

PRINCIPLES OF EPIDEMIOLOGY

A Self-Teaching Guide

LEWIS H. ROHT

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INTRODUCTION

You are about to begin the study of epidemiology, a subject that many consider the basic science of public health. The public health sciences are concerned with the management, prevention, and control of diseases and other health problems in the community. The field of epidemiology stands in the center of the public health sciences, playing an important role in identifying health problems as well as seeking measures to control or prevent the occurrence of illness in human populations. Epidemiologists also participate in teaching and research, and in the organization and administration of programs that attempt to solve actual and/or perceived health problems in the community.

The Epidemiology Self-Teaching Guide consists of a series of problem-solving exercises designed to introduce and guide you toward an understanding of the principles and methods of epidemiology, rather than the epidemiology of specific diseases or subject areas such as "infectious disease" or "chronic disease" epidemiology. The guide has been formulated to be used by itself or as a supplement to standard textbooks. It illustrates and illuminates the principles and concepts of epidemiology and provides the reader an opportunity to practice the application of these principles in a logical sequence.

The guide has two major objectives: when you have completed the exercises you should be able (1) to plan an investigation of a community health problem, and (2) to constructively evaluate research and scientific reports appearing in the literature. These skills will be useful to you whether or not you become an epidemiologist because they are applicable to a wide variety of community health activities including research, review of scientific literature, evaluation of health programs, and administration or decision making based upon the correct interpretation and application of available knowledge.

HOW TO USE THE GUIDE

The guide is divided into 14 exercises. Each exercise will help you to understand principles or methods used by epidemiologists, which are necessary to achieve the two objectives mentioned above.

1. At the beginning of each exercise one or more goals will be stated, to indicate what you should expect to learn from that exercise.
2. A list of standard textbooks keyed to the material of each exercise is provided to supplement the material presented. You are strongly urged to read one or more of these suggested references before working the exercise.

3. Work through the exercise. Space is provided for you to answer questions or construct tables or graphs relating to an epidemiologic problem.
4. For each exercise suggested responses are provided. Use these to verify your answers. In some cases you may disagree with the suggested response. That does not mean your answer is incorrect or that the suggested response is the only correct answer. In fact, there may be other correct answers. The suggested responses are provided as a guide to indicate the type of response we hope would occur to you. They will also raise some issues that concern epidemiologists. Many of the suggested responses go beyond what is called for in the question. These extensive responses are intended to provide additional insight or to stimulate your thinking about the subject. A reader's ability to answer the questions will reflect his or her awareness of health issues and previous professional experience.
5. An extensive bibliography of epidemiologic literature and some examples of test questions are provided in appendices following Exercise 14.

While many of the problems in the exercises will use data from actual diseases, the reader should be aware that our goal is to illustrate a principle, concept, or method commonly employed by epidemiologists. Do not be overly concerned with memorizing epidemiologic facts about the diseases but try to grasp the epidemiologic concepts. We have assumed that you have an understanding of the pathology and other biologic features of the disease, so that emphasis will be placed on the epidemiologic principles and concepts and not on the disease process. For those of you who become epidemiologists or who are involved with disease control programs or research, more complete knowledge of the epidemiology of the specific diseases will be mandatory.

SUPPLEMENTARY REFERENCE BOOKS

There are many useful and suitable reference books concerned with epidemiology. However, no single book is likely to have universal appeal to all readers or to cover a given subject to the same degree or from the same point of view as other textbooks. All texts in the suggested reading list are appropriate and cover the material adequately. The choice of which reference text to use will depend upon the reader's individual preference for writing style and the degree of sophistication required by the reader.

COURSE OBJECTIVES

For use of this guide in a formal education program (medical or public health school, college, or graduate program) student evaluation would be based upon an ability to demonstrate understanding of the concepts, principles, and methods of epidemiology by achieving the two primary objectives:

1. Planning an investigation of a community health situation and carrying out appropriate analyses to determine if an epidemic is present, the epidemic type, and the determinants.

