Understanding Wicked Problems: A Key to Advancing Environmental Health Promotion

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Complex environmental health problems—like air and water pollution, hazardous waste sites, and lead poisoning—are in reality a constellation of linked problems embedded in the fabric of the communities in which they occur. These kinds of complex problems have been characterized by some as "wicked problems" wherein stakeholders may have conflicting interpretations of the problem and the science behind it, as well as different values, goals, and life experiences. Accordingly, policy makers, public health professionals, and other stakeholders who grapple with these problems cannot expect to effectively resolve them by relying solely on expert-driven approaches to problem solving. Rather, they need to acknowledge that wicked environmental health problems are most likely to yield to (1) the application of effective community health promotion skills, (2) a sustained commitment to sound toxicological and epidemiological science, (3) the application of systems thinking, and (4) transparent communication among all stakeholders.

Keywords: *environmental health; health promotion; wicked problems; tame problems; stakeholder involvement*

THE ECOLOGICAL PERSPECTIVE

Health status and quality of life are influenced by a combination of factors including genetic predisposition, the environment and conditions of living, personal action or inaction, and a variety of social and economic factors often referred to as social and economic determinants of health.[1,2] To solve complex public health problems while sustaining their traditional commitment to sound scientific analysis and assessment, researchers and practitioners must realize that problem solving is as much a social and political process as it is a scientific endeavor.

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This ecological perspective is not new. During the 19th century, it was implicit in the development of biological concepts by Darwin and others of the "web of life" and the role of the environment and adaptation in the survival of species.[3] As René Dubos [4] observed,

> Modern man believes that he has achieved almost complete mastery over the natural forces which molded his evolution in the past and that he can now control his own biological destiny. But this may be an illusion. Like all other things, he is part of an immensely complex ecological system and is bound to all its components by innumerable links. (pp. 218-219)

As contemporary environmental health researchers and practitioners have accepted the challenge of solving problems enmeshed in "complex ecological systems" and shaped by "innumerable links," many have found their traditional orientation to problem solving incomplete. That is, a more linear, causal chain of reasoning approach, one that has led to understanding risk factors for cardiovascular disease, the eradication of smallpox, and the development of many life-saving vaccines, yields only part of the information needed to understand complex problems such as brownfields redevelopment or air pollution whose definitions and solutions are entwined in diverse social, economic, political, cultural, and value systems. Ironically, the standard principles of random assignment, control of confounding factors, and experimental manipulation exclude the very conditions, forces, and factors that make the problem what it is.

WHAT ARE WICKED PROBLEMS?

H. L. Mencken said that for every human problem, there is a neat, simple solution, and it is always wrong![5] Those who grapple with difficult health problems complicated by varying scientific interpretations of evidence and by conflicting political, cultural, and economic interests can appreciate Mencken's aphorism. Clearly, not all problems are the same.

In their landmark article "Dilemmas in a General Theory of Planning," Horst Rittel and Melvin Webber made a distinction between two types or classes of problems: "wicked problems" and "tame problems."[6] It is important to note that Rittel and his colleagues chose the term *wicked not* to connote problems as ethically deplorable or in any way reflective of the character, ethics, or values of the community in which a problem surfaces. Rather, they used the term *wicked* to characterize a problem that is illusive or difficult to pin down and influenced by a constellation of complex social and political factors, some of which change during the process of solving the problem. They point out that with wicked problems, the nature of the problem is likely to be viewed differently depending on the perspectives and biases of those with a stake in the problem.

By comparison, problems in mathematics, engineering, and chemistry while certainly complicated and technically demanding are "tame" to the extent that the problems themselves can be clearly delineated (and solved) by experts who produce clear, workable solutions using analytical approaches of their disciplines. Toxicologists assess the potential health impacts of contaminants through toxicological testing programs wherein the route, concentration, and duration of exposure to specific chemical agents (e.g., lead, dioxin, and mercury) are studied in controlled settings. John Snow mapped the sources of drinking water among people who died from cholera in London, which enabled him to determine which well was the source of contaminated water. His analysis enabled him to develop an effective intervention—the removal of the handle of the Broad Street pump.[7]

