REPORT AND RECOMMENDATIONS FROM THE WORKING GROUP ON

EPIDEMIOLOGY 101

Members of the Working Group

Richard Riegelman, MD, PhD -- Chair
Professor of Epidemiology and Biostatistics and Founding Dean
School of Public Health and Health Services
George Washington University

David Fraser, MD
Adjunct Professor of Epidemiology, University of Pennsylvania
Young Epidemiology Scholars Program and
Past President Swarthmore College

Ralph Frerichs, DVM, DrPH
Professor and Founding Chair
Department of Epidemiology
UCLA School of Public Health

Mark Kaelin, EdD
Associate Professor of Health and Nutritional Sciences
Montclair State University

Elahe Nezami, PhD
Director Undergraduate Program in Health Promotion and Disease Prevention
Keck School of Medicine
University of Southern California

Howard Teitelbaum, DO, PhD, MPH
Associate Dean
New York College of Osteopathic Medicine

Morton Winston, PhD
Professor and Chair
Department of Philosophy and Religion
The College of New Jersey

Mark Woodin, ScD
Graduate Programs in Public Health, School of Medicine and Department of Civil and Environmental Engineering, School of Engineering
Tufts University

Background

Brief History of Epidemiology as a Discipline: The discipline of epidemiology initially developed in the era of widespread infectious disease and epidemics in Europe and North America. Epidemiological methods for describing the frequency, course, and risk factors for infectious disease developed even before the germ theory of infectious disease was established. Interventions to establish causal relationship and intervene to reduce disease frequency have been a part of epidemiology from its earliest days. With the advent of the biological revolution of the late 19th and early 20th century, the methods of epidemiology became an intrinsic part of the investigation of disease in populations. (1)

Modern epidemiology, as a science applicable to investigations of disease and other outcomes, policy assessment, and population sciences in general evolved in the last half of the 20th century. Epidemiological methods focused on application of statistical theory, use of survey methods, and utilization of information technology. Epidemiology broadened its scope to include concepts of causation applicable to chronic disease and other health determinants including social and behavior factors. Applications to the effectiveness and safety of interventions, testing and decision-making methods, and policy analysis applicable to a range of social concerns recently begun to take center stage in epidemiology. (2)

In recent years the emergence and reemergence of infectious diseases; the escalating options for and cost of interventions; and the emergence of new threats to health and security from climate change to terrorism are broadening the scope and applications of epidemiology. It is becoming increasingly clear that understanding the principles and applications of epidemiology provides a structure for thinking about underlying causes and potential interventions for addressing the health and well being of individuals as well as populations. (3) Epidemiology has evolved to become a discipline that can and should be seen as an integral part of liberal education.

Brief History of Epidemiology as an Academic Curriculum: Epidemiology has traditionally been taught as a core course for graduate study in public health since the advent of formal public health education in the early years of the 20th century. Epidemiology, like public health education in general, was initially viewed as a graduate discipline for health professionals who had previous clinical training and experience. (4) Curricula in epidemiology have also been integrated, often informally, into the teaching of clinical health professionals often as part of their basic science education.

Epidemiology has not traditionally been taught as part of general education or integrated into liberal education at the undergraduate level. However, the justifications for doing so are not new.

In 1978 Abraham Lillienfeld, former Chairman, Department of Epidemiology at Johns Hopkins University, wrote an article entitled *Epidemiology 101* in which he recommended that epidemiology be introduced into the undergraduate curriculum

consistent with the goals of education in Arts and Sciences. (5) In 1987 David Fraser, then President of Swarthmore College, recommended that epidemiology be taught as a liberal art because it "illustrates the approaches to problems and the kinds of thinking that liberal education should cultivate..." (6)

Despite these early recognitions of the usefulness of epidemiology as part of the general education of a wide range of undergraduates, little attention was paid to the teaching of epidemiology as a part of general or liberal education until quite recently.

