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Part 1

Defining Transdisciplinary Research and Education

Chapter 1

Transdisciplinary Public Health

Definitions, Core Characteristics, and Strategies for Success

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Learning Objectives

- Understand transdisciplinary approaches in public health.
- Define public health problems using a transdisciplinary approach.
- Describe why and when a transdisciplinary approach is needed.
- Explain how a team-based approach to public health works.
- Explain why working collaboratively with diverse communities and constituencies is important in public health.

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The publication of this book reflects the burgeoning interest and investment in cross-disciplinary approaches to scientific questions and societal problems

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in several research domains in recent decades.[1–5] As social problems are inherently complex and multifaceted, their resolution or amelioration often calls for cross-disciplinary research that integrates perspectives from multiple disciplines and fields. Moreover, the translation of science into new and effective programs and policies typically requires the creation of partnerships spanning diverse groups, including academic groups, governmental agencies, nongovernmental organizations (NGOs), and community groups.[6–10] Reflecting these realities, the boundaries between disciplines and fields have become increasingly blurred as scholars and practitioners representing diverse perspectives form scientific and translational teams to work collaboratively at the nexus of their knowledge domains.[11–14] These trends have given rise to a new interdisciplinary field, the *science of team science* (SciTS), which aims to better understand the circumstances that facilitate or hinder effective team-based research and practice and to identify the unique outcomes of these approaches in the areas of productivity, innovation, and translation.[15,16]

The SciTS field includes a special focus on cross-disciplinary, team-based approaches. These approaches aim to draw together the most appropriate conceptual frameworks, theories, and methodological approaches from a variety of disciplines in order to address complex scientific and societal problems most effectively. Disciplines are socially constructed in the sense that large numbers of scholars working in various domains have come to agree over time that particular substantive foci, levels of analysis, and conceptual and methodological tools are associated with particular disciplines (such as physics, biology, sociology, or economics) and professional fields (such as law, business, or medicine). Thus these disciplines emphasize different kinds of knowledge in their subject matter, including particular sets of life, physical, or social science "facts"; their analytical levels range from nano, molecular, and cellular to intrapersonal, organizational, and community perspectives; and each is uniquely associated with particular theoretical and methodological exemplars—for instance, Newtonian and Einsteinian conceptualizations of energy and matter or Freudian and radical behaviorist paradigms or functionalist versus conflict theories of organizations and societies.[17,18]

In this chapter, the term *field* is differentiated from the term *discipline* as defined earlier. A field is a cross-disciplinary area of scientific inquiry or professional practice that focuses on a particular research topic or societal problem. Fields of inquiry and practice encompass multiple disciplinary perspectives that are deemed relevant for understanding a particular research question or societal problem. Examples of fields spanning multiple disciplinary perspectives include public health, urban planning, sustainability studies, and SciTS. The recent growth of cross-disciplinary, team-based research and practice stems from the recognition that whereas disciplines provide useful tools for framing research and practice, approaches derived from a single discipline may

not provide the necessary tools to fully understand and address complex scientific and societal problems, particularly when it comes to identifying and understanding multiple interacting causal factors and developing innovative solutions. Thus a variety of new cross-disciplinary fields have arisen in recent decades to provide more integrative, broad-gauged analyses of complex scientific and societal problems.

Scholars have distinguished various forms of cross-disciplinary collaborative research and practice, with the three most commonly identified forms being *multidisciplinary* (MD), *interdisciplinary* (ID), and *transdisciplinary* (TD) collaborations. Some conceptualize MD, ID, and TD modes of research and problem solving as subtypes of cross-disciplinarity that are arrayed along a continuum ranging from lower to higher levels of integration and potential for innovation.[19–22] Accordingly, the MD approach is typically understood as the sequential or additive *combination* of ideas or methods drawn from two or more disciplines or fields to address a problem; the ID approach involves the *integration* of perspectives, concepts, theories, and methods from two or more disciplines or fields to address a problem; and the TD approach entails not only the *integration* of approaches but also the *creation* of fundamentally new conceptual frameworks, hypotheses, and research strategies that synthesize diverse approaches and ultimately extend beyond them to *transcend* preexisting disciplinary boundaries.[2,5,23,24] Another hallmark of a TD approach that distinguishes it from other cross-disciplinary approaches is the emphasis on translation of research findings into practical solutions to social problems, which Hadorn and Pohl[2] refer to as *problems of the life world* and Stokols[8] characterizes as *transdisciplinary action research*.

These proposed distinctions, however, belie some of the complexities involved in differentiating among the MD, ID, and TD modes of inquiry and problem solving. First, each of these forms of cross-disciplinary research and practice can be pursued by individuals working on their own or collaborating with others on a team. Second, MD, ID, and TD approaches rarely occur in isolation from each other. More often, individual scholars or teams of scientists and practitioners transition among them and also engage in unidisciplinary (UD) modes of inquiry during different phases of a single project.[5,25] It may be a challenge to determine when, exactly, an initiative has transitioned from coordination to integration (from MD to ID) or from integration to synthesis, extension, and transcendence (from ID to TD). Third, among scholars of cross-disciplinary research, there is continuing discussion about whether TD is descriptive of a research process or whether it best describes the research outcomes that eventually emerge from projects that may include some blend of MD, ID, and TD processes. Reflecting the blurred boundaries between areas of specialization in cross-disciplinary collaboration, there is a great deal of overlap in the definitions of ID and TD put forward in various federal

government funding announcements and guidance documents (see, for example, materials from the National Academy of Sciences,[26] the National Institutes of Health,[27] the National Science Foundation,[28] and the US Department of Health and Human Services[29]).