Table 1. Summary of Differences Between Wicked and Tame Problems

Characteristic	Tame Problem	Wicked Problem
1. The problem	The clear definition of the problem also unveils the solution. The solution is determined according to criteria revealing the degree of effect—goal is achieved fully or partially, outcome is true or false.	No agreement exists about what the problem is. Each attempt to create a solution changes the problem. The solution is not true or false—the end is assessed as "better" or "worse" or "good enough."
2. The role of stakeholders	The causes of a problem are determined primarily by experts using scientific data (e.g., clinical trials).	Many stakeholders are likely to have differing ideas about what the "real" problem is and what its causes are.
3. The "stopping rule"	The task is complete when the problem is solved.	The end is determined either by stakeholders, political forces, and resource availability or a combination thereof.
4. Nature of the problem	The problem is like other problems for which there are scientifically based protocols that guide the choice of solution(s).	Solution(s) to problem is (are) based on "judgments" of multiple stakeholders; there are no "best practices." Every problem is unique and solutions must be tailored.

Four of the factors Rittel and Webber describe that help distinguish tame from wicked problems are especially relevant for environmental health. They are summarized in Table 1.

1. *Disagreement about problem definition*. A wicked problem is one for which there is no immediate agreement by those involved about what the problem itself is. Suppose we had data for a segment of a large metropolitan area that revealed that the residents had disproportionately high rates of chronic diseases, violence, mental illness, and poor school performance. Does each one of those health issues constitute a separate problem, or are they connected perhaps by factors like the absence of, or deficiencies in, preventive services because of poverty? Could it be poor or undernutrition or inadequate housing that places children at risk for lead poisoning? Or unemployment? To what extent are these conditions exacerbated by discrimination? Have well-intended efforts aimed at economic development created environmental conditions that threaten health?
2. *Involvement of multiple stakeholders*. Problems become wicked when stakeholders hold diverse perspectives and do not agree on what the problem is, let alone the solution. For example, suppose residents of a community learn they have been exposed to potentially harmful contaminants produced by a company that is a major source of employment and economic vitality in the community. There are likely to be many different reactions to the news—perhaps fear and outrage by some, suspicion about the veracity of the news by others, and widespread alarm that the company's economic viability and consequently its continuing presence in the community may be jeopardized. During meetings to determine actions to take,

community residents will be joined by stakeholders representing businesses, the media, schools, public health, and elected decision makers. Each is likely to see "the problem" somewhat differently. Because it is a highly charged issue, it is likely to trigger the interest and involvement of stakeholders outside the community as well. With wicked problems like this one, expert opinion and technical skill, although important, will inevitably be insufficient to address it.

3. *Lack of a "stopping rule."* We experience the notion of a "stopping rule" when we try to solve a chess problem or mathematical equation—as problem solvers in these instances, we know when our job is done. Tame problems have accepted, often formal, resolution criteria. In public health, we assume that an epidemic can be "solved" when an effective vaccine has been developed and made globally available and accessible and is used by a vast majority of affected people. For wicked environmental health problems, however, resolution criteria are not clear-cut. Because stakeholders see the problem differently, they may see the range of possible solutions differently too.
4. *Unique nature of wicked problems*. Wicked problems have distinguishing properties that tend to rule out the use of "standard" approaches or solutions (p. 164).[6] Thus, intervention strategies shown to be effective in reducing exposure to a given environmental health hazard in one community may not be appropriate for another community. This may be the case even though the health hazard is the same because each community is uniquely defined by its history and culture; values; and social, economic, and political circumstances, among other things.

For practical purposes, we find it useful to think of wicked and tame problems as two anchors at the ends of a continuum (Figure 1). Problems that possess the characteristics associated with "wicked" problems are more likely to fall toward the top of the continuum. Sometimes, however, a tame problem can become transformed by events into a wicked problem. Consider the problem of severe acute respiratory syndrome (SARS). In mid-February 2003, health officials in China reported 305 cases of atypical pneumonia, later classified as SARS. After initial detection of the problem in China, outbreaks of SARS were documented in Hanoi, Hong Kong, Toronto, Singapore, and Taiwan. These outbreaks were simultaneously countered by a global public health response manifested by the activation of medical experts and epidemiologists, and the implementation of disease control protocols including the swift enactment of isolation and quarantine strategies. About 1 month after detection of the first case, SARS was diagnosed in a woman who had traveled from China to Toronto. One week after that highly publicized incident, the World Health Organization (WHO) issued a global health alert. By July 2003, less than 6 months after the first cases were detected in China, WHO declared the epidemic contained.

