

# Public Health and Human Systems Dynamics: What can we learn from each other?

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## Introduction

The purpose of this paper is to investigate some of the aspects of public health practice from the perspective of human systems dynamics with the goal of illuminating both domains—public health and human systems dynamics.

Public health is defined as, “What we, as a society, do collectively to assure the conditions in which people can be healthy. This includes physical, mental, social, and emotional health” (Institute of Medicine, 1988).

Human systems dynamics is an emerging field of study that applies principles from complexity science to theory of and practice in the social sciences.

In this short exploration, we examine how public health and human systems dynamics can inform each other. We include the following topics:

- Public health as a complex adaptive system
- Evolving traditions of public health
- Lessons for human systems dynamics
- Conclusion

## **Public Health as a Complex Adaptive System**

The designator “public health” is used in many different ways. It involves collective action intended to produce system-wide patterns of health. As such, it can be seen as an emergent or complex adaptive system.

In various contexts, public health refers to a profession, a philosophy of action, a vision for the future, subdivisions of governmental institutions, and an accumulation of population-level measures of health outcomes. In all of these contexts, the practice of public health involves complex adaptive systems because it relates to the behavior of collections of semi-independent agents, interacting with each other, and generating system-wide patterns.

The field of public health is a perfect example of a complex system. In fact, it is a complex system composed of many interacting complex systems, so it may be considered a paradigm case of a social system that exhibits complex adaptive system properties.

Public health focuses on emergent patterns—health outcomes across populations. These patterns emerge from the complex interactions of various subsystems, each of which has its own dynamics. Some of the intertwining complex systems that contribute to the patterns recognized by public health include individual health, social networks, political systems, healthcare industry, and professional affiliations.

Individual health, as a contributing component to population-wide health status, is a complicated system in itself. The patterns of physical health emerge at the individual level from many complex interactions. Complex genetic maps interact with complex environmental determinants of health. The electrical, physical, and chemical interactions in the body further complexify dynamical processes that generate health or illness of the individual. Beyond the physical complexities, health includes mental, social, and emotional well being. Each of these incorporates a different cluster of interdependent causal factors, and each is, at least in part, determined by all of the others.

Social networks form another layer of complexity for the study of public health. The health of individuals is determined in part by interactions between and among people in social contexts. For example, peer pressure helps determine early health decisions of teens; parental modeling shapes exercise and eating habits; family violence builds a sense of fatalism and lack of personal efficacy; neighborhood norms reinforce or discourage healthy life style habits; and faith communities establish moral and ethical attitudes and behaviors related to hygiene and health. Every individual is enmeshed in multiple social

networks—each of which functions as a complex adaptive system as individuals and small groups interact, transform each other, and generate emergent system-wide patterns of health and health-related behaviors. These complex interdependencies have a profound influence over population-based health indicators.

Formal political systems add another dimension to the complex interrelationships that shape population health. Municipalities, regional planning authorities, counties, states, federal agencies, and international political entities control some of the determinants of health of population groups. The dynamics among these levels are nonlinear and unpredictable. In addition, each level encompasses its own set of agents: Individuals, bureaus, teams, political affiliations, programs, legislative, judicial, and executive groups, and other formal and informal functional subsets. All of these entities and interactions have an influence over the domain of the public health field.

Another complex agent in the public health field is, of course, the healthcare industry. Again, the dynamics of this subsystem are massively complex and highly unpredictable. Agents contributing to the emergent patterns in healthcare include pharmaceutical companies, insurance companies, managed care institutions, healthcare technology inventors and manufacturers, clinics and hospitals, emergency response teams, and a host of other for-profit and not-for-profit organizations involved in developing, manufacturing, delivering, funding, and/or evaluating health and the distribution of healthcare technologies. Within each of these entities the dynamics of funding, employee relations, quality, innovation, and process control interact to form complex and emergent patterns of behavior. The emergent dynamics of the industry contribute to the health status of population groups of all kinds.