Despite these definitional complexities, we believe there are practical and scientific benefits to conceptualizing transdisciplinary research and practice as distinct from ID research and practice. First, TD approaches emphasize the generation of novel, often paradigm-expanding or -creating, conceptual frameworks, hypotheses, research designs, and translations of scientific outcomes into solutions to social problems.[21,30] These products may have transformational effects in the realms of theory development, research, and community practice. Introducing students, scholars, and community practitioners to TD approaches inspires high aspirations and offers a frame of reference for encouraging scientists and professionals to achieve the most innovative intellectual and translational advances possible (see, for example, Glass and McAtee;[31] Frumkin[32]). In addition, framing TD research and practice as offering the greatest potential for innovation of all cross-disciplinary methods highlights this method's increased likelihood of producing highly significant and effective scientific outcomes and practical applications.[33,34] For instance, by including the term *transdisciplinary* in the title of its request for applications to establish cancer research and training centers (in tobacco use research, energetics and cancer, health disparities, and cancer communications), the National Cancer Institute conveyed to applicant teams the importance of striving to achieve transformative innovations in the field of cancer prevention and control.[35–39]

Second, the distinctive focus of TD approaches on translating scientific outcomes into practical applications leads to unique team compositions and outcomes. TD teams may include not only scientists from multiple disciplines and fields but also practitioners, policymakers, and community members who together offer a broad array of relevant knowledge and points of view useful for translating scientific findings into improved practices and policies. The goal of translation and the breadth of expertise brought to bear by a TD team maximize the potential for scientific and translational innovations and impact.

To reflect these unique characteristics of the TD approach, we propose the following definition of TD research and practice: *an integrative process whereby scholars and practitioners from both academic disciplines and nonacademic fields work jointly to develop and use novel conceptual and methodological approaches that synthesize and extend discipline-specific perspectives, theories, methods, and translational strategies to yield innovative solutions to particular scientific and societal problems*.

This definition highlights the emphasis on integration and innovation in TD initiatives. There are two main forms of TD integration: horizontal and vertical. *Horizontal integrations* involve the linkage of disciplines at similar levels of

analysis, such as an integration of the genetic perspective of biology and the molecular perspective of chemistry. *Vertical integrations* bridge knowledge domains associated with different analytical levels, such as an integration of the intrapersonal perspective of psychology and the societal perspective of urban planning. TD integration can occur in a variety of ways over the course of a TD collaboration, based on the specific needs that emerge in that collaboration given its target problem, team membership, and goals. For example, integration might be reflected in novel conceptual frameworks, research goals, or translational advances. It might result in methodological innovations as well, such as the application of research approaches and methods from one discipline to address research questions grounded in a very different discipline. In sum, TD integration can occur in both the substantive content and methodological approaches of a collaborative initiative, and in both the research and translational phases. We will return to these forms of TD integration later in this chapter, in the section outlining strategic guidelines for TD public health.

In this section we defined TD research and practice and identified key features that distinguish the TD approach from other cross-disciplinary approaches. In the next section we describe the distinctive processes involved in implementing TD collaborations. In the subsequent section, we describe characteristics of the TD approach that are specific to the public health context. Finally, we close with a discussion of key challenges and emerging directions related to the pursuit of TD public health and with our developing understanding of the value of this approach.

The Four Phases of a TD Initiative

We conceptualize TD research and practice as having four relatively distinct phases—*development*, *conceptualization*, *implementation*, and *translation* (figure 1.1). This proposed conceptualization builds on and extends conceptualizations of TD offered by other scholars (Aboelela et al.,[19] Hadorn et al.,[2] Kessel et al.,[20] Lawrence and Despres,[23] TD-Net,[40] Wagner et al.,[22] and Wickson et al.[24]). Briefly, the development phase involves the formation of a team of collaborators and the initial steps toward developing a joint research initiative, including establishing a shared understanding of the problem definition and the mission of the group. The conceptualization phase involves collaborative teamwork to develop research questions or hypotheses and a research design that reflect the integrative nature of the initiative. The implementation phase involves the execution of the planned research, and the translation phase applies research findings toward the development of an innovative solution to the real-world problem.

These four phases of a TD initiative are generally sequential, and the processes and outcomes generated during each phase influence those that

