

Training in Interdisciplinary Health Science: Current Successes and Future Needs

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Commissioned by the **Roundtable on Population
Health Improvement of the National Academies
of Sciences, Engineering, and Medicine**

August 2015 | Available at goo.gl/RDDhpt



Executive Summary

Population health is an approach to understanding and improving health that focuses on the health of entire populations of people and disparities in health across population groups. Population health complements health care by addressing the multiple causes of health that operate at different levels – including biology, behavior, and social and physical environments. It makes explicit the need for strategies that are grounded in an integrative, multi-level understanding of the causes of health and the mechanisms through which health and health disparities are produced.

Population health science is not its own discipline; rather, it integrates knowledge, theory, and tools from multiple disciplines to develop a broad understanding of the multi-factorial pathways that produce health and health disparities so that more effective solutions can be found. While acknowledging a close relationship to public health, population health programs extend traditional scholarship and training in public health to better incorporate the full range of disciplines that contribute to population health knowledge, including basic social sciences.

The adoption of population health strategies within public health, medical, business, government, and educational institutions signals a growing demand for a trained workforce that can develop and apply the evidence from population health science. However, relevant training programs that provide a fundamental understanding of population health science are in short supply. Some have emerged within schools of public health, public policy, health professional schools, and liberal arts programs, but most are limited in interdisciplinary range, health outcomes considered, and in attention to interdisciplinary skills and translation. The only existing postdoctoral program explicitly devoted to training in population health science will be closing in 2016.

On June 1-2, 2015, scientists, educators, and practitioners met at the Institute of Medicine in Washington DC to reflect on future priorities for training in interdisciplinary population health science. This report presents their vision and recommendations.

Key competencies: Training in population health science requires the development of three categories of competencies. These include knowledge (broad knowledge of the fundamentals of population health science, including metrics, methods, and research design); interdisciplinary skills (the ability to effectively lead and/or work with others who have different approaches to

or expertise in population health topics); and knowledge translation and exchange (skills and expertise in communication, knowledge translation and exchange).

Critical elements of training: These competencies can be achieved through a combination of mechanisms, but three are noteworthy for their importance in population health science training. These include: (1) immersion of trainees in an interdisciplinary environment; (2) mentoring (using a multiple mentor model) in scientific areas, knowledge exchange, interdisciplinary skills, and professional development domains; and (3) experience as part of an interdisciplinary research team.

Institutional supports: A diverse and supportive institutional context is essential for success, both within academia and in the collaboration between academic and other sectors (e.g., business, health care, community). Host institutions must value interdisciplinarity and create incentives for strengthening linkages among diverse departments and schools; faculty mentoring; interdisciplinary courses and research opportunities; and enrollment by top students in interdisciplinary programs. Fostering collaboration across departments and sectors and aligning incentive structures and funding supports with the needs of interdisciplinary training are among the important issues to be addressed. While some academic institutions are able to prioritize such initiatives, the leadership of external funders is often required to stimulate and support them.

The training pipeline: Training opportunities are needed at multiple levels. The greatest current need is for advanced scientific training at the doctoral and postdoctoral level. Postdoctoral fellowships are a high priority. Training at the postdoctoral level can transform individuals with demonstrated scientific ability by broadening their understanding of the diverse disciplinary approaches that contribute to improving health, exposing them to the full continuum of knowledge translation, and developing mature interdisciplinary leadership skills. At the pre-doctoral level, both interdisciplinary doctoral programs in population health science and programs that supplement disciplinary training with population health training should be made available. Investment at the high school and college levels is also important to provide early exposure to population health concepts. At these levels, programs can engage students' interest and lay a foundation of basic skills and competencies. Summer

programs, mid-career and senior level sabbaticals can also contribute to an integrated strategy for population health training.

Diversity: Programs should strive to achieve diversity among trainees and faculty, such as by discipline, sector, and racial, ethnic, socioeconomic, and regional background. Attracting students from minority and disadvantaged backgrounds is a critical challenge that may be facilitated by investments at the college or high school level. Attracting trainees with interests and goals that span the continuum from basic science to application is another important challenge.

A recommended model: Participants in the June, 2015 meeting developed a recommended model for future training in interdisciplinary population health science at the pre- and postdoctoral levels. The model is center-based, with participating centers representing three types of strengths: (1) capacity to conduct state-of-the-art interdisciplinary population health research; (2) capacity to engage with and address population health problems in underserved and/or high-need geographic areas and population groups; and (3) capacity to recruit diverse and underrepresented trainees.

Each center engages a critical mass of trainees in hands-on, experiential research training, through involvement in problem-focused research teams that are interdisciplinary and/or multi-sectoral. Each center designs its own curriculum and implements an intensive, multidisciplinary mentoring system. Each center is expected to foster “impactful science” by deepening the integration of science, translation, and research user communities in their programs. The overall set of center-based programs captures broad heterogeneity in the types of population health problems addressed and specific approaches to program design and curricula. Mechanisms are created to promote networking, exchange, and synergies among the individual programs. The model, while requiring a complex set of resources, flexibly leverages existing centers and programs to build a cost-effective strategy for advancing training in interdisciplinary population health science.

Building on this and other potential models to strengthen training in interdisciplinary population health science is of vital importance to efforts to improve health and reduce health disparities. This report provides a vision and a way forward to developing innovative programs.

Acknowledgments

Many generous individuals and organizations contributed to the development of this report:

- Participants at the June 1-2, 2015 meeting, Training in Interdisciplinary Population Health Science: A Vision for the Future, who shared their experience and knowledge of interdisciplinary training and population health, provided input that greatly enriched and strengthened this report, and produced the recommendations of this report.
- Members of the planning group for the June 1-2 meeting: Nancy Adler, Jason Boardman, Bob Hiatt, Sara Johnson, Carlos Mendes de Leon, Briana Mezuk, Bobby Milstein, and Amy Non. Also Kathleen Mullan Harris and Jason Schnittker who provided advice on meeting design.
- Dave Kindig, George Isham and members of the IOM Roundtable on Population Health Improvement for agreeing to host the meeting and commission the paper.
- The NIH Office of Behavioral and Social Sciences Research, the National Institute on Minority Health and Health Disparities, the IOM Roundtable on Population Health Improvement, and the Robert Wood Johnson Foundation Health & Society Scholars program for providing travel support for participants in the June meeting.
- Paula Lantz for leading the Collaborative and providing valuable advice for the meeting.
- Alina Baciu and Colin Fink of the National Academies for amazing support for the meeting and paper.
- Members of the Health & Society Scholars strategic planning group, May 10, 2014, led by Jenn Dowd and Stephanie Robert and including Alexander Tsai, Mark Hatzenbuehler, Nancy Adler, Ray Catalano, Mike McGinnis, Rebecca Thurston, Jonathan Samet, Christine Bachrach.
- Jo Boufford, Gerard Lebeda and Jeff Price of the HSS National Program Office, who provided advice and assistance with searches and Caryn Teitelbaum, New York Academy of Medicine, in identifying foundations.
- Raymond Baxter and Kyra Nead, Kaiser Permanente; Phyllis Meadows, Kresge Foundation for providing information about existing training programs.
- Many NIH staff who met with Yonette Thomas and Christine Bachrach to discuss issues in training in population health, including Sonia Arteaga, Andrea Baruchin, Rebecca Clark, Wilson Compton, Bob Croyle, Susan Czajkowski, Deborah Duran, Courtney Ferrell-Aklin, Larry Fine, John Haaga, Kara Hall, Christine Hunter, Peter Kaufmann, Yvonne Maddox, Shelia McClure, George Mensah, David Murray, Charlotte Pratt, Melissa Riddle, Bill Riley, Shobha Srinivasin, Catherine Stoney, Natasha Williams.
- George Kaplan, Karen Lutfey, Jonathan Samet, and Sara Shostak, and attendees at the HSS May 2105 meeting who provided helpful comments on an early version of this document.

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The need for interdisciplinary population health science

US investments in health and health research traditionally have been shaped by a widespread tendency in US culture to conflate health with health care. Investments in preventing disease or disability have been small relative to the whopping 17% of the US GNP that goes to health care. Investments in biomedical research to find cures for disease greatly outpace those in research that addresses the social, environmental, and behavioral causes of poor health outcomes. Americans regard the health care system as the major defense against poor health; our health policy focuses mainly on making that system work better for us.

While access to quality medical care is important to health, there is growing recognition that factors outside the medical sphere also powerfully affect health. This increasing awareness is reflected in reports from the World Health Organization's Commission on the Social Determinants of Health (e.g., *Closing the Gap in a Generation*), the Robert Wood Johnson Foundation (RWJF) Commission to Build a Healthier America, the National Research Council and Institute of Medicine,¹ and many

other organizations. Evidence documenting the importance of upstream determinants of health has motivated key institutions to adopt multi-sectoral approaches to improving population health; examples include RWJF programs on obesity and its new initiative on "Culture of Health", The California Endowment's "Building Healthy Communities" commitment, the Federal Reserve Bank's initiative on healthy communities, the Centers for Disease Control and Prevention's Health Community Design Initiative, and the Obama administration's place-based initiatives. Another key effort, the Health in All Policies initiative of the National Association of County and City Health Officials, draws attention to the potential consequences of all policies, not just health care system policies, for improving or diminishing health.

These efforts imply a focus on population health: "the health outcomes of a group of individuals, including the distribution of such outcomes within the group" (Kindig and Stoddart 2003). Population health moves beyond the individual focus of the traditional medical model to consider the large disparities in morbidity and mortality

¹ Recent examples include IOM (2012a,b); IOM and NRC (2013); and NRC (2009).

² "Population health" has entered the lexicon of medical care organizations in recent years, and the term's usage in this setting has differed somewhat from that intended here: the populations targeted have, with some exceptions, tended to be enrolled participants and the focus, improved management of clinical populations. By contrast, we define populations broadly to include geographic and/or political entities, as well as population subgroups such as those sharing a particular economic, racial, or ethnic status. Our focus is also broad in the range of health outcomes considered, including for example life expectancy, disability, and "physical, mental and social well-being" (WHO, 1948). These two meanings of population health are complementary, but their co-existence has led to some confusion and calls for modifying terminology to clarify the distinctions. See Kindig (2012) for the suggested term "population medicine" to refer to the meaning common in the health care community.

among population groups in the U.S., to consider why the U.S. population's health lags behind health in other advanced economies despite much larger investments in health care (NRC & IOM, 2013), and to consider how a range of multi-sectoral social, economic, environmental or other policy interventions and investments that operate at local, regional, and national levels can improve population health.²

In recent years, the health care system has recognized the importance of multi-sectoral approaches to population health. As the Affordable Care Act moves payment to health care systems to payments based on quality health outcomes rather than volume of care, hospital administrators are recognizing that non-medical care inputs can be leveraged to improve the health of their patient populations, and that evidence from population health science is needed to inform these strategies (Stoto, 2013; Burwell, 2015). Moving forward, we need a stronger evidence base to drive important decisions about how to improve population health, not only through the health care system, but also through strategies implemented by industry, government, education, and many other sectors at both the national and sub-national levels.

An interdisciplinary evidence base for population health

As the momentum for addressing the multiple determinants of health grows, it is important to take stock of the evidence base that informs these efforts and the pool of scientists who can move the science forward. One of the most striking things about the evidence base is that it can't be ascribed to any one field or discipline. Scientists trained in traditional schools of public health have contributed significantly to our knowledge of upstream determinants, health beliefs and health behaviors, but so have scientists from economics, sociology, psychology, anthropology, demography, geography and other social science disciplines. Geographers have expanded our view to geospatial determinants and measurement approaches. (McClafferty, 2003; Kwan, 2013). Medicine, genetics, neuroscience, endocrinology, and other biologically oriented fields have also contributed the science needed to understand how and why upstream determinants and behaviors produce health outcomes.

The field of population health science has grown over recent decades to embrace the multi-disciplinary sources of science relevant to health and to emphasize the need for a focus on health at the population, rather than individual, level. Population health science:

- focuses on the levels of health within populations and disparities in health within and across different population groups;
- conceptualizes health as the product of multiple determinants at the biologic, behavioral, contextual levels and their interactions among individuals, communities, time, and place;
- often requires scientists to examine common health determinants across different diseases and conditions, and may offer solutions that operate at the population level to improve outcomes across disease categories as well as disease-specific outcomes; and
- produces knowledge about the contextual, behavioral, and biological causes of health and disease, the mechanisms through which overall levels of health and health disparities are produced, and the evidence base for policies and practices that improve population health and ameliorate health disparities.

Population health science is not its own discipline – it is an interdisciplinary field that seeks to integrate knowledge, theory, and tools from multiple disciplines to develop a broad understanding of the multi-factorial pathways that produce health and health disparities so that more effective solutions can be found. Disciplinary science provides a foundation for this interdisciplinary undertaking and many critical insights in population health trace back to individual

disciplines.³ No one discipline, however, has all the answers. Increasingly we will need to call upon interdisciplinary population health science to address our complex population health problems such as asthma, diabetes, obesity, and racial and socioeconomic disparities in a range of physical and mental health outcomes.

While acknowledging a close relationship to public health, population health proponents seek to extend traditional scholarship and training in public health to better incorporate the full range of disciplines that contribute to population health knowledge. This implies a deep commitment to inter- and/or trans-disciplinary science, defined as science that combines discipline-based theories, methods, and knowledge to solve scientific questions.⁴ In interdisciplinary work, researchers work jointly, each drawing from his or her discipline-specific perspective, to address a common research problem. Transdisciplinary work involves an integrative process in which researchers work jointly to develop and use a shared conceptual framework that synthesizes and extends discipline-specific theories, concepts, and/or methods to create new models and language (Stokols et al., 2008a). In this paper we use interdisciplinary to refer to both concepts.

The attempt to develop an integrated interdisciplinary field can draw on: the experience of other interdisciplinary fields that have developed in science and technology, the support and encouragement of funders in the public and private sectors, as well as a growing body of knowledge about the factors that make interdisciplinary teams fail or succeed.⁵ This research suggests that a broad range of intrapersonal, interpersonal and contextual factors contribute to success in interdisciplinary science. Population health science may face particular challenges to the extent that it engages disciplines that are widely separated by institutional structures and scientific approaches.

The integration of the basic social sciences alongside the basic biological, clinical, and behavioral sciences is essential to population health science. Many health-focused sciences treat social contextual determinants as “exposures.” The problem with this approach can be illustrated with an extreme example: one might say that a death was caused by exposure to a bullet, neglecting a larger and more useful explanation that took into account the relationship of social and economic conditions, environmental stressors and stress response pathways, patterns of social interaction, and public policies to the firing of the

bullet. By addressing the processes that drive social systems and produce “social exposures;” processes of stratification, economic cycles, political movements, migration, diffusion, and institutional change, the social sciences can greatly enrich and deepen the understanding of social determinants and the avenues for addressing their effects on health. Conversely, social scientists need to work more closely with biological scientists to understand how social factors “get under the skin” to affect health. Interdisciplinary work on gene by environment interactions, for example, require social scientists and geneticists to collaborate, just as new work on the microbiome will require social scientists and biologists to collaborate to understand how the social world affects the microbiome, and how the social and microbiotic worlds interact to affect health.

³ For example, the contributions of cognitive science to designs for menu and package labeling that enable consumers to more readily understand the health risks and benefits of products (Roberto & Kawachi, 2014).

⁴ This integration both reflects and reinforces the prioritization of interdisciplinary research by the National Academy of Sciences (2004), the National Institutes of Health (2007), and the European Science Foundation (2012), as well as many colleges and universities (Klein, 1996; Latucca, 2001).

⁵ For example, the Science of Team Science is a new field of inquiry that applies rigorous methods to investigate what makes interdisciplinary teams successful (Stokols et al., 2008a,b).

Moving ahead: workforce and challenges

The adoption of population health strategies within public health, medical, business, government, and educational institutions signals a growing demand for a trained workforce that can develop and apply the evidence from population health science. This workforce will include a diverse set of people with skills ranging from basic scientific discovery to translation and implementation, and occupational titles from scientist to policy analyst to social worker, physician, city planner or business owner. Not all workforce members need to be highly skilled interdisciplinary scientists. Training that provides a basic understanding of population health may suffice for most people involved in carrying out relevant programs.

Many members of this workforce, however, will need the skills to create the evidence base for population health and the skills to critically evaluate the products of population health science and its potential application to policy and practice. These needs imply interdisciplinary training throughout the training pipeline, from high school exposure to mid-career and senior level retooling opportunities, but with an emphasis on programs at the pre- and post-doctoral levels. This paper focuses on the training pipeline necessary to produce such

interdisciplinary population health scientists.

Three challenges lay ahead as this growing field moves forward. First, despite the emphasis on interdisciplinary science, most universities retain disciplinary structures that tend to silo the diverse contributors to population health science. As a result, calls for increases in interdisciplinary research to improve population health often overlook the fact that few scientists have been trained to effectively conduct such research. Scientists in schools of medicine and public health tend to be divided from social scientists not only by scientific approach and discipline-based incentive structures but also by institutional boundaries, geography, and weak network connections. While some social scientists hold positions in schools of public health, soft money environments often make such positions disadvantageous compared to those in traditional disciplinary departments. Widespread cultural views that devalue the social sciences as “soft” also function to discourage effective integration of their contributions. Finally, although most health scientists recognize the importance of interdisciplinarity, it is less clear how far this has influenced training. In a recent study of public health programs in Canada, over three quarters endorsed the value of interdisciplinary, multidisciplinary or cross-disciplinary training opportunities, but only one-third (32%) provided them (Mishra et

al., 2011). We need to find ways to train future scientists to be better than current scientists at conducting interdisciplinary population health science.

Second, the success of population health science will depend on letting problems, not familiar toolkits, drive approaches to understanding and improving health. The complexity of pathways that operate at the contextual, behavioral and biological levels to produce health outcomes means reaching out to a wide range of sciences to identify relevant theory and methods and finding innovative ways to improve and adapt methods deriving from different disciplines to fit the problems of population health. The field will need to reach out to systems and computational scientists for powerful ways of distilling and integrating knowledge. It will need to simultaneously retain the strengths of the disciplinary roots of population health science while transcending disciplinary silos. Focusing training of future population health scientists around population health problems rather than disciplinary toolkits holds promise for fostering collaboration across the range of disciplines and sectors that can contribute to understanding and addressing a particular population health problem.

A third challenge is to ensure that the scientific contributions of population health science lead to innovative ways to improve health. The field must embrace not only science on basic mechanisms producing health, but also research that can guide

choices about the most effective levers for improving population health, demonstrate the return on investment for manipulating them, and specify the conditions under which they are most effective. Existing research provides appealing ideas for improving population health in many areas, but too often these are based on narrow disciplinary assumptions and do not produce results. Adler et al. (2013) argue that agile institutional mechanisms that link population health science and practice are needed to build bridges between basic and applied research and among researchers, policy makers, and practitioners. We need a “two-way street” in which the application of population health concepts to practice, programs, and policies is guided by the best possible scientific evidence and scientific agendas are responsive to the need for evidence to guide programs, policies, and practice. This type of interdependent relationship, if done well, can create an innovative learning environment that produces both new knowledge about population health and improved strategies for improving it.

How do we train new scholars the skills to lead and participate in these interdisciplinary and multisectoral initiatives? How to structure training programs to optimally accomplish this remains a challenge, particularly because

we want to produce new interdisciplinary population health scientists who are better than their mentors at producing interdisciplinary population health science through collaboration across disciplines and sectors.

Origins and outline of the report

While population health science holds great promise for advancing new approaches to improving health and reducing health disparities, the future of training in this area is uncertain. The only national post-doctoral training program specifically focused on training in population health science will be ending as of August 2016. As we discuss below, many other related training programs exist, but few, if any, provide the full range of competencies needed to create outstanding population health scientists. To address concerns about the future of training in this interdisciplinary field, the IOM Roundtable on Population Health Improvement commissioned this report and helped to support a meeting to gather advice on training the next generations of scientists in this nascent field. The meeting, “Training in Interdisciplinary Population Health Science: A Vision for the Future,”⁶ was held on June 1-2, 2015. Its overarching goal was to:

develop a vision for the production of outstanding scientists who can integrate knowledge, theory, and methods from diverse disciplines and participate effectively in interdisciplinary teams to address complex population health issues.⁷

⁶ This meeting was hosted by the IOM Roundtable on Population Health Improvement and supported by the Roundtable, the NIH Office of Behavioral and Social Sciences Research, the National Institute on Minority Health and Health Disparities, and Robert Wood Johnson Health & Society Scholars.

⁷ This is not to discount the importance of training nonscientists in population health concepts. As discussed elsewhere, training in undergraduate and graduate settings can also set the stage for people who will contribute to population health through nonscientific activities.

