SECTION 1

Evidence-Based Approaches to Public Health

CHAPTER 1

Epidemiologic Methods Applied in Various Settings of Public Health Practice

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Background

Epidemiology—with its primary goals of determining the causes and extent of disease, investigating the natural history of disease, evaluating preventive and therapeutic interventions, and informing public health policy and preventive medicine guidelines—contributes significantly to the mission of public health.[1,2] Epidemiologic methods are employed in a variety of study designs, and serve as powerful tools that find application in a broad range of public health settings. In this chapter, the utilization of epidemiologic methods to confront important health problems in a number of settings is described.

Setting 1: Public Health Surveillance

As an important tool to estimate the health status and behavior of a community, public health surveillance provides and interprets data to promote disease prevention and control.[3] The Behavioral Risk Factor Surveillance System (BRFSS), one such surveillance program, is an ongoing nationwide adult telephone survey conducted monthly, which collects data about behavior risk factors, chronic health conditions,

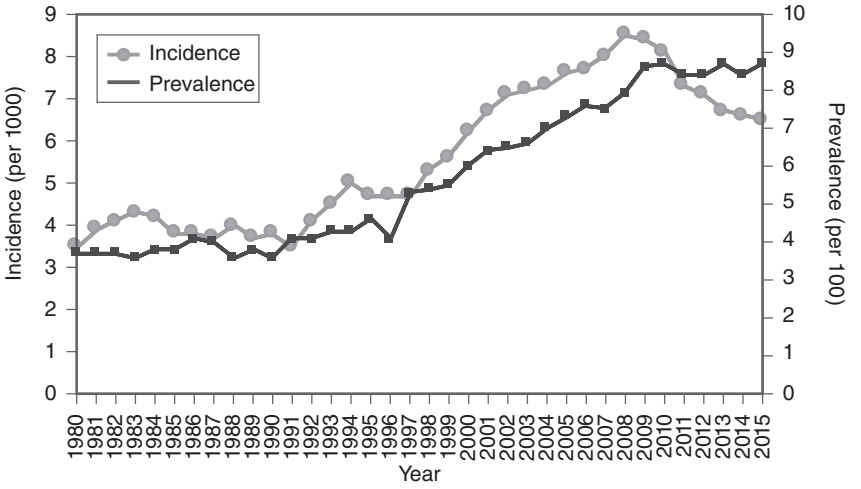

FIGURE 1-1 Trends in incidence and prevalence of diagnosed diabetes among U.S. adults, 1980–2015.

Data from: Centers for Disease Control and Prevention. (2018). *Diabetes report card 2017*. Retrieved from https://www.cdc.gov/diabetes/library/reports/congress.html

and use of preventive services.[4] Information collected in the BRFSS is applied in several important public health practices, one of which is the U.S. Diabetes Surveillance System (DSS). The DSS utilizes data from the BRFSS and the U.S. Census Bureau's Population Estimates Program to estimate and interpret annual prevalence and incidence of diagnosed diabetes at the county, state, and national levels.[5]

FIGURE 1-1 is reproduced from the Diabetes Report Card 2017,[6] which is a Centers for Disease Control and Prevention (CDC) publication based on findings from the DSS. This figure depicts the trends of incidence and prevalence of diabetes from 1980 to 2015. Both estimates show a steady increase over the years. However, there was a decreasing trend in incidence of diabetes from approximately 8.7 per 1000 population at risk in 2008 to 6.5 per 1000 in 2015. Estimates and trends such as these not only inform us about disease burden but also serve as an evaluation tool to assess the effectiveness of the existing intervention programs.

