In one sense, epidemiology is as old as medicine itself. Hippocrates, considered the father of modern medicine, first suggested in the fifth century B.C. that the development of human disease might be related to the external as well as personal environment of an individual [13].

> 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 waters 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.

For the next 2000 years, such causes of disease were considered, but without any attempt to measure their impact. Then, in 1662, a London haberdasher named John Graunt published *The Nature and Political Observations Made Upon the Bills of Mortality,* in which he analyzed the weekly reports of births and deaths in London and, for the first time, quantified patterns of disease in a population [10]. He noted an excess of men compared with women for both births and deaths, the high infant mortality rate, and the seasonal variations in mortality alluded to by Hippocrates. Graunt also attempted to provide a numerical assessment of the impact of plague on the population of the city and examined characteristics of the years in which such outbreaks occurred. His recognition of the value of routinely collected data in providing information about human illness forms the basis of modern epidemiology.

These new techniques saw little further application for almost two centuries, until William Farr, a physician, was given responsibility in 1839 for medical statistics in the Office of the Registrar General for England and Wales. Farr set up a system for routine compilation of the numbers and causes of deaths, and his Annual Reports of the Registrar General during the next 40 years established a tradition of careful application of vital statistical data to the evaluation of health problems of the general public. Like Graunt, Farr recognized that data collected from human populations could be used to learn about illness. He compared mortality patterns of married and single persons, as well as those of workers in different occupations, such as metal mines and the earthenware industry. He noted the association between elevation above sea level and deaths from cholera, and attempted to ascertain the effect of imprisonment on mortality [14]. In doing this, he had to address many major methodologic issues relevant to modern epidemiologic studies, such as defining the exact population at risk, choosing an appropriate comparison group, and considering whether other factors could affect the results, such as age, duration of exposure, or general health status.

Hippocrates, Graunt, and Farr each contributed to an increasing sophistication in the understanding of disease frequency and distribution—two of the three components of the definition of epidemiology. Two decades after Farr began his work, the availability of routinely collected data on the population and mortality patterns of England enabled another **British physician, John Snow, to formulate and test a hypothesis concerning the origins of an epidemic of cholera in London** [20]. On the basis of the available descriptive data, including the observations made by Farr, Snow postulated that cholera was transmitted by contaminated water through a then unknown mechanism. He observed that death rates from cholera were particularly high in areas of London that were supplied with water by the Lambeth Company or the

Southwark and Vauxhall Company, both of which drew their water from the Thames River at a point heavily polluted with sewage. Between 1849 and 1854, the Lambeth Company changed its source to an area of the Thames where the water was "quite free from the sewage of London." The rates of cholera declined in those areas of the city supplied by the Lambeth Company, while there was no change in those areas receiving water from the Southwark and Vauxhall Company.

Table 1.1. Death rates from cholera, 1853-1854, according to water company supplying subdistrict of London

Water company	Population in 1851	Cholera deaths in 1853 - 1854	Deaths per 100,000 living
Southwark and Vauxhall	167,654	192	114
Both companies	301,149	182	60
Lambeth	14,632	0	0

Source: J. Snow, *On the Mode of Communication of Cholera* (2nd ed). London: Churchill, 1855. Reproduced in *Snow on Cholera.* New York: Hafner, 1965.

In 1854, Snow [20] noted that "the most terrible outbreak of cholera which ever occurred in this kingdom, is probably that which took place in Broad Street, Golden Square and the adjoining streets, a few weeks ago. Within two hundred and fifty yards of the spot where Cambridge Street joins Broad Street, there were upwards of five hundred fatal attacks of cholera in ten days." As shown in Table 1.2, Snow tabulated the number of deaths from cholera that occurred from the commencement of the epidemic in August 1853 to January 1854 according to the two water companies supplying the various subdistricts of London. The areas of London supplied by the Southwark and Vauxhall Company experienced a rate of 114 deaths from cholera per 100,000 persons, whereas there were no deaths from cholera during that time in the districts supplied entirely by the Lambeth Company. A large area supplied by both companies experienced a rate midway between those for the districts supplied by either alone.