Appendix 1 provides an agenda and participant list. Participants in the meeting included scientists working in fields contributing to population health research, leaders in academic training in population health science and/or interdisciplinary training in related areas, health care and public health professionals, and representatives from scientific associations, foundations, and the National Institutes of Health. Meeting participants reviewed goals and principles, existing models, and best practices in population health science training at various levels and developed recommended strategies for creating a robust pipeline of interdisciplinary population health scientists. An early draft of this document provided a common starting point for discussion at the meeting.

This paper reviews existing experience and knowledge relating to training in interdisciplinary population health science and points to the needs, lessons learned, and challenges for training in this field. It also draws on the wisdom and vision of participants at the June 2015 meeting to articulate priorities and strategies for ensuring a sustainable future supply of scientists prepared to address critical issues in population health and population health improvement.

Section II provides an overview of programs and funding streams that have supported training in population health science and argues that, despite the many training programs in health, few available programs meet the needs of this

interdisciplinary field. Section III describes critical competencies, training strategies, and institutional factors that contribute to successful training programs. In Section IV, we explore the ways in which programs at different levels, from the undergraduate to the postdoctoral, can contribute to an effective training pipeline, and provide examples of programs at each level. Sections III and IV each contain recommendations for training programs offered by participants at the June, 2015 meeting. Section V summarizes these recommendations and presents a consensus model for graduate training in interdisciplinary population health science developed at the meeting.

An overview of training in population health science

Although the development of training programs in interdisciplinary population health science is a relatively recent phenomenon, training in related fields is well established. Many scientists trained in other fields have made major contributions to advancing research on population health and health disparities. In this section, we acknowledge some of the major disciplines and fields that have offered training relevant to population health and health disparities.⁸ We also discuss the various funding streams that have supported this training. Finally, we focus in on training in interdisciplinary population health science, noting the key features that may distinguish it from other training experiences.

Not surprisingly, schools of public health have played a major role in fostering pioneering work on population health. The health of populations is central to the mission of public health and is explicitly addressed in many traditional departments within schools of public health, including environmental health, health policy, community health, and epidemiology. Outstanding training programs in these areas are long established. Despite concerns, expressed by some scientists, that public health has become too narrowly focused on health care, biological determinants of disease, and individual-level approaches (Krieger, 1994:892), the movement towards

population health science has been embraced by many schools of public health. Indeed, several such schools have adopted names that include “Population Health.” Social epidemiology has grown as a subfield within epidemiology, although only recently gaining broader legitimacy. Many of the leaders in population health science are housed in schools of public health.

Other university programs outside public health have also contributed to the development of population health scientists. Programs in medical sociology and demography have trained many scientists in the study of population mortality trends and differentials, the contributions of social factors in mortality and health, and methods of population analysis. Schools of public policy have trained experts in analyzing the effects of policy on well-being as well as the process of policy-making and implementation. Medical and other health professional schools are increasingly providing attention to social and behavioral as well as biological factors in health and many medical schools are now establishing departments of population health. Training programs in traditional disciplines located within schools of arts and sciences have also generated leaders in the field.

Past training has relied on a variety of funding sources. Central among these, of course, are the traditional sources of funding for universities: tuition, endowments, contributions

⁸ Because so many fields contribute to population health science, our review is necessarily partial.

from state and local governments, and increasingly gifts from donors. “Soft money” grants and contracts from public and private sources tend to dominate funding for schools of public health and other specialized schools. While most of this funding goes to research, training grants from the NIH have played a major role in supporting interdisciplinary training relevant to population health.

A search of NIH training grants active in 2013 identified 70 pre- and/or postdoctoral programs that were related to population health.⁹ (See Appendix 2 for a detailed account of the methods and results of the search). Most of these were focused on specific disease outcomes and some on population science broadly (without a specific focus on health). A few addressed health disparities. While many provided exposure to a variety of relevant disciplines, very few health-focused programs integrated social science deeply in the training. Very few explicitly provided training in the skills needed for interdisciplinary science.

Private foundations have also been important contributors to training activities in population health. The Robert Wood Johnson Foundation has funded the Health & Society Scholars program (HSS), a postdoctoral program explicitly directed toward the development of scientists who can advance the

science of population health and develop innovative approaches to improving health. However, this program will close in August 2016. (The Foundation is discontinuing all site-based human capital programs). The RWJF has also been funding other relevant programs, such as the Clinical Scholars Program and the Scholars in Health Policy Research program; these will also close in 2016. A new program focused on leadership training in four domains related to the Foundation’s new “Culture of Health” initiative will take their place (see Appendix 2 for a summary).

Other organizations and foundations have also supported training relevant to population health. Kaiser Permanente provides support for several important training programs relevant to population health issues, including the Burch Minority Leadership Development Program; support for the Satcher Health Leadership Institute at the Morehouse School of Medicine, training activities within the UCLA Kaiser Permanente Center for Health Equity, and the UC Berkeley Kaiser Permanente Public Health Scholars program. The W. K. Kellogg Foundation’s Kellogg Health Scholars Program provided training on the social determinants of health, academic-community partnering, community-based participatory research, and application of research

to strengthen advocacy and achieve policy change. This two-year post-doctoral program closed in 2012. The Aetna Foundation and the Kresge Foundation offer programs focused on policy, leadership, and community engagement activities related to population health, but not training in science. Appendix 2 provides a description of methods and results of a search of foundation funding in this area.

In sum, there are a number of training programs related to population health science, but each is limited in some regard in terms of the potential to provide the breadth and depth of training necessary to create a new cadre of population health scientists. Most current training programs include only a limited subset of the sciences embraced by population health science or address only one health outcome. Most do not foster training in conducting interdisciplinary science and provide either little training and guidance on the leadership and translational aspects of improving population health or focus training only on the leadership and translational aspects, with little attention to producing the underlying science.

In the next section, we advance a set of “essentials” for training in interdisciplinary population health science. While many of the programs

⁹ This search, conducted by Yonette Thomas and Christine Bachrach, included grants as population health-related if (1) a substantial goal of training was acquiring and/or learning to produce knowledge of the determinants of health within and across populations and (2) the program either explicitly or implicitly acknowledged a multi-level conception of health determinants ranging from the biological to the social/environmental. Programs focused entirely on health services research were not classified as population health.

we have discussed here share some of the characteristics we will present, few if any provide the full range of competencies needed to create outstanding population health scientists. Further, these programs, despite their important contributions, are not designed to produce experts with the broad understanding of the multiple determinants of health and the skills to draw on diverse disciplinary contributions to produce integrated scientific approaches to population health problems. The most common differences are the extent to which social science is integrated – a critically important factor – and the focus on teaching interdisciplinary skills.

Defining the essentials of training in interdisciplinary population health science

What does it take to produce outstanding scientists who can integrate knowledge, theory, and methods from diverse disciplines and participate effectively in interdisciplinary research to address complex population health issues? Certainly there are multiple approaches – diverse and innovative approaches to training that are helpful in developing best practices. In this section, we first outline three domains of competencies that one should consider in designing and evaluating training programs. Second, we describe practices that are commonly used to develop these competencies and identify three of particular significance. Third, we discuss features of the institutional environment that are essential for successful training programs.

Competencies

We identify three core competency domains:

knowledge acquisition, interdisciplinary collaboration skills, and knowledge translation and exchange.

This list is not exhaustive, but is intended to highlight domains that may be *critical* in developing outstanding interdisciplinary population health scientists. There are many additional competencies related to creating strong scientists *in general* (e.g., research ethics, general leadership skills), and we do not list those here.

The competencies discussed in this section are those needed by

RECOMMENDATION

Address basic competencies in knowledge, metrics, methods, and research design relevant to population health; interdisciplinary skills; and knowledge exchange and translation, as appropriate to the goals of the program and the stage of training.

population health scientists *by the end of their training*. It is unlikely that all could be thoroughly mastered in one individual program. Rather, programs will vary in their focus on domains and competencies, depending on stage of training, goals, faculty strengths, and trainee characteristics. In Section IV, we address the potential for developing these competencies across different levels of educational experience, from undergraduate to post-doctoral.

In addition, while exposure to (and some level of competence in) all three domains is critical for population health scientists, individual trainees will differ in their focus across the three domains and, within domains, in the specific competencies mastered.

Knowledge acquisition

GOAL: Population health scientists should have broad knowledge of the fundamentals of population health science. The approach to defining this knowledge base should remain open and flexible. While there may be a core set of knowledge in population health that people need to learn, openness to diverse disciplinary contributions, both in theory, substance and methods, should remain a guiding principle.

RATIONALE: Population health science entails a basic core of knowledge, theory, and principles that: (1) derives from multiple disciplines; (2) addresses health broadly (including well-being, functional status, mortality); (3) includes a multilevel focus on the determinants of health (including, but not limited to, social determinants); (4) addresses population-level health including both across- and within-population disparities, and (5) engages a developmental or life course perspective. Broad exposure to this core provides a common foundation

for members of interdisciplinary teams seeking to integrate diverse theory and methods to address population health problems, and hence should facilitate collaboration. It also provides knowledge of multiple disciplines and approaches that may challenge or complement trainees' prior training.

Training in broad population health knowledge has the aim of increasing the creativity and scope of the population health scientist, improving the scientist's ability to contribute effectively in an interdisciplinary team, and enabling a scientist to produce rigorous population health research alone or in teams. A strong population health scientist will have both depth and breadth in knowledge. No one trainee will master all existing literatures, metrics, methods, and design strategies, but all should have a broad awareness of and respect for diverse contributions and approaches.

EXAMPLES OF COMPETENCIES:

- Demonstrates knowledge of concepts of health as a product of factors operating at multiple levels (e.g., molecular,¹⁰ cellular, organ, individual, family, community, region, nation, global) in dynamic ways over time.
- Achieves broad familiarity with literatures on the contributions of biological, behavioral and contextual factors to population health.

- Demonstrates familiarity with foundational concepts in population health (e.g., population, disparities, selection into and out of populations, ecological fallacy).
- Demonstrates introductory knowledge about the range of disciplines and theories that contribute to understanding and addressing population health.
- Learns the various metrics used to measure population health status and disparities.
- Analyzes the strengths and weaknesses of the analytic methods and research designs that contribute to population health science, particularly those relevant to multilevel analyses,¹¹ and multi-method approaches.
- Demonstrates in-depth expertise in the theory, methods, and knowledge base of at least one discipline or approach that contributes to understanding population health.
- Critically analyzes and integrates knowledge, theory and methods from multiple disciplines in designing and carrying out research on population health.
- Maintains a current knowledge base in population health science and monitors emerging methodologies and technologies (for example, "big data" mining, systems models, geospatial techniques), assessing how they may or may not be relevant to

¹⁰ Many participants at the June, 2015 meeting stressed the need to strengthen training in biology and genetics for social scientists in population health and training in social sciences for biomedical scientists.

¹¹ As part of this matrix of methods, complex system approaches should be better integrated into population health training.

understanding and addressing population health.

Interdisciplinary collaboration skills

GOAL: Population health scientists should develop the ability to effectively lead and/or work with others who have different approaches to or expertise in population health topics in order to understand and address the complex causes of population health problems.

RATIONALE: When working with people from other disciplines and sectors (e.g., business, government, the public), population health scientists must learn to communicate their knowledge in ways that others can understand and to develop an appreciation and understanding of the language and approaches of others. Developing this mutual understanding and respect is difficult without also acquiring particular collaborative skills in fostering and maintaining relationships, group dynamics, conflict resolution, and communication.¹² These skills are sometimes developed in disciplinary approaches to scientific training, but are rarely explicitly attended to. Yet these skills are imperative for future population health scientists to work effectively with people from other disciplines and sectors. Moreover, for population health scientists who expect to work outside of academia (which is a growing proportion

of the population health science workforce), these interdisciplinary and team skills are often crucial. In fact, academia is chastised by non-academic employers who sometimes find new scientists unprepared to work in team environments with people from different disciplines and sectors.

EXAMPLES OF COMPETENCIES:

- Builds and maintains working relationships among people with different approaches to population health science and practice.
- Assesses when an interdisciplinary approach may be necessary or unnecessary and which other disciplines/approaches could contribute significantly to a particular research project.
- Develops research questions and selects appropriate study designs to understand a population health problem from an interdisciplinary perspective.
- Navigates and negotiates roles and responsibilities within an interdisciplinary and/or cross-sectoral team project where there are likely no clear, shared norms at the start.
- Leads and/or functions effectively within an interdisciplinary and/or cross-sectoral team.
- Demonstrates problem-solving and conflict management skills.
- Fosters group cohesion.

- Mentors trainees from one's own and other disciplines, either one-on-one or in team mentorship.

Knowledge translation and exchange

GOAL: Population health scientists should not only produce rigorous science, but they should also know how to communicate that knowledge to appropriate audiences and understand a range of methods of knowledge translation and exchange that may improve population health policy and practice.¹³

RECOMMENDATION

Foster “impactful science” by deepening the integration of science, translation, and research user communities in all programs.

RATIONALE: There is growing consensus that population health scientists should be concerned not only with producing rigorous science, but also with taking an active role in ensuring that the science they produce can contribute to improving population health. Participants at the June 2015 meeting voiced strong concerns that population health science was not yet adequately moving to application, and that training programs should be challenged to remedy this by providing trainees exposure to

¹² See also Canadian Academy of Health Sciences, 2005 for a similar call for training in interdisciplinary skills.

¹³ There is another side to this. Those who will be applying knowledge of population health science should be cognizant of the underlying limits and strengths of the evidence they are working from.

content and activities that span the full continuum from basic research to knowledge exchange, translation, and implementation science.

Training on the dissemination of research in various formats (e.g., clinical guidelines, policy briefs) and media training and engagement provides trainees familiarity with a “*push*” approach to knowledge translation in which the scientist pushes or disseminates knowledge out to user communities (Grimshaw et al., 2012; Lavis et al., 2003; CHSR, 1999; Lomas, 2007). However, training in other forms of knowledge translation may also prove critical for population health researchers. As Lavis and colleagues (2003) suggest, effective knowledge translation may need to go beyond a unidirectional “push” approach to also incorporate “pull” and “exchange” approaches. “*Pull*” refers to how the users of knowledge pull information from knowledge producers, develop capacity for digesting new knowledge, and apply knowledge effectively in decision-making. An understanding of these processes helps scientists better understand when and how to disseminate their research to user communities. “*Exchange*” approaches refer to the development of bidirectional collaborative relationships between the producers and users of knowledge that promote the exchange of ideas over time. Exchange relationships can improve the relevance of the research produced and the efficiency

of take-up of the new research by the users of evidence. Integrating these ideas, we refer to “knowledge translation and exchange” as the domain of inquiry and skill in which new population health scientists must be trained.

While recognition of the need for this training has grown, the extent to which it should be emphasized in scientific training remains controversial.¹⁴ Concerns about the idea of training in knowledge exchange and translation center on a few key issues. Some suggest that when conducting basic science rather than applied science, there is no need for training in knowledge translation. Others believe that requiring training in knowledge translation implies that scientists are being asked to be involved in advocacy; many are concerned that when scientists are viewed as advocates, the credibility of their science is undermined. Some worry that including training in knowledge exchange and translation raises issues of opportunity cost – that trainees’ time is much better spent learning to produce good science, and/or that a mentor doesn’t have enough experience or time to help trainees with knowledge exchange and translation.

We acknowledge these concerns, but believe the time has come to deepen the integration of science, translation, and evidence user communities in population health training programs. Programs should provide not only

training in communication of science, but also an understanding of broader principles of and approaches to knowledge translation and exchange. At a basic level, training in knowledge exchange and translation can help all scientists better communicate their science to other scientists (particularly important in conducting interdisciplinary work) and to the media (few scientists are prepared to do this well). Beyond this, it can help researchers understand how their work contributes to advancing knowledge that can lead to improved health, where it fits along the translational continuum from basic science to application, and how they can effectively move their science forward along that continuum. Perhaps most importantly, understanding the newest approaches, options, and dilemmas regarding knowledge translation and exchange can help trainees develop impactful research agendas – agendas that are tailored to more directly inform efforts to improve health and reduce disparities. Even better, practical experience in knowledge exchange with community members or practitioners working to improve population health can both inform the development of new research agendas and also provide skills in collaborating across sectors to develop evidence-based interventions and strategies.

In sum, we call for training programs in interdisciplinary population health science to deepen their

¹⁴ For example, the RWJF Health & Society Scholars program was designed to provide postdoctoral training in both science and knowledge translation, but the six sites responded to this latter mandate differently. This lack of consensus in the HSS program reflects ongoing debates within and across disciplines.

commitment to the integration of science, knowledge exchange and translation, and user communities. Moving in this direction will not require scientists to conduct applied work or become advocates, and basic training in this domain does not need to be time consuming. While embracing variation among programs in their emphases on different aspects of knowledge translation (e.g., policy research, community based participatory research, implementation research), the challenge to all programs is to do more to strengthen trainees' competencies in this area. Programs with strong competencies in basic science should be expected to introduce training and/or experience with knowledge exchange and translation; programs already emphasizing translational science might extend their efforts and/or broaden and enrich the basic science components that are translated and to improve engagement with science user communities.

EXAMPLES OF COMPETENCIES:

- Understands different theories of or approaches to knowledge translation and exchange.
- Communicates with practitioners, policymakers, the media, and/or other relevant audiences about the findings and population health significance of one's research.
- Summarizes and communicates the importance of a body of research (synthesis of research in a particular area, rather than just one study) for relevant audiences.

- Understands how to engage networks, knowledge brokers, social media, and other avenues to disseminate research.
- Understands the basics of the policymaking process.
- Frames, speaks, and writes about one's research using a variety of approaches to communicate with different audiences.
- Able to evaluate how potential end-users of one's research – user communities (e.g., scientists, practitioners, and/or policymakers) – prefer to access and use those research findings (e.g., their preferred formats and venues).
- Understands the barriers and incentives experienced by potential research users in accessing and applying population health science.
- As relevant, develops and maintains relationships with practitioners/policy makers in one's area to enhance the efficient exchange of information over time between scientists and end users of the science.
- Able to engage policy/practice stakeholders in the design of a study to ensure the results will be useful, as appropriate.

Training practices

The competencies discussed above can be achieved, over time, through a combination of mechanisms. What is most appropriate and feasible will depend on the level of training, the level and kinds of resources available to a program (e.g., funds to support research and other activities, breadth, experience and skills of faculty able and willing to participate, number of trainees that can be supported, applicant pool). We highlight three mechanisms that participants in the June 2015 meeting described as crucial elements of training in interdisciplinary population health science: immersion in an interdisciplinary environment, involvement in an interdisciplinary research team, and intensive mentoring using a multi-mentor model. We then summarize other practices commonly used in graduate training.

Immersion

Learning to be an interdisciplinary scientist requires immersion in an environment that promotes collaboration and the integration of contributions from diverse disciplines. There is no quick substitute for interdisciplinary training that involves working with a group of people who are from different training backgrounds, over an extended period of time. Classroom training alone is not enough to produce interdisciplinary population health scholars with the knowledge, skill, and experience to

produce creative population health solutions.

requires disciplinary diversity at the faculty and trainee level and incentive

RECOMMENDATION

Immerse and engage trainees in a diverse interdisciplinary environment over an extended period of time.

This means designing projects, seminars, and classes to include trainees from diverse disciplinary backgrounds and to require participants to manage and transcend disciplinary boundaries in problem solving. It means providing ongoing opportunities for building scholarly networks across interdisciplinary boundaries and mentoring in interdisciplinary values and skills. It also means providing many opportunities for modeling the behaviors and strengths of faculty who demonstrate interdisciplinary and leadership skills as well as successful strategies for career success as an interdisciplinary scientist.

At a minimum, creating such an environment requires several kinds of resources – the ability to create small-group settings that are large enough to provide disciplinary variability¹⁵ but small enough to force cross-disciplinary exchange;¹⁶ time for sustained interactions that can produce interdisciplinary understanding and commitment; and a faculty engaged in and committed to interdisciplinary research. It

structures that promote engagement with the program by individuals and programs with relevant expertise.

How broad does disciplinary diversity need to be? Ideally, the answer is driven by the nature of the sciences that are needed to address the specific problems in population health targeted within a program. In reality, diversity often depends on the institutional structures, geography, social networks, and incentives in place at a university. Participants noted that epidemiology, sociology, psychology and demography are positioned to make central contributions to population health science, but programs should diversify beyond these strengths. Too often interdisciplinary collaborations have involved arguably similar disciplines working together – sociologists, epidemiologists, and economists working together, or biologists, geneticists, and chemists. Moving forward, training programs need to engage a broader range of scientists, engaging social and biological scientists together, as well as broadening the scope to geographers, communication

scientists, anthropologists, and other fields, as relevant to the population health problem being addressed. Meeting participants encouraged programs to find ways to better incentivize biologists to participate in interdisciplinary population health endeavors. There was broad support for better integrating research and clinical scientists (e.g., physicians, nurses) in population health research teams, and to find ways to engage individuals from various sectors engaged in efforts to improve population health outside of academia (e.g., industry, government, education, social work).