2. Performing a critical review to assess the quality of epidemiologic reports, investigations and studies.

Successful completion of objective 1 requires the skills developed in Exercises 1-9, and includes the abilities to:

1. Obtain existing demographic data to describe the "population at risk."
2. Obtain morbidity, mortality, physiologic, or behavioral data relating to the frequency of the disease or health problem in question.
3. Prepare (or obtain if available) appropriate graphs, charts or tables relating the "disease" to the population at risk so that the pattern of disease in that population is discernible and can be described in terms of the person affected and the place and time of occurrence.
4. Analyze and interpret data to assess whether the observed frequency of disease exceeds the normal or expected amount.
5. Formulate and test hypotheses to explain the disease pattern and suggest measures to prevent or control present and future occurrence of that health problem.

To perform a critical review of an epidemiologic report, investigation or study (objective 2) requires the skills and knowledge developed in Exercises 10-14 and includes the abilities to:

1. Define the health problem being investigated and describe the purpose of the study.
2. Define the population to be studied and its method of selection.
3. Determine if the design of the study is appropriate to the problem being investigated.
4. Identify the potential sources of error in selection of the study population and/or data collection.
5. Determine if the interpretations or conclusions made by the investigator are appropriate to the study design and data presented.

Use of this guide in a formal teaching program could include examinations at the conclusion of Exercises 9 and 14. Examples of an examination format are provided in Appendix 2.

By way of easing you into your studies the remainder of this introductory section will enable you to construct a definition of epidemiology and become aware of the areas of interest and concern to epidemiologists.

WHAT IS EPIDEMIOLOGY?

The ancient Greek scholar and physician Hippocrates wrote a treatise³ "On Airs, Waters and Places" which comes close to illustrating the way epidemiologists approach health problems.

Whoever wishes to investigate medicine properly should proceed thus: in the first place to consider the seasons of the year, and what effects each of them produces. Then the winds, the hot and the cold, especially such as are common to all countries, and then such as are peculiar to each locality. In the same manner, when one comes into a city to which he is a stranger, he should consider its situation, how it lies as to the winds and the rising of the sun; for its influence is not the same whether it lies to the north or the south, to the rising or to the setting sun. One should consider most attentively the water which the inhabitants use, whether they be marshy and soft, or hard and running from elevated and rocky situations, and then if saltish and unfit for cooking; and the ground, whether it be naked and deficient in water, or wooded and well watered, and whether it lies in a hollow, confined situation, or is elevated and cold; and the mode in which the inhabitants live, and what are their pursuits, whether they are fond of drinking and eating to excess, and given to indolence, or are fond of exercise and labor.

While Hippocrates gives us a general impression about epidemiology's content or approach, the subject requires a clearer definition. Several of those which have been proposed are listed below. You will notice that there is no single definition to which all epidemiologists subscribe. However, there are recurrent themes among them. Try to discern the notions common to these varying definitions and write them in the space provided below.

Hirsch (1883):

"A picture of the occurrence, the distribution, and the types of the diseases of mankind, in distinct epochs of time and at various points of the earth's surface; and ... render an account of the relations of those diseases to the external condition."

Frost (1927):

"The science of the mass phenomena of infectious diseases, or as the natural history of infectious diseases... an inductive science, concerned not merely with describing the distribution of disease, but--fitting it into a consistent philosophy."

Greenwood (1934):

"Epidemiology is the study of disease as a mass phenomenon."

Lilienfeld (1957):

"Epidemiology may be defined as the study of the distribution of a disease or condition in a population and of the factors that influence this distribution."

Plunkett and Gordon (1960):

"The field observation of disease under natural conditions in whole populations... medical ecology... deals with the mutual relations between man and his environment, seeing health and disease as selected instances of this total interaction."

Morris (1964):

"The study of health and disease of populations, this is the epidemiology of Farr and Snow, of Hirsch and Goldberger."