Although technically complicated and life threatening, on the complexity continuum, SARS would be closer to the tame end to the extent that it meets all of the criteria for tame problems noted in Table 1. However, as stakeholders became involved with policy issues related to SARS (e.g., reactions of Canadian health professionals, businesses, and political leaders to the WHO advisory limiting travel to and from Toronto and the decision by the University of California, Berkeley officials to turn away 600 Asian students because of concerns that they would expose others to infection),[8,9] this ostensibly tame problem began to slide toward the wicked end of the continuum.

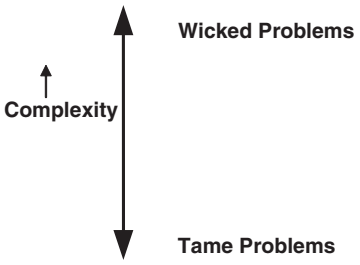

Figure 1. Environmental health problem characterization.

THE IMPORTANCE OF UNDERSTANDING THE DIFFERENCES BETWEEN TAME AND WICKED PROBLEMS

Problems with wicked characteristics are not likely to yield to a problem-solving strategy that is largely expert driven. When we acknowledge the complexities inherent in wicked problems, we are more likely to examine the multiple factors and forces that comprise the problem and seek out stakeholders willing to engage in the problem-solving process. In effect, this process allows wicked problems to be broken into more manageable components, many of which are likely to be amenable to tame problem-solving strategies.

Resolution of tame environmental health problems provides critical information to those grappling with wicked problems. For example, data in the Agency for Toxic Substances and Disease Registry (ATSDR) *Toxicological Profiles*[10]provide information that can help fill technical and public knowledge gaps, which in turn can help strengthen the foundation for community health risk assessments.[11] Similarly, identification of sentinel human health indicators provides crucial information for stakeholders to evaluate health threats in vulnerable communities.[12] Those who work in the area of environmental health rely heavily on the process of *risk assessment*.

Risk assessment is a process wherein environmental health specialists (toxicologists, epidemiologists, biologists, engineers, physicians) gather relevant data to identify serious health hazards and establish realistic goals for enhancing population health by reducing exposure to toxic substances.[13]

Risk assessment consists of four basic steps:

- Hazard identification—review research and literature to identify health problems associated with a potentially hazardous substance.
- Exposure assessment—ascertain the amount, duration, and pattern of exposure to a toxic or hazardous substance.
- Dose-response assessment—estimate the amount of a chemical or toxic agent needed to cause varying degrees of ill health.
- Risk characterization—assess the risk that a given chemical or substance will cause disease or illness in the general population.

Risk assessment provides a basis for understanding what occurs between exposure to hazardous substances and the onset of clinical disease. It also helps risk managers and

community leaders weigh the benefits and costs of alternative strategies for reducing public exposure to hazardous materials or conditions.[14]

During the first decade of application, risk assessments generated useful information; at the same time, however, they caused considerable concern. But because they were carried out exclusively by experts, they were often not understood or trusted by the community. Public reaction led to the creation of guidelines by the Environmental Protection Agency (EPA) in 1999 to incorporate community involvement in the risk assessment process.[15] This formal change in the approach to risk assessment is an acknowledgment that many environmental health problems are indeed wicked.

Efforts to resolve wicked problems are not more important than efforts to resolve tame problems. The distinction calls attention to the need to acknowledge important differences between the two. And, although sole use of expert strategies to resolve wicked problems is unwise, public health professionals should not discard their research tools and evidence because of concern that their "science" will alienate the community. Common ground is more likely to be attained when leaders of problem solving and planning processes encourage all parties to embrace the philosophy of "and" rather than "either/or." Under such leadership, stakeholders and public health professionals minimize the contentiousness and mistrust that can undermine well-intended community-based health promotion efforts.[16] Engaging in such a process is likely to require considerable time, patience, and understanding from all parties, but the long-term benefits will far exceed the costs.

