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Applied Epidemiology Training Needs for the Modern Epidemiologist

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Abstract

Applied epidemiology training occurs throughout an epidemiologist's career, beginning with academic instruction before workforce entry, continuing as professional development while working, and culminating with mentoring the next generation. Epidemiologists need ongoing training on advancements in the field and relevant topics (e.g., informatics, laboratory science, emerging topics) to maintain and improve their skills. Even epidemiologists with advanced skills often want training on methodologic innovations or to practice a skill. Effective applied epidemiology training includes blended learning components of instruction that incorporate hands-on experiences such as simulations and experiential learning, allowing for real-time workflows and incorporation of feedback. To prepare epidemiologists for the future, public health training courses in applied epidemiology must consider the evolution in public health toward a focus on including informatics, technologic innovation, molecular epidemiology, multidisciplinary teams, delivery of population health services, and global health security. Supporting efforts by epidemiologists to increase their skills as part of their career paths ensures a strong workforce that able to tackle public health issues. We explore how to meet current training challenges for the epidemiology workforce, especially given limited resources, based on research and our experience in workforce development across federal agencies and state/local health departments, as well as with international governments and organizations.

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Public health epidemiologists study the occurrence and distribution of factors that influence health-related outcomes and that characterize the health status of a population; they use applied epidemiology as a tool to improve health (1). In applied epidemiology, the application and evaluation of epidemiologic discoveries and methods are used to improve health and to promote a positive health impact (2) for acute and chronic conditions and in all sectors from academia to government. Field epidemiology focuses on epidemiology for action (i.e., outbreak response) and may not include the broader concepts of applied epidemiology seen in academic and research settings (1, 3).

Applied epidemiology is studied from the undergraduate to the doctoral level. However, many public health professionals have no formal epidemiology training, gravitating instead to epidemiology through work assignments that cast them into the epidemiologist role. In the United States, almost 30% of health department epidemiologists have no formal epidemiology training (4); only 17% of the state and local public health workforce have any public health degree (5).

In our experience, regardless of training, many public health professionals who self-identify as epidemiologists will look for epidemiology training, workshops, and webinars to develop, maintain, and improve their skillset. Even those with advanced skills may desire training to ensure awareness of new methodologies and to practice their skills. This indicates the need for quality applied epidemiology training to ensure a competent workforce.

Trainees who enjoy their training experience are more engaged during class time, will seek-out advanced training, and retain the information better when asked to use it in the real world (6). Applied epidemiology training can support epidemiologists in developing or maintaining necessary competencies irrespective of whether they studied and intended to be an epidemiologist or came into the role because their skills, interests, and organizational needs that led them in that direction (7).

Though no single method will work for everyone, trainees are more likely to retain information and seek out learning opportunities when the training occurs in formats that have a less didactic focus and use blended learning methods (8). Blended methods use multiple styles of instruction (e.g., didactic, digital learning, experiential) to teach concepts and are more likely to be effective with trainees in higher education and workforce development (8–11). Additionally, advancements in epidemiology and changes in how the epidemiologic workforce operates might be better understood when taught in multiple formats.

To keep up with rapidly changing methods, technology, and culture, modern epidemiologists must understand how to incorporate the use of digital technology, molecular epidemiology, and informatics; work as part of multidisciplinary teams; and maintain a focus on the health of populations. Additionally, epidemiologists must now understand global connections for

disease threats and take on the shared responsibility of global health security with partners representing health, security, environment, and agriculture (12). These expectations reflect the evolving nature of public health and characterize training needs. Epidemiology training can be slow to change but should always be forward-looking to align with epidemiologic shifts (13). In light of this and given that the volume and value of data collected (for both public health and other purposes, such as electronic health records and electronic laboratory data) is only increasing, epidemiologic training must consider how to prepare epidemiologists to address public health challenges.

We seek to describe our training experience and perspectives gained from our work with the Centers for Disease Control and Prevention (CDC). At the CDC, we participated as trainees in applied epidemiology experiential training programs and then moved into roles leading those programs. We teach applied and field epidemiology to graduate students, emergency responders, and health-care workers and have extensive workforce development leadership across federal agencies and state and local health departments, as well as with international governments and organizations. We discuss training challenges and consider how content can reflect current public health issues and go beyond the didactic model to build an effectively trained workforce.

