

## Epidemiology of Clinical Medicine

Paul K. Whelton<sup>1,2</sup> and Leon Gordis<sup>3,4</sup>

### HISTORICAL PERSPECTIVE

Epidemiology began as an outgrowth of medicine. Many of its earliest practitioners were clinicians who recognized that poor health is often closely related to a patient's environment and that observations and interventions in groups are directly relevant to treatment and prevention of disease in individual persons. For example, the classic studies that demonstrated a causal link between contaminated drinking water and cholera emanated from Snow's belief that quantitative assessment in the community would provide the basis for prevention of illness in individual persons (1). Jenner's historic demonstration of the value of cowpox immunization in preventing smallpox was also rooted in the challenges he faced in his clinical practice (1). During the first half of the 20th century, a number of epidemiologists focused their research on topics directly relevant to clinicians. For example, Frost's observations on the transmission of tuberculosis were of great value in disease surveillance and recognition of new cases (2). However, these and similar findings by the leading epidemiologists of the day were at the periphery rather than the heart of clinical thinking and practice.

As the discipline of epidemiology evolved, it became more technical and less clinically oriented. In parallel, the focus of research in medicine began to shift from the applied to the bench sciences. In part, this shift resulted from an increased capacity to conduct bench research and an expectation that enhanced understanding of basic biology would inexorably lead to improvements in the ability to cure disease. In the

United States, creation of the National Institutes of Health in 1948 marked the beginning of a more vigorous commitment to research in the biomedical sciences. During subsequent decades, growth in research capacity at US academic health centers has been unprecedented. This growth has been coupled with a progressive increase in the prestige and influence of academic health centers with large biomedical sciences research programs. In general, the priority for research at schools of medicine has been molecular biology, with the applied population sciences playing a complementary and secondary role. In contrast, the applied population sciences have always been viewed as central to the educational, research, and practice mission of schools of public health.

A number of epidemiologic studies published in the 1960s and early 1970s began to have an important clinical impact and led to an increasing appreciation of the value of epidemiology as a scientific basis for clinical practice. For example, the Framingham (3) and Bogalusa (4) Heart Studies supported by the National Institutes of Health provided an underpinning for knowledge of cardiovascular disease risk factors in adults and in children, respectively. Likewise, the prospective studies conducted by Doll and Hill (5) in the United Kingdom and by the American Cancer Society (6) and others in the United States formed the basis for clinical thinking regarding the association of cigarette smoking with lung cancer and pulmonary airway disease. Despite the prominence and importance of these and other epidemiologic studies, the discipline played only a limited role in mainstream medical education and clinical research. Training in epidemiology was an unusual choice for clinicians who anticipated a career that included a focus on patient care. Increasingly, epidemiology became the purview of nonclinicians, with less focus on issues related to medical care.

During the second half of the 1970s and in the early 1980s, there was a progressive resurgence of interest in applying epidemiologic methods in clinical medicine. In part, this interest mirrored an increased understanding and use of epidemiologic methods in clinical research (7). It also reflected a shift in the focus of epi-

Received for publication October 8, 1999, and accepted for publication May 16, 2000.

<sup>1</sup> Department of Epidemiology, Tulane University School of Public Health and Tropical Medicine, New Orleans, LA.

<sup>2</sup> Department of Medicine, Tulane University School of Medicine, New Orleans, LA.

<sup>3</sup> Department of Epidemiology, School of Hygiene and Public Health, The Johns Hopkins University, Baltimore, MD.

<sup>4</sup> Department of Pediatrics, School of Medicine, The Johns Hopkins University, Baltimore, MD.

Reprint requests to Dr. Paul K. Whelton, Office of the Senior Vice President for Health Sciences, 1430 Tulane Avenue, Room 1552, New Orleans, LA 70112 (e-mail: pwhelton@tulane.edu).

demologic courses for medical students and clinicians from traditional public health themes and applications toward more clinically oriented topics and examples. Finally, it reflected the relation between illness in the individual person and in the population (8). Over time, epidemiology textbooks with an orientation toward clinical rather than public health concerns were published by a number of authors, including Fletcher et al. (9), Sackett et al. (10), Feinstein (11), Rose (12), and Gordis (13). Progressively, the term "clinical epidemiology," first proposed by John R. Paul during a presidential address to the American Society of Clinical Investigation in 1938 (11), has been used to characterize the application of epidemiology in clinical settings. Although somewhat ambiguous, it is useful in that it accurately designates the fact that much of the focus is on application of epidemiologic methods to clinical research, education, and patient care.