In his classic book, *Survival of the Wisest*, Salk[17] argued that sustained improvements in health and quality of life require embracing what he called "the characteristics of an 'and' rather than an 'or' philosophy—an 'additive' philosophy rather than an 'alternative' one" (p. 80). He characterized the "enemy" to effective problem solving not as those who hold alternative views or who come from different perspectives or discipline "but rather as those who are pathologically divisive or destructive of the unification and coalescence of healthy, contributing, constructive elements of greater complexity necessary to solve problems" (p. 80).

The Example of the Great Lakes Basin

Emergence of public health concerns in the Great Lakes Basin during the past three decades illustrates both the tame and wicked nature of environmental health problems. The Great Lakes Basin is also an illustration of the way scientific information generated in solving tame problems can trigger social and political action when it is perceived to be relevant to the welfare of a population or community.

During the 1970s, concerns began to surface from findings of studies by wildlife biologists revealing reproductive and developmental deficits, disrupted endocrine function, compromised immune competence, cancer, and behavioral anomalies in a wide range of species, including birds, fish, reptiles, and mammals. The environmental public health community became concerned that these findings had significant implications for human health, given the National Academy of Science's view of animals as sentinels of human health events.[18] Long a center of commerce and industry in the United States, the Great Lakes Basin was (and still is) vulnerable to the accumulation of pollutants released as by-products of such commerce and industry. The primary means of exposure to both wildlife and human populations is via the food chain because these chemicals tend to bio-cumulate and bio-magnify at various feeding levels within both wildlife and human

Table 2. Research Findings: Exposure and Health Effects

- Fish consumption appeared to be the major pathway of exposure for some persistent toxic substances (PTSs) including PCBs, dioxins, furans, and chlorinated pesticides (i.e., DDT and mercury).[21-30]
- Residents in the Great Lakes Basin eat more fish than the 6.5 g/day often estimated for the U.S. population. Great Lakes fish consumers reported eating on average 42 g/day.[22,25,27,29,31]
- Body burdens for some PTSs are two to four times higher than those of the general U.S. population.[21,25,29]
- Consumption of Lake Ontario Great Lakes sport fish by women of childbearing age increases the risk for prenatal exposure to the most heavily chlorinated PCBs.[22]
- Conception rates and the incidence of a live birth are lower in some women who are sport fish consumers.[21-23,32,33]
- Neurobehavioral and developmental deficits have been observed in newborns 12 to 24 hours after birth (and again 25 to 48 hours after birth) of mothers who consumed approximately 2.3 meals per month of contaminated Lake Ontario fish.[28]
- Exposure to PCBs is associated with poor performance on the Fagan Test of Infant Intelligence (FTII).[34]

populations. These findings set the stage for some early epidemiological studies in the Great Lakes Basin.

The best known of these studies was the Michigan Maternal Infant Cohort Study.[19] This prospective longitudinal study involved more than 240 mother-infant pairs; the mothers had eaten in excess of 1,200 kilograms of contaminated fish per year during 6 years prior to and during pregnancy. Perinatal effects reported in the study included reduced gestational age (on the order of 5 days), decreased birth weight, and decreased head circumference (Table 2).

The investigators also reported a range of neurobehavioral deficits in the children, among them reduced responsiveness to stimuli. In addition, when tested at 7 months and at 4 years of age, participating children exhibited reduced visual recognition and short-term memory. At 11 years of age, children whose mothers ate contaminated fish were three times more likely than other children to have low normal IQs, two times more likely to be 2 years or more behind in their reading comprehension, and to exhibit impaired short-term and long-term memory and attention deficits compared with other children.[20]