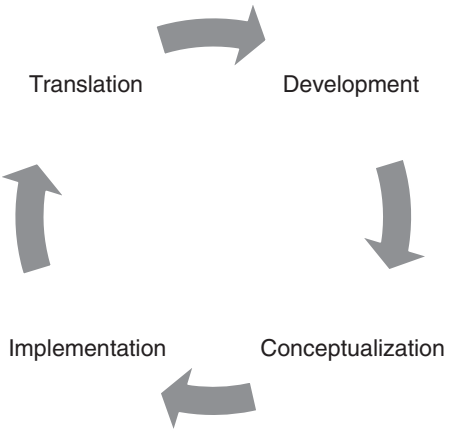

Figure 1.1. Four phases of a transdisciplinary initiative

occur in subsequent phases. However, the four phases also may be recursive, or iterative. For example, insights that emerge during the second through fourth phases may lead to midproject changes in the composition of the TD team formed during the first phase, in order to bring in additional areas of expertise. In addition, preliminary outcomes in the third phase may lead to the production of new research questions and hypotheses, expanding the conceptual work done in the second phase. This recursive process also applies to multiple related scientific and practical initiatives.[8,41] For example, once new knowledge is generated or a novel conceptual framework is developed, it serves as the state-of-the-science example for subsequent research, training, and translational innovations. In addition, findings from community problem-solving efforts may prompt refinements in existing theoretical frameworks and occasionally give rise to entirely new frameworks[13,42] as well as new research endeavors. This occurs, for example, when a city council's or nongovernmental organization's efforts to address a particular social or health problem prompt subsequent scientific research in collaboration with university-based scholars.

Goals and Processes in Each TD Initiative Phase

Each of the phases of a TD initiative has specific goals and distinctive team processes (table 1.1). During the development phase, key goals are to identify the scientific or societal problem of interest as well as the disciplines, fields, and areas of practice relevant to addressing the problem. This work may be done by a core group of collaborators, who then work to recruit additional team members with expertise in the necessary knowledge domains and with

Table 1.1. Goals and processes of the four phases of a transdisciplinary initiative

	Development	Conceptualization	Implementation	Translation
Goals	Identify the scientific or societal problem and the disciplines, fields, and areas of practice relevant to understanding and addressing it. Form a diverse team of scientists, professionals, and community members possessing these areas of expertise.	Develop novel research questions, hypotheses, a conceptual framework, and research methods that integrate and extend approaches from multiple disciplines and fields.	Execute the planned research. Create refinements and additions to the research questions, hypotheses, and methodological approaches as needed to maximize the effectiveness and innovative nature of the initiative.	Apply research findings to develop innovative solutions to real-world problems.
Processes	Develop a shared understanding of the target problem and team mission. Learn the relevance of all team members' expertise to the target problem, and begin to develop a shared vocabulary.	Use team processes and the institutional environment to promote innovation and integration.	Engage in a reflective process to intermittently assess and enhance activities, retaining an integrative approach.	Support sustained participation of the broad team of collaborators, including both scientists and practitioners.

a diverse array of substantive, methodological, and practical knowledge. A TD team's developmental processes are likely to benefit when members include not only scientists but also professionals and members of local stakeholder groups—including practitioners, policymakers, and citizens—who represent several spheres of community practice and whose diverse perspectives can enrich the development of translational applications to particular community problems.[7,43]

Once assembled, team members begin the initial processes that will move them toward collaborative integration and cohesion. Key processes in this phase include developing a shared mission and goals for the particular collaboration and devoting time as a group to establishing an understanding of each member's unique knowledge sets, based on his or her disciplinary or professional training and scientific and practice experiences.[44] To be successful, team members must first understand and acknowledge differences in their perspectives and values, and then they can move on to find common ground and shared values that can be a foundation for their ongoing collaboration.

Another critical process during this phase is to develop a shared vocabulary that spans or transcends team members' unique backgrounds and can be used by members to communicate with one another about their joint initiative. This shared vocabulary begins to emerge during conversations to develop shared goals and learn about one another's areas of expertise. Communication strategies such as the use of analogies and lay language in lieu of discipline-specific jargon help to bridge the gaps between disciplines and fields, as well as the gap between scientists and practitioners, during this early phase of collaboration.[45] As the team moves into the next phase, members may develop new language for key concepts in their collaborative endeavor.

The goals of the conceptual phase are to develop novel ideas, hypotheses, research questions, and research methods that integrate the perspectives and knowledge domains of the team members, enabling them to address the target problem in innovative ways. A hallmark of success in this phase is the development of a conceptual framework that integrates approaches from a variety of disciplines and fields, potentially extending beyond them to introduce previously unthought-of associations and hypotheses.

Processes involved in this phase focus on integrating team members' perspectives and knowledge domains relevant to the target problem in order to develop novel research approaches. The involvement of team members with diverse perspectives is essential to producing TD innovations. Members with varying expertise introduce a breadth of perspectives, and when integrated, these diverse views are more likely to produce new research directions than are the views produced by more homogeneous teams. During the dialogue that is necessary to produce a research program that reflects the integration of multiple disciplinary perspectives, more diverse teams are more likely to

engage in debate.[46] Debate can best lead to creative outcomes when premature consensus is avoided.[47]

Team processes are crucial to the success of the conceptual phase. The presence of multiple effective avenues for communication encourages and supports freedom of expression, promotes creativity, actively encourages the integration of perspectives and approaches, and is critical to supporting the challenging work of synthesizing knowledge domains.[47] Also critical are team and institutional environments that explicitly support integrative approaches, risk taking, and cross talk among colleagues from different departments, institutions, and agencies. Outcomes of this phase may include the creation of novel ideas, hypotheses, and conceptual models; new research programs with innovative integrative designs; and related grant proposals (see, for example, Northwestern University Clinical and Translational Sciences Institute[48]).[8]

During the implementation phase, the focus is on executing the planned research. During this time, team members also, ideally, engage in a reflective process in which they intermittently assess and refine their approaches. This enables the team to revise or create additional research questions and hypotheses and refine data collection and analysis approaches. It is optimal if, during this process, team members retain an integrative perspective. As the collaboration continues and participants both deepen their understanding of the target problem and learn more about one another's areas of expertise and how this knowledge applies to the problem, they may begin to see new research avenues and translational opportunities. They may also identify a need to bring in new team members with different areas of expertise in order to pursue these new research and translational opportunities. New team members who join during this phase may help to refine existing research questions and methods or add new ones, thereby leading to additional innovations in the team's approaches. Outcomes of the implementation phase include shared databases; completed data collection, analysis, and interpretation; empirical discoveries; inventions in research and practice; scholarly publications; and the integration of new knowledge into TD curricula and training resources.