PRIORITY-APPLIED EPIDEMIOLOGY CONTENT

Perhaps one of the most influential changes in applied epidemiology has been the shift toward a population health perspective with a focus on health rather than disease. Although there is no consensus definition (14), population health is defined as “the health outcomes of a group of individuals, including the distribution of such outcomes within the group” (15, p. 1). Population health practice occurs at the intersection of population health outcomes, social determinants of health, and interventions or policies that affect the two (16). This shift is not complete and has been in progress for several years. For example, in 2001, the vision for an applied epidemiologist in the 21st century was an activist whose findings inform policy in a world in which academic epidemiology connects seamlessly with public health practice to incorporate social, behavioral, and economics into training (17). In 2009, the American Public Health Association challenged the field public health to make prevention and wellness a national priority (18), echoing the earlier call from the National Academies Institute of Medicine to refocus public health on community and social determinants of health through infrastructure, workforce, and partnership development (19). Yet, as recently as 2017, noted scholars like Sandro Galea (20, 21) observed that schools of public health have largely neglected social epidemiology in favor of continuing the traditional focus on health outcomes of individuals, tried-and-true 2 × 2 tables, and limited causal models that oversimplify macro-level determinants of health in populations.

Expansion of applied epidemiology curriculum is needed to include multifaceted approaches to community-based prevention and wellness that account for social context and determinants of health in groups. One example of how this can happen in a community-based public health practice is the Accountable Health Communities model from the Centers for Medicare & Medicaid Services. This model, designed to meet the health-related needs of Medicare beneficiaries, improves quality of care and reduces costs by engaging partners to

address community-level gaps in 20 communities (22). Similarly, the CDC recently established the Population Health Workforce Initiative, pairing epidemiology trainees with informatics and economics experts to advance population health science projects and link health departments to health systems in participating states (23). Combining training from a population health perspective with public health informatics instruction is one way that applied epidemiology training programs support emerging fields like Population Health Informatics that integrate medical, data, and public health sciences (24). Understanding both how to incorporate informatics principles into epidemiologic work and how to work effectively with informaticians are important skills.

In the growing field of molecular and metagenomic epidemiology, collaborating with laboratory scientists, geneticists, and informaticians to plan studies, interpret findings, and understand the nuances of the genome is a skill that many epidemiologists will need to understand potential impacts of the genome and community structure on communicable and noncommunicable disease (25, 26). In a recent article describing how molecular epidemiology could help transform human immunodeficiency virus prevention, Oster et al. (27) showed that although the virus is not typically associated with outbreaks, they do occur and can be identified using molecular epidemiology. Combining principles of informatics and epidemiology with molecular data can help identify transmission clusters in order to prevent transmission and reduce incidence of the virus. This is one example of how technological advances in the laboratory intersect with epidemiology and with social and behavioral components to improve health.

Although successful examples are emerging, the current US public health workforce and infrastructure remain largely unprepared to support practice at the intersection of epidemiology, economics, and medical and social sciences (18, 20, 28). Future epidemiologists will need to appreciate and apply the principles of population health if they hope to conduct public health practice and transform it into successful action. For future public health training courses in applied epidemiology, the evolution in public health as a team-based approach with a multidisciplinary perspective should be incorporated into curriculum development and practiced by trainees. Multidisciplinary teams can include clinical care providers, laboratory scientists, epidemiologists from specialty areas, and less traditional partners, such as logisticians and communications experts.

COMMONLY USED AND PREFERRED APPLIED EPIDEMIOLOGY TRAINING METHODS

Didactic learning and digital learning

The most common teaching model for any topic is the didactic model in which the in-person, live instructor lectures to a group of students who are passive listeners. The material is instructor centered and content oriented (29). This model, which has been used for centuries, has increasingly been replaced by digital learning (e.g., webinars and online training). Digital learning could involve simply reading text, seeing pictures, or watching videos (30) and may still mimic the didactic lecturer-student model, potentially rendering it less effective. However, it might incorporate reading, writing, and activities that are

interactive with the computer program itself or with others, such as online chat groups with an instructor and other trainees. Though didactic and digital learning can be useful learning methods, we prefer to use them sparingly and in conjunction with methods we find to work better in cementing the concepts of applied epidemiology.

Case studies

At the CDC, applied epidemiology training makes use of practical case studies to teach epidemiologic principles and concepts. Case studies at the CDC are written descriptions of real health events typically from notification of a case to event resolution. The investigations are modified to protect confidentiality or to make tasks such as creating an epidemiologic curve and calculating odds ratios simple enough to do by hand during a 2–4 hour session. Case studies teach trainees epidemiologic methods but also include bigger picture concepts such as communication strategies, working with a public health laboratory and other partners, and social and behavioral components that contribute to disease prevention and control. When we teach case studies, we use a model in which a trained facilitator and a group of 6–10 trainees take turns reading the case study, “in class, often out loud, stopping to answer questions that are interspersed throughout, without looking ahead. The questions can ask for a decision, but often they instruct the trainees to perform calculations, draw graphs, generate lists, interpret data, or consider the pros and cons of different approaches” (31, p. 1). We find the case study model to be useful for trainees at varying levels and in different settings, including local health departments, federal agencies, ministries of health, and academia.

