8

ISIS: Synthesis and Conclusions

This chapter examines common themes and potential areas of synthesis from a systems thinking perspective across the areas studied in the Initiative on the Study and Implementation of Systems (ISIS). It then presents conclusions based on the findings of its core group of researchers. These conclusions are based on the four core research areas of ISIS—systems organization, system dynamics and modeling, system network methods, and systems knowledge management and translation, as well as a set of crosscutting conclusions. The conclusions are used jointly to form a potential action plan for the future of systems thinking in tobacco control.

The whole is greater than the sum of its parts.

—Fritz Perls (1893–1970)

Introduction

The ultimate aim of ISIS is better health. The basic premise of this project is that the next major round of advances in health resulting from tobacco control will evolve through the adoption of systems thinking. Tobacco control and public health in general stand at a crossroads where further large-scale gains will come through the ability to understand and solve increasingly complex, evolving issues. Systems thinking may provide the means to accomplish these gains by transforming the fragmented ad hoc system that currently characterizes tobacco control to one that is more effectively self-organized, integrated, connected, and adaptive.

This chapter examines the areas studied within this project from a synergistic systems thinking viewpoint and presents the current conclusions of the ISIS team. These conclusions have the potential to move the tobacco control community toward a more integrated environment of systems thinking. The underlying unifying conclusion is that systems thinking is an ecological process, rather than just the implementation of an assortment of techniques or methods. Systems thinking is not about using a specific tool, but as Checkland states, it "is a way of looking at the world."[1] It is an inevitable evolution toward an environment that equips the tobacco control community to solve challenging, complex issues in tobacco control and public health, based on a clear set of fundamentals:

1. Simple rules by which to navigate complex adaptive systems and participatory processes that engage stakeholders at all levels
2. Feedback and evaluation mechanisms that allow adaptive, evolutionary change
3. Tools and infrastructure needed to enable functioning as a system of networked stakeholders
4. Methods for organizing and transforming the knowledge in the system to achieve more effective systemic change

Tobacco control already is heading in this direction, and this project equally reflects and factors in the evolution. Consequently, the purpose here is to encourage and channel a trend that already is in process—one in which the choice is between doing it well and sooner or doing it poorly over a longer period. With the conclusions in this chapter, this challenge is framed around guidelines that could enable the next steps in implementing real-world systems approaches to tobacco control issues.

A systems environment is dynamic. The general conclusions of this project complement the recommendations of individual chapters and are not independent of them. The systems approaches on which this project was based are among the most important of a broad array of approaches that can contribute substantially to the overall future of the systems environment in tobacco control. The four key research approaches explored in this project and the major conclusions relevant to them are presented here.

Systems Organizing

Systems organizing is about an evolution from traditional management theory to a "learning organization"[2] or an adaptive systems perspective within a systems environment. Its major message is the evolution of current concepts of managing and organizing by transforming traditional top-down, command-and-control structures to encompass participatory approaches, community-based methods, organizational change and dynamics, and effective evaluation of such efforts. Methods of organization are envisioned as a continuum from formal organization in the traditional management sense to self-organizing, community-level groups, partnerships, or collaborations.

System Dynamics

System dynamics involve methods that facilitate a more constructive examination of complex adaptive systems by modeling the behavior of actions and their consequences, both intended and unintended. These methods are particularly well suited to tobacco control, which encompasses an ongoing struggle with countervailing factors that change over time and can be strengthened. There is considerable promise in a range of systems approaches, including formal system dynamics modeling techniques, group processes that harness the problem-solving capabilities of multiple stakeholders, and ancillary methods such as simultaneous equations modeling. These approaches constitute tools that help address problems that are increasingly dynamic and complex.

System Networks

Networks represent the backbone of a system by harnessing the power of linking diverse stakeholder groups. Networks offer the means to have the greatest influence on the largest number of people in the shortest time, even more than do system dynamics models and knowledge management. Moreover, research findings suggest that countervailing forces against tobacco control often function within a network environment.[3] Understanding the formation and management of networks and using the knowledge to foster healthy networks in tobacco control are critical components of a systems environment in tobacco control.

Systems Knowledge

The management and transfer of shared knowledge form the basis of interaction between stakeholders in a systems environment. This monograph outlines a comprehensive, sophisticated infrastructure for knowledge management and transfer that is based on integrating existing silos of information and manages both explicit knowledge (what we know we know) and tacit knowledge (what we do not know we know; unconscious lessons from experience). This knowledge environment must be collaborative, in keeping with the needs of the stakeholders it supports, and evolving to meet the changing needs and methods underlying a systems approach to tobacco control.

This project serves the dual purposes of performing original research, as a way of demonstrating the potential for systems thinking approaches in tobacco control, and of exploring the future of a systems environment for tobacco control and public health. ISIS work was accomplished through the efforts of a diverse, transdisciplinary team, which itself served as an example of a successfully functioning system. This chapter examines the implications of this effort within the broader context of recent tobacco control efforts, together with their potential trends toward an integrated systems environment for tobacco control. It then presents the conclusions reached at the two-year point of this ongoing endeavor.

Synthesis: Looking Back and Looking Over the Horizon

The systems thinking approaches studied in this project were selected for reasons beyond their future applicability to tobacco control. In a very real sense, they were seen by the principals of the project as self-evident trends that already are starting to evolve in tobacco control and public health. Moreover, they are not simply islands of automation taking place in isolation. They are part of a consistent trend that tracks throughout the recent history of tobacco control efforts.

Starting with the release of the 1964 Surgeon General's report on smoking and health,[4] efforts to improve public health by controlling tobacco use evolved from

interventions aimed at the individual[5] to community-based interventions such as the Community Intervention Trial for Smoking Cessation (COMMIT) and the American Stop Smoking Intervention Study for Cancer Prevention (ASSIST), both funded by the National Cancer Institute (NCI). COMMIT focused on resources for education, health care, and smoking cessation,[6–9] and ASSIST focused on policy-level interventions such as taxes and legislation.[10,11] Interventions that address elements of the tobacco control problem as an interrelated system are a logical next step in the process, supported by recent successes in applying systems approaches to other areas such as business and defense.[2,12] Figure 8.1 tracks this evolution in tobacco control strategy and its correlation with evolution toward increasing use of systems methods in tobacco control methodology.

These trends lead to a core argument for the future of systems thinking in tobacco control. It is clear that tobacco control is using systems methodologies at increasing levels over time, but much greater benefits would be derived from *using them in a consistent, self-conscious, and methodologically integrated manner.* The most efficacious direction would be promotion of greater integration of systems approaches applied to the complex problems of tobacco control and public health.

Even in the absence of efforts such as this project, these trends toward application of systems methods to tobacco control would continue to boost use and importance. Focusing the work of stakeholders on collaborative use of these systems approaches would create an environment that drives further integration of these methods. Table 8.1 shows examples of recent efforts to apply systems methods to tobacco control. (For more information about any of the programs or references in table 8.1, see chapters 2 and 3.)