Finally, the goals of the translation phase are to apply research findings to develop innovative approaches to effectively addressing real-world problems. This phase involves the sustained participation of the broad team of collaborators, as the participation of both scientists and practitioners is needed to maximize the success of translational activities. TD scholars and practitioners often have divergent opinions and expectations of each other's status as team members and about the goals and intended outcomes of translational research.[6] Consequently, it is essential that TD researchers and scholars develop shared understandings about these and other issues at the outset of their collaboration. These conditions are necessary to produce the intervention designs, timetables, and action plans that are intended near-term outcomes of the

translational phase of TD collaboration. Also, depending on the specific goals and intended deliverables of their partnership, team members may need to work together to establish evaluative criteria and methodologies for assessing the near- or longer-term societal impacts of their proposed programs and policies. Possible outcomes of this phase include the emergence of new structures of multisector collaboration that are sustained even after a funded research project has ended (see, for example, Shen[49]); innovations in existing programs and policies enacted at state, national, and international levels; or entirely new programs and policies; and more distally, demonstrable improvements in the social conditions affected by these innovations, such as positive changes in population health, social justice, or environmental quality (see, for example, Breslow and Johnson[50]).

Influence of Individual, Team-Based, and Organizational Factors

Each phase of a TD initiative influences all the others, and at the same time, the TD process as a whole is influenced by multiple overlapping conditions—including individual team members' characteristics, team-based traits, and organizational contexts—each of which can exert substantial influences on the way that collaboration plays out and, as a result, on the ultimate success of the TD initiative.

At the individual level, team members' values and perspectives, assumptions about the validity of research methods and findings, attitudes about individual versus team pursuits, and opinions of and experiences with cross-disciplinary approaches all influence their activities within the team and, as a result, team dynamics.[51]

Team-based traits, including team structures (for example, hierarchical versus nonhierarchical), work routines and processes, group attributes, and available infrastructure and resources (such as shared databases or shared work space and facilities), shape the ultimate effectiveness of the team in working through the four phases and achieving the ultimate goals of integration, innovation, and transformative solutions (see, for example, Fiore,[52] Katzenbach and Smith[53]). Team-based work routines and processes include the frequency of in-person versus distance interactions among team members, as well as the availability and quality of the cyber-infrastructure and the frequency with which it is used for electronic collaboration.[25,54–56] Team attributes such as leadership structures and styles, shared goals and norms, decision-making strategies, and individualized versus interdependent incentive structures for collaboration and performance have also been found to exert strong influences on the effectiveness of TD teams (see, for example, Paletz and Schunn,[57] Stokols et al.[58]).

TD teams often include members from different organizational units, such as different departments or research centers within a university, or from different organizations entirely, such as universities, businesses, not-for-profit

organizations, and governmental agencies. Each of these organizational contexts brings to bear its own set of expectations and priorities, which may support or impair an individual's participation in a TD team.[59,60] In addition, TD teams may be nested within consortia or networks, such as those created through grant initiatives, which introduce another layer of influences on team processes. Additional aspects of the organizational context that strongly influence collaborative dynamics include factors such as organizational leaders' support or lack of support for team-based and cross-disciplinary initiatives,[61] and formal policies, such as tenure and promotion policies, that do or do not reward team-based work in a manner equivalent to individual work.[30]

Emergent States Important to TD Success

The aforementioned team-based factors affect most collaborative research and practice initiatives. There are specific qualities or states of collaborative teams, however, that are particularly relevant to TD collaborations because of the influence they have over the processes necessary to achieve syntheses and extensions of preexisting discipline- and field-based approaches and to produce innovative research and practice outcomes. Emergent states arise in teams when representative dynamic attitudes, values, cognitions and motivations, or other particular team qualities *emerge* through the team experience.[62] Three particularly potent emergent states in TD research and practice are critical awareness, psychological safety, and transactive memory systems.