Woven within and among each of these complex systems are the threads of professional education and affiliation. Physicians, nurses, administrators, public health professionals (nutrition, environmental health, maternal and child health, administration, and so on), and social workers all bring their own models, tools, techniques, and languages to support health of individuals and communities. These multiple perspectives enrich the field of public health, but they also further complicate its theory and practice at the system-wide level.

Public health, as a phenomenon and as a discipline, represents complex patterns that emerge from complex interactions of multiple complex patterns that emerge from yet other complex interactions of patterns. It is a paradigm of the complex system. The question is how can it be adaptive?

## **Traditions of Public Health**

The field of public health is founded upon and maintained by traditions of theory and practice. Many of these traditions deal with assumptions or practices that have proven effective in a wide variety of circumstances. In the past, the field has developed strategies to cope with the overwhelming complexity of its challenge. Some failed and were rejected over time. Others, however, proved adaptive and were integrated into the

assumptions and norms of theory and practice in the field. Today, those tried-and-true strategies are being challenged because of decreased public support, lower levels of cultural homogeneity and coherence, changing educational landscapes, exploding technology, unpredictable political landscapes, and limited resources. Assumptions and traditions of the past are being challenged, and new strategies will be required to continue the historical benefits of public health practice. Some of the traditions of the field are described below, along with human systems dynamics-inspired suggestions for new adaptive responses within the framework of the traditional discipline. They include the following.

- Use widely accepted, quantitative tools to collect, analyze, interpret, and report data.
- Prepare for cyclic patterns of threat and response.
- Offer core services.
- Invest in reliable health-related institutions and resources.
- Find a balance by alternating focus between individual rights and public good.
- Seek and define an identity for the field of public health.
- Focus on prevention to secure the health of population groups.

**Use widely accepted, quantitative tools to collect, analyze, interpret, and report data.** Historically, the field of public health has depended on mathematical and analytical tools to do its work. The benefit of such quantitative methods is that the proclamations of the field have been credible enough to be accepted by decision makers and funding agencies. In many cases, the use of statistics and sophisticated analytical tools has allowed public health professionals to gain insight and limited control over the high dimensional and emergent patterns that shape the health status of the population. When change is slow and/or when interdependencies of a system are minimal even the most complex system can appear simple and linear so that traditional methods are sufficient. Since its inception, the field of public health has focused on questions and circumstances in which these tools were sufficient for the work.

On the other hand, when change is rapid, connections are loose, causality is mutual, and participating agents are heterogeneous, nonlinear dynamics swamp the analytical capacities of traditional tools. In today's environment, all of the systems that shape the health of populations are becoming more complex. At every level of interaction, agents are more diverse, connections less reliable, and identities less well accepted. The patterns of health that are recognized across a population may be more ambiguous and less stable. The result is a pattern of population-wide health that often transcends the capacity of traditional mathematical analytical tools.

The field of human systems dynamics offers a different set of tools and lends credibility to old tools that have been used in the past. A few of the examples are described here, though many others are available in the field.

- Stories and metaphors capture many more facets of a complex dynamical human system than more simple quantitative tools. Though less demonstrably reliable, qualitative research techniques and discourse-based

data analysis are often better representations of the massively entangled and multi-dimensional realities of public health.

- Mathematical modeling techniques are being perfected to analyze the complex dynamics of some emergent systems. Time series modeling and attractor reconstruction have been used, for example, to analyze births to teen mothers in Texas. The resulting analysis challenges some of the long-held assumptions and expectations about teen pregnancy (Dooley et al., 1997).
- Computer simulation models are another tool that is emerging from the study of natural and human systems dynamics. Various simulation methods (genetic algorithms, cellular automata, other agent-based models) can be used to explore the emergent dynamics of massively entangled, loosely coupled, and high dimensional systems, such as those that engage the field of public health.

**Prepare for cyclic patterns of threat and response.** Public health, like history, seems bound to repeat itself. Today, patterns of health and politics that we associated with the Regan administration or with the industrial revolution are appearing again. Investments in resources and preventive measures make a difference for a time. Over time, however, the will to invest or the resiliency of the system shifts, and the old patterns re-emerge. Human systems dynamics offers some approaches to build an understanding of the past that can contribute to a more productive future.

