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Commentary

Applied epidemiology and public health: are we training the future generations appropriately?

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ABSTRACT

To extend the reach and relevance of epidemiology for public health practice, the science needs be broadened beyond etiologic research, to link more strongly with emerging technologies and to acknowledge key societal transformations. This new focus for epidemiology and its implications for epidemiologic training can be considered in the context of macro trends affecting society, including a greater focus on upstream causes of disease, shifting demographics, the Affordable Care Act and health care system reform, globalization, changing health communication environment, growing centrality of team and transdisciplinary science, emergence of translational sciences, greater focus on accountability, big data, informatics, high-throughput technologies ("omics"), privacy changes, and the evolving funding environment. This commentary describes existing approaches to and competencies for training in epidemiology, maps macro trends with competencies, highlights an example of competency-based education in the Epidemic Intelligence Service of Centers for Disease Control and Prevention, and suggests expanded and more dynamic training approaches. A reexamination of current approaches to epidemiologic training is needed.

We write this commentary at a time of transition as new technologies and associated data streams, changing health care systems, and broader societal transformations are changing the landscape of public health [1,2]. In fact, by the time of publication of this commentary, there will have been a major shift in the U.S. government that will likely have consequences for public health and health care. We focus on these broad trends and their implications for epidemiology, a core science underpinning public health. We address and describe these trends and explore their consequences for the training of epidemiologists. We provide evidence that an immediate need exists to acknowledge these trends and to respond with changes in the training of epidemiologists.

Epidemiology has a rich history of successes in determining underlying causes of diverse health problems and in assessing the effectiveness of preventive approaches [3]. In part, because epidemiology is a relatively new field of science, much effort during recent decades has been directed at development and refinement of research methods; less attention of the academic community has focused on how to effectively apply epidemiologic principles in public health settings (sometimes called consequential epidemiology [4–6]). Instead, different entities, primarily governmental, within the applied sector have taken the lead.

Understanding the similarities and differences between what has been termed classical epidemiology and more applied approaches is helpful. In part, the distinction lies in the setting, academia, or public health practice. Classical epidemiology is rooted in a methodological foundation that focuses on descriptive epidemiology, etiologic research, and causal inference [7]. Particularly in cancer epidemiology, requests have been made to extend epidemiologic training and practice to a more translational focus (e.g., more interdisciplinary and engaged in driving policy and practice) [8,9].

For public health practice and policy, this extended reach of epidemiology includes a greater emphasis on applied science. The domain of applied epidemiology has been characterized by the

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following five core purposes [10]: (1) synthesis of results of etiologic studies as input to practice-oriented policies; (2) description of disease and risk-factor patterns as information to set priorities; (3) evaluation of public health programs, laws, and policies; (4) measurement of patterns and outcomes of delivery of public health services and health care practice; and (5) communication of epidemiologic findings effectively to health professionals, different decision makers, and the public. When compared with classical epidemiology, particularly as carried out in academia, those involved in applied epidemiology face a greater sense of urgency, use data covering a range of quality, and more often learn the methods of epidemiology on the job through experiential learning [11].

Looking to the future, training in epidemiology, whether classical or applied, should be placed in the context of macro trends affecting society. Macro trends reach nationally and globally, involving changing demographics, economic factors, technology changes, and legal, political, or social conditions. In work sponsored by the American College of Epidemiology, a team of senior epidemiologists recently identified the following 12 macro trends that are affecting the practice of epidemiology [12]: (1) greater focus on upstream causes of disease; (2) shifting demographics; (3) the Affordable Care Act or health care system reform; (4) globalization; (5) changing health communication environment; (6) growing centrality of team and transdisciplinary science; (7) emergence of translational sciences; (8) greater focus on accountability; (9) big data or informatics; (10) emerging high-throughput technologies ("omics"); (11) privacy changes; and (12) evolving funding environment (Table 1) [13–17].

