

What does an epidemiologist actually do? A note for non-epidemiologists

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Abstract

Background: During the ongoing COVID-19 pandemic, the importance of epidemiologists and epidemiology as a science is becoming clear. An epidemiologist leads the team that deals with health emergencies and pandemics. Whatever type of epidemiologist they are, they must have specific competencies, skills, functions, and ethics.

Methods: PubMed and Google were searched for full texts of studies published in English using the key words "epidemiologist" in conjunction with definition, competencies, skills, functions, roles, types, and ethics. This narrative review included all of the literature that was retrieved. We only included the most recent and pertinent articles. Standard epidemiology textbooks were also screened for the relevant review heading.

Results: We summarized the contributions of key epidemiologists from Hippocrates to Austin Bradford Hill, as well as their competencies or skills, functions, and 16 types of epidemiologists. Finally, epidemiologists' ethics were discussed.

Conclusion: For early detection and prevention of epidemics and health disasters, effective liaison between epidemiologists, clinicians of various specialties, and policymakers is required. This is especially important in developing and developed countries where the number of epidemiologists is low and the majority work in teaching institutions where their contributions are undervalued.

Keywords: Epidemiologists, Skills, Roles, Competencies, Functions, Types, Ethics

Introduction

Despite being an ancient branch of science, epidemiology has been underappreciated until recently. It is becoming more important in the era of COVID-19 pandemics (1). Whether as researchers or practitioners, epidemiologists are concerned with population health (1). Epidemiologists are scientists or medical professionals who specialize in epidemiology. Epidemiologists are known as disease detectives because they investigate the causes, magnitude, and consequences of various health problems in a specific population (2). They plan research, manage data (collection and statistical analysis), and interpret and

disseminate findings from public health studies, clinical trials, and basic biological research. These activities are advantageous to policymakers. Historically, physicians practiced epidemiology as part of their clinical practice. However, epidemiology is now a distinct specialty that can be practiced by a variety of scientists. Epidemiologists typically collaborate with physicians and other healthcare professionals in a research or clinical setting. Epidemiologists who are not physicians do not physically examine patients, make diagnoses, or prescribe medications (3, 4, 5).

Table 1. Famous epidemiologists and their achievements

Name (Time)	Achievements
Hippocrates [460 B.C. – 377 B.C.]	The originator of medicine and epidemiology. He investigated the relationship between disease and the environment using epidemiologic principles. He blamed illness on an imbalance of the four humors (air, fire, water, and earth). To balance the body, the illness was cured by removing or adding the offending humor. He was the first to differentiate between endemic (within a population) and epidemic (visiting a population) (3). He investigated how diseases affect people and how they spread (4).
Girolamo Fracastoro [1478 – 1553]	Before germ discovery, proposed the idea of contagionism and that epidemics were caused by toxic chemicals passed from one person to another (5).
John Graunt [1620 – 1674]	The bills of mortality from data collected to monitor the plague in England were analyzed. He transformed the concept of disease from a single case to a population of multiple cases interacting with the environment (3, 4).
Thomas Sydenham [1624 – 1689]	Formulated a generic concept of disease based on the specific symptoms and causes shared by all cases, and studied health problems by combining data from multiple patients. He described and distinguished various diseases (4).
Bernardino Ramazzini [1633-1714]	He established occupational medicine and toxicology. He described a malaria outbreak and advocated for cinchona bark treatment (4, 6, 7, 8).
Percivall Pott [1714 – 1788]	He discovered that environmental factors can cause cancer after observing that men cleaning chimneys (who were exposed to ashes and soot) had an increased risk of scrotal cancer (9).
James Lind [1716 – 1794]	He made numerous contributions to epidemiology, including researching disease occurrence in large groups, determining the effect of diet on disease, employing experimental design, and observing population changes and their effects on diseases. He conducted the first known clinical trial for the treatment of scurvy. He divided scurvy sailors into six groups of two and gave each a different diet supplement. Citrus fruits were found to be the most effective treatment when compared to other supplements (4).
Edward Jenner [1749 – 1823]	Prior to the discovery of the smallpox virus, the father of vaccinology. He vaccinated a boy with cowpox lesion material, and the child never got smallpox (10, 11, 12).
Edwin Chadwick [1800 – 1890]	Outlined the link between poor living conditions and disease. Non-specific measures such as safe sewage disposal and clean drinking water have been linked to improved health. He is well-known for his efforts to improve sanitation and public health (13).
William Farr [1807 – 1883]	Applied statistics in medicine, creating a record system for causes of death and monitoring outbreaks. He is credited with inventing the modern concept of surveillance. He advocated for a multifactorial approach to chronic disease etiology (4).
John Snow [1813 – 1858]	The father of modern epidemiology. He investigated the causes of the 19th century cholera epidemics in London, and concluded that contaminated water was the source of cholera. He established the foundation for descriptive and analytic epidemiology. He discovered various modes of transmission and incubation times (4, 14).
Ignaz Semmelweis [1818 – 1865]	The father of infection control. In a controlled trial, he confirmed that washing hands before attending pregnant women reduces post-puerperal sepsis and death (4).
Robert Koch [1843-1910]	He confirmed the existence of microbes as the cause of many diseases. He isolated tubercle bacilli and the cholera bacterium, perfected steam sterilization, and pioneered water purification for disease prevention (4).
Austin Bradford Hill [1897- 1991]	The twentieth century's greatest epidemiologist and medical statistician. He established the link between smoking and lung cancer and is the creator of the "Bradford Hill criteria" for determining causal relationships (4, 15).

