

Systems Thinking and Modeling for Public Health Practice

Many public health workers will regard this issue of the Journal, devoted to the theme of systems thinking and modeling, as a welcome affirmation that our endeavors to protect the public's health do indeed depend on more than the sum of their parts. As Midgley observes, "The whole concept of public health is founded on the insight that health and illness have causes or conditions that go beyond the biology and behavior of the individual human being."^{1(p466)} Animated by this systemic insight, public health leaders have worked for more than a century to identify and transform the processes that leave people vulnerable to afflictions of all sorts. As this work has evolved, our understanding of population health dynamics—and of our power to navigate change—has improved through innovations in the concepts, methods, and moral frameworks that shape the field. The present exploration of systems thinking and modeling, therefore, springs from the very core of our discipline, adding to our repertoire novel and far-reaching tools that the pioneers of public health work could scarcely have imagined.

THE CHALLENGE OF SYSTEMS THINKING

But what do we mean by "systems thinking and modeling," and what is its practical relevance? Part of the answer lies in recognizing that there is no single discipline for systems thinking, precisely because it is oriented to the linkage of disciplines. Equally important is an

emphasis on relating different types of structures that shape our lives, including the biological systems of our bodies, the organizational systems in which we work, and the political systems with which we govern public affairs. Although there is no single operational method for identifying and interpreting these relationships, there is, in fact, a common conceptual orientation recognizable as a systems approach: it is a paradigm or perspective that considers connections among different components, plans for the implications of their interaction, and requires transdisciplinary thinking as well as active engagement of those who have a stake in the outcome to govern the course of change.

Conventional forms of problem framing, action planning, and evaluation often exclude or ignore precisely those features of dynamic complexity that make public health challenges so formidable and public health responses so innovative. Through studies grounded in an explicit systems orientation, we may recognize both the value of understanding health as a system of structured relationships and the value of the diverse methodologies that exist for learning how such systems are organized, how they behave over time, and how they can be better governed in dynamic and democratic contexts. This issue of the Journal goes beyond highlighting the relevance of particular forms of analysis and synthesis that have evolved primarily in fields outside public health. It directs attention to the historical

processes, practical challenges, and ethical considerations that arise when we attempt to transform systems that affect the public's health. Even more, it asks us to reflect critically on the meanings of "evidence" and "evidence-based policy and practice" within a systems orientation.

CRITICAL CONSIDERATIONS IN SYSTEMS THINKING

As we consider how to incorporate systems approaches responsibly in our work, we should keep 4 critical points in mind. First, at the heart of a systems orientation is an emphasis on relationships. But when the systems in question involve humans, understanding the nature of a system and its dynamics requires an understanding of people—such as how we interact with each other in social networks. The study of social networks has matured over the past decades, revealing a number of promising directions for public health practice. For instance, communication researchers are studying the Internet to understand how information networks develop and evolve, epidemiologists are investigating how social ties affect the spread and prevention of disease, and psychologists are delving into complex family relationships to understand the social dynamics of family influence.

Second, efforts to achieve a larger, more connected understanding of the public health enterprise must never obscure the continuing need for specialized studies, on which all good systems theory depends. Four years

ago, in the introduction to a special issue of the journal *Science* on “systems biology,” Chong and Ray noted that the delay between the articulation of general systems theory in the 1960s and the incorporation of those principles into modern systems biology was “necessary, primarily to accumulate sufficient descriptions of the parts to enable a reasonable reassembly of the whole.”^{2(p1661)} Likewise, it appears that the time has come for public health workers to reap the rewards that serious systems thinking and modeling may bring, and leading public health agencies have consistently identified this as a priority for the field.^{3–6} Recently, Centers for Disease Control and Prevention Director Julie Gerberding named “dynamic systems and syndemic approaches” as research imperatives for protecting health, even while acknowledging that applications of this science in the health arena are in their infancy.^{7(p1404)}