How epidemiology is commonly taught in academic training programs

Training in epidemiology occurs both in formal settings where a degree is conferred (e.g., universities) and in less formal settings for a range of public health and clinical practitioners (e.g., public health agencies and elsewhere). In academic settings, epidemiology is now widely taught at multiple levels of competency achievement, ranging from introductory courses at the undergraduate and entering public health levels to early professional training to advanced series of courses that cover the principal study designs, more advanced designs, and complex analyses. Different entry-level texts are widely used, some with multiple revisions (e.g., the textbook by Leon Gordis, *Epidemiology*, fifth edition [18]). At the entry level, emphasis is placed on using laboratory exercises to engage students with data and problem solving; such laboratory exercises date to early curricula, such as that implemented by Wade Hampton Frost, the founding Chair at the Johns Hopkins School of Hygiene and Public Health. Although similarity exists among entry-level courses, which are typically grounded on one of the introductory texts, much greater heterogeneity is noted at more advanced levels. In fact, only one principal advanced methods text is available to support such courses at present, *Modern Epidemiology*, a book firmly rooted in classical epidemiology [19]. Certain schools (e.g., the Johns Hopkins Bloomberg School of Public Health) have established separate applied and methods series of courses in epidemiology. In Australia, a masters degree (MPhil) is conferred to foster development of field epidemiology [20].

Competencies and approaches for training applied epidemiologists

Training programs for applied epidemiology are grounded in a set of competencies that are commonly defined as a cluster of related knowledge, skills, and abilities important for job activity performance in a defined setting and can be measured against well-accepted standards [21]. Training in epidemiology and public health has benefitted from competency-based education, which has helped to shape existing educational programs and guide future planning [22]. To be effective, competencies must be revisited on a regular basis.

Practitioner-oriented on-the-job training in applied epidemiology is even more heterogeneous in teaching methods. Formal and highly developed training programs, such as the Epidemic Intelligence Service (EIS), are taught with a very short didactic portion and also with a longer, supervised, experiential learning component. Beyond such formal programs as EIS, training can be largely experiential with supplemental short courses. Because some epidemiologists in public health practice lack extensive, formal training in epidemiology, numerous short courses are available, ranging from brief online programs to longer in-person trainings.

Mapping existing training programs to macro trends

To assess how well current training frameworks are linked with major societal and scientific shifts, we mapped the 12 macro trends against five sets of competencies (Table 1). Although this is not a comprehensive list, the mapping identified a number of critical gaps. Four of the macro trends are almost absent from current competency sets, including emergence of team or translational sciences, greater focus on accountability, growing availability of big data or informatics, and emerging high-throughput technologies ("omics").

These gaps are present despite considerable new knowledge and material to support training in these areas. For example, regarding team or transdisciplinary science, we know that nearly every public health problem is complex [23], requiring attention at multiple levels and among many different disciplines. Team approaches that bring together diverse disciplines and organizations have the potential for developing new and creative ways of designing and implementing studies and addressing public health concerns. An epidemiologist can often play a vital role within a transdisciplinary team; epidemiologists skilled in adapting traditional epidemiologic methods for application in diverse fields (e.g., engineering, organizational science, urban planning, or public policy) can be particularly effective team members [24].

Training epidemiologist in the Epidemic Intelligence Service

Here, we consider the example of the EIS program from the Centers for Disease Control and Prevention (CDC), which has needed to maintain relevance in the training of its fellows during more than 6 decades of its existence. As such, it is unique for its longevity and its grounding in a model that is fundamentally unchanged but sufficiently flexible to adapt to ever-changing contexts since its founding. Recognizing the importance of field-based education, EIS is a long-standing fellowship program built on a foundation of learning and training through service during the competitive two-year applied epidemiology training program. When EIS was started in 1951 in response to the threat of biological warfare during the Korean War, the program included 22 physicians and one sanitary engineer [25]. A typical EIS class today would include approximately 80 officers with 75% physicians and PhD-level scientists, and 25% veterinarians and other health professionals. In their rigorous on-the-job training, EIS officers participate in approximately 250 field investigations each year in the United States and around the world to identify causes of disease outbreaks, recommend prevention and control measures, and implement strategies to protect persons from injury, disability, illness, and death.