- Complex dynamical systems exhibit emerging patterns over time that can be captured and described through time series analysis. These patterns, called attractors, fall into four categories. Each pattern captures the behavior of the system through time and helps distinguish a variety of population-wide expectations and likely outcomes.
- Transforming exchanges hold the agents in a complex system together so that system-wide patterns can emerge. Professionals should now be building sophisticated knowledge transfer systems between older and younger practitioners within the field of public health, with other fields, and across social and economic boundaries. To be effective, these connections have to admit to two-way communication and learning. The exchanges will be transforming and affect the dynamics of the system only when all constituencies engage in dialogues for learning.
- It is easy, especially in times of change, to choose to focus on the similarities between the present and the past. This strategy can be as dangerous as it is easy. Yes, the patterns of today reflect, in part, those of yesterday. On the other hand, the differences are striking, as well. The more public health professionals come to understand the differences between the past and the present, the more prepared they will be to respond to the changing environments in which they work.

**Offer core services.** Core services in public health are designed to protect the health and safety of all populations. Core public health services have contributed to twenty-five to thirty years of lengthened lifespan during the last century. These core services are: prevent the spread of communicable disease, assure normal growth and development of children and adults, prevent injuries and reduce risky behaviors, protect against

environmental hazards, prepare to respond to disasters and health threats. One of the challenges in public health is to adapt the core services to changing conditions, needs and priorities.

A human systems dynamics approach would encourage public health professionals to reinterpret these core services. The new focus would not negate the old, but would shift energy and resources of the system toward differences that could be more productive in the current climate.

Every complex system includes an infinite number of differences. The traditional interpretations of the core services of public health were selected as focal points not because they were the only differences that made a difference, but because they were the most relevant differences at the time. Today, other differences may be more significant to those who focus public attention and resources. For example, the amount of time a child spends at a television or computer, the popularity of violent professional sports, the prevalence of prescription and non-prescription drugs—all of these differences have negative effects on population health today. Any one of them might lead to a new interpretation of the “core services” that can garner public support for public health initiatives. In recent history, public health has focused on some innovative changes successfully including seat belts and tobacco use. In these cases, public health professionals focused on a difference that made a difference not only to population health, but also to individuals and institutions that shape policy and system-wide patterns of health.

**Invest in reliable health-related institutions and resources.** In spite of the efforts of public health professionals and others, public dollars are not being dedicated to maintenance or development of the institutions and resources that ensure population health. Human systems dynamics recognizes the need to plan for multiple time horizons. Short-term focus allows planning in a relatively predictable and stable environment. Mid-term planning moves beyond the current state into possibilities that are extensions of the existing situations. Long-term planning, which supports investment in institutions and renewable resources, focuses on needs and opportunities beyond the current environment. Human systems dynamics provides ways to demonstrate the efficacy of planning well for all three horizons. Such an approach can help public health professionals encourage sufficient investment today in the population health of the future.

**Find a balance by alternating focus between individual rights and public good.** The field of public health focuses on population-based indicators of health. Often, standards of public health depend on setting best practices, regulatory requirements, or other constraints on individual choice. For example, requiring seat belts and infant car seats improved public health by reducing the number and severity of injuries from car crashes. This requirement, however, limited the individual’s freedom to ride in “comfort.” The public health profession has always recognized a tension between individual freedom and the common good. The tension has been resolved by focusing sometimes on one and sometimes on the other. The target has been an equilibrium status in which individual and population are balanced against each other. When political preferences move toward

self-determination and rugged individualism, then the principles of the common good move into the background, and individual rights replace concerns for the health of the public as a whole.

Tension between the part and the whole—the agent and the emerging systemic pattern—is one of the underlying dynamics of complex adaptive systems. No definitive resolution of the tension has been proposed within human systems dynamics, but one thing does seem to be clear. The question generates more options for action when it is not framed as a dichotomy. Part and whole, individual and group are locked together as necessary complements to each other. The individual cannot be healthy when his or her community is not, and the community cannot be well when enough of its individuals are ill. The causal connections between the parts (which interact to form patterns) and the pattern (which naturally constrain the parts) provide a way of thinking about individual rights and public goods. A new rhetoric might emerge from human systems dynamics that will help individuals and populations recognize these interdependencies and use them to enhance personal and community decision making.