Simulation and experiential learning

We have also found that classroom settings may not prepare trainees for the unpredictable nature of the field settings in epidemiologic investigations. We have seen the best trainees overwhelmed by the reality of working with partners, interviewing patients, and dealing with technological problems. Epidemiology programs may consider transforming the classroom setting to include more real-life examples and active learning tools, especially in the initial phase of implementing an applied epidemiology program. To ease the transition from the classroom to the real world, simulation can help.

For example, a lecture about how to work with clinic staff to recruit participants for a study may not reflect the realities of dealing with a crowded clinic, privacy concerns, language barriers, and the intrusion on staff and patient time to complete a survey. In a simulation of this situation, volunteers serve as patients who have had lengthy wait times and are not interested in your study, overworked clinicians who may have concerns about approvals being in place, and respondents who want to participate but do not speak the language used on the survey or ask unexpected questions while taking the survey. Working through the simulation gives the trainee a better sense of what to expect in a real situation.

Instructors can promote the inclusion of case studies and small-scale simulation using real-world examples in the classroom that address common challenges associated with the implementation of epidemiologic methods in the field. This can be addressed by describing a real situation about which the instructor has knowledge and asking trainees to work through

it in the classroom to come up with a solution. For example, the instructor could ask trainees to work in small but diverse groups to modify a study protocol in real time to address sampling issues encountered when the work was done in the field, including negotiating technology use in a limited resource setting. Other scenarios include dealing with delays in study roll out, handling changes in partner support, managing survey team expectations, communicating necessary study modifications to partners, and addressing ethical and cultural considerations. Inclusion of challenges into the classroom curriculum demonstrates to trainees common setbacks and how these can be learning opportunities when encountered.

For those who learn best by doing, an in-person, interactive training such as experiential learning and simulations will have more success in skill development and retention (32). Experiential learning is defined as follows: “educators purposefully engage with learners in direct experience and focused reflection in order to increase knowledge, develop skills, clarify values, and develop people’s capacity to contribute to their communities.” (33, p.1). This includes any educational opportunity that provides on-the-job experience, whether as part of the actual job experience, part of an academic program, or through workforce development. It also engages the topics covered so far—connection to population health activities, using informatics principles, and working in multidisciplinary teams. Some trainees need to complete a task with supervision and support before they have confidence to attempt it independently; experiential learning and simulations offer the opportunity to do the task in an environment in which mistakes are allowed and can be corrected (32). It provides the opportunity to work with multidisciplinary teams and use tools like electronic health and laboratory records in the real world to increase success in the trainees’ ability respond to health crises.

Working with a mentor and supervisor for consistent monitoring and evaluation is an important component of this kind of training (34). In experiential learning, and often in simulations, trainees learn by doing and see firsthand how team members and supervisors work with them to solve problems. Experiential learning, with its focus on real world, on-the-job training is a way to address the challenges of single-lecturer training and improve career development compared with classroom settings (35–37). Trainees have also expressed to us the indirect benefit of knowing their work is meaningful and having an impact on improving public health through their work with the host group.

Although the advantages of experiential learning are numerous, there are challenges. The jump from a traditional didactic model to an experiential model does not happen quickly. Some argue that experiential learning should be integrated in academic discipline (38). Others note that the experiential learning needs to be focused, including having explicit training objectives, and include opportunities for trainees to conceptualize and reflect on the lessons being learned in the training (39). Implementation requires a large effort by staff to plan and operationalize experiences that may not otherwise be required in more traditional classroom approaches (40). In our experience, to effectively implement an experiential learning experience, support needs to be provided to programs and instructors. This includes the critical partnerships needed to foster field mentorship, instructional design support to ensure alignment with learning objectives and overall curriculum, funding to implement

changes to the curriculum, and training of teachers and mentors to guide the development process (34, 41).

In addition to this implementation challenge, some trainees must adjust to an experiential learning model in which there is less direction and predictability than in didactic classroom work. Though there is group work, the trainee must take initiative and work independently. Classroom-based epidemiology training may promote a reliance on equipment or software for using epidemiologic methods that are not readily available in the field and resource-poor settings. This includes reliance on advanced statistical packages rather than open-source or cheaper, less-advanced statistical software tools. Additionally, tools developed specifically for use in the field for data collection and real-time analysis (e.g., Open Data Kit (Open Data Kit, Seattle, Washington) and KoboToolbox (KoboToolbox, Cambridge, Massachusetts)) or advanced open-source programs (e.g., R (R Foundation for Statistical Computing, Vienna, Austria)) may not be addressed in a classroom-based training program. Thus, in our experience, trainees unfamiliar with the technology may struggle as they learn how to use the tools in real-time. However, the experiential learning environment allows them the opportunity to gain the skills with no expectation of expert status at the start of training. For us, this is the benefit of this model and why we consider it the gold standard. Understanding that challenges occur and are learning opportunities, not failures, is critical to ensuring the trainee perceives the experience as rewarding and productive.