Figure 8.1 Trends over Time in Tobacco Control Strategy and Methodology

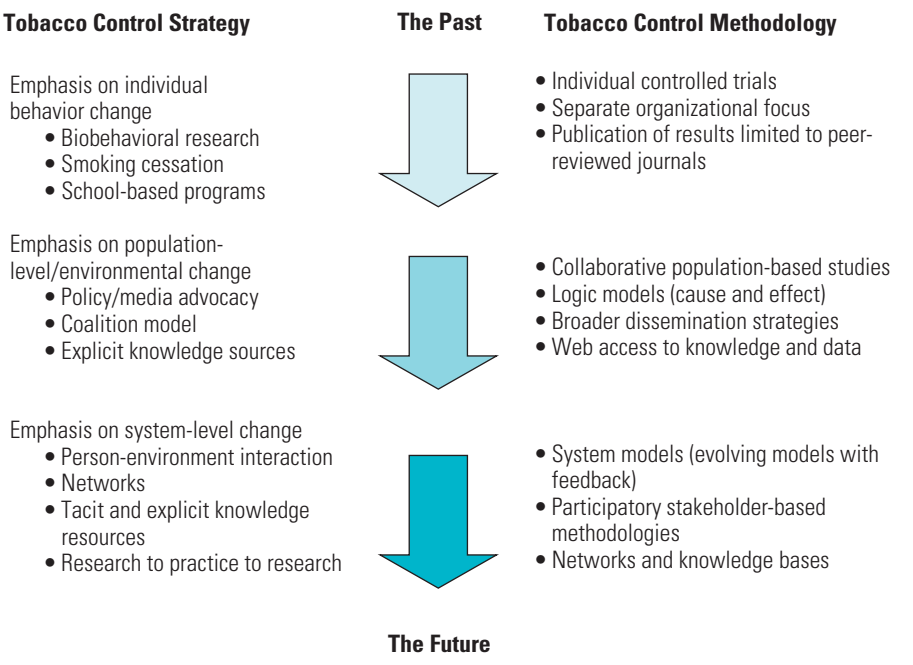

Table 8.1 Examples of Recent Systems Efforts in Tobacco Control

Systems methodology	Tobacco control efforts
Systems organizing Managing and leading as a system	▪ Mapping Integration of Research and Practice Project ▪ State and local SoTC mapping project ▪ Projects on CDC's Environmental Public Health Indicators
System dynamics Modeling and understanding dynamic change	▪ SimSmoke simulation model of prevalence and consumption[a] ▪ Prototype simulation modeling effect of tobacco control on health outcomes in morbidity and mortality due to lung cancer[b] ▪ Tracking evolution of SoTC versus strength of tobacco industry countereforts over time
System networks Understanding and managing stakeholder networks	▪ Global Tobacco Research Network ▪ Tobacco Harm Reduction Network ▪ Tobacco Surveillance Epidemiology and Evaluation Network ▪ Transdisciplinary Tobacco Use Research Centers ▪ Cancer Intervention and Surveillance Modeling Network ▪ Prevention Research Centers
Systems knowledge and its management Managing content and infrastructure for explicit and tacit knowledge	▪ Community Guide project ▪ Cancer Control PLANET dissemination effort ▪ CDC TIPS Smoking and Health databases ▪ Tobacco Technical Assistance Consortium

Notes. SoTC = Strength of Tobacco Control; CDC = Centers for Disease Control and Prevention; PLANET = Plan, Link, Act, Network with Evidence-based Tools; TIPS = Tobacco Information and Prevention Source.

[a] Levy, D. T., F. J. Chaloupka, J. Gitchell, D. Mendez, and K. E. Warner. 2002. The use of simulation models for the surveillance, justification and understanding of tobacco control policies. *Health Care Management Science* 5 (2): 113–20.

[b] Karash, R. 2003. Applying systems thinking to tobacco control. Minutes of the 1st ISIS Systems Thinking Summit, Washington, DC.

The tobacco control community increasingly faces the limits of using systems approaches such as these piecemeal as individual components of a tobacco control strategy. Each of these approaches addresses a need, and their implementation in tobacco control borrows to some extent from the existing processes. For example, members of the ASSIST evaluation team participated in creating a logic model for systems evaluation as part of the strength of tobacco control (SoTC) measure of state-level tobacco control efforts.[13] In addition, NCI's Plan, Link, Act, Network with Evidence-based Tools (Cancer Control PLANET) project for cancer control encompasses elements of both knowledge management and networks in providing tools for implementing evidence-based tobacco control.[14] Also, the project on Environmental Public Health Indicators of the Centers for Disease Control and Prevention (CDC) uses participatory methods and development of logic models.[15]

An integrated systems environment, encompassing these elements and more, would extend the reach of all these efforts by providing access to broader stakeholder groups, knowledge, simulation models, and other systems constructs. Promoting an integrated systems environment can lead to a "critical mass" and precipitate action to address and solve even more complex issues and to optimize improvement in outcomes.

A key finding of this investigation is that methodological features can cut across systems approaches. This finding suggests that integration of approaches is feasible and would result in better performance, improved use, and greater efficiency. For example, many systems approaches use structured brainstorming, conceptual mapping, and network analysis techniques that share quantitative methods, such as multidimensional scaling and cluster analysis. In addition, many of these approaches involve creating and maintaining

data in what could become common data environments. These commonalities fall into three areas:

- *Process:* Logistical processes behind the use of a methodology
- *Technology:* Hardware and software infrastructure on which the methodology is implemented
- *Analysis:* Algorithms and analysis techniques that underlie a methodology

Some of the common methodologies across the systems approaches studied in the ISIS project are listed here by the three dimensions of process, technology, and analysis, with an eye toward how they might work together in the future (table 8.2).

Table 8.2 demonstrates a considerable overlap in methodology that, with proper planning and oversight, could form the basis for a more consistent, integrated approach across these and other areas. There has been little recognition of these methodological similarities among the different systems traditions that tend to operate independently of one another. Examples of overlapping methodologies are as follows:

- Concept mapping and some network analysis methods share a common core of quantitative multivariate analyses, such as multidimensional scaling and cluster analysis, and could, in turn, share a common software architecture and computing environment as tools.[16,17]
- Similarly, there is a great deal of procedural overlap between the brainstorming and data-gathering processes in nearly all of these systems approaches. This overlap can pave the way for more integrated use of group processes in tobacco control projects.
- Knowledge management and translation and systems methods share the need to mine and visualize data, as well as similar front-end processes of data gathering.