In the early years of the 21st century a rapid expansion in undergraduate public health education in general and epidemiology in particular has occurred in Schools and Programs in Public Health. Recent surveys by graduate schools and programs indicate that the majority of colleges and universities with schools or programs in public health now offer *undergraduate* course work in public health including epidemiology. (7) Despite this growing experience teaching epidemiology as part of undergraduate education few undergraduate institutions *without* schools or programs in public health currently offer course work in epidemiology.

This report examines approaches to offering epidemiology as part of general education, building epidemiology into the traditions and future directions of liberal education. It suggests a curricular rationale linked to the Association of American Colleges and Universities' LEAP program (8); outlines a structure and learning outcomes for "Epidemiology 101"; presents a curricular framework and potential curricular resources; and examines methods for facilitating the implementation of Epidemiology 101 in colleges and universities *without* Schools or Programs in Public Health.

Rationale for Epidemiology as part of General Education / Liberal Education: Epidemiology as a Way of Thinking

Epidemiology can play a unique and important role in general education if it is taught broadly as a way of thinking. In developing epidemiology as part of general education, the following rationales linked to the Liberal Education and America's Progress (LEAP) outcomes can form the basis for thinking through a curricular structure. The study of epidemiology teaches critical thinking and quantitative and information literacy using readily accessible approaches with wide applicability.

- The study of epidemiology teaches the methods, ethics, and applications of the scientific method.
- The study of epidemiology provides a vehicle for rigorously linking the concerns of the natural and social sciences, thus enriching understanding of public policy and other population-based disciplines.

The thinking process of epidemiology can be used as a prototype of the scientific method using examples that are accessible to students because of their relevance to their everyday experiences. The concepts of hypothesis generation, control groups, randomization, confounding variables, interaction, and ultimately causation are key components of the

scientific method that can and should be taught as part of epidemiology and generalized to help students understand the scientific methods used by a range of sciences.(9)

Epidemiology provides a framework for measuring and balancing the benefits, harms, and costs of potential interventions. This analytical framework is applicable not only to health related interventions and outcomes but also to a range of other applications from basic science to public policy.

Thus epidemiology can be used to achieve an understanding of the scientific method and also an understanding of the analytical methods for measuring and balancing benefits, harms and costs when considering use of potential interventions. For epidemiology the teaching of the scientific method and the measurement and balancing of benefits, harms and costs may be viewed as what Wiggins and McTighe call the "enduring understandings" (10). These enduring understandings form the starting point for curriculum design.

These enduring understandings also form the basis for development of skills that are key to accomplishing the LEAP goal of lifelong learning. The development of skills requires hands-on, participatory learning that allows students to appreciate the practical applications of the theoretical constructs upon which epidemiology is built.

Analytical skills can be developed in various ways, providing opportunities for considerable resourcefulness in teaching and curricular development. Epidemiological skills can be taught through active participation exercises, reading of the research literature, examination of contemporary issues in the mass media, and a range of other approaches.

The common element is the examination of theoretical frameworks for evidence-based argument and application of these frameworks to a range of specific issues and problems to be solved. In this sense the study of epidemiology parallels that of other sciences that provide frameworks for thinking and hands-on "laboratory" illustrations of their methods for solving problems. Also like other sciences, epidemiological thinking uses the general scientific method in which hypotheses are generated and tested and scientists seek reliable explanations of the cause(s) of disease in populations.

Epidemiology can be taught in a variety of structures and formats. In the context of general education the following approaches are recommended:

- Introductory epidemiology should be taught without prerequisites. This should allow epidemiology to be taught from basic principles to a wide range of students. It should encourage the use of relevant examples and exercises from a range of disciplines and applications.
- Epidemiology should be seen as a science. Epidemiology is generally considered the basic science of disease prevention (11). Its ability to teach students to understand the scientific method, to develop and test hypotheses from data, and to draw analytical conclusions provides key elements of scientific education taught

as part of general education. In addition the analytical methods needed to measure and balance benefits, harms and costs provide students with an additional set of methods for applying scientific results to a range of practical applications.