Interdisciplinary team research

Experience as part of an interdisciplinary research team should be an integral part of scientific training at the graduate and post-doctoral levels and, to a lesser extent, at the undergraduate level. Involvement in an interdisciplinary research team complements didactic training by allowing trainees to apply their growing knowledge and skills to real research problems. This experience hones skills in

RECOMMENDATION

Engage trainees in interdisciplinary research teams focused on problems in population health.

¹⁵ In the RWJF Health & Society Scholars program, sites found that having six trainees in place at a given site was an optimal number, allowing for both rich interdisciplinary interaction and strong mentoring.

¹⁶ In the RWJF Health & Society Scholars program, the trainee selection process was critical to achieving these conditions. Final applicants were evaluated by a multi-disciplinary team of interviewers and trainees were selected to create both disciplinary diversity and intellectual synergies among cohort members. Sites also tended to select applicants with interpersonal styles that lent themselves to the challenges of interdisciplinary collaboration.

research design: for example, in the interdisciplinary context, skill in analyzing concepts and methodologies from multiple disciplines in formulating questions and approach. It also develops competence in navigating the many decision points involved in research, from fieldwork problems to questions about publication and translation. Joining or forming an interdisciplinary team provides the trainee an opportunity to observe and build interdisciplinary skills as the trainee has to navigate the different perspectives and styles of multiple disciplines and personalities and learn how to move complicated projects forward.

RECOMMENDATION

Provide mentoring in scientific areas, knowledge exchange, interdisciplinary skills, and professional development domains, using a multiple mentor model.

Mentorship

Mentorship plays a critical role in helping trainees in the sciences achieve successful academic trajectories (Bland et al., 2009; Pfund et al., 2014). Mentorship is especially important in interdisciplinary population health training because the field encompasses such a broad range of content, disciplinary approaches, and career pathways. As a result, individual training trajectories may (and perhaps should) be highly individualized, and experienced mentorship is required to help trainees stay on course.¹⁷

Mentorship is needed in all three of the competency areas discussed above: knowledge acquisition, interdisciplinary skills, and knowledge translation and exchange, as well as in career challenges such as choosing disciplinary or interdisciplinary publication venues, negotiating authorship expectations, securing academic or other positions, and promotion.

In traditional disciplinary science, faculty members are motivated to mentor and engage trainees in their own research because they provide an accessible and relatively inexpensive source of skilled labor. However, advanced trainees who are developing

their own research careers often benefit more from mentoring that is not tightly tied to faculty research projects, often requiring multiple mentors or a team of mentors who can support the trainees in various aspects of their independent research and professional development. As such, consideration of how to incentivize or reward faculty for such non-traditional mentoring roles needs attention.

Ideally, mentors should be experienced interdisciplinary scientists who have mastered these

competencies themselves (Nash 2008). However, the relative youth of this interdisciplinary field means that such faculty may be in short supply. As a result, new training programs in interdisciplinary population health science need to consider a range of methods of mentoring trainees, including team mentoring, having team research opportunities that gather multiple mentees and mentors in an interdisciplinary research endeavor for co-learning and training, and having training directors who themselves are interdisciplinary or transdisciplinary and are able to advise and support around the challenges of such work, including helping mentees effectively work with multiple mentors for different purposes. “Vertical” mentoring models, in which undergraduates, predocs, and postdocs work together with faculty on ongoing projects provide opportunities for trainee-to-trainee mentoring across stages of training.

New programs should also consider mentor training for mentors and mentees in order to improve both mentor and mentee skills around mentoring interdisciplinary scholars. See information on the new NIH funded National Research Mentoring Network (NRMN) for information about various mentor and mentee training options.

New models for team mentoring in interdisciplinary population health training will require more planning

¹⁷ As discussed in Section V, effective mentorship requires compensated time for faculty. The lack of compensation in NIH T32 grants represents a major challenge for training in population health science.

and effort than traditional one-on-one mentor models. However, such effort around mentoring will be essential to helping future population health scientists both develop the range of knowledge, skills, and expertise needed to address population health problems and garner the needed support to translate that knowledge and skills into successful careers.

Other training practices

Coursework is a traditional educational tool for imparting basic knowledge and skills, and it is likely to play a role in most approaches to population health training. Through coursework, trainees can acquire basic knowledge of the concepts, methods and research that diverse disciplines contribute to understanding population health. Curricula in population health may take the form of “weak” interdisciplinary programs, in which students take courses from a menu of options that span disciplines, or “strong” interdisciplinary programs, which also include integrative courses (Augsburg and Henry 2009; Klein 2010). Integrative courses (for example, an interdisciplinary introductory and/or capstone course) can ensure that students are exposed to a range of relevant disciplinary science and may facilitate the development of skill in analyzing and integrating across disciplinary contributions. The integration of problem based learning approaches and case studies may be especially effective in developing such skills. Coursework can also help to

build a foundation in knowledge translation and exchange, including an understanding of theories and approaches, the basics of the policymaking process, and concepts, theories, and skills relating to communication to different audiences.

Alternatives to traditional coursework include **mentored study** and **interactive seminars**. By necessity, many of the early pioneers of population health science developed interdisciplinary knowledge by studying diverse literatures on their own. Individuals who enter population health at an advanced stage of training may do the same. However, such an approach is more likely to be successful if guided and/or advised by an experienced interdisciplinary mentor who can help to expose the trainee to a broad range of relevant literatures and methods. Interactive seminars are groups of students and at least one faculty member who meet together on a regular, sustained basis to discuss a designated topic. These seminars have much in common with coursework conducted in a small-class setting, but are less likely to follow a pre-structured curriculum. If participants in the seminar are drawn from multiple disciplines, this can be a vehicle not only for substantive learning but also for modeling and developing skills in interdisciplinary communication and integration. Moreover, seminars that include multiple faculty from various disciplines along with trainees may be a particularly rich approach to co-learning and modeling interdisciplinary discourse.

Other forms of experience-based learning can also play an important role in preparing trainees for a successful career in interdisciplinary population health science. Through team-based activities such as organizing conferences, community-based projects, or even completing group course assignments, individuals can develop leadership and teamwork skills needed for interdisciplinary research. Experiential learning can also play an important role in knowledge translation and exchange training. For example, some programs have trainees write op-ed columns that use science to speak to public issues or ask trainees to summarize and communicate research for a lay audience. At advanced stages of training, hands-on experience in engaging potential end-users of one’s research (e.g., scientists, practitioners, and/or policymakers) in research design or translation efforts can help trainees learn about opportunities and challenges inherent in the process of translation. The success of these activities is likely to depend on the availability of faculty mentors with the experience, skills, and networks to guide trainees towards productive experiences, or mentors/programs with the commitment to finding additional trainers or mentors to help with this aspect of training.

Institutional contexts and resources

For even the best designed program with carefully specified goals, a diverse and supportive institutional context is essential for success. Universities and funding organizations alike have an important role to play in building institutional supports for research, training, and knowledge translation and exchange in interdisciplinary population health science. Fostering collaboration across departments and sectors and aligning incentive structures and funding supports with the needs of interdisciplinary training are among the important issues to be addressed.

Population health science draws on disciplines typically distributed across many segments of a university. Ideally, trainees need to have access to top-notch social science, public health, allied health, and medical school departments, and often schools of business, education, public policy, social work, architecture, and more. Access to government, public health, and clinical settings can also benefit training by providing

hands-on experience with knowledge translation and exchange.¹⁸ Even at universities where all of these resources are available, however, linkages between different campuses and schools are often weak or nonexistent. Institutional leaders play an important role in strengthening these linkages.

Federal funders have often created special funding streams and centers for interdisciplinary science. For example, the success of the NIH Centers for Population Health and Health Disparities should lead to new efforts in population health: perhaps creating a network of population health science centers across the country and/or providing incentives to existing centers with relevant interests to deepen their commitment to interdisciplinary population health research. Such efforts can change institutional cultures by drawing a critical mass of faculty, postdoctoral fellows and students together. As shown by the experience of the RWJF HSS, interdisciplinary training programs can be particularly effective in fostering greater communication and collaboration across university

departments as trainees draw faculty from different schools into common networks of research and mentoring.

Many universities also have provided special funding to promote interdisciplinary research among their faculty and supported the development of interdisciplinary centers and programs. In addition, many universities have developed partnerships that link scientists to community organizations in projects that benefit local communities. While some academic institutions are able to prioritize such initiatives, often it is the infusion of external funds that stimulates and supports them.¹⁹ Finding ways to extend these efforts is not only essential for building effective training programs in population health science, but also offers important benefits for universities, the development of scientific knowledge, and the public good.

University leaders and external funders also could do much to align incentive structures and funding supports with the needs of interdisciplinary training in population health science. One key challenge that many universities are now tackling is the need to reform promotion and tenure criteria to explicitly address the value of interdisciplinary work and to set standards for documenting relevant contributions. Another relevant target may be joint appointments that, while offering young scholars

RECOMMENDATION

Invest in strengthening the institutional supports for interdisciplinary population health science and its translation, both within academia and in the collaboration between academic and other sectors (e.g., business, health care, community)

¹⁸ As discussed elsewhere, this may create a quandary, for these resources may be present only at the most elite schools, reducing diversity in the pipeline of population health scientists.

¹⁹ For example, the RWJF Health & Society Scholars program at the University of Wisconsin-Madison has offered annual course development grants for faculty developing new courses or course modules related to population health.

the opportunity to do innovative work across disciplines, may also double their service commitments and thereby impede their progress to tenure. Changing existing practices requires not only new guidelines and procedures, but also the breaking down of long-standing academic cultures that privilege disciplinary contributions. Funders can play a role in promoting such change through their funding streams: for example, by funding interdisciplinary training programs, providing research support to interdisciplinary scholars as they transition to junior faculty positions, or by funding awards to early-career and/or distinguished contributions in interdisciplinary population health research.

There are other challenges as well. Conceptualizing population health as the subject matter of interdisciplinary research rather than a discipline in and of itself implies a need for innovative programs that may not resemble traditional departmental training programs. Some interdepartmental programs tend to rely on affiliated and adjunct faculty, resulting in less continuity and consistency in the curriculum for students and greater administrative burdens for program chairs. At the same time, department chairs express concern that interdisciplinary programs and centers siphon away scarce resources, making it more difficult for departments to fulfill their missions (Handler 2013). At many universities, and for new faculty in particular, there is a lack of resources and reward at the departmental and university level for developing interdisciplinary

coursework. Structural barriers, such as physical distance, departmental philosophical silos, and lack of financial incentives for team teaching make it difficult for faculty members from different departments to join forces to create integrated course material (Canadian Academy of Health Sciences, 2005).

Finally, there is a need for a variety of incentives for faculty to offer mentoring and interdisciplinary research opportunities to undergraduate, graduate, and postdoctoral trainees interested in population health sciences. Often, mentors in training programs are not reimbursed for their mentorship and training, or reimbursed little. This was feasible in the past because mentors directly benefited from having trainees work on their projects and publish with them. In new interdisciplinary training models, mentors may benefit less directly from their mentorship roles because mentees may work with multiple collaborators and mentors and may work less directly on the goals of one primary mentor. Increased funds for effective multi- and team mentoring models will be crucial moving forward. It needs to be recognized, by external funders and universities alike, that taking the role of mentorship seriously in future training in interdisciplinary population health science will make new training programs more expensive.

“If you build it, they will come.” Institutions and funders must also consider incentives that draw students into population health

training programs. Excellent, well-resourced programs attract strong trainees. Arguably, at the pre-doctoral level, programs that fund trainees well and attract strong faculty as mentors are able to attract good trainees. At the postdoctoral level, there are additional challenges. It is a norm in the biological sciences for recent PhDs to take postdoctoral positions, but this is not the norm in the social sciences. In the current economic climate, many of the strongest candidates for faculty jobs often take a good faculty position right away rather than extending their training in postdoctoral positions that have traditionally paid very little. The RWJF human capital programs have had great success in recruiting top candidates because they have paid higher stipends. Other resources for trainees such as travel and research funds are also important. Traditional predoctoral and postdoctoral fellowships often provide inadequate funding for trainees to attend multiple conferences – attendance that can be important to maintaining a presence in one’s discipline and expanding into new areas of interdisciplinary inquiry.

In the next section of this paper, we discuss the pipeline of training, highlighting considerations for undergraduate, graduate, and postdoctoral interdisciplinary training related to population health sciences. We do so with the recognition that the competencies listed earlier may not be equally appropriate at each stage of the pipeline. Applying a scaffolding model to training, one can envision introductory exposure to knowledge and skills at earlier stages, and more advanced exposure, immersion, and independence at later stages of training.

The training pipeline

There is no single path to becoming a population health scientist. Some individuals don't discover the concepts and approaches of population health until they are already in graduate school; increasingly, some may do so during their undergraduate years. Many eminent contributors to the field never received any formal training in population health, instead piecing together the needed expertise through their own efforts and interaction with other scientists.

RECOMMENDATION

Provide a pipeline of training opportunities at multiple levels and begin to engage students early in the pipeline.

In today's world, training in population health should be conducted at all levels. Participants in the June, 2015 meeting stressed that it is important to start early to expose people to population health concepts, and participants encouraged investments at both the high school and college levels. At the same time, they indicated the greatest current need was for advanced scientific training at later stages in the pipeline, particularly at the doctoral and postdoctoral level. Summer programs, mid-career and senior level sabbaticals can also contribute to an integrated strategy.

Offering a variety of entry points can cast the widest net for individuals who can contribute to population

health science. In addition, offering training all levels not only helps to recruit and train future population health *scientists*, but also can expose a broader range of trainees to population health ideas. Such exposure can create a mass of people who are more effective contributors to population health knowledge and action *through the range of careers* that they may engage in, not to mention through their actions as well-informed citizens.

Because subsequent sections of this report focus on training in population health at the undergraduate, graduate, and postdoctoral levels, we briefly touch on other levels and types of training opportunities here. Ideally high school curricula should introduce students to complex thinking about the multiple determinants of and solutions to population health issues. An NIH program²⁰ that develops and distributes science curricula supplements for grades K-12 could provide a useful mechanism for promoting this. Summer programs that introduce college-level students to population health science, located at universities with strong population health centers, can begin to establish knowledge and skills as well as inspire career choices. These programs may be particularly effective in attracting individuals from colleges that lack relevant faculty and programs and/or that draw from underrepresented regions and groups. Finally, mid-career training, typically in the form of sabbaticals at academic institutions

²⁰ See <https://science.education.nih.gov/customers/highschool.html>.

or in applied settings, may be transformative for scientists and for individuals from business, medicine, and other sectors. Sabbaticals can facilitate interdisciplinary population health scholarship and its translation into policy and practice, foster creativity, and help to promote the diffusion of population health concepts and approaches.

In the next three sections, we consider opportunities for population health training at the undergraduate, predoctoral and postdoctoral levels. Based on searches of available programs in population health (see Appendix 2), we then summarize population health-focused programs at that level and describe a few programs selected to represent variations among available programs. In the final two sections, we address characteristics that facilitate success as an interdisciplinary scientist and the challenge of achieving diversity among those trained.

Undergraduate training

Undergraduate education offers students the opportunity to broaden their understanding of the world and their own interests, develop skills (e.g., critical thinking, communication, independence) that are valued on the job market (Handler 2013), and develop knowledge of one or more major subjects. Although training at this stage is not intended to produce independent scientists, the structural and temporal characteristics of undergraduate education provide opportunities to build interest in and capacities for population health science.

Undergraduate education is a fertile time to introduce students to population health science and orient students towards interdisciplinarity. College students are expected to explore multiple disciplines, so college can be a time when students learn to think and work across them. Students interested in health may find courses reflecting the contributions of many different disciplines and this may naturally promote an interdisciplinary orientation. Interdisciplinary majors for undergraduates are growing rapidly: from 1970-2000, the total number of interdisciplinary majors at U.S. colleges and universities grew by nearly 250%, outstripping an 18% increase in college and university enrollments (Brint et al., 2009).²¹

Many of the skills needed as a population health scientist are important to success in various careers. Thus, colleges that provide students opportunities to develop skills in research design and data analysis and/or in team building, leadership development, communication, and knowledge translation prepare students for a diversity of future paths, including population health science. Undergraduate programs can provide experiential as well as didactic learning opportunities, involving students in interdisciplinary teams and community-based research.

Currently, there is an explosion of interest in health among undergraduates, many of whom enter college with interests in attending medical school. New requirements that applicants to medical school demonstrate competence in the social, cultural, and behavioral aspects of health, as ascertained by a new section of the MCAT, provide colleges a powerful incentive for offering courses that cover the broad determinants of population health. Population health training can provide an alternative path to medical school or provide physicians early on with a broader orientation to health than medical school currently provides. Such courses can also expand the imaginations of pre-med students to consider a range of jobs in health, including population health. Exposure to interdisciplinary population

²¹ This study used a very expansive definition of such programs: “We define undergraduate interdisciplinary programs as ‘degree-granting programs that draw on faculty from more than one academic department.’” (Brint et al., 2009: 160).

health topics and approaches at the undergraduate level may help to motivate continued training in population health sciences at the graduate and postdoctoral levels. Even for undergraduates who do not continue along the population health pipeline, exposure to population health topics at the undergraduate level may help create a more informed public who can engage in discourse around health in productive ways and contribute to multi-sectoral approaches to improving health. Moreover, introducing basic competencies that can support later interdisciplinary work at the undergraduate level can uniquely position students to both pursue and succeed in interdisciplinary careers.

Approaches to undergraduate training

In a review of undergraduate programs relevant to health, Sara Shostak and colleagues at Brandeis University²² identified three types of programs of potential relevance to the undergraduate pipeline for population health science. Interdepartmental majors, undergraduate public health majors, and interdisciplinary health and society majors²³ each take a different approach to organizing a program at the undergraduate level. All of the programs provide coursework on the multi-level (e.g., social, behavioral and biological) determinants of health

and include faculty with a broad range of disciplinary backgrounds. Appendix 3 provides descriptions of three example programs selected to elucidate the variety of curricular and organizational features among these programs.

One of these programs, the Health: Science, Society, and Policy Program at Brandeis University, not only “help[s] students understand the biological underpinnings of health, illness and disability, as well as their social, political, legal and economic dimensions” but also introduces students to translation, evaluation, and communication. Students who major in the program complete a capstone project that provides experience in the integration of knowledge from different disciplines. As an interdepartmental major, this program is not located in a specific department but rather draws faculty from a variety of schools and departments.

A similar program, the Major in Medicine, Health, and Society at Vanderbilt University, is located in an interdisciplinary center. This program provides similar coverage of health determinants at the biological, behavioral and social levels. Although it may not explicitly teach interdisciplinary skills, the program’s location in an active interdisciplinary research environment provides students with exposure to these skills.

A final example, the Undergraduate Program in Public Health at the University of Colorado, is a collaboration between the Department of Social and Behavioral Sciences, College of Liberal Arts and Sciences (where the program is located) and the Colorado School of Public Health (CSPH). Substantively, the curriculum mirrors many other undergraduate programs in public health. Unlike other undergraduate majors in public health, however, all core courses are team-taught by one faculty member from each school. In addition to internship and service learning opportunities, students complete the major with a Capstone project wherein they select and analyze a health-related topic from a perspective that integrates social science and public health perspectives. While students are exposed to many different disciplines in the program, interdisciplinary skills are not explicitly taught. Neither of the latter two programs appears to include a focus on knowledge translation or exchange.

By exposing undergraduate students to multiple disciplinary contributions to understanding and improving health, all of these programs have the potential for preparing students for careers in population health science. However, access to these programs tends to be concentrated at elite colleges and resources constraints often limit what programs can offer. Participants at the June,

²² We thank Kathryn Howell for her assistance with this review.

²³ The review also identified a fourth type of program, biology and society majors. We include an example of this in Appendix 2. We omit discussion of this type here because it focuses on the social and ethical dimensions of biological knowledge rather than the determinants of health.

2015 meeting recommended that strategic investments be made at the undergraduate level to level the playing field for education in population health.

Disciplinary and interdisciplinary training at the graduate level

For those undergraduates who wish to continue on the path to becoming an interdisciplinary population health scientist, no single consensus exists on the ideal next step in training. At the June, 2015 meeting, many participants felt that achieving mastery of a discipline provided an important foundation for expanding into interdisciplinary work. On the other hand, many participants also agreed that trainees should develop (or at least have exposure to) an orientation to interdisciplinarity at the predoctoral level.