In dealing with the threat of global health problems, epidemiologists face numerous challenges. The epidemiologist profession encompasses a wide range of activities and professional duties that reflect the contexts in which they work and the nature of the health problems addressed. Data collection from populations should take into account serious ethical considerations such as individual confidentiality and privacy, as well as respect for the populations being studied. In addition to collecting and analyzing data, epidemiologists use evidence to guide action with the goal of improving health (1).

Many scientists have historically contributed to epidemiology. Table 1 lists and summarizes the achievements of famous epidemiologists.

Methods

On June 30, 2022, PubMed and Google were searched for full texts of studies published in English in this narrative literature review. The keywords of epidemiologist, definition, competencies, skills, functions, roles, types, and ethics were used. The review included all of the literature that was retrieved. We only included the most recent and pertinent articles. Standard epidemiology textbooks were also screened for the relevant review heading. This review included 47 citations in total. It is not necessary to include every article on a topic in narrative reviews (16).

Competencies of epidemiologists

"Competencies are statements that define the essential knowledge, skills, and abilities required for job performance" (15). Epidemiologists use critical thinking to design research, collect and analyze data, and solve health problems (2). These abilities vary according to the level of experience of practicing epidemiologists working in various public health agencies. To be an effective epidemiologist, many skills and competencies are required, including (17,18,19,20,21, 22,23,24,25,26):

1. Research methods, research writing, and publication,
2. Plan, design, implement, supervise, and evaluate various types of research/surveys in infectious and non-infectious diseases, health-related behaviors, and public health programs,
3. Biostatistics and computer skills required for data analysis and interpretation using statistical programs and techniques,
4. Disease surveillance system and screening program activities,
5. Effective verbal and written communication skills, as well as report writing,
6. Train, lead, and evaluate others' work,
7. Create and manage budgets, as well as apply for grants,
8. Public health-related social, cultural, economic, and environmental issues,
9. National health system, policies, rules, and regulations,
10. Prioritize national public health issues.

Functions of epidemiologists

An epidemiologist performs a variety of tasks and works in a variety of settings (1).

The two perspectives on epidemiologists' responsibilities differ: one limits practice to science, while the other considers active participation in policymaking (27).

The American College of Epidemiology (28) defines epidemiologists' roles as teaching, consulting, and administration. Their primary responsibilities include the design and execution of research as well as the dissemination of findings to all parties involved. These functions are as follows (1, 3, 29, 30, 31, 32, 33):

1. Recognize, validate, and identify population-wide public health problems, such as source, mode of spread, risk factors, and high-risk groups.
2. Utilize and ensure ethical and legal principles in study design, data collection, dissemination, and use.
3. Organize and manage data from various sources, such as surveillance.
4. Analyze and interpret epidemiologic research data.
5. Based on epidemiologic findings, develop and recommend evidence-based interventions and control measures.
6. Prepare oral and written presentations and reports to communicate important information to policymakers, professionals, and the general public.
7. Use effective recent communication technology to apply basic risk communication principles.
8. Create and assess disease prevention programs.

9. Involvement in public health policymaking. Epidemiologists face a difficult future in public health practice.
10. Collaboration in the administration of the public health system.
11. Develop, implement, and assess health safety standards and programs to improve the health of the general public, industry personnel, health care workers, and others.
12. Standardize drug dosages, immunization methods, and drug and medicinal compound manufacturing procedures.
13. Oversee professional, technical, and clerical staff.
14. Determine the environmental impact of industrial chemicals and toxic wastes.