### ORGANIZATIONAL STRUCTURE

There is a long history of ad-hoc associations of clinicians and clinical departments with departments of epidemiology and with epidemiology units in the community. The Department of Clinical Epidemiology formed in the early 1960s at the St. Thomas Hospital in London, England, may have been the first to use such a title (11). Shortly afterward, a department with the same name was created at the Chaim Sheba Medical Center in Tel Hashomer, Israel (11). In subsequent years, many clinical epidemiology programs, divisions, or centers were formed as freestanding units within or between schools of medicine and/or schools of public health. Indeed, almost every medical school in the United States has a robust program or set of programs that identify epidemiology as a core scientific discipline.

In many academic health centers, primary care units in clinical departments have evolved as an important locus for patient-oriented epidemiology. These units have often grown rapidly in size and in influence. They have been the setting for epidemiologic study of disease outcomes in the same way that more traditional epidemiology units have focused on disease occurrence. Some have defined themselves as "outcomes research" rather than "clinical epidemiology" units, but most have encompassed a broader spectrum of interests that relate to screening, diagnosis, prognosis, and both treatment and cost-effectiveness. In many instances, the growth of these units has been remarkable, and their success in competing for peer-reviewed grant support has greatly enhanced their standing among peers.

At The Johns Hopkins University School of Medicine in Baltimore, Maryland, the Division of

Internal Medicine is the second largest academic unit within the Department of Medicine based on the number of faculty members and generation of peer-reviewed grant support. The faculty of the Division of Internal Medicine also play a central role in educating medical students and providing patient care services. Epidemiology, health services research, and behavioral science are the core sciences that underpin the faculty's research and are also central to the educational and service mission of the division. Similar observations apply to many divisions of general pediatrics, family and community medicine, general psychiatry, and general obstetrics and gynecology.

### IMPACT OF CLINICAL EPIDEMIOLOGY

Although the organizational structure for support of clinically oriented epidemiology varies from one academic health center to another across the United States, the pattern for an increasing role of epidemiology in clinical research, clinical education, and patient care has been remarkably consistent. This is reflected in enhanced recognition of epidemiology as an area of research focus at scientific meetings sponsored by clinical societies, an expanding emphasis on use of quantitative methods to address clinical research topics, a growing awareness that epidemiology is a basic science for practicing physicians, increasing interest in epidemiologic training among young clinicians, and rapid growth of clinical epidemiology units at many academic health centers.

An example of the latter is the Welch Center for Prevention, Epidemiology and Clinical Research at The Johns Hopkins Medical Institutions. This center, jointly sponsored by the School of Medicine and the School of Hygiene and Public Health, evolved from a Program in Clinical Epidemiology initiated by the Department of Epidemiology at the School of Hygiene and Public Health in 1976. From its inception in 1989, the Welch Center has played a progressively more important role in facilitating the conduct of prevention-oriented research as well as in enhancing the availability of epidemiologically oriented courses in patient care and clinical research. By 1994, the size of the core faculty at the Welch Center had grown from 2 to 15. During the same year, they published 116 manuscripts and 20 book chapters, were principal or co-principal investigators for 41 projects, and were directing 11 credit-bearing courses within The Johns Hopkins University School of Medicine and School of Hygiene and Public Health. In parallel with the growth of the Welch Center, clinical epidemiology emerged as an increasingly strong force in clinical departments at the School of Medicine as well as a progressively more vibrant contributor within the School of Hygiene and Public Health.

Clinical epidemiology has emerged as an area of increased focus not only in the United States but also in many other economically developed and economically developing countries. Some of the dissemination reflects the influence of successful role models and changing trends in the content of clinical journals and medical training. The spread of clinical epidemiology can also be attributed to direct support of training programs, infrastructure units, and clinical research projects by federal agencies; the Millbank, Mellon, Dana, Rockefeller, Robert Wood Johnson, Ford, and other foundations; and the private sector.