At a broader level, all these approaches represent mixed methods that share common elements, such as collaboration,

Table 8.2 Common Methodological Elements across ISIS Systems Approaches

Approach	Process	Technology	Analysis
Systems organizing	Concept mapping Structured brainstorming Group processes Data gathering Participant feedback	Data mining Internet use Database management Graphic visualization	Multivariate analysis methods (e.g., multi-dimensional scaling) Clustering methods
System dynamics	Structured brainstorming Group processes Data gathering	Programmable modeling languages Data mining Database management Graphic visualization	Solution of differential equations Fuzzy logic
Network analysis	Data gathering Participant feedback	Data mining Internet use Database management Graphic visualization	Multivariate analysis methods (e.g., multi-dimensional scaling) Clustering methods Data optimization Fuzzy logic
Knowledge management	Data gathering Participant feedback	Data mining Database management Graphic visualization	Data optimization Clustering methods Fuzzy logic

structured processes, algorithms, and data representations. They have both quantitative and qualitative aspects in common, and all approach problems from a systems perspective. As part of an historical trend, they hold the potential for further systems integration around a larger concept that brings all these approaches together. Some examples of this potential integration include the following.

First, combining system dynamics modeling with network analysis may help in understanding tobacco control as an evolutionary process in which some system parts develop more productively than others. Depending on the overall strategy, this understanding can be used to set priorities and allocate resources. System dynamics modeling can indicate where networks might best be strengthened or developed, adapt more effectively, and encourage innovation in the system. Conversely, if strategy dictates, lower priority activities can be redirected or phased out.

Second, combining systems organizing with system dynamics modeling in a new structured form of system modeling with participation of multiple stakeholders can lead to other benefits. Currently in system dynamics modeling, it is typical to begin with brainstorming for potential elements of the system ("stocks" and "flows"). (See chapter 5 for definitions.) These elements usually are grouped or categorized, either by the analyst or by the group as a whole. Structured methods could be used, as in concept mapping, to enable each participant to organize the system dynamic model components individually. Subsequently, these components could be algorithmically or statistically combined into a group model that would enable exploration of stakeholder perspectives.

Third, system dynamics modeling can be combined with knowledge management to access existing knowledge in a particular area or for horizon scanning to understand emerging developments in areas of interest. These techniques also can assist in exploring topics not previously integrated with understanding or practice. For all stakeholders, this combination helps in understanding the options that are so important in developing strategy.

Fourth, combining network analysis and knowledge management has the potential to lead to a better understanding of unknown areas by confirming gaps in knowledge where no one has ventured. This understanding can be used to develop research agendas relevant to multiple stakeholders or to advance strategy development. Work in this area may uncover useful knowledge from networks that cross into other disciplines less directly related to tobacco control, such as public health factors that are concomitant with tobacco use. Importantly, this is an approach for eliciting and processing tacit knowledge from diverse sources for broader access by many tobacco control stakeholders.

Finally, combining all four approaches would promote a shared strategy that recognizes tobacco control as an adaptive system. The strategy should help to guide new ideas toward acceptance and implementation, rather than waiting for natural evolution driven by external processes or trying to impose such concepts through brute force. This project serves as one example of providing explicit, accessible, and transparent processes to engage stakeholders at all levels in "big picture" thinking. The challenge from here will be to develop a vision that is coherent across the entire tobacco control system while promoting locally relevant and tailored missions and actions.

General Conclusions

The confluence of trends suggests that systems thinking as an organizing paradigm

in public health is increasing. The signs are everywhere: the Institute of Medicine's report, *Crossing the Quality Chasm: A New Health System for the 21st Century*[18] in the field of medicine; the evolution of the Santa Fe Institute and the study of complexity;[19,20] the move to systems approaches in the management of large public[12] and private[2] organizations; and the popularization of the idea of chaos and the possibility of unexpected effects of small changes in initial conditions.[19,21] Systems approaches help in grappling with complexity, interconnectedness, rapid change, and uncertainty. The intent of this monograph is to break similar ground for tobacco control and, by extension, to demonstrate the value of systems approaches for the entire public health profession.

Tobacco control constitutes an ideal public health test laboratory for systems approaches. By its very nature, tobacco control needs to be adaptive and ecological and involves complex relationships among a profit-making industry marketing an attractive, addictive, and harmful product; the public health profession; and the population. The details of this complex relationship are constantly developing and are not always fully understood. Systems approaches can elucidate these relationships at a level that guides policy and practice and, more significantly, their evolution.

Perhaps most important, systems thinking contributes to a better understanding of an environment in which the results of single interventions frequently have unforeseen and unintended negative consequences. For example, bans on tobacco advertising may have helped to create a climate in which tobacco firms have taken a lead in sophisticated and highly effective cutting-edge marketing techniques that embed their products in movies, magazine articles, and television programs. Such techniques are much more difficult to regulate and now are used throughout the private sector.[22,23] As another example, dependence on tobacco settlement funds may have influenced the passage of state laws that, in the eyes of some people, defend the competitive interests of major tobacco companies.[24] Systems methods hold the promise of an environment in which effects and countereffects could be more accurately modeled over time, across all affected stakeholders.

Chapter 3 presents the fundamental argument for applying systems methods to the complex issues that stand between stakeholders and improved health outcomes. Here, a roadmap for putting these ideas into practice is presented. The first two years of the ISIS endeavor and reflection on both the outcomes and future directions of systems thinking efforts lead to some initial conclusions about desirable directions for systems thinking in tobacco control specifically and public health more generally. These conclusions, developed as part of a group process in the ISIS innovation team, revolve around the four broad approaches under study in ISIS—systems organizing, system dynamics, system networks, and knowledge management—along with a complementary set of crosscutting recommendations intended as short-term action items. Table 8.3 outlines these conclusions.

The conclusions can be viewed, in the spirit of complex adaptive systems, as "relatively simple rules [that] can lead to complex innovative systems behavior,"[18(p64)] if followed by the tobacco control community in the framework of the four core approaches under study in ISIS. These conclusions are not intended to be an exhaustive list of potential systems efforts but to link synergistically to form an interdependent, systems-based environment for future tobacco control efforts. These system efforts mirror current philosophy in systems thinking on three fronts:

Table 8.3 Initial Conclusions about Directions for Systems Thinking

Approach	Directions
Systems organizing Encouraging transformation to systems culture	▪ Encourage ongoing evolution of vision and paradigms ▪ Foster a systems thinking learning environment ▪ Nurture discussion about shared purpose ▪ Remove barriers to adopting systems thinking ▪ Engender systems leadership
System dynamics Developing and applying systems methods and processes	▪ Encourage and reinforce systems thinking theory and research development ▪ Foster mixed-methods systems thinking ▪ Conduct participatory assessments of systems needs ▪ Encourage ecological perspective on implementation ▪ Foster systems evaluation
System networks Building and maintaining stakeholder relationships	▪ Create multijurisdictional and multilevel networks of stakeholders for systems thinking and action ▪ Study networks of stakeholders to determine their dynamics and effects ▪ Encourage a transdisciplinary approach by fundamentally linking specific disciplines ▪ Prepare for the impact of demographic change
Systems knowledge management and translation Building system and knowledge capacity	▪ Build capacity for systems thinking ▪ Expand public health data to enable systems analyses ▪ Integrate information silos through development of cyberinfrastructure ▪ Foster skills and culture to affect processes and outcomes ▪ Create knowledge-translation networks
Crosscutting conclusions	▪ Create networks of excellence for systems thinking in public health ▪ Develop a Web presence for systems methods in tobacco control ▪ Foster development of systems organizing ▪ Link with systems knowledge in other fields ▪ Develop a systems curriculum in academia ▪ Create a leadership program ▪ Organize a national association and a regular national conference on systems thinking in public health ▪ Remove organizational barriers and build capacity ▪ Link with local efforts

1. They represent the key areas seen as current "gaps" in successful implementation of the kind of systems thinking environment that will lead to substantive improvements in health outcomes in tobacco control.
2. They work in concert to produce improvements in outcomes and are much less effective alone.
3. They provide the needed infrastructure and practice guidelines that underlie an ecological environment for adaptively solving complex issues in tobacco control.

In addition, these areas represent a logical evolution in perspective on the broader field of tobacco control (as outlined in chapter 2). From the 1980s, when NCI's COMMIT represented an aggressive community-level intervention effort with modest results, to the late 1990s, when projects such as ASSIST focused

on population-level policy interventions, there is a clear trend toward intervening at the system level. This trend could be seen in terms of an epidemiological model, as described in chapter 2. The original ASSIST conceptual framework for tobacco control interventions (see chapter 2, figure 2.1) was published in NCI's Smoking and Tobacco Control Monograph 1—*Strategies to Control Tobacco Use in the United States: A Blueprint for Public Health Action in the 1990's*.[5] This "blueprint" proposed application of policy and other interventions across multiple channels to affect outcomes across the target populations.

This framework, which borrows conceptually from earlier representations by epidemiologists such as Sackett and associates,[25] now is nearly 15 years old. Nevertheless, it foresaw an environment in which tobacco control interventions needed to be considered in an interdependent context, pulling together the efforts of multiple stakeholder groups. In subsequent years, such an environment found its way into a broad range of tobacco control and public health efforts, to the point that it is becoming the norm for major initiatives. Examples include the following initiatives:

- The PRECEDE/PROCEED framework for the systematic development and evaluation of health education programs[26]
- Participatory tobacco control research and planning efforts with multiple stakeholders at the state and federal levels[27,28]
- The Transdisciplinary Tobacco Use Research Centers (TTURCs) initiative that established transdisciplinary tobacco control research centers at several major universities through a partnership of public and nonprofit entities[29]

Today, the efforts embodied in ISIS point toward a similar multichannel approach at multiple levels, combined with the growing realization of the need for linkage among researchers, practitioners, community-based resources, and other stakeholders, in all phases of tobacco control and public health. ISIS extends the ASSIST framework from a "push" model for interventions, for example, one that is applied to targeted channels from a central source to a systems-level model engaging all stakeholders throughout the entire research–practice continuum of tobacco control.

Specific Conclusions

ISIS is among a growing group of innovative efforts that address complexities in improving public health. Realizing the promise of improved public health outcomes in a more complex, adaptive environment requires a fresh look at how future efforts in tobacco control are conceived, funded, and executed and at the fundamentals of learning and organization. This section presents conclusions from each of the four core areas of the ISIS project, as well as a set of crosscutting conclusions. Within each of these areas, a discussion of the topic area is followed by the formal conclusion listed in italics.

Systems Organizing: Encouraging Transformation to Systems Culture

The shift to systems thinking involves a new look at what it means to "manage" tobacco control or public health efforts. If the public health system is a type of complex, self-organizing endeavor that requires different individuals, groups, and organizations to agree to coordinate efforts in some contexts and work independently in others, then traditional management models that were designed for top-down hierarchical organizations will not be appropriate for all circumstances. The move from the traditional notion of management to one of systems organizing

is not a rejection of top-down management, but rather an envelopment of it. Such a change requires an understanding of the kinds of management challenges that can be organized centrally and the kinds that require facilitation of participatory and collaborative organizing. This section describes some of the major implications of this shift from managing to organizing.

Encourage Ongoing Evolution of Vision and Paradigms

Systems thinking about tobacco control, and especially the goal of achieving better integration of research and practice, represents not only the application of new areas of research but also a new way of thinking about the process of research itself. This type of shift in thinking already is taking place in other areas such as defense, business, and technology.[2,12,30,31]

A key facet of this shift involves moving past a view of systems thinking as an assortment of methodologies toward a bolder vision and more robust approach for changing the conduct of research and practice. Reaching this new vision will take foresight and a willingness to change the status quo, ranging from the activities of individual tobacco control stakeholder groups to fundamental assumptions in areas such as infrastructure, funding mechanisms, and collaboration. In a system that does not have centralized, top-down control, it is important to develop and continually evolve a common vision. This vision will never be static and will continually be pressured from all sides to adapt to the interests of some of the participants. Nevertheless, this vision development is an essential forum for communication throughout the system and for system learning.

Support for ongoing examination of systems thinking and its implications for the entire paradigm for tobacco control and public health is required to adapt a new vision for the future.

Foster a Systems Thinking Learning Environment

The systems learning environment has been described as "continually expanding its capacity to create its future."[2(p14)] The art of learning itself has evolved as society has moved in a systems direction. To take full advantage of this evolution, the learning paradigm itself must continue to change. Over time, this paradigm has moved away from the simple model of transferring static knowledge from teachers to learners and toward a more ecological approach in which teams of people adaptively pursue and discover knowledge in an atmosphere of experimentation and feedback. Similarly, an environment can be foreseen in which tobacco control stakeholders can explore and model issues in an interactive way that will lead to a broader knowledge base, better solutions, and improved health outcomes.

Today, the seeds of this type of systems learning environment in public health can be seen in efforts such as the Roadmap for Medical Research initiative of the National Institutes of Health,[32] which fosters a transdisciplinary learning approach to biomedical research, and CDC's applied research training programs for public

Creating "What If" Laboratories

There is a strong analogy between a systems learning environment and the way innovation has accelerated over time in the private sector. For example, companies built and tested products linearly in the past. Today, however, design teams can use computer-aided design and manufacturing tools as virtual laboratories in which countless "what if" questions can be explored long before hands are put on a manufacturing tool. The result is an acceleration in the pace of product design. This ability to learn iteratively, with feedback, is the hallmark of both systems thinking and contemporary process innovation.

health professionals. At a deeper level, this direction is taking shape in areas such as increased cross-agency research teams and even a proposed integration of transdisciplinary academic programs for research.[33] Such steps point to a larger trend toward leveraging a system, rather than individual expertise, in the processes of learning and discovery.