Third, a systems approach to health and health care dilemmas requires us to transcend academic boundaries and interact more effectively across organizational lines as we learn to understand and manage ever more complex challenges. A critical aspect of this work is the need for information exchange and synthesis. Considerable investments are being made to think systemically and combine information from diverse sources in an effort to thwart terrorism, control tobacco use, signal the onset of disease outbreaks, track the source of foodborne illnesses, and anticipate the long-term implications of childhood obesity. These and similar ventures are examples of how we may improve the public health

enterprise through a systems perspective. They illustrate the importance of gathering and analyzing different types of data (e.g., biological, behavioral, environmental, administrative), integrating these data with prior research and experience, ensuring that infrastructures are in place to facilitate accurate interpretation of the contextualized information, thinking critically about “what if” scenarios, and communicating all of this information to those who can act on it.

Elaborate cyberinfrastructures, such as a national electronic medical records system, may soon emerge to help streamline these processes. But if such large-scale databases remain unlinked, they will still be “silos”—disconnected repositories of information. With proper planning and safeguards against misuse, however, it may be possible to link information together in ways that provide a shared situational awareness of public health threats, available resources, and options for rapid and effective health protection efforts. Even better, such systems might better enable policymakers to anticipate and forestall potential threats, saving both money and lives.

Such ambitious efforts are not without risk. For example, the potential exists to link not just medical records but local and national surveillance systems, commercial data on health-related purchase patterns (e.g., medications, tobacco, alcohol, food), and administrative data from the private and public sectors. These new and more complex ways of linking data and exploring hidden relationships carry profound ethical, legal, financial, and social implications that must be understood and described.

Fourth, many aspects of systems thinking have ancient philosophical roots, and their modern methodological manifestations are phenomenally diverse.⁸ Such heterogeneity challenges us to match public health problems with the appropriate methodology or mix of methodologies for studying them. For instance, the structure and evolution of sexual partner networks can be studied through the use of matrix algebra; causal feedback processes in the relationship between advertising and tobacco use may be examined through the use of differential equations and tested through computer simulation; complex patterns that emerge from seemingly simple interactions among individuals, some of whom carry a communicable virus, can be explored through agent-based models. These and many more techniques are flourishing in other areas of applied science, opening virtually limitless possibilities for innovative health professionals to learn from these other fields and extend their work.

A NEW FRONTIER IN PUBLIC HEALTH

The task of choosing appropriate methods is made even trickier by the fact that the act of systems thinking itself often changes our perception of what the problems are, where their boundaries lie, and who ought to decide how to approach them. There are no strict rules for ensuring an appropriate fit; however, one may check for internal consistency among the concepts, methods, and moral considerations that define any given approach.

We must guard against the tendency to acknowledge the presence of complex relation-

ships in shaping population health while employing analytic methods or program practices that exclude key parameters or assume independence among those that are included. Systems thinking compels us to study complex health-related phenomena rigorously, but with appropriate techniques. As Green asks, “Will [systems science] achieve methodologically what ‘ecological’ approaches have offered conceptually as a way of encompassing the multiple levels necessary to understand and harness the reciprocal relationships among biology, behavior, and environments?”^{9(p408)}

We believe that systems-oriented inquiry may point the way toward a promising new frontier for public health action in response to the critical challenges of our time. This issue of the Journal provides a glimpse into this frontier. It does not attempt to prescribe what systems approaches should be. Instead, it offers prototypical examples of the eclectic ventures that are now being explored under the umbrella of systems thinking and modeling. The intent is to educate health professionals about the existence of these projects, stimulate our collective thinking about their potential, and open a wider dialogue about the utility of the information they reveal. ■

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Social Injustice and Public Health

Edited by Barry S. Levy and Victor W. Sidel



Social injustice manifests in many ways ranging from various forms of overt discrimination to the wide gaps between the “haves” and the “have-nots” within a country or between richer and poorer countries. It increases the prevalence of risk factors and hazardous exposures, which in turn lead to higher rates of disease, injury, disability, and premature death. The four sections of this book give public health professionals as well as students a clear understanding of social injustice in order to address these problems.

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