As the global population exceeds 6 billion people and modern transport and technology brings people closer together, public health challenges expand. Not only is the transmission of infectious diseases between continents a routine occurrence, but the developed world has begun increasingly to share with the less developed world the modern problems of environmental pollution, tobacco-related diseases, cancer, heart disease, and injuries. At the same time, the practice of global public health has expanded to include a network of practising epidemiologists working together and with other public health practitioners to address commonly shared challenges and opportunities. In this paper, we review the increasing concerns about the adequacy of current training in epidemiology for public health practice. We then describe an existing approach to preparing epidemiologists for the expanded scope of problems relevant to public health intervention. In this approach, epidemiological research and practice are applied toward the end of improving public health and health care; they are not solely seen as a basis for understanding the underlying causes of disease and health conditions.1

The 1988 report on public health in England (The Acheson Report) concluded that academic epidemiology has limited relevance to the everyday practice of public health in that country.2,3 The authors of the report concluded that training in epidemiology should remain in academia, but should be expanded to involve projects in applied public health. In particular, the authors contended that, in addition to methodology in statistics and computing, the major contribution of epidemiology should include a way of thinking which focuses on the many aspects of life that might influence health.

In 1996, a series of articles in the American Journal of Public Health focused on Susser’s critique of the current international focus on risk factor epidemiology, or what Susser termed ‘the black box paradigm’.4–8 Susser underscored the need to anchor epidemiologists to public health and called for a practical programme to ensure that during their training epidemiologists would be socialized to keep the improvement of the public’s health as a primary value.5 Like the authors of the Acheson Report, Susser underscored the need to include faculty with experience in public health that could understand and embody public health values. In commenting on Susser’s paper, Pearce argued that epidemiology as a branch of public health must re-integrate itself into the practice of public health and rediscover a population perspective.8 A second series of articles published...
in the *American Journal of Epidemiology* in 1997 also discussed the failure of academic epidemiology to prepare students in the basic science of public health by assuming (implicitly or explicitly) that risk factors for disease in individuals could be summed to understand the causes of diseases in populations. A third series of articles that appeared in the *Journal of Epidemiology and Community Health* in 1998 also discussed the Susser position. In 1999, a fourth collection of articles which was published in the *International Journal of Epidemiology* focused on what Saracchi characterized as tensions: the tension between methods and population health; the poles within epidemiology from the biological to the societal; the tension between integration and specialization; and the tension between investigator-initiated research and research driven by population needs. In his contribution, Pearce argued that modern epidemiology is based on methods that are inadequate for studying population health and that the loss of the population perspective risks limiting epidemiology to a measurement tool for testing hypotheses developed by other researchers.

In all of these discussions, critics argue that the modern epidemiologist often seems more concerned with intricately modelling complex relationships among risk factors than understanding their origins and their implications for public health and doing something about a problem. These critics further contend that graduate students in epidemiology focus on learning study design and data analytical methods rather than how to generate hypotheses regarding the social dynamics of health and disease. This perspective is supported by a review of the content of textbooks which highlighted the gap between academic epidemiology and public health practice.

This emphasis on methodology is not new, evolving from the 1915 report that led to the formation of the Johns Hopkins School of Hygiene and Public Health. This report emphasized a biomedical as opposed to a sociological approach to public health. Criticism of the biomedical approach is not new—McKeown has written that the social inequalities in health are the defining problem of the discipline of epidemiology, and the loss of this perspective is a loss to public health. More recently, Terris, Gordis, and others have discussed and debated the challenges confronting current epidemiological practice.

Public health epidemiology usually traces its origins to John Snow's investigation of cholera in London and his successful public health action. A much more complex history of epidemiology has been traced to others in the UK and continental Europe. We describe an approach to epidemiological training that has evolved from the approach of Snow and his contemporaries and whose trainees are anchored to public health by mentors that are public health practitioners with a population-based perspective.

Training in applied epidemiology: the Epidemic Intelligence Service

The Centers for Disease Control and Prevention's (CDC) Epidemic Intelligence Service (EIS) is a 2-year, on-the-job training and service programme that provides health professionals with an opportunity to engage, in the US and abroad, in the public health practice of epidemiology. The programme is based on a philosophy of 'learning while doing' with an emphasis on the development of epidemiological judgement—the reasoning process that indicates when one has sufficient data on which to make public health decisions. Since 1951, more than 2500 professionals have served in the EIS.