Systems learning environments must be encouraged at several levels: within the universities that train future public health professionals, within whole-of-life education, and in the course of daily life within existing research and practice environments in tobacco control. This process will involve engaging stakeholders within academia, government, professional practice, community, and the private for-profit and not-for-profit sectors. The further methodological development of systems learning environments themselves also is required. The outcome of such environments will change the process of learning and will be part of a process that facilitates the carrying capacity to tackle increasingly large and complex issues.

Nurture Discussion about Shared Purpose

Ultimately, the measure of ISIS's success will be an increased mass of stakeholders sharing this new perspective of systems thinking. How could this process be accelerated to reach the "tipping point"[34] of a new paradigm? One could envision a process, for example, in which nodes of practitioners, scientists, and policy analysts who use systems thinking create knowledge-translation networks (KTNs) around specific topics, work together through better networking techniques, adopt emerging software technologies to manage shared knowledge, and use system modeling techniques to define priorities and scope of work. Will such an ecological approach become the new landscape of tobacco control? In some sense it already is. Research efforts like the TTURCs and an increased emphasis on community-based participatory research are pioneering many of the systems thinking approaches emphasized here. A key in such efforts is to work toward developing a strong shared purpose, marrying the promise of systems approaches with the passion of those who toil for tobacco control.

Nurturing discussion about shared purpose is the beginning of building the foundation for all other strategic discussions.

Remove Barriers to Adopting Systems Thinking

Among the most difficult aspects of moving toward a systems model are the functional and structural barriers in today's tobacco control environment. These include a lack of coordination across stakeholders, a lack of infrastructure for using participatory approaches to problem solving, silos of information, and cultural barriers ranging from how research is funded to expectations for gaining tenure in academia. Removing these barriers will require a broad, collaborative effort, and in some cases, a greater openness to transformative change.

Some of the precursors of such a collaborative systems thinking environment already exist in the form of databases linking stakeholders and public and proprietary tools such as the "Web of Science"—a commercial database linking transdisciplinary research citations across major journals.[35] Precursors also exist in the growth of online communities and information resources and in the growing use of multiple stakeholders in planning and evaluation. Much as tools such as these were forged in response to past barriers, the systems environment of the future will continue to evolve. Understanding existing roadblocks will help guide this evolution in a more productive manner.

An open, honest examination of the practical barriers to systems thinking will be a key

and necessary component of implementing a systems thinking environment.

Engender Systems Leadership

Traditional management theory is evolving over time to encompass a more ecological, participatory approach both within and between organizations. This trend is examined in greater depth in chapter 4. The skill set of the systems leaders must evolve from the emphasis on managing to one of facilitating and empowering, from organizing to self-organizing, from delegation to participation, and from discrete evaluation to continuous evaluation.

The public health field should actively develop and implement education and training that encourage this evolving view of leadership and should investigate how to provide career incentives and rewards for such leadership.

System Dynamics: Developing and Applying Systems Methods and Processes

Many of the systems approaches and traditions that evolved over the past half-century show great promise in specific applications. However, it has been only in the past 10–15 years that the potential for a broader view of systems that encompasses and integrates these varied approaches has been seen—both computationally and methodologically. Component technologies such as dynamic models and simulations, stakeholder networks, knowledge bases and information infrastructures, and participatory and systems organizing methods have begun to emerge. Nevertheless, their integration into common methodologies for practice remains at an early stage. ISIS represents an important marker in what promises to be an ongoing development process for systems methods and processes. Specific conclusions reached in this area are presented here.

Encourage and Reinforce Systems Thinking Theory and Research Development

The research efforts funded by ISIS are early steps in an important direction for tobacco control and for public health in general. To see these efforts to fruition, further development in the theoretical basis and research methodology behind systems methods is required, together with the resources and infrastructure, strategic planning, and decision making needed to achieve this goal. Today, individual components of a systems approach are having an impact on tobacco control and public health. These efforts include the following:

- Early simulation of model outcomes such as reduced prevalence of tobacco use and consumption of tobacco products
- Involvement of stakeholder networks such as the Global Links program for sharing surplus surgical materials[36] and the Global Tobacco Research Network
- Harnessing the input of stakeholders for planning purposes through approaches such as concept mapping and creation of integrated tobacco control knowledge bases

Moreover, integrative efforts such as NCI's Cancer Control PLANET show the value in linking knowledge and stakeholders together with tools and methodologies. At the same time, consensus has not been reached regarding what an integrated systems environment for the future might look like.

Expanded development of systems thinking theory and research methods in tobacco control and public health is critical to achieving a consensus and, thus, substantially improved public health outcomes.

Foster Mixed-Methods Systems Thinking

Throughout the ISIS project, polarities in systems thinking were discovered: between reductionist and holistic theories, between qualitative and quantitative approaches, and between views on "soft" systems and

"hard" systems. For example, examination of systems approaches ranged from quantitative (simulation-based) techniques such as system dynamics modeling and network analysis to participatory and ecological approaches such as concept mapping, community-based participatory research, and "soft" systems methods.

An important conclusion from these efforts is renewed appreciation of the broad range of systems approaches and their role in the mosaic of solving complex issues in the future. A numerical simulation may provide answers that were previously hidden, and so might a self-adaptive process involving multiple levels of stakeholders. Different systems traditions have advantages in different situations, and many might be usefully integrated or used in concert.

Stakeholders at all levels can leverage formal network concepts to understand and manage their own strategic alliances, referral patterns, growth prospects, and even succession planning to replace and continue their efforts. They can use systems concepts to move from the cynical motto that "Today's solution is tomorrow's problem" to a more strategic understanding of complex environments. Stakeholders can harness their tacit knowledge in an environment in which subjective influences, such as perception and intention, shape behavior as much as objective influences. Above all, they can use mixed methods for a deeper understanding of cause and effect as well as barriers and facilitators, helping them to analyze leverage points and priorities for action.

A mixed-methods systems approach should be encouraged and developed to more effectively address the multiple facets of complex problems.

Conduct Participatory Assessments of Systems Needs

Research and practice have evolved away from a top-down process of proposed solutions to problems toward a more dynamic process of understanding needs and working collaboratively to fill them. Many systems approaches, such as concept mapping or community-based participatory research, have the roots of their philosophy and methodology in a process that engages stakeholders to establish needs and evolve solutions.

Formalized and structured assessment of systems needs must be a cornerstone of future systems efforts and of the public health endeavor as a whole.