Critical awareness describes an understanding among team members that all disciplines and fields, including their own, have substantive and methodological strengths and limitations.[63–65] It also describes an awareness of the strengths and limitations of integration, given these circumstances. Ideally, critical awareness is combined with a strong grounding in one or more disciplinary traditions, including familiarity with those traditions' theoretical and methodological approaches as well as their overall strengths, limitations, and blind spots.[63,65] The combination of these abilities enables team members to consider and identify the potential contributions of other disciplines, fields, and areas of practice in order to effectively address the target problem.[65] It also helps to eliminate bias toward a particular disciplinary approach, which can limit the quality and novelty of new research and translational directions. Ultimately, these abilities empower the team to produce the highest quality, most innovative approach to the target problem.[64] Critical awareness also enables team members to stay goal oriented, remaining focused on solving the research or practical problem at hand using the variety of available approaches, rather than becoming deadlocked over the disciplinary approach that should be pursued.[63]

Critical awareness among most or all of the members of a TD team enables processes necessary to integrative approaches, such as discussions that weigh

the relative merits and weaknesses of various discipline- and field-based approaches that explicitly address the challenges and processes involved in the task of integration and also potentially collaborative benefits and synergies.[64] By recognizing the limitations of their own customary approaches, team members may be better able to work integratively to produce an approach that transcends the limitations of the participating disciplines and fields.

Psychological safety within the team,[66] also called intragroup safety,[67] is what team members experience when they believe that the team environment is a safe place to express independent thoughts and opinions and even divergent assumptions about the nature of varied research approaches[14] and that they need not fear embarrassment, rejection, or punishment. In teams representing particularly different areas of expertise and knowledge—such as teams that include scientists from both the social and biological sciences along with practitioners, policymakers, and community members—team members may feel their expertise is not understood, acknowledged, or valued. In addition, members of diverse teams may fear that they may appear uninformed or that their ideas may be misinterpreted by colleagues with different disciplinary values and terminologies. All these factors may affect team members' ability to engage in the group processes needed to produce integration and innovation.

Psychological safety in the team helps support the same collaborative processes that are supported by critical awareness and that are necessary to achieve the integrative and innovative outcomes that distinguish TD initiatives, including weighing the relative merits of different disciplinary approaches to the target problem. Psychologically safe team environments promote active listening and discussions that are characterized by open sharing of ideas and mutual respect. These characteristics, in turn, foster co-learning and productive work toward developing novel, integrative ideas.

Finally, *transactive memory systems* refer to team members' shared awareness of each individual member's expertise, knowledge, and skills.[68] Teams begin to develop these transactive memory systems in the developmental phase of the TD initiative, as members learn about one another's areas of expertise and the relevance of these areas to the joint endeavor. Transactive memory systems continue to deepen and expand as teams progress through the four phases of the initiative. These systems can enhance team performance throughout these phases[44] by supporting the interactive processes that lead to the generation of integrative conceptual models, research questions, hypotheses, and research methods. In addition, transactive memory systems may facilitate team coordination activities, including division of responsibilities and knowledge transfer, which can lead to more successful research outcomes.[69] These coordination activities also reinforce transactive memory systems by formalizing knowledge about the expertise and skill sets possessed by each team

member and making that knowledge more visible. The addition or departure of team members and the development of new expertise by existing team members require that transactive memory systems be updated. Regular interaction among group members, including planned opportunities to learn about existing and new expertise on the team, can ensure that team members' transactive memory systems remain up to date and include the unique characteristics, roles, and knowledge recently acquired.

Characteristics of TD Public Health

As other scholars have noted (see, for example, Hadorn et al.,[2] Klein,[5] Lawrence and Despres,[23] Neuhauser et al.,[43] Carew and Wickson[70]), the conceptualization of TD research and practice is enriched when it is contextualized; that is, when it is related to a particular set of scientific questions and societal problems, such as those addressed by a particular discipline or field. In this section, we discuss TD approaches within the specific context of public health.

An important characteristic of public health is the field's inherently multidisciplinary structure, which is reflected in the five areas of emphasis required of all accredited training programs in public health: biostatistics, epidemiology, environmental health science, health policy and management, and social and behavioral sciences.[71] MD fields such as urban planning and urban studies similarly encompass several disciplines within their scholarly, educational, and problem-solving missions. Much of the training and research in those fields reflects interdisciplinary and transdisciplinary as well as multidisciplinary approaches.[72,73] Moreover, many public health graduate courses and also research and translational programs emphasize ID integration of concepts, methods, and data among, but not limited to, the five core areas of emphasis included in accredited training programs. This overarching emphasis on MD and ID approaches establishes a reference point for scholars' and practitioners' work to achieve solutions to public health problems.

Added Value of a TD Public Health Approach

Given the highly integrative nature of the field of public health, it seems reasonable to ask what added value there is in encouraging public health scientists to move beyond the already prevalent MD and ID approaches to achieve TD approaches. In this section, we attempt to answer this question. We start by invoking the analogy of a geographical landscape. The current landscape of public health research and practice is defined by varied methodological and knowledge domains drawn from different disciplines and fields. These diverse domains, comparable to the varied regions of a country, can perhaps provide fertile ground for building collaborative partnerships and projects spanning several health-related disciplines. The diversity of this public health landscape

provides opportunities for cross-disciplinary research and practice that are considerably greater than those found in fields that are more *discipline-centric*, such as the field of sociology, which faces interdisciplinary challenges.[74]

The potential for moving from ID integration to TD innovations that transform public health research and practice increases when scholars and practitioners begin to envision, and to actively pursue, new regions and more transformative forms of partnerships within the public health landscape. It is the divergence or tension between the *existing landscape* comprising prior and ongoing public health scholarship on the one hand and the *futurescape* comprising potential integrative opportunities envisioned by scholars and practitioners on the other that fuels transformative TD innovations in science and translation. In the field of landscape ecology, the term *futurescape* refers to "landscapes of the future that may be so far from our current landscape visions that they seem fantasy."[75] TD approaches are distinct from ID approaches owing to their potential not only to synthesize but also to extend current conceptualizations and thus to lead scholars and practitioners into unexplored terrain that may redefine the map of the public health landscape and transform public health research and practice. As these new regions of the public health landscape are discovered, they establish new understandings of what cutting-edge or highly innovative research and practice is, and they act as reference points for judging subsequent innovations. As a result, the leading edge of both research and practice continues to be pushed forward, while past innovations are gradually adopted and institutionalized. TD approaches have the potential to accelerate the pace of this forward progress in both research and practice.