The arguments for interdisciplinary training at the pre-doctoral level focus on the need to develop interdisciplinary skills and perspectives early on, before commitments to disciplinary practices become fully set. Students matriculating in interdisciplinary programs will be exposed to a wide variety of theoretical frameworks, content and methods that will provide them with an expansive overview of the state of population health. They may learn to ‘speak the language’ of various disciplines and even to use those approaches in their own work to contribute to new knowledge (Giacomini, 2004). They are likely to take classes

from, conduct research with, and have on their committees, faculty members that utilize interdisciplinary approaches to population health. At the same time, trainees can develop some specialized “deep” expertise, e.g., in a particular population health problem. And, given this problem focus,²⁴ they are likely to receive training in knowledge and exchange activities and to learn to value this as an integral part of the research process. Because of these broad exposures, students with graduate-level interdisciplinary training may be advantaged in their ability to take leadership positions on interdisciplinary population health research teams after graduation (Giacomini, 2004).

The arguments for deferring interdisciplinary training until the post-doctoral level rest mainly on the belief that trainees need a prolonged period of study in a single discipline before becoming interdisciplinary.²⁵ Proponents of this view believe that a solid grounding in the basic theory, knowledge, and methodological approaches of one discipline is needed in order to integrate it with other approaches. If knowledge is superficial, elements of disciplinary knowledge/ methods could be inappropriately transferred, taken out of context, or compromised. Deep disciplinary knowledge also may be essential for

²⁴ Most of the programs that identified in the search for predoctoral programs, for example, included language about the legal and/or policy environments in their mission statements or program descriptions.

²⁵ Another motivation for disciplinary doctoral programs is concern about the job market. When the RJWF HSS program was first designed, advisors unanimously agreed that universities would have no use for interdisciplinary scholars trained in population health. This was a large part of the motivation for making HSS a post-doctoral program – trainees needed a disciplinary base to fall back on. However, graduates from the HSS program have been extremely successful on the job market -- many alumni of HSS have taken jobs outside their disciplinary homes and many who returned to disciplinary homes have continued at least some interdisciplinary work and still received tenure.

critical analysis of the differences among disciplinary approaches, which in turn provides the basis for developing integrated models and/or innovative approaches. On the other hand, there is no doubt that students in disciplinary doctoral programs face potential disadvantages if they undertake interdisciplinary research. Such students are likely to have difficulty finding advisors to guide their research, face challenges in negotiating the validity of interdisciplinary framework(s), and may also have trouble finding an intellectual community among fellow students and faculty in graduate school (Golde & Gallagher, 1999).

Given the value placed on both early involvement in interdisciplinary science and the mastery of a discipline, there is no agreed-upon ideal sequence for graduate training in interdisciplinary population health science. This argues that a diversity of training opportunities – interdisciplinary doctoral programs in population health science, predoctoral programs that supplement disciplinary training, and postdoctoral training – should be available to accommodate the many pathways individuals may take to becoming a population health scientist.

Predocutorial training

Graduate school is arguably the educational stage requiring the most intense knowledge development. In doctoral work, the individual develops deep knowledge of a field and the research skills needed to advance knowledge in that field.²⁶ Graduate education is also the stage at which most individuals form professional identities (Walker et al., 2008). As such, it is a crucial aspect of the pipeline for enticing, producing, and forming population health scholars.

A typical graduate program includes both didactic and experiential learning. Students take coursework and engage in at least one major research project. They may also participate in small seminars that encourage critical engagement with the theories and methods of one or more disciplines, or that introduce students to interdisciplinary exchange and skills.

Coursework provides the opportunity to introduce students to the fundamental principles and knowledge that support population health science as well as the spectrum of methodological approaches used in research. Graduate students can be exposed to the multi-level determinants of health and to some of the social, behavioral, biological, and clinical

sciences that contribute to the field of population health. They can learn about quantitative and qualitative methods, about the process through which research can be moved into practical applications, and knowledge “exchange” between scientists and the various users of science.²⁷ Although it is impossible for students to achieve in-depth training on all theoretical and methodological approaches from each discipline, they can receive exposure to many, and achieve basic knowledge in several that are most relevant to their area of study. Graduate education may also include training in a variety of professional development skills, though there is great variation in the range and quality of this training.

Research projects provide hands-on experience that may include theory development, research design, data analysis, and also the methods used to engage communities in research and translate research findings. Participation in research involving an interdisciplinary team provides opportunities for a student to observe, learn, and practice the range of interdisciplinary skills we listed above under competencies. Research projects necessarily focus the student on a particular problem, but participating in a variety of research projects involving different problems, tools, and disciplinary perspectives can lay a rich foundation for an interdisciplinary

²⁶ We focus here on scientific training, and not professional training, recognizing that individuals trained in medicine, nursing, and other clinical fields may also obtain research training that enables them to become population health scientists.

²⁷ Training in knowledge translation and exchange often receives only minor emphasis in graduate training. When it is addressed, it is typically at the end of a project. This mode of training has perpetuated the lack of integration of knowledge translation and exchange ideas throughout the research process. If graduate students learn about knowledge translation and exchange hand in hand with the other research skills and knowledge they develop, it is more likely that it will always be a part of their research process considerations in the future.

career. Some graduate programs have begun to teach interdisciplinary skills in classroom settings as well.²⁸

Approaches to predoctoral training

Our discussion of population health predoctoral programs focuses on interdisciplinary M.A.- and PhD-level graduate programs that explicitly label themselves as population health programs in some manner.²⁹ Tiffany Green and colleagues at Virginia Commonwealth University identified 25 U.S. and 1 Canadian University that offered such programs (see Appendix 2 for methodology and a complete listing of results; see Appendix 3 for three examples discussed below). The majority of programs explicitly use the terms “interdisciplinary” and “population health” in program descriptions, and some use the term “transdisciplinary.” Many programs also provide similar training in population health without labeling it as such; for example, Appendix 2 also reports on a large number of NIH-supported programs that provide related training,³⁰ but often focused on specific disease outcomes or population studies.

Many of the programs we identified lead to an interdisciplinary degree in population health. These programs aim to address a range of competencies in interdisciplinary population health science within one degree program. For example, the PhD program in Population Health at Northeastern University is a unified interdisciplinary training program that focuses on the multiple determinants of health. The focus of these programs differs depending on where the program is housed at each institution. Some programs³¹ based in medical institutions are more clinically focused; these represent an opportunity for developing the pipeline of clinician-scientists in population health. Other programs³² integrate population health approaches within a more traditional public health model. Yet another³³ is housed within a School of Medicine and Public Health but has faculty members with diverse disciplinary backgrounds from the social sciences, public health, and clinical sciences. While all of these programs explicitly aim to produce interdisciplinary scientists, the extent to which they emphasize interdisciplinary and transdisciplinary, as contrasted

with multidisciplinary, population health education and research remains unclear.

An alternative approach to population health training at the graduate level is to offer students enrolled in traditional disciplinary or clinical doctoral programs supplementary training in interdisciplinary population health science. These programs recruit predoctoral fellows from different departments and schools and provide knowledge, skills, and experience relevant to interdisciplinary population health science. These opportunities may take several forms, all of which were strongly endorsed by participants in the June 2015 meeting.

First, minors and certificate programs in population health provide opportunities for a disciplinary scholar to acquire basic knowledge about population health by taking courses outside of his/her field. Some minors and certificates may also provide additional interdisciplinary research opportunities. Most, but not all, minor and certificate programs in population health are housed in schools of public health. For

²⁸ For example, Johns Hopkins University has recently begun offering “Interdisciplinary Research Practice in Sustainability and Health”. The course, which is open to all doctoral students, provides students with the skills to build and manage interdisciplinary teams and promotes the synthesis and integration of existing sciences as they relate to environmental sustainability and public health. The course includes teaching faculty from various areas of the university and also requires that students work in interdisciplinary groups to complete a capstone research proposal.

²⁹ See Appendix 1 for a discussion of implications for errors of omission and commission.

³⁰ Search conducted by Yonette Thomas and Christine Bachrach – see Appendix 1 for details.

³¹ For example, those at the School of Nursing at the University of Massachusetts and the Jefferson College of Population Health at Thomas Jefferson University (See Appendix 1 for details).

³² Examples include those housed in the Columbia University Mailman School of Public Health and the Division of Epidemiology, Department of Family Medicine and Population Health, VCU School of Medicine (See Appendix 1 for details).

³³ E.g. the Department of Population Health Sciences at UW-Madison.

example, Johns Hopkins University offers a Certificate in Population and Health, which allows masters, doctoral, and professional trainees the opportunity to expand their knowledge of population dynamics and its linkages with public health issues.

Second, disciplinary trainees may be able to enroll in an interdisciplinary population health training program supported by an NIH T32 or foundation funding. The strongest examples of such programs recruit scholars from a range of disciplines and provide them classroom training, mentoring, and research experiences. For example, the University of Michigan's Interdisciplinary Research Training in Public Health and Aging, funded by an NIH T32 award, recruits students (usually at the dissertation stage) who are pursuing degrees in a variety of fields³⁴ and provides funding support and additional training and mentoring in the social, behavioral and biological influences on healthy aging. In our review of programs, we found many such programs with relevance to population health, but none with an explicit population health focus. Training programs have several advantages over minors and certificate programs. They assemble a cohort of scholars who learn from each other over time, gather faculty from different disciplines, and provide opportunities for interdisciplinary research projects. They are also more likely to directly

address the professional challenges of conducting interdisciplinary research, although few program descriptions explicitly mention this.

Postdoctoral training

Postdoctoral training (hereafter, postdoc) is “a temporary period of mentored research and/or scholarly training for the purpose of acquiring the professional skills needed to pursue a career path” (National Postdoctoral Association, 2015). Postdoctoral training can be used to meet a variety of goals. In some cases, postdocs provide opportunities for further specialization in a field already mastered; in others, they allow a trainee to acquire new skills and methods that extend or broaden prior research; and in fields such as population health, it can provide both new knowledge and skills needed to conduct interdisciplinary science. In the postdoc, didactic coursework generally is de-emphasized and research takes center stage.

A population health postdoc may be useful regardless of whether a trainee is coming from a disciplinary or interdisciplinary predoctoral program or one that combines elements of both. Trainees with disciplinary backgrounds may have “discovered” health as an interest during their doctoral programs and chosen a health topic for their dissertation work. These trainees can use the postdoc to develop the interdisciplinary knowledge and skills needed for population health science. Other trainees may have come from interdisciplinary programs

³⁴ Examples include epidemiology, biostatistics, environmental health sciences, health behavior and health education, sociology and social work.

and need further time to develop interdisciplinary skills, or the depth or breadth of disciplinary knowledge and methods needed for their work.

Participants in the June, 2015 viewed interdisciplinary training at this level as a high priority. Many population health scientists view postdoctoral fellowships as the ideal setting in which to bring skilled researchers together with researchers from other fields to train them to conduct inter- or trans-disciplinary research. By the time of the postdoc, trainees have established themselves as experienced researchers with strong research skills. Most have developed an understanding of disciplinary cultures and have the maturity and breadth of perspective that allows them to engage across fields. Training at the postdoctoral level provides an opportunity to transform these individuals *who have already demonstrated their scientific abilities* by exposing them to the full continuum of knowledge translation, broadening their understanding of the diverse disciplinary approaches that contribute to improving health, and developing mature interdisciplinary leadership skills.

The optimal duration of a postdoctoral training program depends on program goals and the skills and experience of incoming trainees. Trainees making a larger interdisciplinary stretch (e.g., from biology to social science) may need more time to complete training.

In training programs that provide immersion in an interdisciplinary environment, two-three years may be ideal. However, as suggested by a recent National Academy of Sciences report, postdoctoral work should be time-limited and dedicated to advanced training in research and include a strong emphasis on mentoring to maximize the success of post-training career trajectories.

Approaches to post-doctoral training

The Robert Wood Johnson Foundation Health & Society Scholars program is currently the only postdoctoral program explicitly devoted to training in population health. In this section we review this model in detail and subsequently comment on other programs that have a somewhat narrower focus.

HSS provides two years of post-doctoral training at a number of³⁵ university sites for scholars at the post-doctoral or early-career level. The program seeks to produce outstanding scientists who can contribute to understanding multiple determinants of health and their integrative effects on health as well as their implications for interventions to improve population health. Because population health training was in its infancy when the program was launched in 2001, faculty from the six chosen sites collaborated in designing the program. They

developed a training model that incorporated lessons learned from existing interdisciplinary health programs and also provided flexibility for sites to experiment with different approaches. All programs included a core set of elements deemed essential for effective interdisciplinary training in population health science. Elements included:

- Immersion in an interdisciplinary environment and culture: each site has six post-doctoral trainees in residence, drawn from diverse disciplinary backgrounds. These trainees interact continuously with each other, with a set of interdisciplinary core faculty, and with faculty from departments across the university. The program explicitly fosters cross-disciplinary thinking and dialogue among individuals with different backgrounds and skill sets around problems in population health.
- An explicit expectation that scholars will move beyond their own disciplinary backgrounds, learn from other disciplines, and engage with other disciplines to conduct population health research. Trainees are provided travel allowances at levels that permit attendance at conferences in addition to their own disciplinary meetings.
- Curricula that expose scholars to multi-, inter- and transdisciplinary approaches to research on the

³⁵ Columbia University; Harvard University; University of California, San Francisco/Berkeley; University of Michigan; University of Pennsylvania; and University of Wisconsin-Madison. As of 2013, budgetary reductions required that sites at the University of Michigan and the University of Pennsylvania discontinue accepting scholars.

broad range of factors that influence health, with special focus on the interactions among context, behavior and biology. At some sites, scholars participate in a structured course or seminar on population health research; at others weekly seminars provide broad exposure to this material.

- Scholar-directed research projects, usually involving both individual and team efforts, supported by seed funding and faculty mentoring.
- Intensive group-level and individual mentoring on skills needed to conduct interdisciplinary research and navigate future career challenges as an interdisciplinary scientist. Trainees work with mentors from multiple disciplines. The program provides salary support for mentoring and other faculty training activities.
- Modeling, mentoring, experience-based learning, and/or direct instruction on leadership skills and the translation of knowledge to policy and practice.
- Mechanisms that facilitate networking with other interdisciplinary population health scientists who are former or current trainees and faculty at other sites, as well as with a nationally prominent group of health leaders who serve as an advisory committee to the overall program.

Through these mechanisms, the program not only provides trainees with an integrated knowledge base in population health science that transcends disciplines, but also equips them to become leaders in interdisciplinary population health science. Through immersion in an interdisciplinary environment, trainees become comfortable with and skilled at team science and learn how to practice it effectively within disciplinary institutions.

The HSS program also sought to strengthen interdisciplinary cultures and the concept of population health at participating universities. To address this goal, each site was provided a pool of funds that could be used flexibly to support not only scholar research but also projects that would engage non-program faculty in interdisciplinary population health research. For example, many programs used these funds for supporting new interdisciplinary research projects or working groups on population health topics, drawing faculty, students, and postdocs from different corners of the university. Other programs used some of the funds to support the development of new population health courses or course modules in departments not traditionally tasked with population health training. Funds were also used to support cross-sectoral efforts – bringing researchers and knowledge users together to create projects that both examined and addressed population health problems.

A key element of the program's success has been its carefully designed process for selecting scholars. Demand for the program has been high, allowing sites to recruit highly talented scientists from diverse disciplines.³⁶ About half of those selected and trained by the program come from public health, epidemiology, sociology and psychology; the other half include individuals trained in anthropology, demography, public policy, economics, medicine, architecture/urban history, biological sciences, communications, ecology, education, environmental health, ethics, geography, gerontology, health behavior, health policy, health services, history, human development, marketing, human development, neuroscience, policy analysis/management, political science, physical therapy, social work and urban planning. Sites have purposively created cohorts of scholars who are diverse in terms of discipline but complementary in terms of skills and interests, thus further enriching the learning environment.

In addition to HSS, Appendix 3 profiles three programs – one in cancer health disparities; one in cardiovascular epidemiology training; and one in medicine and public health research – that provide postdoctoral training relevant to population health. The first two are funded by NIH T32 awards. The Cancer Health Disparities Training Program at the Gillings School of

³⁶ Applications for the last three cohorts averaged 292 for 12 slots, an average of over 24 applicants per slot.

Global Public Health, University of North Carolina, Chapel Hill supports 1-3 fellows in a 2-3 year postdoc. Like HSS, this program emphasizes mentoring by faculty from multiple disciplines, career development, and involvement in interdisciplinary research. Training provides fellows with educational and research knowledge related to research on cancer health disparities based on a socio-ecological model of health. The program differs from HSS in that it has narrower substantive focus, draws faculty only from medical- and health-related schools and centers, and has a small cohort size. A larger cohort size might be necessary to have the critical mass of trainees and faculty to engage together in informal and formal interdisciplinary exchange. However, the breadth of biological, behavioral and social factors considered in its approach to health disparities and its extensive relationships with health-related centers and departments at UNC make it a strong model for population health science training.

The Cardiovascular Disease Epidemiology Training Program at the Johns Hopkins University Bloomberg School of Public Health trains both pre- and postdoctoral fellows within the same program. The program provides fellows a multidisciplinary orientation and emphasizes collaborative approaches. It covers multiple aspects of cardiovascular epidemiology, including biology, behavior, treatment and prevention.

The postdoc requires a year of structured coursework but otherwise emphasizes engagement in research. Mentors are drawn from faculty involved in population-based and clinical research. As at UNC, the program is focused on a specific substantive problem and draws faculty only from health/medical institutions. Nevertheless its long-standing commitment³⁷ to collaborative approaches in research and interdisciplinary training has laid an important foundation for designing programs in population health.

The Fellowship in Medicine and Public Health Research, active at the New York University School of Medicine between 2005 and 2009, focused on training post-residency physicians in applied public health research. This CDC-funded, 2-year fellowship was distinguished from other programs by its core emphasis on issues of implementation, dissemination, and sustainability and its strong relationships with front-line public health agencies. Although the program was centered in three departments within the school of medicine, mentors and seminar leaders were also drawn from health economics, health policy, nutrition, and other fields. Trainees (6 per cohort) assembled multidisciplinary mentorship teams, including academic mentors and “real world” mentors from community organizations or public health departments, and completed a core curriculum in public health

concepts and methods as well as an applied research project.

As suggested above, our review of training opportunities with population health relevance has not been exhaustive. One key omission has been attention to “short courses” that provide exposure to population health issues and science for people at many stages of professional development. For example, the University of Michigan offers a 10-week summer course for students in health-professional degree programs that provide training in health disparities research through individual and team-based learning experiences. The University of Manchester offers a 6-week online Introduction to Population Health that covers basic concepts and approaches. Such courses cannot produce experienced population health scientists, but can form an important link in the training pipeline.

Each stage of the pipeline reviewed in this section can make an important contribution to the development of interdisciplinary population health scientists: by engaging interest and laying a foundation of basic skills in undergraduate education and by developing mastery of subject matter, research skills, and competencies in interdisciplinary teamwork and translation during pre- and postdoctoral training. The programs we have reviewed vary significantly. Some specifically target population health science,

³⁷ This program was established in 1975.

some provide similar training under another name, and some focus on related, but distinct, subjects. Programs also vary in the extent to which they explicitly address the competencies described in Section III. For a field with a still-evolving vision, having a plethora of models to work with is a good thing. For *all* programs, another important pipeline issue is who to recruit into training, and we address two aspects of this issue in the remainder of this section: identifying promising trainees and building diversity.

Identifying promising trainees

At the predoctoral and postdoctoral levels, selecting individuals for training who have the potential to become effective interdisciplinary scientists becomes increasingly important. Participants in the IOM workshop identified a number of relevant skills and characteristics to consider. Personal characteristics such as humility and openness were identified as important, coupled with the ability to “play well with others.” This involves interpersonal skills for listening and communicating, cooperating, and engaging others with different backgrounds and ideas. Participants also stressed the need for curiosity, the willingness to explore outside conventional boundaries, and the ability to push back against a discipline or accepted wisdom. These characteristics provide the foundation for not only understanding different disciplines but actively bridging across the multiple disciplines and sectors involved in population health (biology, social science, medical care, policy, practice, etc.). In these contexts, the ability to “prove your worth” – to communicate the value of your contributions in a variety of environments – is also a necessary skill. Leadership and team management skills may be acquired during training, but the potential for leadership and being a team player is important.

Recruits to an interdisciplinary training program in population health science must also show

evidence of abilities that will lead to successful academic or scientific careers. These include the ability to generate creative ideas for research, develop appropriate designs, master technical skills needed to successfully carry out research, and produce publishable work. In order to assure that science effectively contributes to addressing population health problems, at least some also need the interest in and commitment to conducting research that can be readily translated into action.

Diversity

Achieving diversity within training programs is essential to ensure a robust and diverse workforce for population health science and action. Several types of diversity are relevant, such as racial, ethnic, socioeconomic, and regional background; interests related to research across the continuum from basic science to application; and goals for working in academic vs. practice settings. Diversity with respect to disciplinary background, discussed in Section III, is also crucial.