The findings from the Michigan Maternal and Infant Cohort Study raised serious concerns among residents of the Great Lakes Basin and triggered controversy and problem-solving dialogues between Canada and the United States, states and provinces, and tribes bordering the Great Lakes. This was a wicked problem of international dimensions. One approach, a tame one, was to seek more information about contaminants and vulnerable populations. Congress authorized ATSDR to fund a series of epidemiological studies. During the past 10 years, the ATSDR Great Lakes Human Health Effects Research Program has revealed important information about health effects among vulnerable populations throughout the Basin including sport and subsistence fishermen, pregnant women, fetuses, nursing infants, young children, and the elders and guidance for the development of communication and education activities (Table 3).[38]

In some ways, the Great Lakes Basin is a wicked-problem success story. Built on the traditional elements of health protection and disease prevention (i.e., surveillance, evaluation, interventions and control strategies, infrastructure development, and impact

Table 3. Research Findings: Social/Behavioral and Demographic Data

- It is estimated that 4.7% of adult residents of the eight Great Lakes states consume Great Lakes sport fish in a given year, and 43.9% of the respondents are women.[35]
- Knowledge of, and adherence to, health advisories for Great Lakes sport caught fish varies across different genders and populations, for example, men versus women and Whites versus Native Americans.[27,35-37]
- Fifty percent of residents who had eaten Great Lakes sport fish were unaware of the fish advisory; awareness was especially low among women.[35]
- Eighty percent of ethnic minorities who had eaten Great Lakes sport fish were unaware of the fish advisory, and awareness was especially low among women.[35]
- Ninety-seven percent of Native American men were aware of local advisories against consuming Great Lakes sport fish; however, 80% of the men ate those fish.[37]
- Fish is an essential component of diets of minority populations and Native Americans. These populations consume fish that tend to have higher levels of contaminants.[27,36,37]

assessment),[39] elevated body burdens in vulnerable populations have decreased dramatically in 6 years. Central to this effort were the ongoing problem-solving dialogue, research to answer gaps in the knowledge base, and the use of targeted health communication (advisories) on fish consumption without compromising fish as an essential element in the diets and cultures of those living in the Basin.[40]

COMMUNITY HEALTH PROMOTION AND SYSTEMS THINKING

We concur with Conklin's suggestion[41] that wicked problems are best resolved through a planned process with input from multiple sources in an atmosphere where scientific certainty is tempered by the perspectives of community stakeholders. Such an adaptive process is consistent with the principles of community health promotion, including a widely used health promotion planning framework known as the PRECEDE-PROCEED (Predisposing, Reinforcing, and Enabling Constructs in Educational/Ecological Diagnosis and Evaluation; Policy, Regulatory, and Organizational Constructs in Education and Environmental Development) model.[42] From its earliest applications in the late 1970s, the model has evolved from a largely linear, causal-chain planning model to an ecological one accounting for a wide range of factors that include social, economic, and environmental determinants of health.

The PRECEDE-PROCEED model assumes that the community is usually the most appropriate center of gravity for population health programs.[43] Meaningful local-level engagement ensures the greatest relevance and appropriateness of programs for people affected and establishes essential ingredients for sustained collaboration: trust and mutual respect.

"Systems thinking" characteristic of health promotion planning approaches lends itself to addressing wicked problems.[44] Systems thinking, which emerged from the systems dynamics research of J. Forrester,[45] takes into account the complexity and interdependence associated with wicked problems because it

- Focuses on interdependencies. The language of systems thinking focuses on closed interdependencies where x influences y, y influences z, and z influences x.