Encourage Ecological Perspectives on Implementation

An ecological perspective recognizes the interrelatedness of the components in the environment. In systems implementation, one example of such a perspective is "environmental scanning." This phrase, popularized in the private sector, refers to the ongoing process of observing the macroenvironment and making strategic changes based on these observations. In a tobacco control context, it constitutes a more active, interdependent, and less procedural approach to observing and reacting to factors in the environment.

The ecological approach lies at the heart of systems thinking in that it encompasses the ability to evolve according to observation and feedback. This cybernetic view of the world already has shown results in areas such as the concept of "shared situational awareness" in national defense, in which a networked force that shares information in a self-synchronizing manner has demonstrably led to greater effectiveness with smaller fighting forces.[31] In public health, it serves as a logical next step in a field that has progressed from disease control, to prevention, to cause-and-effect intervention, and now toward working systemically to affect health outcomes. Such an approach does not reject a reductionist (single-discipline) approach to

Dynamic Program Development and Evaluation Databases

The past 50 years have seen the rise of the computer and the accompanying development of databases that store critical information. In evaluation, those asked to provide data often complain that evaluation is a task they are required to do and that they get little in return for such efforts. Funders and decision makers wonder why their grantees resist evaluation and do not make use of its results. Systems thinking and approaches are beginning to change these dynamics. This can be seen, for example, in the data system used at Amazon.com, the online bookstore. Regular users of that Web site discover that when they browse for a particular book, they are given suggestions about other books that were purchased by people who also purchased the book of interest. When the user makes a purchase, this information is stored and other purchases are linked to it in a type of information network. This type of dynamic database principle adds value for all the users and enables linkages that previously were not possible.

These principles can be applied to evaluation databases. For example, imagine a Web site for designing a local tobacco control program. Users would enter descriptions of the programs they are thinking about, and its activities, outputs, and outcomes. The program could print a logic model based on the input. That is a static database application. It might be used, but it does not add much value, and it does not provide users with much incentive. However, imagine if the Web site was designed so that information from others could be provided to users as they enter their own program ideas. If users enter in a few keywords such as "local clean indoor air regulations," the program might show them what others who previously designed such programs had done, how they had managed their campaigns, and how they evaluated results. Researchers who visit the site would be able to learn about what ideas local tobacco control people are searching for, could link in relevant evidence, and could identify potential practice sites for collaboration. Funders could see how interests are evolving and could provide funding as an incentive in real time. By the time users are finished designing their programs, they would be informed by other practitioners' experience, would know the relevant evidence base, could have some potential evaluative tools and measures, and might have a lead on potential research and funding collaborations.

Many of these systems thinking principles are emerging in sites like Amazon.com, as well as wiki applications like wikipedia.com. Such dynamic planning and evaluation databases would provide greater incentives for all parties to contribute, thereby dramatically increasing the value of the database itself over time.

science. Instead, it takes advantage of the interrelationships of those theoretical and methodological approaches to address more effectively some of the most difficult public health challenges today.

An ecological approach, including systematic environmental scanning, will become a fundamental paradigm for tobacco control and public health.

Foster Systems Evaluation

Any new direction that may require substantive change in both practice and culture requires a clear appraisal of its effectiveness. The practice of evaluation itself must evolve.

At a deeper level, the increasing connectivity across society is making research in behavioral and social sciences increasingly difficult, because control of one or more variables cannot be ensured. Behavioral and population-specific factors either cause or contribute to the diseases causing most premature mortality, so it behooves the scientific community to ensure that methods to study these factors and intervene appropriately are developed and adapted. This is fundamentally a systems process, and

it further underscores the need to develop evaluation methods for assessing system behavior, such as (1) indirect measures of outcomes and (2) participatory evaluation criteria driven by stakeholders.

A move toward systems approaches requires the further development of evaluation methods that accurately reflect progress toward outcomes, while preserving the energy and innovation of interventions. In the process, it is possible to add a further degree of rigor to the practice of public health, while helping the concept of evidence continue to evolve.

Build and Maintain Network Relationships

Today's tobacco control environment is characterized by a diverse and expansive group of stakeholders at all levels of the process, including researchers, funding agencies, public health authorities, elected officials, community-level organizations, advocacy groups, and the population groups affected by tobacco control interventions. When these groups create their own agendas, the result is not only inefficiency and duplication of effort but also a lack of shared information that in turn could change outcomes. Thus, there is a need to build the important structural connections and collaborations among tobacco control stakeholders and strategies to encourage support for improved health outcomes.

Create Multijurisdictional and Multilevel Networks of Stakeholders for Systems Thinking and Action

The formation of networks that cross levels of action and jurisdiction is one of the most promising and challenging avenues for changing outcomes in tobacco control and public health. Structured collaborations of multiple stakeholders can fundamentally change the direction of efforts and outcomes. Strategies such as face-to-face meetings of researchers, policy makers, practitioners, and clients and collaborative interaction through group processes such as concept mapping are essential for addressing the significant gaps between research and practice.[16] Such approaches also have relevance to public health more generally. For example, the disconnect between research and practice is considered to be a root cause of the slow diffusion of successful cancer treatments.[37]

Creation of multijurisdictional, multilevel stakeholder networks holds the potential for enhancing the ability of tobacco control stakeholders to work effectively and achieve breakthrough results. Creation of such networks will lead to new research priorities and reexamination of the funding and career issues that drive current tobacco control research. Moreover, such a network environment represents a new infrastructure for future tobacco control practice, giving voice to a system of participants that, in turn, will continue to evolve with changes in tobacco control and public health.

Study Networks of Stakeholders to Determine Their Dynamics and Effects

The promise of having tobacco control stakeholders operate more effectively in a network environment brings with it a concomitant need to explore the dynamics of these networks and evaluate their effects, ranging from formative evaluation such as exploratory research and concept testing to ongoing process evaluation. Some of these areas will involve new approaches to evaluation. In addition, ancillary outcomes such as cost-effectiveness, time-effectiveness, and dissemination of results may be important areas for further study.

The evolving networks of stakeholders should be actively encouraged, and evaluation of networks should be an integral part of planning for a network environment within tobacco control.

Encourage a Transdisciplinary Approach by Fundamentally Linking Specific Disciplines

The evolution of public health over the past century has increasingly engaged multiple disciplines. Therefore, today's tobacco control environment includes a broad range of experts such as clinicians, psychologists, epidemiologists, and mathematicians. The complexity of future tobacco control issues will likely require insight and expertise from multiple disciplines. These disciplines must work collaboratively to build a common base of understanding and knowledge. Moreover, the systems environment of the future will move from collaboration to integration. Disciplines such as these have become part of the overall mosaic of fields including tobacco control and public health.

Transdisciplinary approaches are a key component of a systems approach to tobacco control. The systems, networks, and knowledge infrastructures that evolve within this field should explicitly encourage integration of multiple fields of knowledge.