Each year approximately 65 health professionals enter the EIS programme beginning with a 3-week course oriented around a series of epidemiological case studies, many of which are based on investigations conducted by EIS officers. Up to 10 case studies are complemented by interactive didactic sessions in applied epidemiology and biostatistics as well as a field exercise in which, over a matter of days, the officers work with local public health officials to collect data in the field, analyse the data, report the data in a summary manner and make recommendations regarding the findings.

During the 50 years of the EIS programme, the structure of the introductory course has remained the same but the content has evolved substantially. Today’s officers are presented with case studies in infectious disease as well as chronic diseases, injury, and bioterroism. Sophisticated analytical methods are included in the course along with specialized training in the use of software designed for the applied epidemiologist. The new officers learn immediately that the EIS programme is not a typical academic credentialing programme, rather it is a structured experience of service and training that embodies an approach to the learning and practice of epidemiology that is grounded in applied public health.

During the two years of their training, the officers participate in additional one-week courses; one on the methods of public health surveillance and scientific communications (including how to communicate effectively with the media) and a second on prevention effectiveness methods (economic techniques in public health). The essence of the EIS programme, however, is not the coursework. Rather it is mentored experience in the field addressing current public health challenges using the tools of epidemiology. The hands-on training in epidemiology is accomplished through a 2-year assignment working directly with a CDC programme, a state or local health department, or another federal agency. The focus for each assignment is either in a specific programme area such as a chronic or infectious disease or in general public health activities in a state or local health department. In these assignments, EIS officers learn the basic skills of epidemiology under the supervision of an experienced, practising public health epidemiologist. During the two years, each officer is required to complete a set of core activities, including the conduct of field investigations, the analysis of large data bases, the evaluation of public health surveillance systems, the publication of a scientific paper, effective oral communications, and response to public enquiries. In these field investigations and other activities, the officer typically assumes lead responsibility not only for the scientific issues but also for communication of the results of the work to local
officials, the public, and the media. In addition, large numbers of officers have taken the opportunity to participate in at least one international experience during the 2-year programme.

Upon completion of the EIS programme, graduates are likely to practice what they have learned in the public health system. As of 1999, of the 2272 men and women who had completed the programme, 129 were retired or deceased and employment status was unavailable in 130. The current occupations of the remaining 2013 graduates were often in public health positions at the national level (709—35.2%) and the state and local level (180—8.9%). In recent years, increasing numbers of EIS graduates choose public health careers. In the decade ending in 1987, 338 (58.8%) of the 575 graduates worked in public health positions at the local, state, or national levels at a comparable time in their careers. Of the 697 graduates in the classes of 1988–1997, in 1999, 459 (66.0%) were working in public health positions at the local, state, and national levels. In comparison, of 86 graduates of the University of Washington from 1986 to 1996 who obtained PhD’s in epidemiology, 44 (51%) were members of university faculties, 9 (11%) were in non-faculty university positions, 14 (16%) were in medical institutions and 14 (16%) were in positions in national, state, or local governments.

Since the creation of CDC in 1946, the agency has expanded its mission from the investigation and control of communicable diseases to include prevention programmes in chronic and occupational diseases, injury and environmental exposures, and their sequellae. These changes at CDC parallel a growing international need for epidemiologists in the expanding areas of disease and injury control in both the public and private sectors. Through these changes, the EIS programme has had the flexibility to evolve from a team of ‘disease detectives’ with a mission to track and protect the public from possible biological warfare to include investigation and prevention of non-infectious diseases and injuries. Changes in the training of officers have been implemented through their mentors in anticipation of these changes in public health practice to include social and behavioural sciences, prevention effectiveness and informatics. In addition, the programme has attracted new kinds of professionals. Before the 1980s nearly all EIS officers were US citizens, and more than 90% were physicians, the remaining 10% being mostly veterinarians, nurses, and dentists. Today, EIS officers include increasing numbers of non-physicians with doctoral degrees in the social and behavioural sciences as well as epidemiology. In addition, increasing numbers of non-US citizens have entered the programme.