- Epidemiological instruction should employ group interactive learning. Teamwork for problem solving, a LEAP goal, can be effectively developed through the exploration of epidemiological problems, which can draw on various disciplines and lines of inquiry. A range of approaches from web-based collaboration to in-class exercises to laboratory-style problems to solve can be effectively utilized.

A number of structures are compatible with these recommendations. The following approaches should be considered:

- Epidemiology can be taught as a laboratory science. In institutions that require a formal or separate laboratory experience to qualify for fulfilling a science distribution requirement epidemiology can be taught with formal laboratory exercises.
- Epidemiology can be integrated into a wide range of majors as an elective or a selective. Potential majors that can benefit from epidemiology as part of a major include but are not limited to biology, environmental sciences and engineering, psychology, economics, statistics, sociology, urban planning and public policy.

These two approaches are not mutually exclusive, and it may be useful to utilize both approaches.

Learning Outcomes specific to Epidemiology 101

The following learning outcomes were developed using Bloom's Taxonomy. (12) Recommended outcomes are classified as Category 1 – Knowledge / Describe Category 2 Understanding / Explain, Category 3 - Application, Category 4 - Analysis, Category 5 - Synthesis, Category 6 - Evaluation.

Category 1 knowledge should not be seen as a free-standing goal of Epidemiology 101 but rather as key information to build upon for higher levels of the taxonomy. Sets of Basic (Categories 1-3) and Advanced (Categories 4-6) Outcomes are defined below. Institutions might select to focus on Basic or Basic plus Advanced Outcomes.

Basic Learning Outcomes

1. Describe the historical roots of epidemiologic thinking and their contribution to the evolution of the scientific method.
2. Critique epidemiologic research in terms of key ethical principles.
3. Use rates and proportions to numerically express the amount and distribution of health and nonhealth related outcomes.
4. Given the distribution of a health-related outcome, generate hypotheses that might explain that distribution.
5. Explain basic statistical and epidemiological concepts of estimation, inference and adjustment to establish association.

6. Given evidence of an association, critique the evidence for the purpose of determining whether the association is causal.
7. Describe the basic epidemiologic study designs that are used to test hypotheses, identify associations and establish causation.
8. Describe the concepts of measurement of test performance and be able to apply the concepts of testing and screening in a range of health and other settings.
9. Apply the concepts of evidence-based policy based on measurement of benefits, harms and costs.
10. Describe the wide applicability of epidemiological methods to clinical and basic sciences as well as public policy.

Advanced Learning Outcomes

1. Utilize evidence-based methods for the analysis, synthesis, and evaluation of recommendations for intervention
2. Utilize epidemiological concepts for the analysis, synthesis, and evaluation of a problem such as the investigation of a disease outbreak
3. Utilize epidemiological tools to analyze and evaluate the strengths and weaknesses of assertions in the scientific literature and popular press
4. Design an epidemiological investigation demonstrating the ability to reconcile scientific validity and ethical sensitivity

Undergraduate courses in epidemiology taught as part of general education should not be taught as simplified versions of graduate courses using the same learning outcomes. The goals of Epidemiology 101 appropriately differ from the goals of an epidemiology course that is taught as a core course toward a graduate degree in public health or as part of the basic science education of clinicians.

Specifically, Epidemiology 101:

- Should be conceptual rather than technical. For instance it might employ stratification rather than regression methods to illustrate adjustment for confounding, because the emphasis is on active engagement and ensuring an intuitive and transparent understanding of key principles.

- Should stress learning outcomes that are part of the broader LEAP goals of general education including ethical reasoning, teamwork for problem solving, integration of learning and skills for lifelong learning. These can be seen as compatible with and additional to the LEAP outcomes of understanding scientific methods, critical thinking, and quantitative literacy and information literacy.