**Seek and define an identity for the field of public health.** The field of public health encompasses a wide array of disciplines and interests. Any profession, from sanitation worker to school teacher to chef to corporate attorney, can influence population health status, so all might all be considered public health workers. On the other hand, a set of traditional values, tools, skills, and methods for the practice of public health do exist and have effectively responded to many threats in the past. Public health institutions are necessary to support public health initiatives, and a cadre of professionals is able to garner support for initiatives by formally representing the field of public health.

This is another tension that under-girds the work of the field: Public health is most influential when it is dispersed across multiple interests and fields; but when dispersed, it risks losing the power of its unique voice for issues related to the population's health. The constituencies in the field of public health are large, diverse, and loosely connected. For this reason, changes take a long time; communication among practitioners and with the public at large are essential to success; and the society-wide patterns of health will always be elusive. The leaders of the field acknowledge these constraints on their work, but they continue to be committed none-the-less. To be effective, the field must demonstrate both focused decisive action and broad-based systemic vision. Such a two-pronged perspective emerges naturally from the field of human systems dynamics.

**Focus on prevention to secure the health of population groups.** Prevention has always been a hallmark of public health practice. Of course the system must respond to treat illness when it occurs, but the field is committed to preventing illness whenever possible. Prevention is based on two assumptions. 1) The links between a cause and an effect are rational, predictable, and preventable. 2) The time lag between the cause and the effect is long enough to allow effective intervention, but short enough that the outcome can be logically connected to the intervention. There was a time in public health when these two were valid assumptions. Bacterial infection, for example, provides a clear causal chain between exposure and illness, and the time-lapse from one to the other

can provide a window in which preventive steps can be taken. Seat belts and head injuries, smoking and heart disease, and drinking during pregnancy and fetal alcohol syndrome are other examples of the efficacy of prevention over treatment.

Many of the challenges of public health today, however, do not play by these rules. Health disparities, challenges of aging, obesity, reproductive health, violence, substance abuse, and environmental threats belie the two assumptions that make prevention activities effective. In all of these cases, the causes are not clear. They are myriad; they involve loops of mutual causality that are beyond the realm of traditional tools or descriptive models; or they lie beyond the reach of public health intervention. Time is also an enemy of prevention related to these issues. In some cases, the time between cause and effect is so short that preventive action is unreasonable. In other cases, the time lag is so great that the individuals who might take preventive action fail to connect the cause with the likely outcome. For these issues, prevention in its traditional guise is simply not feasible.

Complexity science was invented to deal with just such environments, and human systems dynamics applies the same approaches to social systems. High dimensionality and variable time lags are standard features of complex adaptive systems. Models and tools that emerge from human systems dynamics may provide alternative interventions when prevention is not possible. The CDE Model (Eoyang, 2002) for the conditions for self-organizing, options for simulation and time series modeling, applications of short lists of simple rules, effective storytelling, and conscious design of feedback are some of the tools and techniques that are emerging to deal with systems in which prevention is a practical impossibility.

Public health depends on a complex combination of massively entangled complex systems. When social, technical, physical, economic, and governmental systems were more controlled and predictable, the practice of public health moved forward as if its systems were simple and predictable. The current climate, on the other hand, amplifies the instability and unpredictability in all of these domains, making the practice of public health more emergent and complex than ever before. As the field of human systems dynamics develops, it will provide more tools to support the theory and practice of public health.

## **Lessons for Human Systems Dynamics**

Considering a domain, such as public health, through the filter of complexity usually provides information about the thing considered, but it always generates insights about the theory and practice underlying human systems dynamics. The current endeavor was no exception. This section outlines the lessons learned or reinforced about complexity in a human systems context and explores possible strategies to improve the efficiency and effectiveness of the practice of human systems dynamics.