RECOMMENDATION

Promote diversity by discipline; sector; and racial, ethnic, socioeconomic, and regional background among trainees and individuals involved in training programs.

Attracting students from minority and disadvantaged backgrounds is a critical challenge for training in population health science. Starting early in the pipeline – during college or even high school – may be an important step. Research suggests that disparities in access to interdisciplinary training in health may begin at the undergraduate level. From 1975-2000, interdisciplinary majors thrived especially at “large, wealthy, arts and sciences-oriented universities on the East or West coasts” (Brint et al., 2009: 175). As such, undergraduate programs may have produced and maintained inequalities in the population health science pipeline. One way to address this inequality would be to provide incentives to less advantaged undergraduate colleges and universities to offer interdisciplinary

training relevant to population health science. Another reason for difficulties in attracting students from economically disadvantaged backgrounds may be that such students may be disproportionately drawn to medical careers because of their potential for providing the means for paying off student loans. Providing student loan programs and other financial opportunities that make population health careers more financially viable may help some students feel able to make that choice.

At the graduate level, minorities and disadvantaged groups are also

underrepresented in the fields that comprise population health, including the social sciences, STEM, and basic sciences (Darity, Sharpe & Swinton, 2009; Crisp, Nora & Taggart, 2009; Change et al., 2008). Recruitment into population health science training at the predoctoral and postdoctoral level should include strategies to recruit trainees from less privileged backgrounds and educational institutions. There is increasing awareness that it is not enough to recruit and provide financial support for underrepresented groups. Often the training environment also needs more resources to provide the types of mentorship, opportunity, and support that are crucial to academic success. Finding ways to recruit and support underrepresented trainees by promoting strong mentorship and mentor training is critical to

achieving diversity of thought and continued progress in the field of population health. High quality training programs that support cohorts of population health trainees may be more effective in creating the necessary environment than individualized traineeships in separate institutions.

Attracting trainees with interests and goals that span the continuum from basic science to application is another critical challenge. Often, those who matriculate in PhD programs do so because they anticipate careers in academia. Indeed, PhD programs are typically geared towards such career goals. However, recent data suggest that half of PhDs in the sciences do not take academic jobs (National Science Foundation, 2014). The field of population health needs basic scientists *and* individuals who can translate scientific findings into application and implementation. Further, it needs both individuals who are well grounded in scientific theory and methods *and* individuals who understand on-the-ground opportunities and constraints that affect how problems in population health can be addressed. Given mandates under the Affordable Care Act, many physicians and hospital administrators now need training in population health science. So do individuals from the business community seeking to find ways to improve employee health. Diversity, both within and across training programs, in the interests and goals of recruited trainees is needed to meet the workforce demands and strengthen the movement of knowledge “from bench to curbside.”

Recommendations

On June 1-2, 2015, a diverse group of scientists, educators, and practitioners met at the Institute of Medicine in Washington DC to reflect on future priorities for training in interdisciplinary population health science.³⁸ During the first day of this meeting, panelists discussed an earlier version of this paper, provided independent perspectives on the future of training, and elicited additional perspectives from audience participants. On the second day, four breakout groups independently considered priorities for future training. Some of the recommendations derived from this meeting have been highlighted in earlier sections of this paper. These include:

Recommendations for developing new training programs:

- Foster “impactful science” by deepening the integration of science, translation, and research user communities in all programs (see p. 12).
- Invest in strengthening the institutional supports for interdisciplinary population health science and its translation, both within academia and in the collaboration between academic and other sectors (e.g., business, health care, community) (see p. 18).

- Provide a pipeline of training opportunities at multiple levels and begin to engage students early in the pipeline (see p. 20).
- Promote diversity by discipline; sector; and racial, ethnic, socioeconomic, and regional background among trainees and individuals involved in training programs (see p. 31).

Recommendations on the critical elements of training in interdisciplinary population health science:

- Address basic competencies in knowledge, metrics, methods, and research design relevant to population health; interdisciplinary skills; and knowledge exchange and translation, as appropriate to the goals of the program and the stage of training (see p. 10).
- Immerse and engage trainees in a diverse interdisciplinary environment over an extended period of time (see p. 15).
- Engage trainees in interdisciplinary research teams focused on problems in population health (see p. 15).
- Provide mentoring in scientific areas, knowledge exchange, interdisciplinary skills, and professional development domains, using a multiple mentor model (see p. 16).

³⁸ This meeting was hosted by the IOM Roundtable on Population Health Improvement and supported by the Roundtable, the NIH Office of Behavioral and Social Sciences Research, the National Institute for Minority Health and Health Disparities, and Robert Wood Johnson Health & Society Scholars. The participant list and agenda may be found in Appendix 1.

In this final section, we describe the recommended model for future training in interdisciplinary population health science that emerged from deliberation by meeting participants. This model is targeted primarily at pre- and postdoctoral training. Meeting participants also viewed programs at the high school and undergraduate levels as important, but did not recommend specific models at these levels apart from those discussed in section IV.

A model for a national program of training in interdisciplinary population health science

Breakout group discussions on the second day of the meeting led to

a consensus on a new integrated model for training that builds on, but differs in important ways from, existing and prior efforts. It leverages existing mechanisms and resources where possible, and builds in flexibility, experimentation, and heterogeneity in programs.

THE PROPOSED MODEL HAS THE FOLLOWING FEATURES:

- Consists of a set of center-based training programs.
- Participating centers represent three types of strengths:
 - › capacity to conduct state-of-the-art interdisciplinary population health research;
 - › capacity to engage with and address population health problems in underserved and/or high-need geographic areas and population groups; and
 - › capacity to recruit diverse and underrepresented trainees.
- Each center:
 - › engages a critical mass of trainees in
 - › hands-on, experiential research training, through
 - › involvement in problem-focused research teams that are
 - › interdisciplinary and/or multi-sectoral.
- Each center designs its own curriculum.
- Each center designs an intensive, multidisciplinary mentoring system.
- The overall set of center-based programs captures broad heterogeneity in:
 - the types of population health problems addressed, and
 - specific approaches to program design and curricula.
- Each center is expected to demonstrate a deepening or extension of knowledge exchange/translation activities currently in place in order to enhance the effectiveness of training in this domain.
- The overall program provides mechanisms that promote networking, exchange, and synergies among the individual programs.
- This model, while requiring a complex set of resources, flexibly leverages existing resources to build a cost-effective strategy for advancing training in interdisciplinary population health science.

The proposed model is center-based. This feature of the model reflects strong agreement that interdisciplinary training requires immersing a diverse, critical mass of trainees in interdisciplinary networks and research over an extended period of time. A center-based model provides trainees the opportunity to engage in ongoing research with faculty from different backgrounds, and to learn from other trainees-in-residence who are from diverse backgrounds but who are similarly committed to learning how to collaborate to produce creative and impactful population health research. This model implies funding training at the institutional (program) level rather than at the individual level, to enable institutions to assemble appropriate diversity among trainees, faculty, and training resources.

The model implies programs with three types of strengths. The overall program should include centers with the capacity to conduct state-of-the art interdisciplinary population health research, and also centers with the capacity to engage with and address population health problems in geographic areas and population groups that are underserved and/or high-need. Another important capacity is the ability to recruit diverse and underrepresented populations for participation in the training. These capacities may overlap in some universities, but an optimal strategy may be to recruit centers

with diverse strengths, involving not only well-established centers in elite research universities but also new centers located in institutions with the potential for strong interdisciplinary population health research and also strengths such as an orientation towards community engagement and the ability to address population health problems facing local or regional underrepresented communities.

The model emphasizes **experiential research training through involvement in problem-focused research teams that are interdisciplinary and/or multi-sectoral.** Involving trainees in conducting problem-focused research as a part of a diverse interdisciplinary team promotes experiential learning related to all three major competencies. A problem focus gives trainees the experience of applying principles of interdisciplinary population health science to address a specific question: learning how to assemble the needed knowledge and expertise, learning how to function in an interdisciplinary team, and learning how to ensure that the results of the research can be moved forward towards translation and implementation.³⁹ It complements the learning of abstract principles about best practices with tangible hands-on experience in striving to realize them. This learning process requires achieving appropriate diversity within the team. Depending

on the nature of the problem, team composition might differ on many dimensions, including academic discipline, the basic to applied continuum, professional stage, and sector (academia, business, community, policy). Engaging trainees in teams that comprise both scientists and practitioners from other sectors can be an important impetus for knowledge exchange and the development of impactful research agendas.

While engagement in team science can broaden trainees' understanding and perspectives, each problem and each team will inevitably produce different experiences and learning opportunities. Thus, it will be important for programs also to ensure that trainees have the opportunity to share what they are learning across different team experiences. This sharing implies that each center has in residence at all times a critical mass of trainees, ideally at least six at the pre- and/or postdoctoral level. Designing programs to ensure that trainee cohorts have exposure to a diverse set of problems would also strengthen the training.

Each center would design its own curriculum and training strategies to complement learning gained from participating in a research team. The training curriculum would draw on tools such as regular seminars, coursework and independent study to ensure that trainees develop

³⁹ Questions may be focused anywhere along the continuum from basic to implementation, but even trainees participating in basic research projects should be given the experience of designing and communicating the research so that results can be used to inform research further towards the translational end of the continuum.

basic competencies in population health knowledge, metrics, methods, research design and knowledge translation and exchange. Given the breadth of competencies relevant to population health science, it is unrealistic to expect that trainees will gain in-depth expertise in all areas. The goal of structured curricula instead should be to make trainees aware of the diversity of disciplinary contributions, methodological approaches, and design and measurement strategies that may be used in population health research as well as the ways in which research results may move to translation and application. The appropriate curricular offerings are likely to depend on the program goals, the stage of training, and the existing skills, knowledge, and goals of each trainee.

Intensive mentoring is another essential ingredient in the structure of a center-based training program. Individual programs will need to ensure that each trainee has a primary mentor who ensures that broad competencies are achieved, guides the trainee towards a focused research agenda, facilitates access to resources and expertise the trainee needs to advance that agenda, and provides a sounding board and resource for trainee concerns. In addition, trainees will need multiple mentors with expertise in relevant disciplines, knowledge exchange, and other competencies. The primary mentor would help navigate the challenges of a multiple-mentor or team mentor model.

The program should capture broad heterogeneity in the design of curricula and training strategies and in the types of population health problems addressed within programs. Participants at the meeting stressed the importance of heterogeneity and flexibility in designing center-based training programs. Given the relative youth of interdisciplinary training and the field of population health, and given the complexity of both, providing wide scope for innovation is an important priority. Heterogeneity and flexibility encourage creativity in the design of training programs and the “adaptive management” of program designs in response to lessons learned.

Allowing heterogeneity across centers also acknowledges that the overall training initiative will need to produce diverse products. Some graduates will pursue academic work and some will work in applied settings. Centers will also have different strengths: they will vary with regard to the key topics in population health science they are positioned to address and with regard to the kinds of expertise they can assemble to address them. In designing its training program, each center should build its curriculum around local strengths and resources, while providing exposure across all competencies. Centers also should be encouraged to adapt their programs as they learn, through experience or exposure, about the effectiveness of alternative training approaches.

All programs would be expected to demonstrate a deepening or extension of knowledge exchange/translation activities currently in place that would enhance the effectiveness of training in this domain. As discussed in section III, meeting participants forcefully argued that training in population health science must give greater emphasis to knowledge exchange and the development of impactful science. The proposed model embraces this challenge in three ways: by including knowledge exchange and translation as a basic competency that all training programs should address in some way; by recommending that the overall program include a substantial number of centers with strengths in this domain; and by requiring that all participating centers, even those primarily concerned with basic science questions, stretch themselves to engage more fully in questions of knowledge exchange and translation. Given the many potential ways in which population health science can be applied and the many potential partners in knowledge exchange, we believe this is a feasible and important requirement.

Mechanisms should be created to promote networking, exchange, and synergies among the individual centers. The existence of heterogeneity in subject matter, capacities, and training approaches across centers participating in the program opens up opportunities for learning and exchange across centers and an enriched training experience for trainees. However, such exchange is unlikely to occur unless the

program is structured to facilitate it. A central coordinating office could foster communication and resource sharing among programs, manage common resources (e.g., funds to support specialized summer courses), provide technical assistance, and perhaps organize annual meetings, depending on available resources.

This model, while requiring a complex set of resources, flexibly leverages existing resources to build a cost-effective strategy for advancing training in interdisciplinary population health science.

While some elements of the proposed model (e.g., trainee stipends and tuition) are traditionally provided through mechanisms such as the NIH T32, others will require creative forms of investment. Funds would be needed to support faculty time for mentoring, to engage interdisciplinary and inter-sectoral partners in research teams, and to incentivize technical support and exchange among funded centers. For example, centers at elite research universities could be funded to expand access to their resources (e.g. through technical support, mentoring, and targeted summer programs or other educational offerings) to students and faculty at less well-resourced universities. A coordinating center would require additional support. Ideally, funding for the overall program would include resources for evaluation.

While these investments will be crucial, the model achieves cost-efficiency by leveraging existing resources. Participants suggested that, instead of starting from

scratch, the program can be built on the foundation of existing population centers, health centers, policy centers and other relevant structures, many of which already do relevant interdisciplinary science. Some centers could be located in academic centers partnering with non-academic partners, such as an Accountable Care Organization, a local United Way Agency, a public health department, or a business. Existing training programs could be supplemented to meet the need for faculty support and other resources. Investments should be strategic and variable across sites, geared to the types and level of resources already available at an institution and the additional elements needed to achieve the program goals.

Perhaps most importantly, the goal of constructing such a program creates opportunities for collaboration between traditional funders in health science training such as the NIH and other interested federal, nonfederal, and private organizations. Within the NIH, a partnership across the many institutes and offices that have a stake in population health science could provide the necessary scientific foundation for the program.

However, without modification, traditional NIH T32 mechanisms, for example, may not suffice to fully support the different facets of this training model. The model's focus on an integration of science and translation opens the door to broader collaborations: with other federal agencies with a stake in, or a potential impact on, population health (e.g., CDC, CMS, HRSA;

HUD, Education, EPA); with accountable care organizations and the health care finance industry; with other industries seeking to improve employee health; and with private foundations. Creative partnerships should be formed around the vision, described in this report, put forward by a distinguished group of scientists and practitioners in population health. In this way, we can ensure a robust future pipeline of leaders with the scientific and translational skills to improve the health of our population.

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Appendix 1.

Agenda and participant list
for June 15, 2105 meeting,
training in interdisciplinary
population health science:
a vision for the future

Agenda

The Keck Center

500 Fifth Street, NW | Washington, DC

June 1-2, 2015

A meeting hosted by the IOM Roundtable on Population Health Improvement and supported by the NIH Office of Behavioral and Social Sciences Research, the National Institute on Minority Health and Health Disparities, the Roundtable, and Robert Wood Johnson Foundation Health & Society Scholars

DAY 1

8:45 – 9:15 AM

Welcoming remarks

Paula Lantz, George Washington University and IOM Roundtable on Population Health Improvement

Yvonne Maddox, National Institute of Minority Health and Health Disparities

William Riley, NIH Office of Behavioral and Social Sciences Research

Christine Bachrach, University of Maryland

9:15 – 10:15 AM

Session 1. Setting the Stage:

Perspectives from Early Career Scientists

Each panelist will summarize the significance of his/her work, what s/he needed to learn (content and skills) to make it possible, and the ways in which the panelist's particular training experience helped or failed to help them gain these skills. These presentations will be followed by a moderated discussion with the goal of integrating and expanding on key points in conversation with the panelists.

MODERATOR

Kara Hall, National Cancer Institute

PANELISTS

Rachel Johnson-Thornton, Johns Hopkins School of Medicine

Mark Hatzenbuehler, Columbia University Mailman School of Public Health

Briana Mezuk, Virginia Commonwealth University

Melissa Martinson, University of Washington

10:30 AM – 12:30 PM

Session 2. Defining the Essentials

This session addresses the principles and essential elements of training in population health science. What kinds of skills and knowledge should such training impart and how is this best accomplished? Drawing from the discussion paper, the initial speaker will propose an ideal set of knowledge and skills that are needed to become a scientific leader in interdisciplinary population health science. Discussants will bring their own perspectives to the discussion of key principles and elements and consider what is most important in the design of training that is both feasible and effective. The chair of the session will conclude by summarizing key points.

MODERATOR

Paula Lantz, George Washington University

SUMMARY OF PRINCIPLES AND PRACTICES

Stephanie Robert, University of Wisconsin, Madison

DISCUSSANTS

Kathleen Mullan Harris, University of North Carolina, Chapel Hill

Dan Dohan, University of California, San Francisco

Dan Stokols, University of California, Irvine

Tom LaVeist, Johns Hopkins University

Rachel Kimbro, Rice University

12:30 – 1:30 PM

Lunch break (on own)

1:30 – 3:30 PM

Session 3. The Training Pipeline

This session addresses training in population health science by career stage, starting with the undergraduate and moving to the post-doctoral level. What are the appropriate goals, best practices, and models for training at each stage? Who gets drawn to training (or should be attracted to training, and how) at each stage? What skills should they have to undertake training at each stage? What does the training prepare them to do?

MODERATOR

Carlos Mendes de Leon, University of Michigan

UNDERGRADUATE

Sam Preston, University of Pennsylvania

GRADUATE (masters and doctoral)

Thom McDade, Northwestern University

POSTDOCTORAL

Nancy Adler, University of California, San Francisco

3:45 – 5:00 PM

Session 4: Reactions and Day 1 Wrap-Up

This session will begin with a panel of discussants who will discuss key points they have heard during the prior sessions, focusing on important take-away lessons and messages. These brief remarks will be followed by moderated discussion, first with the discussants, and then opening up to audience participation.

MODERATOR

Lisa Berkman, Harvard University

DISCUSSANTS

Allison Aiello, Gillings School of Global Health, UNC

Bobby Milstein, ReThink Health

Bob Kaplan, Agency for Healthcare Research & Quality

Mark Hayward, University of Texas, Austin

5:00 PM

Concluding Comments and Adjourn Day 1

Yonette Thomas, University of Miami and the Association of American Geographers

DAY 2 (By invitation only)

9:00 – 9:30 AM

Session 5: Orientation to Break-Out Groups

This session will begin with a presentation summarizing key points from the prior day and setting out the charge to breakout groups. Specific questions for consideration will be finalized after Day 1. Illustrative questions include:

- What are the most important next steps to ensure pipeline of interdisciplinary population health scientists? Do some stages of the pipeline need more attention than others at this time?
- Does the group have ideas for one or more specific programs that would be a high priority, and if so, what characteristics should it have?

9:30 – 11:00 AM

Priority-Setting and Developing Action Steps in Break-Outs

BREAKOUT SESSION LEADERS:

Dorothy Daley, University of Kansas

Amar Hamoudi, Sanford School of Public Policy, Duke University

Sara Johnson, Johns Hopkins School of Medicine

Sara Shostak, Brandeis University

11:15 AM – 12:00 PM

Reports from Break-Out Groups

MODERATOR

Stephanie Robert, University of Wisconsin, Madison

12:00-12:30 PM

Concluding comments

Nancy Adler, University of California, San Francisco

Christine Bachrach, University of Maryland

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Training in Interdisciplinary Population Health Science: A Vision for the Future June 1-2, 2015

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Appendix 2.

Searching Programs in Population Health Science: Methodologies and Results

In developing this analysis of training in population health science, the authors and contributors to the document conducted several independent searches for existing training opportunities. The targets for searches included programs at the undergraduate level, the predoctoral level, and the postdoctoral level, and also programs supported by three sets of funders – the National Institutes of Health, the National Science Foundation, and private foundations. This appendix summarizes the methods and results of these searches.

Undergraduate Level Programs

The undergraduate programs identified in the paper are part of a larger review of interdisciplinary undergraduate programs in health conducted by Brandeis University's HSSP program in Fall 2013.⁴⁰ The total number of programs found and the number that would meet a definition of population health was not reported. The four programs highlighted in this section were selected to represent four categories of programs identified in the review and to elucidate differences in the curricular and organizational aspects of potential “pipeline” programs. A fifth category consisting of undergraduate pre-professional programs designed to prepare students for careers in health education, nursing, nutrition, and global health is not illustrated.

1) Interdepartmental Majors

CASE STUDY

Brandeis University, Health: Science, Society, and Policy Program⁴¹

The objective of the Health, Science, Society, and Policy (HSSP) program is to “help students understand the biological underpinnings of health, illness and disability,

⁴⁰ Sara Shostak, Chair of the HSSP program at Brandeis, directed this search with the assistance of Kathryn Howell.