- Should utilize a range of examples not limited to health and medicine. Cause and effect might be illustrated by examples from biology or economics; quantitative decision-making might use examples ranging from forensics to environmental monitoring. The specific examples are less important than the emphasis on a range of illustrations reinforcing the wide applicability of epidemiology from basic science to public policy. Epidemiology should be taught as a way of thinking.

Curriculum Framework

The use of a common curriculum framework for Epidemiology 101 is useful in helping structure a course and communicating regarding the course. The following curriculum framework and commentary may be useful for organizing Epidemiology 101 as well as serving as the basis for a web-based laboratory as part of Epidemiology 101. The italics represent commentary on the meaning of the preceding section of the framework. Cross-cutting issues such as ethics should be integrated throughout. The order of the framework may vary depending on the teaching style and level of the students.

Framework for Epidemiology 101

I. History, Philosophy, and Uses of Epidemiology

1. Historical contributions of epidemiology- development of epidemiological thinking
2. Current uses of epidemiology
3. Ethics and philosophy of epidemiology

Provides a framework placing epidemiology in historical and current perspective. Appreciation of the linkages between epidemiology and broader ethical and philosophical traditions and issues

II. Descriptive Epidemiology

1. Condition, Frequency and Severity -
   case definition and populations; incidence, prevalence, case-fatality
2. Data and Disease - vital statistics, surveillance and measures of health status
3. Generating hypotheses
   Patterns of Disease - person, place, time; changes and difference in rates; exposure; incubation period; disease spread

Basic tools of epidemiological analysis that provide the methods for quantitatively describing the natural history, frequency, and changes in disease and other conditions. Applications of the basic tools to generate hypotheses regarding causation.

III. Association and Causation

1. Estimation - measures of the strength of the association, graphical display of data; risk, relative risk, attributable risk
2. Inference - concepts of statistical significance and confidence intervals
3. Bias and Confounding – information and selection; adjustment; effect modification
4. Causation – risk factors and other determinants of diseases and conditions
5. Efficacy of Interventions

Concepts of cause and effect applied to the etiology of disease and the efficacy of interventions. Integration of statistical / epidemiological concepts of estimation, inference bias and adjustment into the concept of causal relationships.

IV. Analytical Epidemiology

1. Ecologic/ Population Comparison- populations as the unit of analysis
2. Case-control and Cross-sectional
3. Cohort - prospective and retrospective
4. Experimental studies - randomized clinical trials and community trials

Understanding and application of basic epidemiological study designs and their applications to investigating differences and changes in rates of disease, etiology of disease and the efficacy and effectiveness of potential interventions

V. Evidence-Based Public Health- Evidence-Based Recommendations

1. Harms and Benefits - decision analysis and perceptions of risk and benefits
2. Cost-effectiveness

Frameworks for development of evidence-based recommendations utilizing concepts of benefits, harms and costs.

VI. Applications to Policy, Basic and Clinical Sciences

1. Outbreak investigation
2. Testing and Screening
3. Public health policy
4. Special Applications - molecular/ genetic epidemiology, environmental/occupational, behavioral

Application of epidemiological methods to screening, policy, basic and clinical sciences as well as analysis of public health problems such as outbreak investigations

It should be noted that introductory courses may aim to achieve basic or basic and advanced learning objectives. The same framework may be used to achieve both types of learning objectives. However, the specific learning outcomes and materials used will differ.

This curricular framework should be viewed as an initial effort that should be systematically reviewed and revised based on accumulating experience teaching and evaluating the teaching of Epidemiology 101 as part of general / liberal education at a wide range of colleges and universities.

Curricular Resources

The working group does not recommend specific textbooks nor does it want to imply that the use of a textbook is essential for teaching Epidemiology 101. However, the preceding

learning outcomes and curriculum framework should assist textbook authors who intend to write or revise texts to address the needs of Epidemiology 101.

A unique resource for developing introductory skills in epidemiology through interactive practice is the Young Epidemiology Scholars (YES) materials developed with the support of The Robert Wood Johnson Foundation and the College Board. The YES materials were originally designed to engage high school students as a component of course work in mathematics, natural sciences and the social sciences (13) but they can also be utilized with college students.