Examples of TD Public Health Research and Practice

Over the last two decades, conceptualizations of public health research and practice have become increasingly interdisciplinary, and in some cases, transdisciplinary. Exemplifying this trend are the *social ecological models* of public health problems that have emerged in recent years (see, for example, Green et al.[76]).[77–80] These models offer a *broad conceptual scope* and *holistic, integrative orientation*, often combining concepts from multiple fields and disciplines in ways that address multiple levels of analysis and create previously unexplored intersections of widely varied knowledge domains. For example, ecological theorists have drawn connections among societal conditions of urban sprawl, physical activity patterns, and population health.[9,81–83] Other scholars have documented the separate and joint influences of environmental racism, air pollution, substandard housing, lack of social cohesion in neighborhoods, and the psychological sequelae of poverty to explain the ways in which health disparities and low socioeconomic status "get under the skin" to engender a wide range of health problems.[84–90] Still others have investigated the influences

of the natural (nonbuilt) environment on population health,[32,91,92] as well as the joint impacts of psychological, sociocultural, economic, and biological factors on the etiology of chronic and infectious diseases (see, for example, Cassel[93]).[94–96] Some of the ecological analyses and empirical studies noted here have included in a single conceptual model individuals' genetic heritage and health behaviors; family, neighborhood, and community-level circumstances; population health characteristics; and health care expenditures. The social ecological models underlying these and many other studies have created numerous new opportunities for TD collaborations in public health research and practice.

Overview and Strategic Guidelines for TD Public Health

In this section, we return to the major themes presented in this chapter in order to highlight their practical implications, specifically as related to strategies for successful TD initiatives and lessons for the evaluation of TD initiatives. We then envision the broad outcomes of TD approaches for the advancement of research and practice. Finally, we consider emerging directions and challenges for TD public health, including the specification of criteria for gauging the novelty and assessing the outcomes of TD research and translational innovations.

Strategies for Successful TD Initiatives

We began this chapter by defining TD public health and highlighting the attributes that distinguish TD approaches from other cross-disciplinary approaches. TD approaches include unique goals for both the processes and outcomes of research, namely to transcend the boundaries among disciplines and fields in order to create innovative approaches that integrate and build upon the most promising approaches, wherever they may have originated, with the ultimate goal of producing practical solutions to real-world problems. This three-part emphasis on integration, innovation, and practical solutions sums up the essence of the TD approach and is also at the root of the four interrelated phases of a TD initiative that we have described in this chapter.

Each of the four phases of a TD initiative is crucial to its overall success. For instance, the development phase is vital to ensure that the right team members are included in order to maximize the innovative potential of a research and practice initiative. The absence of team members with knowledge in areas of science and practice particularly relevant to the target problem can produce an initiative that more closely resembles a UD approach. Alternatively, the absence of team members with skills specific to integrating approaches from multiple domains—such as strong knowledge in two or more disciplines and the critical awareness necessary to consider the strengths and weaknesses

of approaches from varied disciplines—can hinder integration and produce an initiative that resembles an MD or ID approach. In a reflection of the importance of team building, universities are increasingly investing in faculty members and organizational units dedicated to supporting the development of research teams.[26,97] In addition, in 2010 the National Organization of Research Development Professionals was established to develop and operate programs that facilitate cross-disciplinary, team-based research and reduce administrative and institutional constraints on these scientific approaches.[98]

The conceptual phase affords team members dedicated time to collaborate in developing novel ideas, hypotheses, research questions, and methodological approaches. Recognizing the importance of this phase, funding agencies have created dedicated financial support for the formation of teams and the team processes necessary to develop integrative research questions, hypotheses, and conceptual frameworks.[99,100] For the success of the implementation phase, adequate support is needed—at the levels of the team, academic institution, and funding institution—for continued team collaboration to implement the research plan, revise it as needed, and pursue emerging research directions. Finally, the translation phase is crucial to achieving the ultimate goal of a TD initiative—to create solutions to real-world problems. Only by including practitioners in the TD team, from the early stages of the initiative, can this goal be fully realized within the initiative's context. Although research findings can be translated into practice by other teams, at other times, and at other geographical locations, TD initiatives aim to incorporate immediate application to real-world problem solving, and the inclusion of practitioners in the team enables this final phase.

It is important to recognize that each of the four phases of a TD project requires team members to invest considerable time and other resources if they are to fully engage in key processes within each phase to achieve the most collaborative outcomes. The recent emergence of funding to support the first two phases of a TD initiative—which supplements longer-standing funding for TD research implementation—is now enabling teams to dedicate the necessary time to these foundational phases of a TD initiative.