Prepare for the Impact of Demographic Change

Demographers make dire predictions about future shortages of human resources. There is a scarcity of skilled personnel in many areas of tobacco control. As in the good old days, key informants describe hard-to-fill vacancies and staff turnover affecting programs throughout the United States. From a systems perspective, retaining organizational memory and sharing tacit knowledge can help to protect tobacco control agencies in future demographic transitions.

Systems thinking can help to mitigate the impact of demographic change by generating feedback about performance, developing workforce skills, improving teamwork, and ensuring that services are coordinated with other agencies.

Knowledge Management and Translation: Building System and Knowledge Capacity

If a systems environment were adopted within tobacco control tomorrow, what tools would people use? How would they collaborate? What mechanisms exist for linking stakeholder efforts? How would their knowledge be disseminated? These questions all touch on the area of building capacity: creating tools and procedures that underlie the adoption of systems methods across stakeholder groups within tobacco control.

Build Capacity for Systems Thinking

A clear analogy exists between the systems environment envisioned today and the computer and Internet environment envisioned more than a decade ago. In the 1980s and 1990s, a diverse range of tools and research efforts across the public and private sectors ultimately coalesced into the integrated computer and network environment that is taken for granted in the twenty-first century. Systems thinking requires the same coalescence. This capacity development must itself be a systems-oriented effort by multiple stakeholders. Moreover, to gain public acceptance, this effort will need to engage the private sector to develop systems tools that have ongoing commercial potential in broad areas beyond tobacco control and public health.

Efforts to develop tools for systems and knowledge capacity must move forward together and proceed with an eye toward stronger standards and improved tools as systems methods are more widely adopted across many of society's areas of endeavor.

Expand Public Health Data to Enable Systems Analyses

Methods for systems thinking involve a move away from linear, top-down modes of action toward models that assess, interpret, react to, and incorporate feedback

at multiple levels. Bringing such an environment to reality requires access to timely accurate data to support decisions at multiple levels. Examples of expansion of public health data include measures of the impact of social and political interventions, such as the Strength of Tobacco Control and the Initial Outcomes Index used in the recent evaluation of the ASSIST program.[13] In addition, health outcome data have been expanded in areas such as prevalence of tobacco use, consumption of tobacco products, and morbidity and mortality at the population and community levels.

The analysis and delivery mechanisms for public health data need to be evaluated in the light of a growing systems thinking environment and implemented in a way that supports this environment.

Integrate Information Silos Through Development of the Cyberinfrastructure

The current environment of multiple stakeholders in tobacco control involves multiple silos of explicit and tacit knowledge. Creditable efforts are under way to provide integrated knowledge resources in tobacco control. These efforts include CDC's Tobacco Information and Prevention Source, a central online clearinghouse for published documents on tobacco control research; CDC's State Tobacco Activities Tracking and Evaluation System; and NCI's Cancer Control PLANET, which supports evidence-based tobacco control practice with links to data, tools, and resources.

The trend toward increased knowledge translation and transfer must continue as an important part of the infrastructure for systems thinking efforts in tobacco control. Further integration of stakeholder resources and information is clearly indicated in the future.

Foster Skills and Culture to Affect Processes and Outcomes

Capacity building for systems approaches to tobacco control involves much more than tools and data. Beyond this narrow slice of "capacity" is a multidimensional environment. This environment ranges from an organizational infrastructure that fosters collaboration and change to a culture that supports working as a system, for example, examining the processes for tenure and for research grants to encourage bridging multiple disciplines and stakeholder groups.

The human side of knowledge capacity must be addressed as organizations critically examine how to build the skills and learning culture needed to affect both the processes and outcomes of tobacco control.

Create Knowledge-Translation Networks

Participative approaches and involvement of colleagues are essential for building capacity. A knowledge-translation network could formalize and focus other networks so they can benefit from planned development. It would become the vital third leg of a three-legged stool, balancing the evidence base and progressive practice. Knowledge-translation network activities could include "better practice" colloquia, focus groups to share tacit and explicit knowledge, and collaboration on specific issues. In the long run, theory-driven exploration of better

Beyond Islands of Knowledge: ISIS Knowledge Review at NCI

The review of knowledge management undertaken as part of ISIS at NCI underscored the strategic importance of knowledge and a growing trend to make this knowledge accessible to a broader range of stakeholders. More important, the review provided a framework for understanding the gaps in current knowledge capabilities by exploring the scope of explicit and tacit knowledge in key areas, such as policy, evidence, experience, and contact, and by outlining the start of an action plan to fill these gaps through an integrated and planned knowledge environment.

practice also can benefit from the evolving KTN, which provides an environment for practitioners to "drive the evidence."

Knowledge-translation networks need to be developed to encourage greater integration of practice and research.

Crosscutting Conclusions

The conclusions presented here represent broad areas of effort and activity designed to accelerate an evolutionary process that already is beginning to take place in tobacco control and in public health more generally. The implementation of systems-level concepts in practice remains an area for future study. However, a number of crosscutting steps would provide a basic foundation for future systems activity. Below are near-term actions that flow from these conclusions.

Create Networks of Excellence for Systems Thinking in Public Health

The tobacco control community would benefit from development of several multidisciplinary, cross-institutional networks designed to promote systems thinking. These networks could be based on the notion of "centers of excellence." However, they would differ in that the efforts would be explicitly collaborative, that is, not based in a single institution (e.g., a specific university or organization). The networks should be dedicated to the study of systems thinking in tobacco control specifically and in public health generally. Multiple networks of this type are needed to encourage more rapid evolution and to foster a healthy sense of competitiveness. These networks should promote accelerated implementation of systems thinking theory and research development in areas such as the following:

- Encouraging development of new methods
- Exploring integration of existing methods
- Performing research on research methodology itself in areas such as systems methods, applications, and evaluation
- Researching better practices for participatory action research and systems leadership

Develop a Web Presence for Systems Methods in Tobacco Control

Systems methods are fundamentally participatory in nature. The Internet has emerged as a core medium for interaction, participation, and transfer of knowledge. The intention of this effort is to not end only as a report or monograph such as this one but to continue as a living, evolving process with one or more homes on the Internet.

Foster Development of Systems Organizing

There is a critical need for processes that bring in the diverse range of stakeholders in tobacco control, public health, and related areas and create a framework for their collaborative effort. Existing partner networks and collaborations stand to gain considerably by pursuing such joint efforts within an appropriate infrastructure. Through closer collaboration among stakeholders, the tobacco control stakeholder community will help create the conditions for emergence of more complex and effective systems in tobacco control.