Setting 2: Public Health Research Studies

Prospective cohort studies are used to evaluate the *incidence* of a specified disease over time, and to determine whether there is a difference in disease incidence between study participants with and without an *exposure* of interest. An example of this type of study is the *Framingham Heart Study*, which is one of the most widely recognized and informative epidemiologic studies on the frequency and determinants of cardiovascular disease (CVD) conducted within the community setting.[7] Beginning in 1949, a general population sample of 5209 women and men, age 30–62 years, residing in the middle-class, relatively stable community of Framingham, Massachusetts, completed *baseline* assessments that included a blood collection, resting blood pressure and electrocardiogram, physical measures, and a detailed medical history. Every 2 years the examinations were repeated to update exposure information and to identify cases of CVD that had occurred since the previous visit.

The originally enrolled cohort represented 68% of the community members eligible, which requires epidemiologists to consider the extent to which this might introduce a *selection bias* in subsequent study results. *Follow-up* for incident cases of CVD over time, which is a critical component of the prospective cohort design, has been exceptional, with a greater than 95% completion rate. This high completion rate decreases the risk of a *loss to follow-up bias*.

One of the exposures of high interest in the Framingham Heart Study was resting blood pressure (BP), and its relationship with future development of CVD (e.g., heart attack, stroke). Adults who were without CVD at baseline had their BP measured and then were followed for an average of 11 years, during which 397 incident CVD cases were documented.[8] **FIGURE 1-2** shows the study findings. In both women and men, there is a *positive association* between baseline BP level and CVD incidence. The results shown are *adjusted* for age (a possible *confounder*) and are *sex-specific* (shown separately for women and men). Note that CVD incidence is higher in men than in women at each level of BP. The *relative risk* (incidence in exposed/incidence in nonexposed) can be used to compare CVD incidence between BP groups. In women, compared to those with the lowest BP (incidence = 1.9), the relative risks of incident CVD are 1.47 (3.8/1.9) and 2.32 (4.4/1.9) for those in the middle and highest categories, respectively. In other words, women in the middle and highest BP categories had 47% and 132% higher age-adjusted incidence of CVD as compared to women with the lowest BP.

Experimental studies, often called *randomized clinical trials* (or prevention trials), provide the strongest evidence of causality. In these studies, consenting and enrolled study participants are *assigned randomly*, or by *chance*, to be in the exposed (*intervention*) or nonexposed (*control*) group. Chance assignment balances all characteristics of participants between groups so that the only difference is

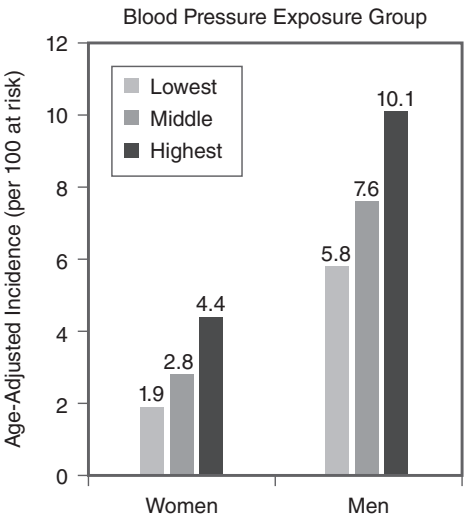

FIGURE 1-2 Cumulative incidence of CVD in adults followed for 11 years in the Framingham Heart Study.

Data from: Vasan, R. S., Larson, M. G., Leip, E. P., Evans, J. C., O'Donnell, C. J., Kannel, W. B., & Levy, D. (2001). Impact of high-normal blood pressure on the risk of cardiovascular disease. *New England Journal of Medicine, 345*(18), 1291–1297. doi:10.1056/NEJMoa003417

being exposed or not exposed. The study then proceeds much like the cohort study, with follow-up over time for incident disease and comparison of disease incidence between the intervention and control groups.