### REASONS FOR INCREASING PROMINENCE OF CLINICAL EPIDEMIOLOGY

It is difficult to pinpoint the exact basis for the explosion of interest in clinical epidemiology within and outside the United States. Some possibilities include the following:

- A better recognition of the relation between sick patients and their community of residence
- A clearer understanding that there is a large residue of preclinical illness in the community
- A greater emphasis on disease prevention and health promotion
- An increased emphasis on management of resources as tensions grow between escalating demands for health care services and concurrent acceleration in the costs necessary to provide these services
- An increased focus on the practice of evidence-based medicine, with greater attention to critical reviews of the medical literature
- More frequent publication of manuscripts based on observational and experimental epidemiology
- A greater emphasis on study design in reviewing manuscripts submitted to clinical journals
- Greater attention paid to documenting the effectiveness of clinical interventions
- A revolutionary shift in the organization of health care providers from being solo practitioners to members of health care systems that often provide care for large populations with various degrees of health and illness
- Disillusionment with the results of national investments in biomedical research
- Improvements in the content and methods for teaching epidemiology in schools of medicine
- An increased recognition of the importance of epidemiology as a scientific basis for clinical research
- Greater ease in computation

Much of the increasing interest in epidemiology among clinicians seems to relate to their recognition that epidemiologic methods are of fundamental importance in evaluating strategies for screening, the value of new prognostic indicators, and the efficacy and effectiveness (including cost-effectiveness) of therapeutic interventions.

### AREAS OF EMPHASIS IN CLINICAL EPIDEMIOLOGY

Some groups have emphasized the importance of epidemiology as a "basic science" in the care of patients and have focused considerable attention on the capacity for epidemiology to contribute to diagnosis, prognosis, treatment, and prevention for the individual patient. As a reflection of this interest, at least 10 textbooks have been published during the past decade primarily oriented toward improving the skills of medical students and clinicians as consumers of health information. There has also been a fundamental change in the manner in which epidemiology and the other population sciences are taught in medical schools. In most such schools, students are required to take an introductory course in epidemiology. Typically, the focus of these courses has shifted from teaching students the rudiments of public health to ensuring that they understand the relevance of epidemiology and related population sciences to patient care. In the past, these courses were often taught by faculty members who had traditional public health experience. In contrast, most such courses are now being directed by clinicians or are being team taught by an integrated group of clinicians and more traditionally oriented public health faculty. Most of the epidemiologic concepts in these courses are being presented in the context of their relevance to clinical problems.

Opportunities for advanced training of medical students and clinicians at the masters and doctoral levels have also become increasingly common. For example, at Tulane University in New Orleans, Louisiana, medical students can study in an integrated MD/MPH program jointly supported by the Tulane University School of Public Health and Tropical Medicine and School of Medicine. Students in this program can complete their studies in the same 4-year time period required for all medical students at Tulane. A total of 154 students were enrolled as MD/MPH candidates in 1998–1999, and the number would have been even larger if more scholarship support had been available to help pay for the MPH component of their training.

Others have focused much of their energy on the application of epidemiology to clinical research. Their efforts have led to not only a progressive increase in epidemiologic research in clinical settings but also a

better understanding of epidemiologic study designs and the corresponding inferences that can be drawn from application of these designs as well as to enhanced standards for presenting and reviewing research findings in peer-reviewed clinical journals. In many instances, research-oriented clinical epidemiologists have played a central role in training fellows and faculty who aspire to conduct patient-oriented research. Moreover, they have played an important role in facilitating interaction between clinicians and population scientists in schools of public health. Rapid growth in our knowledge of molecular biology has fueled the need to conduct high-quality evaluation of bench laboratory findings to determine the relevance of these discoveries in clinical settings. An increasing number of research-oriented clinical epidemiologists are engaged in evaluations at this interface of "molecular epidemiology."

