provide additional insights.

Additionally, as the depth and breadth of systems science can be daunting, it would be prudent to highlight similarities between public health and systems science approaches when advocating their use to public health practitioners. As has been pointed out above, there is a similar underlying principle behind ecological models and systems thinking. Also, traditional public health methodologies can play an important part within systems science models, such as the use of regression models to determine parameters for a systems science model.

Most importantly, systems scientists would benefit from engaging stakeholders and decision makers from the beginning to the end of the model-building process, using a participatory modeling approach. This process can be essential to identify the questions to be answered by systems science methods; determine what factors and parameters should be included or excluded from the analysis; help stakeholders develop an understanding of the model; and develop a sense of ownership among stakeholders in the model development, which could increase the likelihood of them translating model results into action.

About the Author

Irene Vidyanti, Ph.D., M.Eng., County of Los Angeles Department of Public Health and USC Schaeffer Center of Health Policy, was commissioned by AcademyHealth to develop this commentary for the 15th Annual Public Health Systems Research Interest Group Meeting. This report was made possible by the generous support of the Robert Wood Johnson Foundation.

About AcademyHealth

AcademyHealth is the professional society for health services and policy research. Its Public Health Systems Research Interest Group (PHSR IG) is its largest, with close to 3,400 researchers, students, and decision makers who work at the federal, state, and local levels.

AcademyHealth has commissioned this discussion paper for the 15th Annual PHSR IG Meeting to invigorate the field of PHSR and spotlight promising ideas. One of four commentaries, this paper draws on the author's experience and perspective on the changing public health system and offers their insights to the PHSR community.

Suggested Citation

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* Note: Although there is agreement that systems science has not yet been used to its potential in health services research, it is not completely new. The 2012 Public Health Systems Research Article of the Year Award went to "Why Behavioral and Environmental Interventions Are Needed To Improve Health At Lower Cost", a study that deployed dynamic systems modeling. In 2014, a study using network analysis, "Implication of Network Structure on Public Health Collaboratives", received notable article recognition for the same award. The Systems for Action Program, housed at the University of Kentucky and funded by the Robert Wood Johnson Foundation, has identified systems science as particularly relevant to the Foundation's new Culture of Health initiative: http://systemsforaction.org/sites/default/files/resource_files/S4A_ResearchAgenda_FinalForWeb.pdf