The *SPRINT trial* is a randomized prevention trial that evaluated whether lowering BP in adults with hypertension would decrease CVD incidence.[9] A total of 9361 adults, who had high BP at enrollment, were randomized to intensive drug therapy or usual treatment for hypertension and then followed for an average of 3 years for development of CVD. The incidence of CVD in the intervention group (intensive therapy) was 1.65 per 100 at risk per year, while the incidence of CVD in the control group (standard treatment) was 2.19 per 100 at risk per year. These results showed a clear benefit for CVD prevention in participants receiving intensive BP treatment as compared to those who received usual care. Because the intervention was assigned randomly, the assumption is that nothing other than exposure status differed between groups; thus the only factor that plausibly explains the difference in CVD incidence is exposure to the intervention. That is, the exposure caused the disease incidence to be lower in one group compared to the other. Importantly, results of observational studies, such as prospective cohorts, inform development and completion of randomized prevention trials to further evaluate a specific exposure–disease relationship in a manner that is most conclusive for cause and effect.

Setting 3: Outbreak Investigation

Outbreak investigation is one of the key applications of epidemiology in public health practice. "*Outbreak epidemiology* is the investigation of a disease cluster or epidemic with the goal of controlling or preventing further disease in a population."[10] Every outbreak investigation is handled slightly differently due to the varying nature of outbreaks. As a result, it is useful to utilize a systematic process when engaging in an outbreak investigation. The CDC has developed a list of steps (**FIGURE 1-3**) that investigators can apply when managing an outbreak.[3] Note that the

1. Prepare for field work
2. Establish the existence of an outbreak
3. Verify the diagnosis
4. Construct a working case definition
5. Find cases systematically and record information
6. Perform descriptive epidemiology
7. Develop hypotheses
8. Evaluate hypotheses epidemiologically
9. As necessary, reconsider, refine, and re-evaluate hypotheses
10. Compare and reconcile with laboratory and/or environmental studies
11. Implement control and prevention measures
12. Initiate or maintain surveillance
13. Communicate findings

FIGURE 1-3 Epidemiologic steps of an outbreak investigation.

Reproduced from: Centers for Disease Control and Prevention. (2012). *Principles of epidemiology in public health practice: An introduction to applied epidemiology and biostatistics.* Retrieved from https://www.cdc.gov/ophss/csels/dsepd/ss1978/ss1978.pdf

steps may not be performed in this specific order and that multiple steps may be occurring simultaneously.

An *influenza outbreak at a military transit center in Kyrgyzstan* is reviewed here to illustrate a number of steps listed in Figure 1-3. The details of this outbreak have been published, and the features discussed here were derived from this publication.[11] The Transit Center at Manas, Kyrgyzstan, was the former gateway to Afghanistan; all troops moving into and out of Afghanistan passed through Manas. During the month of December 2013, only 7 individuals with influenza-like illness (ILI) had sought medical attention and 0 cases of influenza had been diagnosed. In early January 2014, medical personnel at Manas began to see a significant increase in the number of individuals seeking medical attention for ILI; on January 4, the first confirmed case of influenza was diagnosed. By mid-January, numerous individuals with ILI were seeking medical attention daily and more cases of influenza were being confirmed daily via laboratory analysis (**Step 3**). During the first 2 weeks of January, medical personnel identified 18 cases of laboratory-confirmed influenza, whereas 0 cases had been confirmed during the previous month of December. Medical personnel were aware that they were seeing a higher number of cases than expected, which helped to establish the existence of an outbreak (**Step 1**).

A *case definition* "is a standard set of criteria for deciding whether an individual should be classified as having the health condition of interest."[3] The following influenza-like illness case definition was established for this outbreak: oral temperature of 100.5°F or higher and cough or sore throat. Individuals considered to be cases of influenza were those with laboratory confirmation of influenza (**Step 4**). Laboratory confirmation was obtained by collecting respiratory specimens from ILI patients and testing the specimens for influenza A and B via polymerase chain reaction (PCR) (**Step 10**). Manas public health personnel maintained updated electronic line lists of all cases of ILI and confirmed influenza cases involved in the outbreak. Additional demographic and clinical information was collected for each case (**Step 5**). A total of 215 individuals met the case definition for ILI, and 85 individuals were determined to be laboratory-confirmed cases of influenza. All laboratory-confirmed influenza cases had been vaccinated (**Step 6**).