Blended learning

To help reach all learners, a combination of learning methods should be used to improve retention and mastery (8, 42), particularly when it comes to professional development because trainees come from different cultural, economic, and professional backgrounds and have different educational levels (4, 5). A blended approach that includes less of the didactic model and incorporates components of case studies, simulation, and experiential learning is a good way to ensure understanding of content by the largest number of trainees.

The transition to a formalized applied epidemiology training curriculum that includes experiential training may require substantial resources but can be done gradually, incorporating aspects of experiential learning into the traditional classroom setting. In our experience, pairing a full experiential learning program that includes a small portion of classroom teaching will accommodate more learning styles and guarantee a uniform trainee knowledge base. It will also help to ensure that concrete learning objectives and deliverables are identified before the start of the experiential learning training program. The mentor supervisor or program director can confirm the objectives are met during the program as a quality control strategy. Additionally, by using technology such as real-time video conference, instant messaging, and electronic guidance documents, an environment is created that can enable remote mentorship without requiring the mentor to always be physically present. A monitoring and evaluation system to confirm that the trainees complete activities and learning objectives, that the program was implemented as designed, and that trainees are receiving adequate mentorship is critical to a high-functioning experiential learning program.

CDC WORKFORCE CAPACITY DEVELOPMENT EXAMPLES

At the CDC, we have had success using the training methods outlined in this paper and those that incorporate the concepts trainees must understand to be successful applied epidemiologists. The first example comes from the CDC's Global Emergency Alert and Response Service's Global Rapid Response Team. Staff who serve as emergency public health responders participate in a simulation using scenario-based training to prepare them for the realities and challenges of the field. Rather than learning through a didactic approach, trainees participate in a mock response scenario in which workgroups of multidisciplinary teams determine how to manage the mock emergency. This simulation is facilitated by experienced public health specialists such as epidemiologists, laboratory scientists, statisticians, communications specialists, and others who can relate the scenarios to actual events that have taken place, making the lessons more real and engaging for trainees. It also helps them see how people from many backgrounds are needed to respond effectively. Trainees also understand the connection to global health security. They see how quickly an emergency in one part of the world can not only affect disease transmission but also have impacts on the environment and security that limit the ability to stop transmission (12, 43). Though the simulation occurs in the classroom, this model may better show the trainee the bigger picture and allow them to translate and understand how to apply their skillset to a field setting or their applied work in an office setting.

Two examples of formal experiential training programs at the CDC that use a blended learning approach include the Epidemic Intelligence Service (EIS) (44), which is based in the United States, and the Field Epidemiology Training Program (FETP)-Advanced, which is for those outside the United States (45). These programs are applied epidemiology experiential learning programs with a focus on learning by doing under the guidance of a mentor supervisor. The mentor supervisor serves as an epidemiology mentor, as well as the supervisor for the program requirements. Trainees have a set of competencies and goals to accomplish over the course of the program that are documented through their work products (41). There is a small component of classroom training, but for EIS, more than 90% of the training is experiential (44); more than 75% is experiential in the FETP (45).

To address the challenges covered, including moving from didactic models and incorporating shifting epidemiology priorities into training, applied epidemiology training programs with a more formal curriculum structure such as those we have with EIS and FETP should use 4 components: 1) defined concrete learning objectives and deliverables, 2) combined classroom and experiential learning, 3) quality-control monitoring of the experience, and 4) training of trainers on the experiential learning model. For training to be effective and worth the time investment by both the trainee and instructor, use of the skill and corresponding improvements should lead to better opportunities to work on advanced projects and to career development (46). The EIS and FETP combine supervising and mentoring with training that affords an opportunity to supervise, reinforce, or correct steps taken by trainees in real time. These activities aid the trainee in gaining the needed skills and the readiness to take on larger tasks and leadership roles.

CONCLUSION

Applied epidemiology in public health has had to evolve with changing technology and health issues. We believe that training that includes different learning modalities and provides hands-on, real-world experience is better than didactic-based settings alone. Future applied epidemiology training programs must account for shifts in the focus of public health to help with navigating how to work with multidisciplinary teams, informatics, delivery of population health services, and global health security in the digital age. Experiential learning, with its real-world, real-time aspect, can help trainees experience this firsthand. Simulations can be an alternative when resources are not available for a full experiential learning approach. Finally, seeing a path to improved career development should encourage uptake of training activities for all applied epidemiologists.

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Abbreviations

CDC	Centers for Disease Control and Prevention
EIS	Epidemic Intelligence Service
FETP	Field Epidemiology Training Program

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