Taylor (1967):

"The study of health or ill health in a defined population."

MacMahon, Pugh, and Ipsen (1970):

"The study of the distribution and determinants of disease frequency in man ... distribution... (descriptive epidemiology) and... determinants of the noted distribution (analytic epidemiology)."

Stallones (1971):

"Epidemiology is the description and explanation of the differences in occurrence of events of medical concern in subgroups of a population, where the population has been subdivided according to some characteristic believed to influence the occurrence of the event."

Epidemiology of Non-Communicable Disease British Medical Bulletin (1971):

"Like so many words 'epidemiology' has changed its meaning over the years. It is not mentioned in Samuel Johnson's Dictionary of the English Language, although not surprising in 1775, epidemic--'that which plagues'--is mentioned. Its original usage was to describe 'that branch of medical science which treats of epidemics,' but it is now widely understood to be 'a science that deals with incidence, distribution, and control of disease in a population 'whether or not the disease in question is epidemic or communicable'... . The definition of the term may require modification again in the near future to include the critical evaluation of measures directed at treatment of disease as well as its prevention (and therefore by implication the study of prognosis)."

Epidemiology--A Guide to Teaching Methods (1973):

"Epidemiology is defined as the study of the factors determining the frequency and distribution of disease in human populations. For many years the word covered only and quite specifically, the study of the spread and decline of communicable disease in human populations and the prophylaxis and control of

those diseases... the scope includes all disease acute or chronic, physical or mental; communicable or non-communicable."

Sartwell (1973):

"The study of the distribution and dynamics of diseases in human populations."

Lasagna (1975):

"The science dealing with the incidence, spread, and control of disease."

Lilienfeld (1977):

"Epidemiology is a method of reasoning about disease that deals with biologic inferences derived from observations of disease phenomena in population groups."

Frerichs and Neutra (1978):

"Epidemiology is the study of the prevalence and dynamics of stages of health in populations."

Webster's Unabridged Dictionary:

"The term epidemiology is derived from the Greek epi, on, upon; -demos-, the people; -logos, theory, source, the study of."

Stop for a moment to consider these definitions. Before you read any further, write your summary of the factors that are common to these definitions.

Your definition should include or mention that epidemiology is a basic science of preventive medicine and public health concerned with:

1. Disease (or some health status).
2. Frequency (enumeration of amount present or rate of development within a specific time period).
3. Distribution (patterns produced by disease occurrence in population).
4. Determinants (the factors affecting the distribution).
5. Methods (processes employed to describe frequency and distribution and scientific rationale used to determine causal relationship of disease distribution in populations).
6. Populations (a defined human population).

These definitions clearly indicate that the subjects of interest to epidemiologists (diseases and health conditions) have grown through time, and also that the range of factors that the epidemiologist considers in search for determinants of disease distribution has markedly expanded. The epidemiologist has come to recognize that patterns of diseases observed in a community reflect the interaction of multiple factors (genetic, environmental, social, physiologic, etc.).

By now you should have a feeling that epidemiology encompasses a wide range of activities, but at the same time you should also have the impression of an overall consistency among these definitions. Before laying this issue to rest, two other views bear mentioning.

Frost (1936):

"Epidemiology at any given time is something more than the total of its established facts. It includes their orderly arrangement into chains of inference which extend more or less beyond the bounds of direct observation."

Gilliam (1963):

"Epidemiology is what epidemiologists do."