### CHALLENGES FOR THE FUTURE

A number of challenges can be identified. In the context of teaching, there is a need to share materials and methods and to take full advantage of electronic formats for self-learning. Some of the research challenges are methodological. For example, better mathematical models are needed to capture the complex behavior of health care providers and their patients. It has been particularly difficult to mimic the complex nature of therapeutic decision making in the standard designs currently used in randomized clinical trials. Other challenges relate to the availability and quality of data necessary to address research questions of interest to clinical epidemiologists. For example, greater attention must be paid to the standardization and collection of data gathered in patient care settings. Having high-quality clinical databases with a sufficient sample size will facilitate recognition of potential adverse effects from new treatments and provide a better means to document the effectiveness of treatments in practice settings. Data that have been collected for administrative and fiscal purposes are being used with increasing frequency to answer clinical research questions. This approach is cost-effective and provides a mechanism to address questions that cannot be examined adequately by using more traditional research designs. In recognition of the attributes of the approach, more attention must be paid to determining the validity of the data in the context of clinical research.

Another challenge is the ability of clinicians to devote sufficient time to clinical research and teaching in an era in which their time is being tightly scheduled and monitored by their employers. They often are under intense pressure to see more patients. The avail-

ability of reimbursement for patient care services and for traditional population-oriented research provides an incentive to gravitate to one or the other of these two domains rather than to remain at their interface as a clinical epidemiologist. A further challenge is the need to increase the availability of appropriate clinical epidemiology role models who can devote sufficient time to encouraging and mentoring the many young clinicians and population scientists who demonstrate such great enthusiasm for applying epidemiologic concepts to patient care issues (14). Also, there is a need to ensure a sufficient pool of patients to participate in clinical research projects in the managed care environment. Managed care organizations are often interested in outcomes research that involves secondary analysis of administrative data but are frequently less committed to research in the clinic or the health care provider's office. In this context, research is commonly perceived to be disruptive and to add more time to the clinical encounter. Continuity of care is also an issue. There is an increasing tendency for both patients and providers to switch their affiliation among health care maintenance organizations, with the result that providers and patients are less attached to each other. This is a particular concern for the conduct of clinical trials and cohort studies in which long-term follow-up is essential.

These challenges are not the universe of those who confront clinical epidemiology but are presented merely as examples of some relevant issues. Likewise, the fact that these challenges exist by no means diminishes the achievements made in recent decades. Much has been accomplished over a relatively short period, and the stage is set for even more progress in the years to come.

### REFERENCES

1. Gordis L. Introduction. In: *Epidemiology*. Philadelphia, PA: WB Saunders, 1996.
2. Beaglehole R, Bonita R. Evolution of epidemiology: ideas and methods. In: *Public health at the crossroads: achievements and prospects*. Cambridge, MA: Cambridge University Press, 1997.
3. Dawber TR, Meadors GF, Moore FE Jr. Epidemiological approaches to heart disease. The Framingham Study. *Am J Public Health* 1951;41:279-86.
4. Berenson GS, Wattigney WA, Bao W, et al. Rationale to study the early natural history of heart disease: the Bogalusa Heart Study. *Am J Med Sci* 1995;310(suppl 2):S22-S28.
5. Doll R, Hill AB. Smoking and carcinoma of the lung: preliminary report. *BMJ* 1950;2:739-48.
6. Hammond EC, Horn D. Smoking and death rates—report on forty four months of follow-up of 187,783 men. *JAMA* 1958;166:1159-72, 1294-308.
7. Weiss NS. *Clinical epidemiology: the study of the outcome of illness*. New York, NY: Oxford University Press, 1986.
8. Rose G. Sick individuals and sick populations. *Int J*

- Epidemiol 1985;14:32-8.
9. Fletcher RH, Fletcher SW, Wagner EH. Clinical epidemiology: the essentials. Baltimore, MD: Williams & Wilkins, 1982.
  10. Sackett DL, Haynes RB, Tugwell P. Clinical epidemiology: a basic science for clinical medicine. Boston, MA: Little, Brown & Company, 1985.
  11. Feinstein AR. Introduction. In: Clinical epidemiology. Philadelphia, PA: WB Saunders, 1985.
  12. Rose G. The strategy of preventive medicine. Oxford, England: Oxford University Press, 1992.
  13. Gordis L. Epidemiology. Philadelphia, PA: WB Saunders, 1996.
  14. Nathan DG. Clinical research: perceptions, reality, and proposed solutions. National Institutes of Health Director's Panel on Clinical Research. JAMA 1998;280:1427-31.