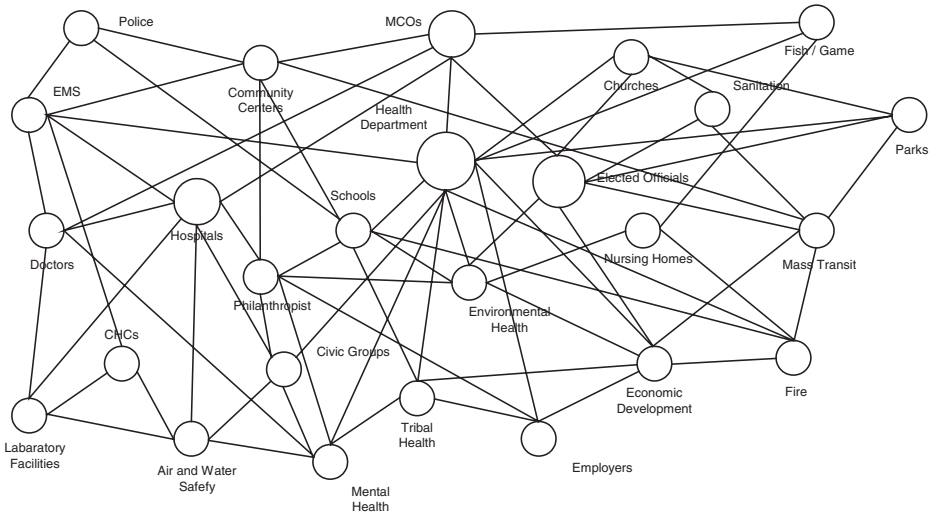

Figure 2. The public health system.
SOURCE: Public Health Program Planning Office, Centers for Disease Control and Prevention: *The National Public Health Performance Standards Program*. Atlanta, GA, Centers for Disease Control and Prevention. http://www.phppo.cdc.gov/nphpsp/PresentationLinks.asp

- Provides a "visual" language. Many systems-thinking tools such as causal loop diagrams, system archetypes, and structural diagrams have significant visual components that capture complex issues concisely and clearly.
- Adds precision. The rules governing systems thinking can help reduce ambiguities and miscommunication.
- Allows examination and inquiry. Systems thinking can be a powerful means for fostering collective understanding of a problem.
- Embodies a "worldview." Systems thinking looks at the whole, the parts, and their interconnectedness (adapted from Goodman).[46]

Figure 2 provides an overview of the complexity of the public health system and examples of organizations and groups making up the system network.

In the Great Lakes Basin illustration, the success manifested by the dramatic declines in elevated body burdens of hazardous chemicals in vulnerable populations had to be tempered by the reality that other sources of exposure other than fish consumption had not been vigorously pursued. When a systems view is taken and community stakeholders are involved, omissions of this sort are less likely to occur. In tackling wicked problems, public health practitioners should ask themselves questions like the following:

- Have multiple stakeholders been meaningfully engaged?
- Are we using a process grounded in thoughtful consensus building?
- Are we mindful that change is a normal part of the process?
- Are we establishing mutually agreed-upon markers for progress?
- Are we framing those benchmarks in realistic time lines?
- Do we have an integrated system for monitoring progress?

- Is communication between all stakeholders transparent?
- Are communications carried out in an atmosphere of mutual respect and trust?

The wicked nature of many health problems (including environmental health problems) means that throughout, program planning and implementation adjustments or modifications will be required. Applying the essential skills of health promotion practice (Table 4) will aid practitioners in navigating changing conditions and circumstances.

THE PRECAUTIONARY PRINCIPLE

Many environmental health problems fit the criteria of wicked problems because they are enmeshed in the community's political, cultural, social, and economic structure. This complexity is often compounded by scientific uncertainty. Complete data on health effects in vulnerable populations are available on relatively few of the chemicals present in the environment. This weak or missing link in our understanding results partially from limitations in analytic and technical capacities (including the difficulty of assessing human exposures in terms of body burden, i.e., the level of substances present in human tissues and fluids).

What is the correct response when the public asks what health hazards at what levels of exposure should be of greatest concern? Will we get sick in the future? What about our children and our grandchildren? What can we do to protect ourselves from health risks posed by naturally occurring hazardous substances like asbestos? Uncertainty about health risks has given rise to the concept of the "precautionary principle."

In 1992, the United Nations Conference on the Environment and Development offered this interpretation of the Precautionary Principle: "Where there are threats of serious or irreversible environmental damage; lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[47] The precautionary principle has four essential elements:[48]

1. Creating policy and taking preventive action in the face of uncertain risk
2. Shifting the burden of proof to the proponents of a potentially harmful activity
3. Exploring a wide range of alternatives to possible harmful actions
4. Increasing public participation in decision-making

In effect, the precautionary principle serves as a wicked problem-solving "device" in that it calls for all stakeholders to seek solutions that protect population health against a backdrop of scientific uncertainty.