APPLICATIONS OF EPIDEMIOLOGY

In your study of epidemiology you will discover that epidemiologists have played a role in many areas of public health, including the study of infectious disease, chronic disease, accidents and injury, maternal and child health, family planning, iatrogenic diseases (diseases resulting from medical treatment, as with Thalidomide), mental health, nutritional disorders, health education, medical care delivery, health services administration, and health planning. Specific activities include:

1. Collection and analysis of vital records (births and deaths).
2. Collection and analysis of morbidity data from hospitals, health agencies, clinics, physicians, and industry.
3. Surveillance of diseases or community health problems.
4. Investigation leading to control or prevention of epidemics and other community health problems.
5. Design and implementation of clinical research studies and health surveys.
6. Design and implementation of health registries for problems of interest such as birth defects, cancer incidence, or drug and medication use.
7. Screening for diseases.
8. Evaluation of the effectiveness of existing or newly proposed treatment methods.
9. Describing the clinical course as well as the natural history of specific diseases.
10. Identifying individuals or subgroups of the general population at increased risk of developing certain diseases.
11. Identifying links in the etiology of disease.
12. Identifying public health problems and measuring the extent of their distribution, frequency or effect on the public's health.
13. Evaluation of health programs.
14. Providing data necessary for health planning or decision making by health agency administrators or health policy makers.

In the guide we present some examples of the approaches and applications to the health problems that have been described. Space and the limitations on a student's time prevent a complete exposition of all of these topics. The authors' intent is to introduce the principles, concepts, and methods used by epidemiologists with the hope that you the student will be able to apply the ideas and techniques to your own areas of interest. We hope you find the exercises interesting and challenging, and that they will enable you to build a firm foundation for the development of ideas and skills that you will need in future academic and professional activities in public health.

Suggested Readings

1. Friedman, G. Primer of Epidemiology, McGraw-Hill, 1980, Chapter 1.
2. Mausner, J., and Bahn, A. Epidemiology, W.B. Saunders Co., 1974, Chapters 1,2.
3. MacMahon, B., and Pugh, T.F. Epidemiology, Principles and Methods, Little, Brown & Co., 1970, Chapter 1.
4. Paul, J.R. Clinical Epidemiology, The University of Chicago Press, 1958, Chapter 1.
5. Fisher, I. An Introduction to Epidemiology, Appleton-Century Press, 1975, Frame 1-44.

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6. Hirsch, A. Handbook of Geographical and Historical Pathology, London: New Sydenham Society, 1883.
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11. Epidemiology--A Guide to Teaching Methods, Churchill Livingstone, 1973.
12. White, K.L. Contemporary Epidemiology, Int. J. Epidem., 3:295, 1974.
13. Lilienfeld, D.E., Definitions of Epidemiology, Am. J. Epidem. 107:87, 1978.
14. Frerichs, R.R., and Neutra, R. Re: Definitions of Epidemiology. Am. J. Epidem. 108:74, 1978.
15. Frost, W.H. Introduction. In: Snow on Cholera by J. Snow. Cambridge: Harvard University Press, 1936.
16. Gilliam, A.G. Quoted in Stallones, R.A. Epidemi(olog)²y. Am. J. Pub. Health 53:82, 1963.

PART I. BASIC TENETS OF EPIDEMIOLOGY

Exercises 1 and 2 will illustrate the basic tenets of epidemiology:

1. THE DISTRIBUTION OF DISEASES OCCURS IN PATTERNS IN A COMMUNITY.
2. THE PATTERN OF DISEASES IN COMMUNITIES IS PREDICTABLE.
3. CHARACTERISTICS OF THE PATTERN MAY SUGGEST OR LEAD TO MEASURES TO CONTROL OR PREVENT THE DISEASE.

An epidemiologist seeks to identify and describe the individuals or groups within a community who are ill or likely to become ill. Description includes answers to the questions WHO? WHAT? WHEN? WHERE?

Who became ill? What type of illness and under what circumstances did the illness occur? When and where did the illness occur?

The epidemiologist arranges this information to determine if patterns might exist, i.e., whether or not certain groups will be observed to have a health problem more frequently than others in that community. Based upon these observations, conclusions (the validity of which might be tested through research or experimentation) may be drawn concerning HOW? and WHY? the illness occurred in a particular group. When these questions have been answered and the relationship between the causes of a disease and factors associated with those causes becomes understood, it may be possible to develop measures that can PREVENT OR CONTROL the occurrence of that disease in human populations.