The 26 modules now included in the YES materials can be organized and presented using the Epidemiology 101 curriculum framework as demonstrated by David Fraser in the material that appears in the appendix. Organizing the YES materials using the curriculum framework should facilitate the adoption of specific YES materials to fulfill specific components of the framework. Alternatively the YES materials may be used to illustrate most components of the curriculum framework as part of an epidemiology laboratory conducted as a distinct portion of a course or as a web-based activity.

In addition, the YES materials have been designed to reflect low, moderate and high degrees of difficulty which should allows instructor to select from among the YES materials to achieve basic or advanced learning outcomes as defined in the outcomes section of this report.

The implementation of the Epidemiology 101 curriculum framework may be accomplished using a range of materials. The Epidemiology 101 Working Group recommends this include the following approaches:

- A web-based resource center should be developed as a key resource for faculty who are teaching Epidemiology 101 for the first time or are seeking to expand or improve their teaching.
- A web-based resource center should provide the opportunity for a range of individuals to contribute their materials to the resource center.
- A well thought-out process for review of submitted materials -- including a “screening” element designed to ensure that the material is appropriate in term of the learning outcomes expected of Epidemiology 101 -- should be part of the web-based resource center.
- The Young Epidemiology Scholars (YES) materials may be included along with other materials that can assist faculty to teach Epidemiology 101 using the curricular framework.
- Mechanism for identifying and communicating with others who are teaching “Epidemiology 101 should be included.

The working group recommends that materials submitted for a web-based resource center should undergo review to establish their relevance and identify the learning outcomes that they can be expected to fulfill as well as the most appropriate location(s) within the curriculum framework. Additional user review, with revisions based on feedback, is an

important component of the resource center. Voluntary peer review would also be a desirable feature.

Implementation

The implementation of Epidemiology 101 as part of general education needs to take into account the unique expectations and structure of each institution. The best administrative structure, course structure, and choice of faculty will differ from institution to institution. A series of generic principles, however, may assist institutions in thinking through the available options.

- Epidemiology 101 should be taught from a broad base by faculty who appreciate the range of applications to a variety of disciplines.
- Epidemiology 101 should be taught without need for prerequisite courses such as statistics. Required statistical principles should be integrated into the course.
- Epidemiology 101 should be compatible with enrollment in Public Health 101 as recommended by the Public Health 101 Working Group. Thus the basic introduction to epidemiology recommended for Public Health 101 requires coordination between the courses.
- Few colleges and universities *without* Schools or Programs in Public Health have had experience teaching introductory courses in epidemiology. Therefore, successful widespread introduction of Epidemiology 101 will require faculty development and faculty support efforts. These require national efforts coupled with local support. The development of Epidemiology 101 provides unique opportunities to develop, evaluate, and coordinate approaches to such teaching on an ongoing basis.

A series of coordinated approaches designed to assist faculty and institutions that are preparing to offer Epidemiology 101 is key to successful widespread implementation. All of the following are desirable and necessary pieces of an implementation strategy:

- A well designed web-based resource center organized using the Epidemiology 101 curricular framework which for ease of access also includes a parallel component for the Public Health 101 curricular framework
- A structure for providing consultation including individualized consultation by those with experience teaching and developing materials for introductory epidemiology
- Formal curricular development and training efforts such as a national conference on Epidemiology 101 curricular materials and a summer institute for faculty preparing to teach Epidemiology 101
- Demonstration trials to evaluate approaches to teaching Epidemiology 101 in Schools of Arts and Sciences including ongoing mentoring efforts

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APPENDIX TO EPIDEMIOLOGY 101 REPORT
Framework for Epidemiology 101
Use of Young Epidemiology Scholars Materials Hyperlinked