Link with Systems Knowledge in Other Fields

Systems thinking is evolving rapidly, but much of that knowledge is diffused across a broad spectrum of disciplines in everything from physics to ecology. Within these disciplines, a great part of the systems discussion is buried in local technical language and conventions, making it less accessible to other disciplines. Strategies must be developed to tap into and understand the emerging systems thinking in other disciplines. One promising and relatively inexpensive option would be to

seek approaches for tobacco control and public health to become structurally engaged with existing groups and organizations that explicitly encourage cross-disciplinary translation and understanding. Networks or collaborations in tobacco control are likely to be more effective than individuals in the field in eliciting an entré into established transdisciplinary endeavors.

Develop a Systems Curriculum in Academia

Much as the computer revolution was fueled by a fresh generation of newly educated technology and software experts, the systems environment of the future will be strongly aided by upcoming graduates of public health and related areas. With input from deans and administrators in public health programs, particularly at the graduate level, a curriculum addressing both component areas of systems approaches and their integration can help make this environment part of the reality of public health. An exciting recent development along these lines is a proposal of the Australian National University and the Australian Commonwealth Scientific and Research Organization for a joint institute for research integration[33] to serve as a prototype for future programs on integrative theory and methods in public health and other areas.

Create a Leadership Program

Encouraging the development of a new generation of leaders who can function in a collaborative systems environment is one of the most important short-term tasks for the adoption of systems approaches. Individuals must possess an unusual set of talents, together with a wealth of new skills and tools, to be effective systems leaders. An early priority should be to identify potential leaders and to nurture them through a broad program of education and experience. Stakeholders need to include recognized leaders in the field defining the characteristics, designing the program, and mentoring prospects.

Organize a National Association and a Regular National Conference on Systems Thinking in Public Health

A regular forum encompassing a broad range of stakeholders can become an important part of the collaborative process and transfer of knowledge that underlie a systems approach in public health. Possible benefits of such a conference include the following:

- Creating a collaboration for systems thinking in public health that integrates existing groups such as the Syndemics Network and ISIS and provides a broader venue in tobacco control to engage people
- Increasing the linkages between systems thinking groups and stakeholders in tobacco control and public health
- Encouraging systems thinking in public health communities and vice versa
- Establishing areas of common ground
- Forming special interest groups

Remove Organizational Barriers and Build Capacity

Perhaps the most challenging but potentially fruitful near-term activity is to examine the future roles of major current stakeholders in tobacco control, with an eye toward an enhanced systems environment. The most important roadblocks to a truly collaborative, systems-based approach to tobacco control, such as funding issues, incentives for academic tenure, and organizational and information silos, can be resolved only through collaboration and engagement, as a true systems effort unto itself.

Link with Local Efforts

A core theme of many of the participatory approaches with multiple stakeholders that were studied within ISIS is the importance of community-level participation in tobacco control in all phases of planning, implementation, and evaluation. Local involvement is much more than a lofty

ideal. The disconnection between research and community-based practice has been identified by other researchers as a roadblock to fundamental progress in areas such as cancer and public health.[37–39] Conversely, initiatives such as the recent Community–Campus Partnerships for Health,[40] a formal effort based at the University of Washington in Seattle to link campus research and community public health stakeholders in a participatory environment, represent an important direction for the future. Specific action items in this area include establishment of local pilot projects for future tobacco control initiatives, involvement of community-level stakeholders in planning and evaluation processes, and further linkages of local groups with a broader spectrum of tobacco control stakeholders.

Near-term action items such as these represent tangible next steps that will help translate research into action in creating a systems environment for tobacco control. Taken as a group, these action items are part of an evolution toward larger objectives such as widespread adoption of systems approaches, creation and use of networks, and development of an underlying knowledge infrastructure. More important, they will help the tobacco control profession itself move toward the kinds of stakeholder collaboration and interaction that, in turn, will form a basis for working together more effectively as a system.

Summary

What would people like the world to look like 5 to 10 years from now? If this question is posed to a group of top experts in most fields, a deterministic vision usually emerges: do X, Y, and Z, and a specific outcome will happen. In comparison, the ISIS effort yielded a very different and much more important answer to this question. The vision is of a new and more ecological environment that could potentially allow innovation to flourish as never before. The specific steps leading to improved tobacco control and public health outcomes are not yet known. However, there is a strong consensus on the basics of a process that, if allowed to naturally evolve, could create these steps and in turn dramatically change these outcomes.

Simply stated, with more inputs, more stakeholders, and better evaluation and adaptation, the infrastructure of knowledge, networks, and analysis methods needed for the support of this adaptive environment will be the key to transforming the state of public health in the future. The rubric of "systems thinking" that underlies the ISIS effort is not simply an assemblage of component technologies, such as system dynamics models, network analyses, or knowledge bases. It is instead a philosophy that reflects the basic engine of change in life, whether it is in the form of biology, economic competition, democracy, or nature itself. This rubric has a strong theoretical base and a growing level of implementation in many fields. More important, it is a fundamental shift from much of current research and practice in tobacco control and public health.

Tobacco control provides a case study for exploring the complex interplay of collaborative (e.g., differing tobacco control programs and policies) and competing (e.g., tobacco companies and supporters of tobacco companies) factors, as demonstrated in the system dynamics analysis "shard" presented in this monograph. For example, NCI Tobacco Control Monographs 16[11] (on the American Stop Smoking Intervention Study for Cancer Prevention—ASSIST) and 17[13] (on the evaluation of ASSIST) qualitatively and quantitatively characterize the complex factors that influenced tobacco control efforts within and between states. The analysis presented in Monograph 17 includes a measure called Strength of Tobacco Control (SoTC), which begins to

take this complexity into account. This modeling effort starts to quantify the relationship between tobacco control efforts in the ASSIST states and countervailing influences by the tobacco companies, including their efforts to undermine ASSIST by influencing policy makers at the state and federal levels.

By understanding the interplay of these and other complex factors relative to policy and program implementation—that is, to more fully characterize the complex "system" of tobacco control—the tobacco control community increases its ability to improve public health efforts by anticipating and tracking countervailing influences. This approach could serve as a model for addressing other public health threats such as overweight and obesity and communicable disease.

In conclusion, this monograph demonstrates that the ability to maximize knowledge of and change in such complex systems depends on the ability to (1) improve information tracking and exchange (knowledge management), (2) analyze and implement complex networks, (3) analyze relationships among complex and sometimes competing variables, and (4) understand and implement organizational structures and functions that will improve health practices. There are, of course, additional challenges, but these steps provide the essential foundation of any effective public health effort.

Against this backdrop, systems approaches clearly are a major hope for substantial improvement in health outcomes in the future. Moreover, this trend mirrors fundamental changes in how problems are solved within society as a whole. Much as efficient hierarchical organizations became a fundamental concept in the twentieth century, systems thinking may become a central concept for the twenty-first century. It could fundamentally change the nature of tobacco control and public health and play a key role in addressing a leading cause of preventable death. The conclusions offered here hold the promise of further evolution toward such a systems thinking environment that, in turn, holds the potential to substantially change the state of the nation's health.

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