These observations were consistent with Snow's hypothesis that drinking water supplied by the Southwark and Vauxhall Company increased the risk of cholera compared with water from the Lambeth Company. Snow also recognized the possibility that many factors other than the water supply differed between the two geographic areas and thus could account for the observed variation in cholera rates. His unique contribution to epidemiology lies in his recognition of an opportunity to test the hypothesis implicating the water supply. Snow [20] outlined his natural experiment in his book *On the Mode of Communication of Cholera:*

> In the subdistricts enumerated in the above table as being supplied by both Companies, the mixing of the supply is of the most intimate kind. The pipes of each Company go down all the streets, and into nearly all the courts and alleys. A few houses are supplied by one Company and a few by the other, according to the decision of the owner or occupier at that time when the Water Companies were in active competition. In many cases a single house has a supply different from that on either side. Each company supplies both rich and poor, both large houses and small; there is no difference either in the condition or occupation of the persons receiving the water of the different Companies. Now it must be evident that, if the diminution of cholera, in the districts partly supplied with the improved water, depended on this supply, the houses receiving it would be the houses enjoying the whole benefit of the diminution of the malady, whilst the houses supplied with the water from Battersea Fields [the Southwark and Vauxhall Company] would suffer the same mortality as they would if the improved supply did not exist at all. As there is no difference whatever, either in

> the houses or the people receiving the supply of the two Water Companies, or in any of the physical conditions with which they are surrounded, it is obvious that no experiment could have been devised which would more thoroughly test the effect of water supply on the progress of cholera than this, which circumstances placed ready made before the observer.
>
> The experiment, too, was on the grandest scale. No fewer than three hundred thousand people of both sexes, of every age and occupation, and of every rank and station, from gentlefolks down to the very poor, were divided into two groups without their choice, and, in most cases, without their knowledge, one group being supplied with water containing the sewage of London, and amongst it, whatever might have come from the cholera patients, the other group having water quite free from such impurity.
>
> To turn this grand experiment to account, all that was required was to learn the supply of water to each individual house where a fatal attack of cholera might occur.

Within the area supplied by both companies, Snow walked from house to house and, for every dwelling in which a cholera death had occurred was able to determine which company supplied the water. The death rates from cholera according to source of water supply are shown in Table 1-2. These data provided Snow with convincing evidence that water supplied by the Southwark and Vauxhall Company was responsible for the outbreak of cholera in London. Thus, Snow charted the frequency and distribution of cholera and also ascertained a cause, or determinant, of the outbreak. In so doing, he was perhaps the first investigator to draw together all three components of the definition of epidemiology.

Table 1.2 Death rates from cholera in London, 1853-1854, according to water company supplying actual house

Water company	No. of houses	Deaths from cholera	Deaths per 10,000 houses
Southwark and Vauxhall	40,046	1263	315
Lambeth	26,107	98	37
Rest of London	256,423	1422	59

Source: J. Snow, *On the Mode of Communication of Cholera* (2nd ed). London Churchill, 1855. Reproduced in *Snow on Cholera.* New York: Hafner, 1965.

John Snow's investigation of the cholera epidemic of 1853 to 1854 utilized the approach that epidemiologists still use today. Both his clinical knowledge and observations concerning the distribution of cholera rates helped formulate the hypothesis that the disease was spread through the water supply. He then proceeded to test this hypothesis, while recognizing the need to allow for evaluation of alternative explanations for his observations. This approach was applied primarily to outbreaks of infectious diseases throughout the nineteenth and early twentieth centuries. Thus, the term *epidemiology* was originally used almost exclusively to mean the study of epidemics of infectious disease. Over the past 80 years, patterns of mortality in developed countries have changed markedly, with chronic diseases assuming increasing importance. As a consequence, the concept of an epidemic has become much broader and more complex, necessitating more advanced methods than those first developed by Snow.