One area of increased trainee recruitment has been non-medical, doctoral level scientists. Since 1964 more than 160 non-medical level doctoral level scientists have entered the EIS programme, including 94 with advanced degrees in epidemiology and others with degrees including demography, anthropology, sociology, behavioural science, psychology, statistics, economics, and other health-related areas. Nearly all of these officers came to EIS after 1980. This recruitment was in response to changing needs at CDC as the agency not only expanded its mission but also recognized the multi-factorial determinants of disease and injury in all of public health. Following completion of the programme, 84% of these non-medical graduates continued to work in public health activities with about half employed at CDC and others either in academic institutions, state and local health departments, other federal agencies, or international health agencies.

Global training in applied epidemiology

With the growing recognition of the need for epidemiologically trained health professionals in many countries in the past 20 years, there has been expansion of training in applied epidemiology. Since the first non-US citizen enrolled in EIS in 1975, 174 officers have been non-US citizens; half came from industrialized nations (Western Europe, Australia, New Zealand, and Canada); of the 174, 17% come from Asia or the Pacific Islands; 14% from the Caribbean, Central or South America; 10% from Eastern Europe or the Middle East; 9% from Africa. Their entry into EIS was in recognition of the need for CDC to help build an international epidemiological network to respond to emerging global health issues. Most are physicians (90%). Following EIS, 43% of these graduates work in government agencies; 22% in academics; 14% in international agencies, 13% in private organizations, and 8% in fields outside of public health. The majority of non-US citizens completing EIS return either to their country of citizenship or another international setting to work in public health areas of international scope. In 1999, 62% were working outside the US.

Epidemic Intelligence Service graduates and CDC staff have also served as technical consultants to 19 countries aiding their efforts to create programmes of training similar to EIS. Most of these programmes are known as Field Epidemiology Training Programmes (FETP), and trainees in these programmes are citizens of the countries sponsoring the programmes. Beginning with Canada in 1974, and Thailand in 1981, FETP provide training designed to build public health capabilities and infrastructure within the participating country through the development of field-trained epidemiologists competent in applying epidemiological methods to local public health problems. As of January 2000, approximately 900 men and women had completed training in these programmes.

Another applied epidemiology training programme founded on the EIS model, the European Programme for Intervention Epidemiology Training (EPIET), was financed through a grant from the Commission of the European communities. The first cohort of EPIET fellows was enrolled in November 1995 in an effort to create a network of professionals throughout Europe trained to use a standard approach to applied epidemiology including field work, surveillance, applied research, communication, and the use of epidemiological information for public health action. The World Health Organization (WHO) has offered an assignment in EPIET and has had a supporting role in several FETP. In addition, in 1999 WHO initiated the Global Health Leadership Programme in which WHO and CDC teach applied epidemiology and management skills to WHO staff throughout the world.

Since 1989, the Rockefeller Foundation has sponsored international training in clinical epidemiology, the International Clinical Epidemiology Network (INCLEN), in 20 countries. The Rockefeller Foundation also funded Public Health Schools Without Walls (PHSWOW) which are the public health equivalent of INCLEN. Three of these programmes, in Uganda, Zaire and Vietnam, were developed with technical assistance from CDC. Another PHSWOW was established by the Ministry of Health and School of Public Health in Ghana. The PHSWOW were established in part to narrow the gap between the academic sector in these countries and the Ministries of Health.
Training in applied epidemiology has also taken the form of short courses, usually modelled on the introductory 3-week course for EIS officers, but adapted for different student populations. For example, since 1986, the Institut pour le Developpement d’épidemiologie de Terrain (IDEA), the Merieux Foundation, and the National School of Public Health in France, in consultation with CDC, have offered an intensive 3-week course in the principles and practices of applied epidemiology to nearly 500 students from around the world. Similar courses have been conducted in the US, Europe, Asia, and Africa.