**They already “know” it.** Experts in the public health profession have successfully dealt with complex dynamics of human systems throughout their careers. Each has a highly

developed intuitive grasp of the dynamics of human systems, and their practices already are intuitively adaptive. Human systems dynamics and the models of complexity can be helpful, however. The language captures the intuition, makes it explicit, allows one to generate more options, and supports shared meaning and decision making. It does have value, but it is not different in kind from successful interventions of the past, it merely makes explicit, amplifies, and enriches the existing levels of expertise.

**Simple is good, but too simple is dangerous.** Human systems dynamics is a complicated topic. The scientific and mathematical foundations, the rich and growing literature in both theory and application, and the multiple explanatory models make human systems dynamics an incredibly challenging field for newcomers. It is possible to simplify the concepts to move co-researchers or students into the language and models quickly, but this approach introduces a risk. The jargon of human systems dynamics runs the risk of merely collapsing a complex reality into a new, but no more insightful, simplicity. When the substance of the field is simplified to make it more accessible, the differences between it and other approaches become indistinct. An effective presentation uses what others already know, but it also establishes the distinctions that make human systems dynamics different in kind from other approaches to social systems.

**Sometimes linear ladders lead to nonlinearity.** Practitioners need supporting structures to understand and implement human systems dynamics concepts. Though the processes are iterative and reflexive by nature, neophytes need to be presented with linear processes and objective criteria to help them enter into the field. Over time, their skills develop and they see and can engage in the nonlinear processes. Initially, however, only structured guides and step-wise techniques make the beginner's journey possible.

**New understanding is not enough.** If human systems dynamics does not provide new options for action, then busy, successful professionals will see no value in it. Often complexity is used only in retrospect—to explain why or how something happened in the past. This approach is interesting for an academic and an elegant explanation can be reinforcing for the practitioner, but it is of little interest to public health professionals. The field has generated multiple explanatory models in the past, and one more holds no particular interest. On the other hand, highly qualified public health professionals face challenges for action today that are different in kind from those of the past. They recognize the need for new methods to generate, select, implement, and evaluate options for effective action to improve the health of the population. If human systems dynamics cannot provide these options, then it is of minimal value to the field.

**Scaling is a radical concept.** Those of us who have worked in complex dynamics for some time assume that similar patterns appear at various levels and places across a system. For others, the idea of scaling is unfamiliar and a bit threatening. Different language and causal patterns are believed to exist across scales, so problem solving procedures were radically different from one level to another.

Traditional approaches selected a unit of analysis (individual, subgroup, or community) then built a whole data collection, analysis, intervention, and evaluation strategy

optimized to that level. Within complex systems, one can use scaling to cross from one unit of analysis to another. Patterns recognized or relationships articulated at one scale can provide clues to the presence or meaning of patterns at other scales. Interventions at one can be expected to generate outcomes at all others, over time and with the usual unpredictability of complex causal relationships.

Human systems dynamics can provide new insights for professionals in the field of public health, but it also has much to learn. Critical lessons for the future will include both developments in the content of human systems dynamics, but also in the most effective and efficient ways to disseminate the theory and practice of this emerging field.

## **Conclusion**

This paper has explored the intersections between public health and human systems dynamics. The insights contained herein emerged in the course of conversations between expert practitioners in the fields of public health and human systems dynamics. This investigation is just the beginning of a research program that will continue to articulate the dynamics of public health in all its guises and to extend our understanding of human systems dynamics in this and other applications.

Future research might fruitfully address the following questions:

- When applied to specific issues or situated cases, what value does a human systems analysis approach add beyond more traditional models and techniques?
- What new findings emerge when computer simulation models or nonlinear time series analysis are applied to questions and issues in public health?
- How might human systems dynamics and/or complexity sciences be incorporated into initial and advanced training and education of public health professions?
- What concrete articulation of the CDE Model would relate directly to the theory and practice of public health?
- How might human systems dynamics content and practice be applied to shape a more productive public debate about what we, as a society, do collectively to assure the conditions in which people can be healthy?

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