⁴¹ All quotations are from the HSSP program website, at URL: <http://www.brandeis.edu/programs/hssp/>, accessed 1/2/2015.

as well as their social, political, legal and economic dimensions.” The learning goals of the program include interdisciplinary knowledge and skills. Students are expected to gain knowledge about the nature of disease and illness from a basic scientific perspective; the social and cultural contributions to health and illness; the impact of health care systems in diverse social and cultural settings, and; how public policies in health and health care are developed, implemented, and evaluated. Likewise, students are expected to learn core analytic and critical thinking skills, including the ability to synthesize information and perspectives from different disciplines, evaluate health care system organization and delivery, evaluate health issues using tools from epidemiology and basic biostatistics, conduct research on health-oriented problems, and communicate findings in both written and oral presentations.

The HSSP program offers a BA, BS, and minor, with elective requirements varying across these options. For all students, the core requirements of the program include introductory classes (one each) in biology, sociology, and health policy; introduction to epidemiology, biostatistics, and population health; a “hands-on-experience” (typically either an internship or independent research project); and, a capstone course (for majors), which uses a problem based learning model that requires that students integrate knowledge from the life sciences, social sciences, and policy analysis to address a contemporary population health problem.

Within 10 years of its inception, the HSSP program had become a “top five” major at Brandeis. Both program governance and academic advising for students are provided by a Faculty Executive Committee, which consists of professors from both the College of Arts and Sciences and the Heller School for Social Policy and Management. Likewise, the program chair is appointed from the faculty of the College of Arts and Sciences, with an associate chair appointed from the faculty of the Heller School for Social Policy and Management.

2) Undergraduate Public Health Majors

CASE STUDY

University of Colorado - Denver, Department of Social and Behavioral Science, Undergraduate Program in Public Health⁴²

The Undergraduate Program in Public Health at the University of Colorado, Denver, is a collaboration between the Department of Health and Behavioral Sciences (HBS), College of Liberal Arts and Sciences (where the program is located) and the Colorado School of Public Health (CSPH). As the home for this program, HBS has an interdisciplinary faculty with all the terminal degrees coming from anthropology, sociology, demography, social psychology, or psychology (i.e., none from public health). Three of the 9 tenured/tenure-track faculty in HBS have received population health/health policy training in one of the RWJF post-doctoral programs.

Substantively, the curriculum mirrors many other undergraduate programs in public health, with core courses in topics such as global health, environmental health, epidemiology, health policy, social determinants of health, etc. Unlike other undergraduate majors in public health, however, all core courses for the major are team-taught by one faculty member from HBS (with a social/behavioral science background) and one from the School of Public Health (with a public health background). Students learn core courses jointly and explicitly from multiple disciplinary perspectives. In addition to internship and service learning opportunities, students complete the major with a Capstone project wherein they select and analyze a health-related topic from a perspective that integrates social science and public health perspectives. Neither of the latter two programs appears to include a focus on knowledge translation or exchange.

⁴² All quotations are from the undergraduate public health program website, at URL: <http://www.ucdenver.edu/academics/colleges/CLAS/Departments/hbsc/Programs/Bachelors/Pages/Bachelors.aspx>, accessed 1/2/2015.

3) Interdisciplinary Health and Society Majors⁴³

CASE STUDY

Vanderbilt University, Center for Medicine Health and Society, Major in Medicine, Health, and Society⁴⁴

Vanderbilt University's Center for Medicine, Health, and Society (CMHS) offers an undergraduate major for students who wish to “investigate...the cultural, economic, demographic and biological factors that impact health.” The curriculum is designed to train students “to meet emerging challenges in our healthcare system as well as changes in medical education.” The CMHS is dedicated to “training the next generation of national and international health leaders—from doctors and nurses to economists and policy makers.”

The major is located in the CMHS, which describes itself as “an innovative multidisciplinary center that studies the social and societal dimensions of health and illness.” The program's core faculty are appointed to the CMHS where “scholarship, teaching, and wide-ranging collaborative projects explore medicine and science in a wide array of cultural contexts, while at the same time fostering productive dialogue across disciplinary boundaries.” The Center's mission is supported further by a network of faculty with joint appointments, between the CMHS and departments, and “affiliated faculty” with appointments in departments across the University.

The major in Medicine, Health, and Society offers a major (BA), a minor, and a combined BA/MA (4+1) program. Within the major, students can choose from a variety of concentrations, including global health; health behavior/health sciences; health policy and economics;

race, inequality, and health; medicine, humanities, and the arts; and, critical health studies.

4) Biology and Society Majors⁴⁵

CASE STUDY

Cornell University, Department of Science & Technology Studies, Biology and Society Major

The Biology and Society major at Cornell University is located in the Department of Science & Technology Studies (STS). The goal of the major is to “equip... students with the skills and perspectives needed to address...complex problems” that are linked to “recent remarkable gains in biological knowledge” and “involve...complex relations between biological and sociocultural forces.” Towards that end, majors “combine the study of the biological sciences with courses that explore the social and ethical dimensions of biological knowledge, providing an understanding of ethics, social science, and history as they relate to biological issues.”

The major is very flexible, with multiple options for almost every requirement. Students must take classes in biology, math, ethics, and social sciences and/or humanities. There is a core course requirement that can be met with a variety of courses offered by faculty from the STS Department (i.e., “Science in Western Civilization,” “Life Sciences and Society,” “Nature and Culture). Additionally, students, in consultation with their advisor, develop a “theme,” or area of substantive focus, within which they select (5) additional courses.

⁴³ The University of Pennsylvania's Department of the History and Sociology of Science also offers a “health and society” (HSOC) major. The focus of the program is interdisciplinary, but primarily within the social sciences: “the program utilizes methods and courses from three core disciplines: history, anthropology, and sociology. Other disciplines and fields - including epidemiology, political science, business/economics, law, environmental studies, and bioethics - supplement the core disciplines and provide the skills necessary to grasp the forces that have shaped our contemporary health landscapes.” At URL: <https://hss.sas.upenn.edu/hsoc>, accessed 1/2/2015.

⁴⁴ All quotations are from the MHS program website, at URL: <http://www.vanderbilt.edu/mhs/undergraduate/>, accessed 1/2/2015.

⁴⁵ The Institute for Society and Genetics at UCLA also hosts a major in Biology and Society, which includes both BA and BS options. The broad goal of the major is to “bridge the gap between life sciences and humanities/social sciences, generating an interdisciplinary perspective needed to address many important and current questions of ethics, history, and public policy about food and nutrition, genetics research and commercialization, genetic origins and relatedness of human populations, medical privacy rights, etc.” The core classes for the major are offered through the Institute for Society and Genetics, with electives available from units across the University. At URL: <http://socgen.ucla.edu/academics/undergraduate/major-2/>, accessed 1/2/2015.

Programs at the Predoctoral Level

Identified programs at the predoctoral level were identified through two searches: a search of NIH T32 awards (described below) and a search conducted by Tiffany Green and colleagues at Virginia Commonwealth University.

Green and her colleagues used a Google search cross-referenced with Grad Schools (gradschools.com) to identify accredited U.S. and Canadian graduate-level programs with population health in the description. It found 25 U.S. and 1 Canadian University offering M.A.- or Ph.D.-level education that referred to population health. Like all searches, this one is characterized by errors of inclusion and exclusion. In some cases, it identified schools that used “population health” in their names but were not evidently offering degrees in population health as defined in this document. These schools, many of which offered traditional MPH degrees, are included in the table below. Further, the search necessarily omitted programs that offer population health-related training but do not use the term “population health” on their websites. For example, the University of Colorado Denver has a 20-year old interdisciplinary doctoral program in Health and Behavioral Sciences. This program does not use the term “population health” in its description, yet the content of the program is well aligned with other population health programs.

In addition, the search of NIH-supported graduate training programs revealed a large number of universities providing training in population research, including health in many instances. The University of California, Berkeley School of Public Health offers many offerings related to population health, but no programs specifically labeled as such. Thus, this search should be viewed as providing a lower bound on relevant programs within the U.S. and Canada. Further, the programs identified appear to be variable in the extent to which they share our definition of population

health and related competencies. The 26 programs identified by the search are summarized in Table 1.

TABLE 1.

SEARCH RESULTS:

Programs Explicitly Targeting Population Health at the Pre-Doctoral Level

NAME OF PROGRAM
Population Health Sciences

SCHOOL
Virginia Tech

DEGREE
MPH

WEBSITE
<http://mph.vetmed.vt.edu/>

The Public Health Program in the Department of Population Health Sciences is administered by the Virginia-Maryland College of Veterinary Medicine in partnership with the Virginia Tech Carilion School of Medicine. The program is grounded in an interdisciplinary "One Health" approach which recognizes the dynamic interdependence of human, animal, and environmental health and encompasses the interdisciplinary efforts of medical, veterinary, environmental health, and public health professionals to protect, promote, and improve health. Students gain the requisite knowledge and skills to examine the human, animal, and environmental factors that contribute to the control and prevention of disease and the promotion, enhancement, and maintenance of health. Two concentrations are available: public health education and infectious disease and trainees may obtain simultaneous degrees with other Virginia Tech departments and programs. This is a 42-credit program requiring a two-year plan of study.

NAME OF PROGRAM
School of Biological and Population Health Sciences

SCHOOL
Oregon State University

DEGREE
MA, PhD

WEBSITE
<http://health.oregonstate.edu/bphs>

The School of Biological and Population Health Sciences comprises the fields of Exercise and Sport Science, Nutrition, and the Public Health disciplines of Biostatistics, Epidemiology, International Health, and Environmental and Occupational Health & Safety. These disciplinary approaches link individual biology and behavior to population and environmental health to better understand how environmental and behavioral factors, including food and nutrition, physical activity, water, pollution, carcinogens, biohazards, etc., influence the development and progression of biological disease. Applying the quantitative methods of epidemiology and biostatistics allows better understanding of the causes of population-level disease as well as methods of intervention and prevention. NOTE: none of the graduate programs listed are explicitly identified as population health.

(CONTINUED ON PG 52)

NAME OF PROGRAM
**Bouvé College of Health
Sciences, Population Health**

SCHOOL
Northeastern University

DEGREE
PhD

WEBSITE
<http://www.northeastern.edu/bouve/health-sciences/programs/population-health-phd/>

This program trains students to become public health leaders through simultaneous examination of multiple determinations of health, including social, environmental, nutritional, and behavioral risk factors. Students investigate the underlying causes of adverse health, including disease, disparities, and disability, through training in core population health disciplines — biostatistics, epidemiology, and health services — together with individual-specific and specialized training in topics related to student research. Students are mentored by faculty who individually and together conduct innovative, solution-focused research in critical population health topics. Population Health doctoral students learn to conduct research that addresses five key health determinants: Social and Community Context, Environment and Neighborhoods, Health and Health Care Delivery, Education, and Economic Stability.

NAME OF PROGRAM
**Center for Demographic
Population Health**

SCHOOL
Florida State University

DEGREE
NA

WEBSITE
<http://popcenter.fsu.edu/>

Specialized training in Demography and Population Health is provided for masters and doctoral students from across campus in coordination with their individual academic departments. Training opportunities at CDPH include courses, research assistantships, and individual mentorship provided by affiliated faculty. Some departments may allow a doctoral level specialty in one or more of the subject areas represented by the CDPH faculty. For instance, Demography is a formal specialty area for the PhD in Sociology and a field for the PhD in Economics, and Population Health is a major component of the Sociology specialty in Health and Aging. Other academic programs may allow one or more specialty courses in Demography or Population Health to count as doctoral program electives.

NAME OF PROGRAM
**Community and Population
Health**

SCHOOL
University of New England

DEGREE
MPH

WEBSITE
<http://dune.une.edu/scph/>

The School of Community and Population Health is dedicated to advancing public health knowledge and practice in rural and global communities through innovative education, training, research, capacity building and service. The school offers a standard public health curriculum as well as an online master's degree program in Public Health.

(CONTINUED ON PG 53)

NAME OF PROGRAM

**Center for Demographic
Population Health**

SCHOOL

University of Massachusetts

DEGREE

PhD

WEBSITE

[http://www.umassmed.edu/
cphr/](http://www.umassmed.edu/cphr/)

This transdisciplinary doctoral research training program is focused on epidemiology, biostatistics, and health services research geared toward translating research into effective disease prevention programs, clinical practice and policy. The program recruits a pool of pre-doctoral trainees that is diverse with respect to socio-demographic characteristics, clinical background, and disciplinary perspective. It provides trainees with individual mentoring, academic training, and technical skills necessary to ensure their success as independent investigators as well as contributors to team science. It also provides “hands on” research experience that builds on the strengths of the current environment of linkages between UMMS Departments, Centers, and Institutes. Program highlights include careful mentor matching, individualized career development planning, opportunities for students to be directly involved in research, and rigorous academic training in theory, ethics, epidemiologic methods, biostatistics, health services research, outcome measurement, and behavioral science.

NAME OF PROGRAM

**Department of Global Health
and Population**

SCHOOL

Harvard University

DEGREE

ScD, MS, MPH

WEBSITE

[http://www.hsph.harvard.edu/
global-health-and-population/](http://www.hsph.harvard.edu/global-health-and-population/)

The Department of Global Health and Population (GHP) seeks to improve global health through education, research, and service from a population- based perspective. The department’s approach to these problems combines the analysis of population and health using quantitative and qualitative methods, the investigation of policies that affect health, and a concern with the politics and ethics of health and development. Departmental research span a wide spectrum of topics, including social and economic development, health policy, and demography; design and financing of health care systems; women’s and children’s health; global nutritional epidemiology and practice; prevention and control of infectious and chronic diseases; program evaluation; and humanitarian assistance and ethics. The program draws on a range of disciplinary perspectives and provides students with advanced competencies covering conceptual approaches, theory and applications, problem solving and analysis, as well as a wide range of quantitative and qualitative methods. Doctoral students must select one of the three majors currently offered by the Department, Population and Reproductive Health, Health Systems, or Economics.

(CONTINUED ON PG 54)

NAME OF PROGRAM
Department of Population Health

SCHOOL
NYU Langone School of Medicine

DEGREE
MS, MPH, PhD

WEBSITE
<http://pophealth.med.nyu.edu/>

The Department of Population Health focuses on research to improve human health at the population level, promoting proactive approaches to disease prevention and management at the community, health system and policy levels. By bridging diverse yet related disciplines and methodologies, the department advances discovery, translation and dissemination of health-related interventions. Faculty include investigators in epidemiology, biostatistics, and related fields of methodologic research; and medical ethicists. Degree programs include Comparative Effectiveness Research Certification Program, Master's of Bioethics, Global Master's of Public Health, Master of Science in Clinical Investigation, and PhD programs in Biostatistics and Epidemiology.

NAME OF PROGRAM
Epidemiology & Population Health

SCHOOL
University of Louisville

DEGREE
MS, PhD

WEBSITE
<http://louisville.edu/sphis/departments/epidemiology-population-health>

The Department of Epidemiology and Population Health seeks to identify the determinants of health, disease, disability and death in populations for the purposes of promotion, control and prevention. The Department offers an MPH concentration and MS and PhD degrees in Epidemiology. The department is also planning a PhD concentration in Outcomes Research.

NAME OF PROGRAM
Family Medicine and Population Health

SCHOOL
Virginia Commonwealth University

DEGREE
PhD, MPH

WEBSITE
<http://www.epidemiology.vcu.edu/>

The Division of Epidemiology in the Department of Family Medicine and Population Health offers a Master's of Public Health degree and a PhD in epidemiology. Close ties to the Virginia Department of Health allow us to provide opportunities for our students to immerse in experiential learning with our public health partners. The doctoral training program in epidemiology cultivates public health scientists equipped to use state-of-the-art research methods for the purpose of advancing fundamental knowledge of issues central to the improvement of population health. Faculty research is aimed at understanding the interface between behavior and physiology to integrate social, psychological and biological approaches to understanding health and illness over the life course. Division faculty research programs are in aging, cancer prevention and control, mental health, and maternal and child health.

(CONTINUED ON PG 55)

NAME OF PROGRAM
**Health Education &
Behavioral Science**

SCHOOL
Rutgers

DEGREE
MPH, DrPH, PhD

WEBSITE
[http://sph.rutgers.edu/
departments/HEBS/index.html](http://sph.rutgers.edu/departments/HEBS/index.html)

The curriculum is designed to prepare the MPH Student to participate in the formulation of policy; assess and define health and educational needs of target populations through diagnostic and consultation skills; develop and successfully implement theory based health programs; design and conduct program evaluations; and design and conduct research. Students are prepared with skills to plan, implement and evaluate health promotion and intervention programs in settings that range from hospitals to industries, schools and communities. The doctoral programs are based on the scientist-practitioner model, and provide balanced training in behavioral science and health education research and practice. While both the DrPH and PhD programs have a series of required courses, each curriculum has flexibility to customize particular research and/or practice skills that are determined in close consultation with the academic advisor.

NAME OF PROGRAM
**Jefferson School of Population
Health**

SCHOOL
Thomas Jefferson University

DEGREE
MS, PhD

WEBSITE
[http://www.jefferson.edu/
university/population_health.
html](http://www.jefferson.edu/university/population_health.html)

Provides graduate academic programming in population health, public health, health policy, healthcare quality and safety, and health outcomes research. Educational offerings are enhanced by research, publications and continuing education and professional development offerings in these ml areas. Training at the masters level emphasizes competencies in five key public health areas – behavioral and social sciences, biostatistics, environmental health sciences, epidemiology and health policy, advocacy and management. The interdisciplinary curriculum stresses leadership skills, systems thinking, health communication, global health and cultural humility and competency. PhD students specialize in one of four areas: health policy, healthcare quality and safety, applied health economics/ outcomes research and behavioral/health sciences.

NAME OF PROGRAM
Master of Population Health

SCHOOL
Washington University

DEGREE
MS

WEBSITE
<http://www.mphs.wustl.edu/>

The MPHS program prepares students for distinguished clinical research careers by accelerating and deepening their expertise in population health and clinical outcomes research. Students gain a strong foundation and hands-on experience in leading, designing, conducting and moving clinical research findings to applications that will improve patient care and treatment. Students also establish a broad network of mentors and collaborators by interacting with Washington University medical and public health faculty. The Master of Population Health Sciences program's courses are designed to ensure that students substantially advance their research methods competency and boost their research productivity through applied coursework rather than a thesis or capstone requirement.

(CONTINUED ON PG 56)

NAME OF PROGRAM
Various Departments

SCHOOL
**Columbia University Mailman
School of Public Health**

DEGREE
MPH, MS, DrPH, PhD

WEBSITE
<https://www.mailman.columbia.edu/academics/degree-offerings/phd-and-drph-programs>

Four academic departments at the Mailman School (biostatistics, epidemiology, environmental health sciences, and sociomedical sciences) offer both PhD and DrPH degree programs. In Epidemiology, students gain advanced knowledge and skills in epidemiologic methods. Building on foundational strengths in the biologic and social determinants of population health, the degrees focus on innovative, interdisciplinary research with a broad “cells-to-society” approach. Population and Family Health offers students the skills, knowledge and vision to take on leadership roles in the fields of global health and humanitarian response in an innovative DrPH in Leadership in Global Health and Humanitarian Systems. The degree program combines formal classes, and field-based research, and the opportunity for remote and work-based learning. Sociomedical Sciences students complete rigorous coursework in theories, methods, and topics relevant to social and behavioral sciences approach to public health. PhD students also work closely with, and take classes from, faculty in the Graduate School of the Arts and Sciences (in Anthropology, History, Sociology or Psychology).

NAME OF PROGRAM
Population and Health

SCHOOL
**Johns Hopkins Bloomberg
School of Public Health**

DEGREE
Certificate

WEBSITE
<http://www.jhsph.edu/academics/certificate-programs/certificates-for-hopkins-and-non-degree-students/population-and-health.html>

The certificate is designed to serve two audiences—masters or doctoral degree students at The Johns Hopkins University and professionals—desiring to expand their knowledge of population dynamics and its linkages with public health issues and their ability to relate population-level concepts and measures of fertility, morbidity and mortality, and migration to health conditions. Students completing the certificate gain competency in knowledge of the components and measures of population dynamics, knowledge of population dynamics’ linkages with public health issues, and the ability to relate vital events and duration exposures with risk factors at the individual and population level. Note: also within the School of Public Health, the Department of Health, Behavior & Society also offers degree programs, include a MHS in Social Factors in Health.