Discussion
The applied epidemiological approach of the EIS programme, the FETP, the PHSWOW, and EPIET respond to the concerns that the teaching of epidemiology must be anchored to public health practice. The epidemiologist-in-training should be supervised by experienced faculty who understand and embody population-based public health values. Just as physicians learn the practice of medicine as interns and residents caring for individual patients, students in each of these programmes learn the practice of epidemiology by addressing public health problems of communities, and through application of epidemiological judgement are expected to practice rigorous research in a social context. Putting epidemiological research methods to use in public health practice is a crucial orientation of applied epidemiology. The epidemiological field investigation is a special illustration of a training opportunity in applied public health. The inclusion in the EIS programme of people with training in behavioural and social sciences complements the work of traditional epidemiology in pursuit of the goal of enhanced public health practice. The goal is not to make epidemiologists into social scientists or economists, rather to give the applied epidemiologists the tools to work with experts on other disciplines to address the public health issues that affect human populations. The increased inclusion of non-US citizens in the EIS programme and the establishment of training opportunities in applied epidemiology throughout the world has been a deliberate response to the global recognition of the crucial role of epidemiologists in public health issues.

The adaptation of a new paradigm—whether it be the ecologic framework of Krieger, or some other modification—must recognize the underlying principle that social inequalities in health remain a defining problem for the practising epidemiologist. In the words of Rose, ‘To find the determinants of prevalence and incidence rates, we need to study characteristics of populations, not characteristics of individuals’. Epidemic Intelligence Service training and applied epidemiology focus on active public health problems, and the research conducted by EIS officers is driven by population needs and the desire to improve the public’s health.

Development and subsequent implementation of training for a new paradigm in epidemiology includes a continuous adaption of coursework to involve new knowledge (e.g. genetics and molecular biology), new methods such as seen in the information sciences (e.g. hand-held computers), new and more wide-reaching communications mechanisms such as the Internet, and the recognition of societal challenges at the local as well as the global level. In this context of adapting to change, the traditional tools of the applied epidemiologist (e.g. public health surveillance) must be adapted to new technologies and new societal norms (e.g. effect of regulations on privacy on public health surveillance) to best serve the public’s needs. At the same time, the gap between academic epidemiology and public health practice must not widen further, and the training of applied epidemiologists should be a part of the effort to close that gap. The applied epidemiologist is by definition an activist, moving rapidly from findings to policy, putting epidemiological knowledge to good use. Skills in communication must be an integral part of an epidemiologist’s repertoire, as must the ability to work in multi-disciplinary coalitions. The 21st century epidemiologist must do all these things in addressing public concerns while maintaining a foundation of high-quality epidemiological research and practice.

The EIS and other training programmes in applied epidemiology demonstrate the vitality of epidemiology as a discipline. In response to the eco-social critique, these programmes hold public health as a primary value and are anchored in public health practice. The faculty are epidemiologists practising in public health settings which by their nature provide a population-based perspective. On a daily basis these trainees are confronted with the tension between the search for causes of disease and injury and the pressure to improve the public’s health. They are asked to apply the modern tools of epidemiology to public health problems that require immediate response, yet must also apply these tools with scientific rigor in the context of social and cultural pressures. Essential to the viability of these training programmes is the flexibility to incorporate not only new analytical tools and technologies, but also different perspectives to address pressing public health issues. The entry of social and behavioural scientists into the EIS and the inclusion of economic methods into the training programme illustrate this flexibility and a responsiveness that is essential to maintaining the relevance of epidemiology to the modern world.

In the waning years of the 20th century, the practice of epidemiology came under serious scrutiny, from both inside and outside the field. The limits of epidemiology, however, are imposed primarily by perspective. If epidemiology is narrowed to the black box of risk factor epidemiology, what we learn and what we can contribute to the public’s health is constrained dramatically. On the other hand, an applied approach to epidemiology links the discipline to public health practice and population-based research, addressing evolving global needs in a responsible and effective manner.
KEY MESSAGES

- Training in applied epidemiology holds public health as a primary value, and training programmes are anchored in public health practice.
- Essential to the viability of training programmes in applied epidemiology is the flexibility to incorporate new analytical methods and integrate perspectives in social, behavioural, and economic sciences into the learning process.
- The essence of training in applied epidemiology is a 2-year field experience mentoried by a practising public health epidemiologist.
- Since 1951 more than 3000 health professionals have completed training programmes that have been established in 20 countries.

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