Types of epidemiologists

Epidemiology is a multidisciplinary field that includes biological sciences, clinical medicine, social and behavioral sciences, toxicology, law, informatics, and statistics (34) As public health practitioners learn more about the determinants of health, which now include environmental, behavioral, psychological, biological, sociological, genetic, and lifestyle factors, the interdisciplinary nature of epidemiology continues to grow (35). Epidemiologists can specialize in a variety of fields due to their multidisciplinary nature. Specialization can be achieved through disease topic area (e.g., infectious diseases, chronic diseases, environmental health, and so on), methodology (e.g., needs assessments, pharmaco-epidemiology, genetic epidemiology, health services research, and so on), or workplace (e.g., academic, industry, hospital, or field) (34)

Epidemiologists work in a variety of settings, including research, academic, and applied settings. They teach epidemiology and conduct epidemiologic research in medical institutions or schools of public health in research and academic settings. The use of epidemiologic methods to address public health issues is referred to as "applied epidemiology." Governmental public health agencies are the most common places to find applied epidemiologists (36) Many types of overlapping epidemiologists exist (2,26,32,37,38,39):

1-Hospital epidemiologists (clinical or infection control):

They apply epidemiology science in the healthcare setting. They work to control and limit the spread of healthcare-associated infections by monitoring and reporting infection data, educating and enforcing hygiene among health care workers, and improving hospital safety.

2-Pharmacoepidemiologists (pharmaceutical epidemiologists):

They typically work in laboratories and pharmaceutical industries, describing and analyzing drug usage and effects on the population in order to estimate their likely beneficial and adverse effects.

3-Medical epidemiologists:

A medical doctor epidemiologist who monitors disease outbreaks and recommends appropriate prevention and control measures.

4- Infectious disease epidemiologists:

They study the effects of infectious diseases on the general population or on specific groups, as well as vaccine efficacy. During the current COVID-19 pandemic, they have played important roles.

5- Field epidemiologists:

They look into how public health disasters or acute crises affect communities. They provide direct service to communities. They work in areas where unexpected disease outbreaks occur.

6-Genetic (molecular) epidemiologists:

They usually work in pharmaceuticals, biotech, or academia and combine molecular biology with statistical disease analysis. They investigate disease mutations and genetic risk factors, as well as the interaction of genetic and environmental factors in disease causation.

7-Veterinary epidemiologists (epizootiologists or epizooologists):

Veterinarians who specialize in disease prevention and control in animals in order to prevent zoonotic diseases from spreading to humans. They contribute to the safe supply of food for humans by preventing and controlling livestock diseases.

8-Applied epidemiologists:

They concentrate on medical statistics and data analysis in order to create policies and health reform measures. They put research findings into action to promote health and disease control. They disseminate information to health professionals and the general

public, assess public health services, and develop effective health policies using evidence-based methods.

9-Occupational epidemiologists:

They describe workplace-related diseases and their underlying causes in order to protect workers from the hazards of various occupations.

10- Environmental (climate) health epidemiologists:

They investigate the long- and short-term effects of physical, chemical, and biological environmental changes on human health and well-being.

11- Academic research epidemiologists:

They conduct epidemiologic research and teach students while working in universities and educational institutions.

12- Statistician epidemiologist:

They collect and analyze epidemiologic data on public health issues in order to assist policymakers in their prevention and control.

13- Clinical trial research epidemiologists:

They work in laboratories to create new medications to treat diseases. They keep track of clinical trial progress as well as the drug's efficacy and effectiveness.

14. Disaster epidemiologists:

They assess the population's needs, plan responses, monitor recovery efforts, and use data to forecast the effects of future disasters. All of these activities aim to reduce disaster-related illnesses, injuries, and deaths.

15- Nutritional epidemiologists:

They investigate the relationship between diet and disease occurrence in order to develop dietary interventions to prevent and control diet-related diseases.

16. Social epidemiologist:

They investigate the health effects of social inequality, social relationships, and work stress.

Epidemiologists and ethics

There has recently been increased interest in the code of ethics for epidemiologists. In the course of their professional duties, epidemiologists frequently encounter numerous ethical issues and concerns that must be carefully considered (40). These ethics include epidemiologists' obligations to colleagues, funders, subjects, employers, and society. This ethics

must be integrated into epidemiologists' professional lives. There have been numerous proposals for ethics guidelines for epidemiologists (40).

They have ethical and professional obligations as epidemiologists to maximize the potential benefits and minimize the risk of their studies by avoiding and declaring conflicts of interest, obtaining informed consent, ensuring privacy and confidentiality, communicating the results of their studies to the community, respecting cultural diversity, scientific misconduct, and intellectual property (41,42,43,44).

In epidemiology, ethics should include not only core values and mission, but also obligations to participate in research and obligations to colleagues and employers. The challenge is to ensure their utility and impact (45). As molecular epidemiology, genetic epidemiology, and other fields advance, ethical considerations become more important and complicated (46).

Conclusion

Epidemiologists play critical roles in public health as well as clinical practice. For early detection and prevention of epidemics and health disasters, effective liaison between epidemiologists, clinicians of various specialties, and policymakers is required. This is especially important in developing and developed countries where the number of epidemiologists is low and the majority work in teaching institutions where their contributions are undervalued. Each country must develop standards for epidemiologic practice in terms of training, competencies, responsibilities, and ethics.

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