As described earlier in this chapter, multiple overlapping factors influence the likelihood that TD initiatives will engage successfully in processes essential to developing integrative, innovative approaches and achieving the team's major scientific and translational goals. These include both scientific challenges and practical factors, such as characteristics of TD team members, team processes, conditions in the organizational and institutional environments where team members are located, and infrastructure and support—or lack thereof—in related funding. Each of these influences has the potential to introduce challenges or barriers to engaging in TD processes or to provide support for these processes.

A scientific challenge for all efforts at integration, whether horizontal or vertical, is how to balance concerns of breadth versus depth. Teams should strive to identify the key goals they hope to achieve through integration and synthesis of concepts, and work toward them while also retaining the integrity of the original discipline- or field-based approaches and promoting the synthesis necessary to innovate. Concerns about potentially superficial results from trying to address and integrate highly disparate knowledge domains spanning scholarly and community practice contexts can best be addressed by keeping a dual focus, seeking both to create innovative and practical outcomes and to retain the integrity of the approaches that are synthesized.

With regard to nonscientific influences on success, challenges at one level often can be addressed successfully at another level. For example, although it sometimes is the case that members of a TD team have competing rather than complementary goals related to their participation, team processes can help to accommodate these discrepancies so that teams are still able to meet their collective goals. Also, whereas a larger number of participating institutions and organizations can impose a wider array of bureaucratic and administrative challenges, institutional policies and procedures that support collaboration across institutions and organizations can facilitate TD team science. Furthermore, these multi-institutional collaborations have the capacity to integrate a broader range of intellectual, material, and financial resources, which can better support success in TD initiatives. If care is taken—by team leaders and members, participating institutions and organizations, and funders of TD initiatives—to develop team processes and institutional environments that support the processes central to each of the four phases of TD research, success is more likely.[69]

Lessons for Evaluation of TD Initiatives

The overall goals of a TD initiative not only lay the foundation for the goals and processes in each of its four phases but also provide benchmarks and indicators of success that can structure process and outcome evaluations of that initiative. The goals and process we identified in each of the four phases of a TD initiative also provide reference points for evaluation efforts. They can be used for process evaluations, ideally with feedback loops that can support quality improvement during the course of the initiative. Evaluation that examines processes and outcomes within each phase can help to identify whether a team is engaging in all the processes necessary to fully realize the goals of its TD initiative, identify areas where the team could benefit from technical assistance, and support obtaining enhanced quality of assistance. Toward the end of a TD initiative, evaluation can help to explain potential reasons why particular initiative goals were met. For example, process evaluations may be able to assess whether or not team members effectively implemented the core

phases and processes of a TD initiative and achieved the phase-specific outcomes over the course of their collaboration, or whether their teamwork might be more accurately characterized as a UD, MD, or ID effort.

In addition to process factors, evaluations of TD initiatives can assess a wide variety of near- and far-term scientific and translational outcomes, which may occur over years or decades and at multiple scientific and societal levels. Outcomes to be examined include integration, innovation, and the ultimate scientific or societal value of an initiative, as measured by its varied impacts on programs, policies, and ultimately the public's health.

Assessments of such varied and complex outcomes introduce certain conceptual and methodological complexities, such as how to establish criteria for both defining and measuring success in each of these outcomes. A helpful rule of thumb in evaluations of innovation is to compare outcomes to such elements of the preexisting research or practice context as conceptualizations and theories, methodological approaches, empirical knowledge, and best practices, as well as to emergent opportunities for conceptual, methodological, and translational advances that have not yet been fully achieved.[70]

Multimethod evaluation approaches that use a wide variety of quantitative and qualitative data sources reflecting different discipline- and field-based perspectives to assess outcomes at varying points in time are most likely to thoroughly capture and characterize results of a TD initiative. Multimethod approaches may include, for example, observations and reports of team processes; objective indices of team productivity such as number of papers published, the caliber of the journals publishing these papers, and number of additional grants obtained to build on the research or practice endeavor; and peer-experts' subjective appraisals of the degree of cross-disciplinary integration and the level of innovation and possible transformative impact, as demonstrated in team products such as publications, research proposals, and community problem-solving strategies.

Multimethod approaches have been used in recent evaluation studies to measure TD processes and outcomes and to compare them to their UD, MD, or ID counterparts.[51,101] Criteria for gauging the degree of TD innovation and conceptual departures from the existing landscape of public health research and practice include (1) the number of analytical levels vertically bridged through a particular collaboration and reflected in the products of that work,[102] (2) the number of distinct disciplinary or epistemological perspectives integrated in a particular research or translational project,[25,103] (3) peer subjective appraisals of the novelty and transformative impact on science and society associated with a TD innovation,[104] and (4) evidence for the creation of fundamentally new concepts, research methods, or translational best practices that depart from and improve on the current landscape of public health research and practice, as discussed earlier in this chapter. These multiple

criteria can be applied to both processes and outcomes of a TD collaboration as they emerge during the conceptual, research, and translational phases of TD action research.