(CONTINUED ON PG 57)

NAME OF PROGRAM

Population Health

SCHOOL

University of Ottawa

DEGREE

PhD

WEBSITE

<http://www.grad.uottawa.ca/Default.aspx?tabid=1727&page=SubjectDetails&Kind=H&SubjectId=97>

The transdisciplinary doctoral program in population health is closely linked to the University's Institute of Population Health, which brings together ten faculties within the University. The program is modeled around a framework which encompasses population health issues, determinants and causes of illness, design of multi-component interventions, health care delivery systems, and health policy. The program draws basic and applied disciplines and brings together the insights of social, biological, clinical, organizational, and political sciences; and the strengths of quantitative and qualitative methods. Its transdisciplinary approach recognizes the inherent complexity of many health problems and seeks to assemble and mobilize all pertinent scientific and scholarly disciplines. Students are encouraged to apply the science of their individual background disciplines to issues of population health. They acquire a broad knowledge of population health through courses and the comprehensive examination, and pursue in-depth study in an area of specialization (health determinants, global and local health inequities, health interventions and policies, or health risk and resilience).

NAME OF PROGRAM

Population Health

SCHOOL

UMASS Lowell

DEGREE

MPH

WEBSITE

<http://www.uml.edu/Health-Sciences/Public-Health/Programs-of-Study/masters/Focus-areas.aspx>

The goal of the Population Health specialization is to educate practitioners who have a broad foundation of the fundamental principles of public health with a focus on program planning and evaluation. Targeted competencies include: find, understand, and apply relevant public health literature; design and implement programs that improve public health by fostering change in individual behaviors, environmental conditions, and social policy; evaluate public health programs through data collection and analysis; and engage individuals and communities in discussion and decision-making to clarify shared public health goals. The program includes a practicum that provides students with applied experience in health promotion and disease prevention. The school also offers other relevant degree programs, including Global Environmental Sustainability and Health, Epidemiology, and Nutrition.

(CONTINUED ON PG 58)

NAME OF PROGRAM
**Population Health & Clinical
Outcomes Research**

SCHOOL
Stony Brook University, SUNY

DEGREE
PhD

WEBSITE
[https://publichealth.
stonybrookmedicine.edu/phcor](https://publichealth.stonybrookmedicine.edu/phcor)

This small and highly specialized graduate degree program seeks to train population health and clinical outcomes researchers, academicians, and practitioners. Working under faculty mentor guidance, students conduct research on substantive current health care problems affecting population health, health policy, clinical practice, and patient-based health care decisions. Competency goals include: identification of the determinants of health and factors associated with disease prevention; assessment the health care needs of populations as related to their environment; understanding the context for population health and clinical science research questions, as well as the organization, politics, and financing of the health care system; appraisal of the performance of the health system in terms of access to care, safety, quality of care, resource consumption, cost-effectiveness, and accountability; conduct of independent studies of the health care system using state of the art research methods.

NAME OF PROGRAM
Program in Nursing

SCHOOL
**University of Massachusetts
Boston**

DEGREE
PhD

WEBSITE
[https://www.umb.edu/
academics/cnhs](https://www.umb.edu/academics/cnhs)

The PhD Program in Nursing offers concentrations in population health and health policy. It prepares graduates as nurse leaders in addressing critical population health problems/conditions, and for leadership roles as policy analysts, researchers and educators. The program focuses on the intersection of nursing, population health, and health policy. Graduates are prepared to: analyze the historical, sociological, economic, political and nursing perspectives of population health problems and existing proposed health policies, evaluate and critique health policies that influence the access, quality, and cost of healthcare services, conduct theory-guided qualitative, quantitative, and mixed methods research that advances knowledge of population health problems and health policies, and influence the development of innovative solutions to population health problems and health policies at local, state, national and international levels.

(CONTINUED ON PG 59)

NAME OF PROGRAM
Population Health Sciences

SCHOOL
University of Wisconsin-Madison

DEGREE
MS, PhD

WEBSITE
<http://www.pophealth.wisc.edu/Prospective-Students/MS-Degree-Program-Pop-Health>

These research-oriented programs are designed to provide rigorous, interdisciplinary training to develop students' abilities to synthesize knowledge and skills needed to address health related problems. The interdisciplinary approach of our graduate program prepares students to be leaders in their professions by instilling strong methodological research skills together with understanding of basic biological, epidemiological, social and behavioral, and health services constructs in the context of a population-based focus. Through coursework and research collaboration, students learn to employ rigorous scientific and analytic methods to reduce the burden of morbidity and early mortality, to identify the most effective ways to prevent and treat diseases and disorders, and to promote population health. The doctoral program offers concentrations in epidemiology, health services research, social and behavioral health sciences, and clinical research.

NAME OF PROGRAM
Population Health Sciences Program

SCHOOL
University of Texas Medical Branch

DEGREE
MS

WEBSITE
<http://pmch.utmb.edu/education/population-health-sciences-program>

The Population Health Sciences (PHS) Graduate Program prepares students to conduct, communicate, and apply research aimed at the protection, promotion, and restoration of health in human populations. Curricula within the Program share a population health perspective that explores the interplay of individual biological and behavioral factors with aspects of the physical, social, and policy environments. Research focuses on health risks, determinants, outcomes, and interventions in clinical and community settings and in unique occupational or patient groups. Training is interdisciplinary and emphasizes the development and mastery of high-level quantitative skills in data collection and analysis.

NAME OF PROGRAM
Population Health & Disease Prevention

SCHOOL
UC Irvine Program in Public Health

DEGREE
MPH, PhD

WEBSITE
http://publichealth.uci.edu/ph_docs/dphdp_message

The MPH program educates students in the global dimensions of public health principles and prepares them to lead and work collaboratively on the assessment of health-risk factors and the management of prevention strategies. Students may concentrate in one of three emphasis areas: environmental health, epidemiology, or sociocultural diversity and health. The Ph.D in Public Health offers two concentrations, global health and disease prevention. It is not clear whether the Department of Population Health & Disease Prevention offers any graduate degrees.

(CONTINUED ON PG 60)

NAME OF PROGRAM

Public Health

SCHOOL

The University of Vermont

DEGREE

MPH

WEBSITE

[http://learn.uvm.edu/
programs/public-health-
programs/online-master-of-
public-health/](http://learn.uvm.edu/programs/public-health-programs/online-master-of-public-health/)

This program leads to a Generalist MPH degree focused on excellence in Environmental Public Health; Quantitative Public Health Sciences; and Health Policy, Leadership, and Advocacy. The program provides a strong foundation in population health sciences by teaching students to: evaluate and improve the health of various populations, work with a network of professionals in healthcare, government agencies, and non-profit organizations, navigate the levels of community resources, identify changes to healthcare systems and requirements for accountability, and implement new models for population-based medical practice.

NAME OF PROGRAM

Public Health Genetics

SCHOOL

University of Washington

DEGREE

MPH, PhD, JD/MPH, certif

WEBSITE

[http://iphg.biostat.washington.
edu/](http://iphg.biostat.washington.edu/)

All IPHG degree programs emphasize an interdisciplinary approach to using genomic advances to improve population health. The PhD program provides training in the core knowledge areas of public health genetics (genetic & molecular epidemiology; ecogenetics & Pharmacogenomics; clinical aspects of genomics; ethics & social science; law & policy; health economics & outcomes research) so that graduates can address scientific and policy questions from a variety of perspectives. The MPH degree develops competencies in genetic epidemiology, pharmacogenetics, and toxicogenomics, within the broader context of law, ethics, culture, and policy. The degree requires coursework in epidemiology, biostatistics, genetic epidemiology, health services, environmental health, law, and bioethics.

NAME OF PROGRAM

**The Master of Public Health
(MPH) Program**

SCHOOL

University of Maryland

DEGREE

MPH

WEBSITE

[http://www.medschool.
umaryland.edu/epidemiology/
mph/](http://www.medschool.umaryland.edu/epidemiology/mph/)

This program offers three concentrations: Epidemiology, Community & Population Health and Global Health.

Programs at the Postdoctoral Level

To our knowledge, there is no national registry of postdoctoral training programs. We therefore searched on the basis of funding organizations: NSF, NIH, and Foundations. We found no relevant programs at NSF. Results for NIH and Foundations are summarized in the next two sections.

NIH-Supported Pre- and Post-Doctoral Training Programs

Because health-related training is often supported through the NIH, we surveyed current NIH training activities within the broad domain of population health. We conducted a NIH RePORTER search of all current T32 grants⁴⁶ using the terms “population” and “epidemiology”. We also looked at information on the limited number of institutional K awards and determined that none related to population health. We limited the search to institutional awards because of the need for a critical mass of trainees in interdisciplinary training. We surveyed grants supporting pre-doctoral, post-doctoral and both levels of training, although our focus is on those providing post-doctoral training.

Although 479 T32 grants were identified through the RePORTER search, the vast majority of these did not fit the definition of population health. We included grants as meeting the definition if (1) a substantial goal of training was acquiring and/or learning to produce knowledge of the determinants of health within and across populations and (2) the program either explicitly or implicitly acknowledged a multi-level conception of health determinants ranging from the biological to the social/environmental. Programs focused entirely on health services research were not classified as population health. Only 70 of the grants met our criteria.⁴⁷

Our analysis of the 70 grants suggested three broad categories:

(1) training programs related to specific diseases or conditions; (2) training programs in demography and aging; and (3) other training programs with a population focus. We subdivided the programs in the first category, further classifying them into groups that offer different contrasts to training in interdisciplinary population health science. Table 2 shows the number of grants in each of the categories and subcategories, along with two representative examples of the programs in each

⁴⁶ This search was conducted in August, 2014 by Christine Bachrach and Yonette Thomas. Also, we examined previous NIH initiatives that have targeted interdisciplinary training. Two Common Fund RFAs (RFA-RM-05-010 and RFA-RM-04-010) funded 8 programs in 2004 and 2005. Only one of these addressed a population health issue (obesity) but this program is no longer funded.

⁴⁷ Full results from the search are available upon request, as is a complete list, with descriptions, of the 70 grants that fell within our criteria.

category. By necessity, our classification of grants was based on information in the abstract. The brief descriptions of example grants in the table are also adapted from the abstracts.

Not surprisingly, the largest number of programs (45) fall into the category of **training related to specific diseases or conditions**. Included in this number are 16 grants for which the focus on population health is unclear – for example, because a program made reference to population concerns but did not appear to address them or provided too little information to determine the range of science deemed relevant to health.

Eighteen of the disease- or condition-focused programs provide training specifically in epidemiology or address population level issues primarily through epidemiology (and in some cases also community-based research or intervention). While many of these programs offer exposure to multiple disciplines, the range of disciplines typically clusters within the basic biological, clinical and public health sciences. Integration of social science is rare even though all of the programs recognize “social” or “psychosocial” exposures that create risk. In the majority of programs, training is specifically in epidemiology. Some of these programs provide exposure to other disciplines, but trainees are nevertheless socialized to the culture, priorities, and methods of one – epidemiology. Only three of these program mention training in interdisciplinary skills as a goal in their abstracts, and of these only one specifies mechanisms for providing such training.⁴⁸

The remaining eleven disease- or condition-focused grants provided training in population health but did not focus primarily on epidemiology. These also differed from an ideal model of training in interdisciplinary population health science. As discussed earlier, the integration of basic social sciences to address the mechanisms that produce or modify social conditions is a crucial element of population health science.

Therefore, an ideal training program addresses the contributions to health of not only the biological and behavioral sciences but also the basic social sciences. While all of these training programs clearly articulate a “cells-to-society” vision of the determinants of health, only two report involving basic social science disciplines in their training programs. For one of these, there is insufficient information to judge whether the program represents social determinants of health as “exposures” that put individuals at risk of adverse health outcomes, rather than conditions or processes to be studied in their own right. The other provides pre-doctoral training only and engages social science only in relation to policy and health services research.

Among all of the 45 programs providing training related to specific diseases or conditions, nine mentioned providing training in interdisciplinary skills as a goal in the abstract or indicated practices (such as assigning multiple mentors from different disciplines) that help to promote such training. Only two of these programs (T32DA037183 and T32HL120823) indicated multiple strategies for training in interdisciplinary skills. Thus, for most programs, inter-disciplinary training appears to expose trainees to problem-specific knowledge generated by different disciplines, but does not develop the skills necessary to conduct interdisciplinary science.

Training programs in demography and aging. We found 18 grants that include some focus on population health in the context of training in demography and the economics and/or demography of aging supported by NICHD and NIA. These programs include training in the social sciences (largely sociology and economics) but capture a narrow disciplinary range. Public health was represented in some of these grants, but in only one case are basic biological or clinical sciences represented. For most programs, health is one aspect of the program’s focus on population (other aspects include, e.g., aging, migration, fertility, family demography, social inequality). None of these programs emphasize training in interdisciplinary skills, and most are oriented largely to

⁴⁸ As discussed later, very few abstracts mentioned interdisciplinary skills training. Given the limited information available in abstracts, it was impossible to rule out that such training may occur. However, it seems reasonable to assume that if such training was a significant goal of a program, the abstract would mention it.

pre-doctoral training. Those that do enroll post-doctoral fellows lack the critical mass needed for interdisciplinary training and typically have fellows work with a single mentor, often from their primary discipline.

Other programs with a population focus. In this category we include training programs that emphasize health disparities and those that focus on environmental health, gene-environment interactions, or global health. We found 7 programs across these categories. These programs also differ from the model proposed here for interdisciplinary population health science training. We found no indication of the involvement of multiple disciplines within the health disparities programs' abstracts; two of the three were targeted to clinical scientists and did not include basic science training. The environmental programs were grounded in epidemiology, conceptualized environment as "exposures," and lacked any involvement of the social sciences.

TABLE 2. NUMBERS AND EXAMPLES OF NIH-FUNDED T32 TRAINING GRANTS RELATED TO POPULATION HEALTH, BY CATEGORY

CATEGORY	# OF GRANTS	EXAMPLE 1	EXAMPLE 2
Training programs related to specific diseases or conditions			
Unclear relationship to population health	16	<p>IMPROVING MENTAL HEALTH CARE IN SAFETY NET MEDICAL SETTINGS; T32MH08270 (post)</p> <p>The program aims to increase the number of early career investigators trained in mental health and addictions services research with a safety net medical setting focus, using an interdisciplinary approach embedded in an academic-public sector partnership. It draws faculty from the Departments of Psychiatry and Medicine in the School of Medicine, and from the Schools of Social Work, Nursing, and Public Health.</p>	<p>TRAINING IN SEXUALLY TRANSMITTED DISEASES AND HIV; T32AI007001 (pre and post)</p> <p>The program trains scientists from a variety of fields to conduct outstanding STD/HIV research. Other goals include the development of the skills necessary to conduct productive interdisciplinary research and facilitating professional growth and development to ensure academic and research success. The program engages faculty members from four departments (Microbiology & Immunology; Infectious Diseases; Epidemiology; and Health Behavior/ Health Education.</p>

(CONTINUED ON PG 65)

CATEGORY	# OF GRANTS	EXAMPLE 1	EXAMPLE 2
Training programs in epidemiology	18	<p>DIGESTIVE DISEASE EPIDEMIOLOGY TRAINING PROGRAM; T32DK007634 (pre and post)</p> <p>The goal of this program is to train independent researchers who will improve our understanding of the magnitude, etiology and impact of digestive diseases. The program includes: 1) formal advanced training in epidemiologic methods and biostatistics; 2) a 2 - 3 year period of training culminating in an MPH, MSCR or PhD in epidemiology; 3) concurrent training of MD and PhD candidates in a program that ranges from molecular epidemiology to population-based health outcomes research. A stable, diverse, and multidisciplinary faculty provides trainees expert guidance in epidemiology, biostatistics, and health outcomes research.</p>	<p>EPIDEMIOLOGY OF SUBSTANCE USE DISORDERS TRAINING PROGRAM; T32DA031099 (pre and post)</p> <p>This program provides specialized training for careers in substance abuse epidemiology. The program takes a cells-to-society perspective on substance abuse epidemiology, and offers training at multiple levels of causation, ranging from the molecular to large-scale social forces. Training provides fellows with broad yet intensive training in substance abuse epidemiology and related areas, depth in an area of specialization; and a set of methodological and conceptual skills.</p>

(CONTINUED ON PG 66)

CATEGORY	# OF GRANTS	EXAMPLE 1	EXAMPLE 2
Training programs without a central epidemiology focus	11	<p>CANCER HEALTH DISPARITIES TRAINING PROGRAM; T32CA128582 (post)</p> <p>The Program addresses health disparity issues in cancer from etiology and primary prevention to survivorship. Topics include genetic and molecular epidemiological bases of disparities; cancer epidemiology; research methods; cancer prevention and control (screening/early detection, health promotion, health communications, community-based participatory research, dissemination, policy); disparities related to access to care, socioeconomic status, culture, and survivorship; and critical thinking and synthesis. Training is offered by four participating departments: Nutrition, Epidemiology, Health Behavior and Health Education, and Environmental Sciences and Engineering.</p>	<p>RESEARCH TRAINING PROGRAM IN SUBSTANCE ABUSE PREVENTION; T32DA019426 (post)</p> <p>This training program: 1) understands substance use/abuse and related behaviors within an ecological framework that emphasizes relevant developmental, neurobiological, environmental, and cultural contexts, such as families, schools, worksites, neighborhoods, and communities; 2) emphasizes that knowledge development and application progresses through specific phases (pre- intervention, intervention, and diffusion or going-to-scale); 3) teaches rigorous research methodologies including mixed methods designs; 4) emphasizes interdisciplinary and transdisciplinary research and the translation of research into real-world contexts that impact prevention practice and policy.</p>
Training grants in demography and aging	18	<p>TRAINING IN THE DEMOGRAPHY AND ECONOMICS OF AGING; T32AG000221 (pre and post)</p> <p>In the predoctoral program students combine disciplinary training in sociology, economics, or public health with specialized training in demography. Postdoctoral training is coordinated with a faculty mentor and includes course work, seminars, and collaborative or independent research. A major focus of the program is socioeconomic, racial, and ethnic disparities in health.</p>	<p>DEMOGRAPHY; T32HD007163 (pre and post)</p> <p>This program provides interdisciplinary instruction with a firm base in the social sciences and strong training in the technical aspects of demographic and statistical methods for careers in demographic research and teaching. The program has five signature themes: (1) health and wellbeing, (2) migration and development, (3) children and families, (4) social inequality, and (5) data/methods.</p>

(CONTINUED ON PG 67)

CATEGORY	# OF GRANTS	EXAMPLE 1	EXAMPLE 2
Other training programs with a population focus	7	<p>TRANSDISCIPLINARY TRAINING IN HEALTH DISPARITIES SCIENCE (TTHDS); T32NR012718 (post?)</p> <p>This program prepares nurse scientists to leverage the culture of the groups, communities, and organizations with whom they work to understand and describe disparate health outcomes, intervene to improve health outcomes, and translate and disseminate scientific findings for widespread impact.</p>	<p>TRANSLATIONAL RESEARCH TRAINING PROGRAM IN ENVIRONMENTAL HEALTH SCIENCES; T32ES019851 (pre and post)</p> <p>This program is housed at the Center of Excellence in Environmental Toxicology (CEET) which is a P30 Environmental Health Sciences Core Center funded by NIEHS. The CEET is a Translational Environmental Health Sciences Center with a focus on major societal disease that affects the Philadelphia area: including but not limited to lung and airway disease, and reproductive, endocrinology, and developmental disorders (including the developmental basis of adult disease). Additionally, there is a strong emphasis on disease mechanism involving oxidative stress and gene-environment interactions. Trainees will be equipped to deal with environmental exposures, how they relate to disease and how their findings may be translated at the patient-, community- and public health- levels.</p>

DEFINITIONS:

Population health:

Does the goal of training include scientific knowledge of the determinants of population health (defined as health of and across populations and including a cells to society frame)?

Training in epidemiology:

Programs in which the training is specifically in epidemiology or population level analysis is brought in entirely through epidemiology.

Unclear:

For example, because a program made reference to population concerns but did not appear to address them or provided too little information to determine the range of science deemed relevant to health.

Foundation-Supported Programs

Information on foundation support for training in population health was developed through a multi-pronged strategy. First, with the assistance of development staff at the New York Academy of Medicine,⁴⁹ a list of foundations with potential interest in supporting activities in population health science was developed. Using expert informants, this list was narrowed to a subset of thirteen foundations most likely to have relevant interests. We then conducted a search of foundation websites using search terms such as “fellows”, “scholars”, post-doctoral, and training; and examined foundation priorities posted on the Web and information on grants awarded where available. Other searches included <http://foundationcenter.org/>, and <http://www.pathwaystoscience.org/index.aspx>. We also conducted interview with an individual supported by one of the Kaiser Permanente programs and with a staff member at the Robert Wood Johnson Foundation. We found that the Robert Wood Johnson Foundation and Kaiser Permanente are currently active in providing training programs in population health science. While other foundations have supported programs with relevance to population health, these tend to focus on leadership training for policy and/or community action. The program descriptions below are organized by foundation.

The **Robert Wood Johnson Foundation** (RWJF) currently supports 29 human capital programs, of which nine bear on population health concerns in some way. Of the nine, RWJF Health & Society Scholars (HSS) is the only one explicitly devoted to training in population health science. RWJF will end HSS and five of the other relevant programs listed below (denoted by *) during the period 2015-2018.