IMPLICATIONS FOR PRACTITIONERS

Distinguishing between tame and wicked environmental health problems is important for two reasons. First, it requires examining that we carefully consider the complexity of the problem from the perspective of science and stakeholders. Second, it prevents applying tame solutions to attempt to solve all environmental health problems.

Because of the wicked nature of most environmental health problems, traditional expert-oriented and mechanistic methods of problem solving alone are inadequate and inappropriate. Because wicked problems seldom have a right or wrong answer, a solution

Table 4. The Essential Skills of Community Health Promotion Practice

Skill	General Indicator of Competence
Understanding the health problem (or problems) that constitute the focus of the health program	A working knowledge of a given health problem, including what is known about the factors and conditions known to influence the presence (or control) of the health issue in question and how that specific problem, and its multiple determinants, may be linked to other health and social issues.
Conducting an appropriate health and social assessment	The ability to ascertain population health needs, taking into account cultural and historical idiosyncrasies of the area in question, and availability of economic and human resources, and the views and perceptions of multiple stakeholders.
Planning theoretically sound health promotion programs	The ability to incorporate, where feasible, the application of the combination of strategies (shown to be effective in previous applications) to address the program needs based on evidence obtained in the health and social assessment.
Applying appropriate health promotion strategies	The ability to implement and/or direct the effective implementation of health promotion strategies by others, including (1) community development and community organization; (2) health education programs tailored to the needs of those in multiple settings (e.g., the community, schools, work sites, and clinical settings; (3) specific education of health care providers; (4) social marketing; (5) advocacy; (6) targeted health communication; and (7) the use of policies and the enforcement of existing regulations.
Providing effective leadership and management to deliver programs and relevant services	The ability to (1) promote a common vision and framework for the program in question, (2) call on skilled staff to carry out the program, (3) motivate staff at all levels (from top levels for funding to school level for implementation), (4) manage human and financial resources, and (5) work collaboratively with stakeholders from a wide range of sectors and interests.
Collaborating across sectors	The ability to (1) identify common ground in priorities and unique contributions of different sectors and stakeholders, (2) actively engage those stakeholders in aspects of the program relevant to them, and (3) maintain transparent communication with stakeholders.
Monitoring and evaluating processes and outcomes in health promotion	The ability to (1) routinely monitor relevant health status indicators and their multiple determinants; (2) assess program progress including the effectiveness of intervention components; and (3) document, disseminate, and use monitoring and evaluation results to publicize achievements and improve efforts.

SOURCE: State Health Promotion Capacity: *An Assessment Report to ASTDHPPHE*. Washington, DC, 2003. http://www.dhpe.org. Note: The Association of State and Territorial Directors of Health Promotion and Public Health Education (ASTDPHHE) is now the Directors of Health Promotion and Education (DHPE). Adapted in part from (1) "A Framework for Collaborative Public Health Action by Communities." See Fawcett SB, Francisco VT, Hyra D, Paine-Andrews A, Shultz, JA, Roussos S, Fisher JL, Evensese P: Building healthy communities, in Tarlov AR, St. Peter RF (eds.): *The Society and Population Health Reader: A State-Community Perspective*. New York, the New Press, 2000; and (2) *Indicators to Help With Capacity Building in Health Promotion*. New South Wales, Australia, NSWHealth, 2001, Web site: http://www.health.nsw.gov.au/public-health/health-promotion/hpss/capacitybuilding/indicators/indicators.htm.

that may address one aspect of the problem may lead to the creation of other problems. Toxicological and epidemiological advancements may call into question earlier environmental health decision making as the "best-available data" changes. Consequently, public health practitioners need to be attuned to changes in science, changes in stakeholder goals and values, and the impact of actions intended to protect the public against environmental health threats.

Because there is no single solution to wicked environmental health problems, public health practitioners should seek transdisciplinary involvement when making decisions and maintain stakeholder involvement throughout the problem-solving process. The quality of the process may be the best benchmark of the extent to which the wicked problem is being solved. The complexity of environmental health problems requires public health practitioners to exhibit patience, pragmatism, and respectful inclusion to their foundation of sound health science. Combining health promotion skills and a systems-thinking approach will better position researchers and practitioners to address wicked problems like those in environmental health.

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