I. History, Philosophy, and Uses of Epidemiology

1. Historical contributions of epidemiology
   - Casualties of War: The Short- and Long-term Effects of the 1945 Atomic Bomb Attacks on Japan
   - The Tuskegee Syphilis Study
   - Examining the Plague: An Investigation of Epidemic Past and Present
   - Mortality and the Transatlantic Slave Trade
2. Current uses of epidemiology
   - Disease Outbreak Investigation [lesson #3: the leukemia cluster described in *A Civil Action*]
3. Ethics and philosophy of epidemiology
   - Ethical Issues in Epidemiology
   - Should the Population Be Screened for HIV?
   - The Tuskegee Syphilis Study

II. Descriptive Epidemiology

1. Condition, Frequency and Severity -
   case definition and populations; incidence, prevalence, case-fatality
   - Descriptive Epidemiology of Births to Teenage Mothers
   - Mortality and the Transatlantic Slave Trade
2. Data and Disease - vital statistics, surveillance and measures of health status
   - Descriptive Epidemiology of Births to Teenage Mothers
   - Cross-Sectional Study Design and Data Analysis
3. Generating hypotheses
   Patterns of Disease - person, place, time; changes and difference in rates; exposure; incubation period; disease spread
   - Mortality and the Transatlantic Slave Trade
   - An Outbreak of Legionnaires' Disease
   - Outbreak Investigation in a Vermont Community Hospital

III. Association and Causation

1. Estimation - measures of the strength of the association, graphical display of data; risk, relative risk, attributable risk
   - Measures in Epidemiology
   - Attributable Risk Applications in Epidemiology
2. Inference - concepts of statistical significance and confidence intervals

3 Bias and Confounding – information and selection; adjustment; effect modification
   - TV and Aggressive Behavior
   - Observational Studies and Bias in Epidemiologic Research
   - Confounding in Epidemiology

   - An Outbreak of Legionnaires' Disease
4. Causation – risk factors and other determinants of diseases and conditions

Alpine Fizz and Male Infertility: A Mock Trial
Web of Causation
TV and Aggressive Behavior
Attributable Risk Applications in Epidemiology
An Outbreak of Legionnaires' Disease

5. Efficacy of Interventions
Adolescent Suicide: The Role of Epidemiology in Public Health

IV. Analytical Epidemiology

1. Ecologic/ Population Comparison - populations as the unit of analysis
Ecologic Studies
2. Case-control and Cross-sectional
Case Control Study
Cross-Sectional Study Design and Data Analysis
TV and Aggressive Behavior
Observational Studies and Bias in Epidemiologic Research
Adolescent Suicide: The Role of Epidemiology in Public Health
An Outbreak of Legionnaires' Disease
3. Cohort - prospective and retrospective
Observational Studies and Bias in Epidemiologic Research
Casualties of War: The Short- and Long-term Effects of the 1945 Atomic Bomb Attacks on Japan
The Tuskegee Syphilis Study
4. Experimental studies - randomized clinical trials and community trials
Observational Studies and Bias in Epidemiologic Research
Testing Ephedra: Using Epidemiological Study to Teach Concepts of the Scientific Method

V. Evidence-Based Public Health- Evidence-Based Recommendations

1. Harms and Benefits - decision analysis and perceptions of risk and benefits
Risk Perception
2. Cost-effectiveness
Bicycle Helmet Effectiveness in Preventing Injury and Death

VI. Applications to Policy, Basic and Clinical Sciences

1. Outbreak investigation
Disease Outbreak Investigation
An Outbreak of Legionnaires' Disease
Outbreak Investigation in a Vermont Community Hospital
2. Testing and Screening
Screening and Diagnostic Tests
Should the Population Be Screened for HIV?
3. Public health policy
Epidemiology and Public Health Policy: Using the Smoking Ban in New York City Bars as a Case Study
4. Special Applications - molecular/ genetic epidemiology, environmental/occupational, behavioral
An Outbreak of Legionnaires' Disease
Outbreak Investigation in a Vermont Community Hospital