- *RWJF Health & Society Scholars (<http://www.healthandsocietyscholars.org/>) is intended to produce leaders who will change the questions asked, the methods employed to analyze problems, and the range of solutions to reduce population health disparities and improve the health of all Americans.

It trains scholars to investigate the connections among biological, genetic, behavioral, environmental, economic and social determinants of health and to develop, evaluate and disseminate knowledge, interventions, and policies that integrate and act on these determinants to improve health.

- New Connections: Increasing Diversity of RWJF Programming (www.rwjf-newconnections.org/), which uses grantmaking, career development and mentoring of early and midcareer scholars to increase participation from historically underrepresented groups in all areas of RWJF programming.
- *RWJF Center for Health Policy at Meharry Medical College (<http://www.mmc.edu/about/rwjf/>), which supports training in health policy for doctoral students in economics, political science or sociology at Vanderbilt University and medical, dentistry and other graduate students at Meharry Medical College. The program also offers other professional development and externship opportunities.
- *RWJF at the University of Center for Health Policy New Mexico (<http://healthpolicy.unm.edu/about/>), which trains scholars in health services and health policy research through on-the-job research, policy analysis training, leadership development and community capacity building. The program invests in five disciplinary areas: economics, political science, public health, sociology, and nursing.
- *RWJF Clinical Scholars (<http://rwjcsp.unc.edu/about/overview/>), which offers physicians master's degree graduate-level study and research in a university-based, 2-year post-residency training program for physicians. The program integrates scholars' clinical expertise with training in program development and research methods to help them find solutions for the challenges posed by the U.S. health care system and the health of U.S. communities.
- RWJF Community Health Leaders (http://www.rwjf.org/content/dam/farm/reports/program_results_reports/2013/rwjf69522), which makes awards to honor individuals working in communities across

⁴⁹ We thank Caryn Teitelbaum, Gerard Lebeda and Jo Boufford for helping with this search.

the country to improve health and access to care for underserved and often disenfranchised populations.

- RWJF Health Policy Fellows (<http://www.healthpolicyfellows.org/home.php>), which provides mid-career health professionals and behavioral and social scientists the opportunity to participate for one or more years in policy processes at the federal level and gain hands-on policy experience.
- *RWJF Investigator Awards in Health Policy Research (<http://www.investigatorawards.org/>), which provides research funding for studies of challenging health, health care and health policy issues on topics such as prevention, health disparities, health care & public health policy, medical workforce, quality of care, and patient-provider relationships.
- *RWJF Scholars in Health Policy Research (<http://healthpolicyscholars.org/>), which provides two-year site-based training in health and health policy for economists, sociologists and political scientists. Scholars are expected to pursue careers within their disciplines, making important research contributions to future health policy in the United States.

Four new programs are currently under development by RWJF (RWJF, 2015). The new programs will emphasize leadership training and greatly increase the number of trainees enrolled compared to prior programs. One of these programs has a research focus: the RWJF Interdisciplinary Research Leaders will “support a network of researchers whose leadership and whose community-relevant, policy-relevant, action-oriented research will help to drive social change toward a Culture of Health.” Based on current information, none of the new programs appear to provide scientific training in population health.

Kaiser Permanente supports a number of training programs relevant to population health. These include the following:

- The Kaiser Permanente Burch Minority Leadership Development Program supports 12 junior minority researchers in developing connections and dialogue with health policymakers in federal, state and local governments; research agendas that effectively address

policy concerns; and visibility as leaders promoting health and health care. The two-year leadership development program generally supports researchers with a population or public health focus.

- A grant to the Satcher Health Leadership Institute at the Morehouse School of Medicine supports a workforce leadership program that trains scholars to encourage effective policy and practice addressing the causes of health disparities and access to care and also develops health care leaders who will advance the integration of mental and primary health care.
- Training for new investigators in health disparities research takes place within the UCLA Kaiser Permanente Center for Health Equity. This collaborative “center without walls” fosters multidisciplinary research and promotes population-based intervention approaches to health promotion and disease prevention and control with a focus on the underserved. The Center’s members include academic, government, foundation and private/non-profit investigators.
- The UC Berkeley Kaiser Permanente Public Health Scholars program enables 15-20 students a year from underserved communities to attend one of the nation’s premier schools of public health, with the goal of improving the flow of public health expertise to vulnerable communities.

The W. K. Kellogg Foundation played a major role in training scholars and leaders in health over the period 1990-2012, with a special emphasis on policy, community-based research, and health disparities. Its flagship program in this area, the Kellogg Health Scholars Program, closed in 2012. This two-year post-doctoral program provided training on the social determinants of health, academic-community partnering, community-based participatory research, and application of research to strengthen advocacy and achieve policy change. The program had its roots in three related programs:

- The Community Health Scholars Program, established in 1997, was designed to develop and strengthen the competences of university faculty in community-based approaches to teaching service and research. The

program operated at three training sites⁵⁰ and located its National Program Office at the University of Michigan. CHSP provided fellowships to 46 scholars.

- The Kellogg fellowship Program in Health Policy Research, established in 1998, supported the training of health policy researchers with expertise in the area of program evaluation and measurement and the development of a network of minority leaders in health policy research. Fellowships were awarded to minority men and women enrolled in doctoral programs in public health, health policy or social policy at seven participating schools.⁵¹ The Center for Advancing Health served as national program office.
- The Scholars in Health Disparities Program, established in 2001, was established to train future faculty and policy-makers in a multi-disciplinary approach to studying the social determinants of health disparities. The program emphasized increasing the diversity of faculty in schools of public health and other health-related academic settings. The program was located at the Center for the Advancement of Health.

Two of the above programs, Community Health Scholars Program and the Scholars in Health Disparities Program, were combined to create The Kellogg Health Scholars Program in 2006. The Kellogg Health Scholars offered two year postdoctoral fellowships at eight training sites. It made two tracks available. The Community Track highlighted community based participatory research and relationships between academic health disparities research, public health practices in communities, and policy development. The Multidisciplinary Track highlighted a multidisciplinary approach to studying the determinants of health inequalities and inequities. Both tracks highlighted the translation of health research into policy findings and recommendations.

In addition to these programs, the W. K. Kellogg Foundation also supported other fellows programs relevant to leadership in population health action.

The Food & Society Policy Fellowship (also known as Food and Policy Fellows and Food and Community Fellows) was a leadership program promoting cultural and policy change toward sustainable, just, and healthful food and farming. This program ended April 2013.

Finally, the Foundation has supported several international fellows programs. While one of these programs focused on food systems, none targeted population health more generally. Most emphasized leadership training and not research or academic training.

The Kresge Foundation's health team has a strong population health focus. The Foundation seeks to “reduce health disparities by promoting conditions and environments that lead to positive health outcomes for all Americans.” The Foundation’s mission emphasizes improving health by improving the environmental and social conditions affecting low-income and vulnerable populations through cross-sector efforts to improve community-health systems. The health team has provided support to leadership development efforts to build the capacity of community-based organizations to advocate for health. Recent leadership grants include funding to support the AcademyHealth Population Health Scholars Program which provided policy “boot camps,” networking with policymakers and health leaders, and complementary participation in AcademyHealth’s National Health Policy Conference for 10 emerging community leaders in 2015. The Foundation recently launched the Emerging Leaders in Public Health program, to develop the capacity of local governmental public health leaders. This program provides resource grants and technical support for 12 teams of health department leaders working to transform their services to improve population health.

The mission of the **Aetna Foundation** is “to promote wellness, health, and access to high-quality health care for everyone, while supporting the communities we serve.” The Foundation provides funding for research, policy analysis, and programs in three program areas – obesity,

⁵⁰ Schools of public health at the Johns Hopkins University, the University of Michigan and the University of North Carolina.

⁵¹ The Heller Graduate School at Brandeis University, the Mailman School of Public Health at Columbia University, Harvard School of Public Health, the John Hopkins School of Hygiene and Public Health, the UCLA School of Public Health, the University of Michigan School of Public Health, and the Rand School.

racial and ethnic health care equity and integrated health care. Investments in obesity focus on community-based initiatives that encourage healthy eating and active living. These include structural approaches such as community gardening, access to healthy foods and policy as well as behavioral interventions. The Foundation supports five scholars programs, four of which are oriented towards careers in health care. The fifth is the AcademyHealth/Aetna Foundation Minority Scholars Program, which provides 15 students, post-doctoral trainees and fellows a scholarship to attend AcademyHealth's annual research meeting, along with adjunct meetings and mentoring activities. The program seeks to attract men and women from underrepresented groups to the field of racial and ethnic disparities research in health outcomes and access to health care.

Two foundations, **Atlantic Philanthropies** and the **John A. Hartford Foundation**, support the Health and Aging Policy Fellows Program, which prepares professionals in health and aging to make a positive contribution to the development and implementation of health policies that affect older Americans by supporting research and work experience in policy settings.

Other programs that provide training relevant to population health also receive support from foundations along with support from federal and other sources. For example, the Satcher Health Leadership Institute receives funding from a variety of public and private sources to develop “public health leaders, foster and support leadership strategies, and influence policies and practices toward the reduction and ultimate elimination of disparities in health with the focus on neglected diseases and underserved populations...” The Institute offers two fellowship programs relevant to population health. The Health Policy Leadership Fellowship Program (est. 2009) is a multi-disciplinary postdoctoral program designed to prepare trainees for leadership roles promoting and implementing policies and practices that reduce health disparities and advance health equity. The Community Health Leadership Program provides leadership skills for and experience in community-based research and programs that address health disparities.

Appendix 3.

Examples of Training Programs Relevant to Population Health Science

UNDERGRADUATE PROGRAMS

PROGRAM NAME	Health: Science, Society, and Policy Program
UNIVERSITY	Brandeis University
GOALS/ DESCRIPTION	The objective of the Health, Science, Society, and Policy (HSSP) program is to “help students understand the biological underpinnings of health, illness and disability, as well as their social, political, legal and economic dimensions.”
WEBSITE	http://www.brandeis.edu/programs/hssp/
LOCATION/ ENVIRONMENT	Interdepartmental major; program governance and academic advising for students are provided by a Faculty Executive Committee, which consists of professors from both the College of Arts and Sciences and the Heller School for Social Policy and Management.
CURRICULUM	Includes introductory classes (one each) in biology, sociology, and health policy; introduction to epidemiology, biostatistics, and population health
RESEARCH	“Hands-on-experience” (internship or independent research project)
MENTORING	Not discussed
INTER-DISCIPLINARY SKILLS	Yes
TRANSLATION	Yes
OTHER COMMENTS	Offers BA, BS, and minor

UNDERGRADUATE PROGRAMS

PROGRAM NAME	Undergraduate Program in Public Health	Major in Medicine, Health, and Society
UNIVERSITY	University of Colorado - Denver	Vanderbilt University
GOALS/ DESCRIPTION	Emphasizes the “broad array of disciplines” that offer “unique insights” relevant to public health, including “the social and behavioral sciences, medicine, nursing, pharmacy, physical therapy, business, economics, statistics, epidemiology, law and biology.”	Designed for students who wish to “investigate...the cultural, economic, demographic and biological factors that impact health.” The curriculum is designed to train students “to meet emerging challenges in our healthcare system as well as changes in medical education.”
WEBSITE	http://www.ucdenver.edu/academics/colleges/CLAS/Departments/hbsc/Programs/Bachelors/Pages/Bachelors.aspx	http://www.vanderbilt.edu/mhs/undergraduate/
LOCATION/ ENVIRONMENT	Department of Social and Behavioral Science, College of Liberal Arts and Sciences in partnership with Colorado School of Public Health, each course team taught by faculty from each school.	Located in the in the Center for Medicine Health and Society, “an innovative multidisciplinary center that studies the social and societal dimensions of health and illness.” Core faculty are appointed to the CMHS; “affiliated faculty” have appointments in departments across the University.
CURRICULUM	Mirrors graduate training in public health: core courses are public health, health policy, env. health, epidemiology, global health, and social determinants of health.	Offers a variety of concentrations: global health; health behavior/health sciences; health policy & economics; race, inequality, and health; medicine, humanities, and the arts; and, critical health studies.
RESEARCH	Not discussed	Not discussed
MENTORING	Not discussed	Not discussed
INTER-DISCIPLINARY SKILLS	Not discussed	Not discussed
TRANSLATION	Not discussed	Not discussed
OTHER COMMENTS	BA and BS in public health, and a minor	Offers a major (BA), a minor, and a combined BA/MA (4+1) program.

PREDOCTORAL PROGRAMS

PROGRAM NAME	PhD in Population Health	Interdisciplinary Research Training in Public Health and Aging
UNIVERSITY	Northeastern University	University of Michigan
GOALS/ DESCRIPTION	This program trains students to become public health leaders through simultaneous examination of multiple determinations of health, including social, environmental, nutritional, and behavioral risk factors. Population Health doctoral students learn to conduct research that addresses five key health determinants: Social and Community Context, Environment and Neighborhoods, Health and Health Care Delivery, Education, and Economic Stability.	The overall objective is to provide training in the social and behavioral determinants, and their mediation through or interaction with biological susceptibility processes of adverse health outcomes in older age, such as reduced survival, geriatric syndromes and co- morbidities, cognitive decline and dementia, and disability. The rationale lies in the potential of this research to identify new opportunities for the prevention, management and treatment of aging-related chronic health conditions and their functional consequences.
WEBSITE	http://www.northeastern.edu/bouve/health-sciences/programs/population-health-phd/	http://micda.psc.isr.umich.edu/project/detail/35519
LOCATION/ ENVIRONMENT	The Bouvé College of Health Sciences offers five undergraduate programs and over 34 graduate programs within our three schools – health professions, nursing, and pharmacy, with an interdisciplinary emphasis that reflects today’s team approach to health care.	Center for Social Epidemiology and Population Health, Department of Epidemiology, School of Public Health; ties to other research centers, institutes.
CURRICULUM	Courses in biostatistics, epidemiology, and health services; specialized training in topics related to student research; research concentrations in Social & Env. Determinants of Health and Health Service & Policy.	Structured program including: mentored research activity; courses in epidemiology of aging and related subjects, research seminars; other training.
RESEARCH	Yes	Yes
MENTORING	Not discussed	25 mentors with well-established research and training records in various disciplines
INTER-DISCIPLINARY SKILLS	Not discussed	Not discussed
TRANSLATION	Not discussed	Not discussed
OTHER COMMENTS		Funded by T32AG027708, 4 pre-doctoral slots

PREDOCTORAL PROGRAMS

PROGRAM NAME	Population and Health
UNIVERSITY	Johns Hopkins Bloomberg School of Public Health
GOALS/ DESCRIPTION	This program offers a certificate designed to serve masters or doctoral degree students and professionals. Objectives are to expand trainees' knowledge of population dynamics and its linkages with public health issues and their ability to relate population-level concepts and measures of fertility, morbidity and mortality, and migration to health conditions.
WEBSITE	http://www.jhsph.edu/academics/certificate-programs/certificates-for-hopkins-and-non-degree-students/population-and-health.html
LOCATION/ ENVIRONMENT	Department of Population, Family and Reproductive Health.
CURRICULUM	Students complete 18 credits of coursework on population dynamics & their linkages with public health issues and demographic methods for public health.
RESEARCH	Not discussed
MENTORING	Not discussed
INTER-DISCIPLINARY SKILLS	Not discussed
TRANSLATION	Covered by an elective course
OTHER COMMENTS	

POSTDOCTORAL PROGRAMS

PROGRAM NAME	RWJF Health & Society Scholars	Cancer Health Disparities Training Program
UNIVERSITY	U Michigan, U Penn, Harvard, UCSF & Berkeley, U Wisconsin, Columbia U	University of North Carolina, Chapel Hill, Gillings School of Global Public Health
GOALS/ DESCRIPTION	Seeks to improve the nation's health by addressing the full spectrum of factors that affect health and creating the evidence to inform policy in multiple sectors that can promote health. The program trains scholars to investigate the effects of contextual factors on behavior and biology in order to strengthen the knowledge base supporting population-wide interventions.	The Program trains public health researchers in the competencies needed to address and understand cross-cutting health disparity issues in cancer across the cancer continuum from etiology and primary prevention to survivorship. Trainees gain research skills and familiarity with the many scientific disciplines and methods involved in research on cancer health disparities based on a socio-ecological model of health.
WEBSITE	http://www.healthandsocietyscholars.org	http://sph.unc.edu/hb/chd/
LOCATION/ ENVIRONMENT	University sites selected on the basis of outstanding talent in specific disciplines, commitment to interdisciplinary collaboration, breadth and depth of research opportunities, and the presence of faculty leaders in population health. The sites share their training and research resources for the benefit of scholars and faculty at all sites.	Administered through the Department of Health Behavior, but draws upon collaborative, interdisciplinary research teams that focus on cancer health disparities at UNC-Chapel Hill (18 faculty, 6 departments, 2 centers).
CURRICULUM	Intensive seminars, research and analysis; study of interactions among context, behavior and biology across the life span; training in leadership skills, translation.	A specialized curriculum includes a cancer disparities seminar, training on research ethics and courses in health disparities & cultural competency.
RESEARCH	Scholar-directed research	Training experience in interdisciplinary research that focuses on cancer health disparities
MENTORING	All program activities conducted with the guidance or collaboration of distinguished faculty mentors	Mentors assigned in more than one discipline; focus on career development
INTER-DISCIPLINARY SKILLS	Expand cross-disciplinary thinking & dialogue; intellectual scope, collaborative competence, shared language	Not discussed
TRANSLATION	Program implementation & policy change; communication to decision-makers and opinion leaders	Trainees learn research communication
OTHER COMMENTS		Funded by T32CA128582, post only, 1-3 slots, 2-3 yr appts

POSTDOCTORAL PROGRAMS

PROGRAM NAME	Cardiovascular Disease Epidemiology Training Program (pre and post)	Fellowship in Medicine and Public Health Research (post)
UNIVERSITY	Johns Hopkins University, Bloomberg School of Public Health	New York University School of Medicine
GOALS/ DESCRIPTION	The overall objective is to produce cardiovascular disease epidemiologists with training of sufficient rigor and multidisciplinary orientation to carry out high quality research in cardiovascular disease issues, and to prepare them to serve as teachers and role models of excellence for the next generation of cardiovascular disease epidemiologists. The program integrates knowledge on all aspects of cardiovascular disease: biology, behavior, treatment and prevention.	To increase the nation's supply of physician investigators focused on health promotion, disease prevention, and preparedness. Primary objectives included training physician investigators in research; developing sustainable linkages with front line public health organizations; and leveraging these efforts to create a substantive institutional focus on population health research.
WEBSITE	http://www.jhsph.edu/academics/postdoctoral-training/cardiovascular-disease-epidemiology-training-program/	NA
LOCATION/ ENVIRONMENT	A number of large ongoing cohort studies and clinical trials provide a rich environment for the conduct of research. Many trainees are based in the Welch Center for Prevention, Epidemiology and Clinical Research and are mentored by individuals active in both population- based and clinical research. Among other outstanding collaborations, the program benefits from close ties with the Johns Hopkins University divisions of General Internal Medicine, Cardiology and Endocrinology.	Three participating departments in the School of Medicine: General Internal Medicine, Pediatrics, Emergency Medicine; also participation of mentors and seminar leaders in health economics, health policy, nutrition, and other fields at allied NYU Schools and NYC agencies.
CURRICULUM	Postdoctoral students complete a year of course work followed by a publishable research project. Core course on CVD risk factors and prevention; also seminars, journal club, research progress meeting.	Didactic training in public health content and research methods and a required Integrative Seminar. Courses included Principles of Study Design, Biostatistics, Epidemiology, Medical Informatics, Health Services Research, Environmental Medicine, Health Economics and Payment Systems, Infectious Health Threats and Preparedness, and Grant Writing.

(CONTINUED ON PG 78)

RESEARCH	Training emphasizes a collaborative approach and active participation in research.	Mentored research initiatives which addressed real-world challenges in advancing the health status of vulnerable urban populations.
MENTORING	Mentoring by individuals active in both population-based and clinical research.	Diverse multidisciplinary mentorship teams including academic mentors and “real world” mentors from community organizations or public health departments.
INTER-DISCIPLINARY SKILLS	Not discussed	Not discussed
TRANSLATION	Not discussed	A central focus; program distinguished by its core emphasis on issues of implementation, dissemination, and sustainability, and on forging collaborations with front-line public health agencies.
OTHER COMMENTS	Funded by T32HL007055 (pre and post)	Funded by CDC; active 2005-2009

Commissioned by the **Roundtable on Population Health Improvement
of the National Academies of Sciences, Engineering, and Medicine**

August 2015 | Available at goo.gl/RDDhpt