The articulation of criteria for judging the novelty and translational value of TD innovations is a key challenge that must be addressed by each team in the context of its research and translational goals and the state of the art in its particular area of inquiry. The evaluation of translational outcomes of TD collaboration, in particular, poses a distinctive set of challenges relative to assessing outcomes associated with TD development, conceptualization, and implementation. First, long timelines are typically required to assess the value and impacts of translational innovations (for example, new community programs, clinical practices, or public policies). Moreover, securing multiyear funding to assess both mid- and longer-term outcomes of TD translations is becoming increasingly difficult, particularly during an era of budgetary constraints. One strategy for evaluating the outcomes of TD collaborations is to incorporate annual archival data (pertaining, for example, to team publication rates and changes in public health outcomes in particular communities) into longitudinal, time series designs that assess changes in community outcomes.[101] These extended time series research designs that incorporate publicly available data on scientific, community, and societal outcomes have the added advantages of being unobtrusive (for example, by avoiding direct surveys and interviews of community members) and, in many cases, anchored in substantial data sets that are gathered routinely by research, governmental, and community organizations.

Envisioning the Broader Outcomes of TD Approaches

In addition to the focus on creating practical solutions to real-world problems, one outcome of collaborative, interdisciplinary TD processes is that TD initiatives typically take a holistic, systems approach. Systems thinking is an approach to problem solving that situates problems in holistic systems with complex interacting factors that exert influences on one another.[105] It proposes that efforts to solve a complex problem require identifying and considering the array of factors that may interact in a complete system to produce the problem, factors that may in turn be subjected to interventions to solve the problem. In the field of public health, system approaches consider factors from multiple areas of science, including biological, behavioral, environmental, and socioeconomic factors, in attempts to identify the causes of and solutions to public health problems. TD approaches are ideally suited to supporting systems-level research and solutions to public health problems.

These approaches are also one means of speeding progress toward practical solutions to public health problems, as they produce scientific inquiries that

consider and include interacting factors from a wider range of disciplines and fields than are typically examined in other approaches. These inquiries can therefore produce findings with implications for a range of fields and produce expansive applications to practice that address a variety of factors in the system of interest. In contrast to UD research, which involves a slow, iterative approach that remains bounded within a single disciplinary area, TD research initiatives with a systems perspective can produce dramatic advances in a shorter period of time. They can also identify potential needs to explore entirely new and fruitful research directions that may be outside of the realm of any one discipline, and thus test new relationships, pathways, and paradigms.

Different areas of science and practice are typically dissimilar in their development and maturation. For established areas of inquiry, the systematic boundaries and dynamics of the target phenomena may be clearly delimited and defined, along with the particular disciplines and fields that are deemed to be the essential for understanding the scientific or societal problems at hand. In other newly emerging areas of science and practice, potential causal factors that influence and explain the major target problems and those disciplines most relevant to their analysis and resolution have yet to be identified. Clearly defining the problem to be addressed and understanding the state of the science related to that problem can help a TD team to identify the next set of research questions, or the next set of practical goals, that should be pursued and also the disciplines and fields that should be engaged in that pursuit. For instance, problem domains in which challenges still exist related to basic measurement or in which knowledge is still highly limited may not be ready for the development of translational solutions. For example, although there is burgeoning interest in personalized medicine, which tailors treatments to individuals based on their unique genetic and demographic profiles, knowledge must first be gained about the genetic markers that would be of most benefit in this approach. TD public health research and practice cannot circumvent fundamental gaps in the knowledge about a particular problem area, but they can facilitate progress toward practical solutions by creating more holistic, comprehensive analyses of and solutions to complex health problems at community, national, and global levels.

Summary

The increase in interest in cross-disciplinary approaches to scientific questions and the need to solve societal problems is leading to a demand for cross-disciplinary research that integrates perspectives from multiple disciplines and fields. Reflecting this demand, scholars and practitioners are increasingly working collaboratively in scientific and translational teams that produce team-based research and practice. The recent growth of cross-disciplinary,

team-based research and practice stems from the recognition that single disciplines may not provide the necessary tools to fully understand and address complex scientific and societal problems, particularly as related to identifying and understanding multiple interacting causal factors and developing innovative solutions. This chapter has outlined the practical and scientific benefits of the transdisciplinary approach to research and practice. It has also described the distinctive processes involved in implementing transdisciplinary collaborations, the unique characteristics of the TD approach in the public health context, the emerging directions for pursuing this approach in public health, and the scientific and societal benefits associated with this scientific approach.

Key Terms

four phases of a TD initiative	Development, conceptualization, implementation, and translation
interdisciplinary	Integrating two or more academic disciplines or fields of study in research or practice.
multidisciplinary	Combining several academic disciplines or fields of study in research or practice.
science of team science	A field focused on conceptual and methodological strategies aimed at understanding and enhancing the processes and outcomes of collaborative, team-based research.
transdisciplinary	Involving an integrative and creative process whereby scholars and practitioners from both academic disciplines and nonacademic fields work jointly to develop and use novel conceptual and methodological approaches that synthesize and extend discipline-specific perspectives, theories, methods, and translational strategies to yield innovative solutions to particular scientific and societal problems.

Review Questions

1. What are the important differences among the unidisciplinary, multidisciplinary, interdisciplinary, and transdisciplinary approaches?
2. Why has the demand for transdisciplinary approaches to public health grown so much in recent years?

3. Describe a current public health problem that is well suited to a transdisciplinary approach. Why is it a good candidate for this approach?
4. Why is it necessary to use a team-based approach when studying problems using transdisciplinary methods?

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