Public health personnel at Manas implemented numerous control measures to mitigate the outbreak. Isolation of influenza patients was the primary measure utilized; additional measures included strict hand washing, cough etiquette, education and awareness campaigns, and administration of antiviral medication for both the treatment and prevention of influenza (**Step 11**).

The last case of influenza occurred on February 14, 2014. The Transit Center at Manas continued to surveil for influenza-like illness cases until June 2014, when the Center was turned over to the Kyrgyz Republic (**Step 12**). Details of the outbreak as well as the outbreak response were communicated in various ways, including situation updates, influenza surveillance reports, and a published report in an academic military journal (**Step 13**).

Epidemiologic outbreak investigations like the one described here can help identify the etiology or cause of the outbreak, inform public health practitioners regarding proper control measures to mitigate the outbreak, and inform preventive measures that can be utilized to avert a similar outbreak in the future.

Summary Points

To sum up the review presented here, epidemiologic methods find significant application in the following areas:

1. The surveillance of important diseases to estimate their burden in the community and monitor trends over time, which helps in the planning and evaluation of intervention programs
2. Identifying risk factors of disease, and developing and evaluating therapeutic interventions
3. Investigating the etiology of outbreaks and informing control and preventive measures to confront and prevent similar outbreaks in the future

Application of CEPH MPH Competencies

This case study addresses CEPH competencies 1, 2, 3, 4, and 5.

Competency 1: Apply Epidemiological Methods to the Breadth of Settings in Public Health Practice

In addition to the three previously mentioned areas, epidemiologic methods find their application in several other settings in public health practice: (1) identifying and prioritizing key health issues affecting the community; (2) developing and evaluating screening programs for deadly diseases such as cancer, enabling early treatment, and enhancing survival rates; and (3) evaluating the impact of public health interventions and policies.

Competency 2: Select Quantitative and Qualitative Data Collection Methods Appropriate for a Given Public Health Context

The BRFSS conducts telephone surveys to collect various quantitative data such as age, height, and weight.[12]

Competency 3: Analyze Quantitative and Qualitative Data Using Biostatistics, Informatics, Computer-Based Programming, and Software, as Appropriate; Competency 4: Interpret Results of Data Analysis for Public Health Research, Policy, and Practice

As described in the three previously mentioned settings, data collected using various study designs are analyzed using appropriate statistical methods and analytical software to derive useful study estimates such as incidence, prevalence, and relative risks. Careful and accurate interpretation of these estimates contributes to public health research and facilitates development of guidelines for public health policy and practice.

Competency 5: Design a Population-Based Policy, Program, Project, or Intervention

The application of epidemiologic evidence from observational studies and randomized prevention trials to clinical and public health practice is best appreciated through the development and implementation of guidelines aimed at improving population health. An example is the recently published blood pressure guidelines in the United States.[13] Evidence from several published studies, utilizing a variety of study designs, including the two studies referenced previously, were evaluated by an expert panel. This panel then wrote practice guidelines to aid healthcare providers in managing the blood pressure of their patients, and to aid public health practitioners in developing community-level education and screening programs.

Discussion Questions

1. How can you evaluate the effectiveness of an intervention program designed to reduce disease burden in the community using public health surveillance?
2. How do prospective cohort studies and randomized controlled trials differ in their application in public health practice?
3. Discuss the principal findings from the Framingham Heart Study and the *SPRINT trial* on the relationship between blood pressure and cardiovascular disease.
4. When engaging in an epidemiologic outbreak investigation, why is it important to uncover the etiology or cause of the outbreak?
5. If you were asked to identify the three most important steps of an outbreak investigation, which would you identify and why?

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