Introduction to and History of Epidemiology

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Lecture Contents….

1. Epidemiology defined.
2. The components of epidemiology
3. Major examples of epidemiologic investigation.
4. History of epidemiology

Definitions…

Epidemiology is a core science of public health.

Public health

The science & art of

Preventing disease,
prolonging life, and
promoting health & efficiency
through organized community effort

(Winslow, 1920)

Definitions

Health: A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (WHO,1948)

Disease: A physiological or psychological dysfunction

Illness: A subjective state of not being well

Sickness: A state of social dysfunction

Definitions

Epidemiology

The science of the mass phenomena of infectious diseases or the natural history of infectious diseases. (Frost 1927)

The science of infective diseases, their prime causes, propagation and prevention. (Stallbrass 1931.)

Definitions…

Epidemiology

"The study of the distribution and determinants of health-related states or events in specified populations, and the application of the study to the control of health problems".

(J.M. Last 1988)

Epidemiology as a Science and a Method

Epi = upon, among

Demos = people

Ology = science, study of

Epidemiology = the science or the study of diseases in populations

It is the scientific method of disease investigation – Typically, it involves the disciplines of biostatistics and medicine.

Components of the definition

Study: Systematic collection, analysis and interpretation of data

Epidemiology involves collection, analysis and interpretation of health related data

Epidemiology is a science

Components of epidemiology

Distribution: Epidemiology is concerned with the frequency and pattern of health events in a population:

Disease frequency: The core characteristics of epidemiology are to measure the frequency (number of cases) of diseases, disability or death in a specified population.

It is always as a rate, ratio and proportion.

This falls in the domain of biostatistics, which is a basic tool of epidemiology.

Components of epidemiology

Disease frequency:

E.g. Prevalence, Incidence rates, Death rate etc.

These rates are essential for comparing the disease frequency in different populations or sub groups of the same population

Components of epidemiology

Distribution….. The study of the pattern of an event by person, place and time.

Epidemiology studies distribution of diseases among subgroups of the population, in certain geographic areas, and also any increase or decrease over time.

It answers the question who, where and when? This is descriptive epidemiology.

An important outcome of this step is formulation of etiological hypothesis

PERSON DISTRIBUTION

- In descriptive studies disease is further characterized by defining the persons who develop the disease by age, gender, ethnicity, occupation, marital status, habits, social class & other host factors.

- These host factors help us to understand the natural history of disease.

PLACE DISTRIBUTION

- Study of the geography of the disease (geographical pathology) is one of the important dimensions of epidemiology.
- With the geographical pathology we learn the differences in disease patterns between two geographical areas (e.g. international, national, or urban/rural differences).
- These variations may be due to variations in population density, social class, deficiencies in health services, levels of sanitation, education & environmental factors.

TIME DISTRIBUTION

- The pattern of a disease may be described by the time of occurrence
- The occurrence of disease changes over time.
- Some of these changes occur regularly, while others are unpredictable.
- Two diseases that occur during the same season each year include influenza (winter) and West Nile virus infection (August– September).
- In contrast, diseases such as hepatitis B and salmonellosis can occur at any time.
- Day of the week or time of the day may be important.

TIME DISTRIBUTION

Epidemiologists have identified three kinds of time trends or fluctuations in disease occurrence:

1. Short term fluctuation: Single (one incubation period and one peak)(e.g. food poisoning)

   or multiple or continuous exposure (well of contaminated water-cholera)

   Minamata disease in Japan??

2. Periodic fluctuation:

   Seasonal: GI infection in Summer

   Cyclic: Influenza every 7-10 years..antigenic variations).

3. Long–term or Secular trend (e.g. CVD, lung cancer)

Components of the Definition of Epidemiology

Determinants:

Factors the presence/absence of which affect the occurrence and level of a health event.

Epidemiology studies what determines or influences health events:

- ✓ **It answers the question: how and why?**
- ✓ **Epidemiology analyzes health events "analytical epidemiology". Here we test a hypothesis to prove right or wrong.**
- ✓ **Analytical strategies help in developing scientifically sound health programes, interventions & policies.**

Components…

Health-related states and events

Epidemiology is not only the study of diseases.

The focus of Epidemiology is not only patients' health as individuals, but anything in the environment that may affect their health and well-being in any way.

- ✓ **It studies all health related conditions**
- ✓ **Epidemiology is a broad science**

Components…

Specified population

Epidemiology diagnoses and treats communities/populations

- ✓ The unit of study is a population (groups of people)
- ✓ Clinical medicine diagnoses and treats patients after they get sick and go seek physician's help.
- ✓ Epidemiology is a basic science of public health

Components…

Application

Epidemiological studies have direct and practical applications for prevention of diseases & promotion of health

- ✓ Epidemiology is a science and practice
- ✓ Epidemiology is an applied science

Epidemiology provides data essential to the planning, implementation & evaluation of services for the prevention, control & treatment of disease.

Objectives of Epidemiology

- Investigate the etiology of disease and modes of transmission
- Determine the extent of disease problems in the community
- Study the natural history and prognosis of disease
- Evaluate both existing and new preventive and therapeutic measures and modes of health care delivery
- Provide a foundation for developing public policy and regulatory decisions

Epidemiology

In Epidemiology, we ask the following questions related to the health event:

What is the event? (The Health problem).

What is the magnitude?

Where did it happen ?

When did it happen?

Who is affected?

Why did it happen?

Epidemiology

In Epidemiology, we ask the following questions related to the health action:

- What can be done to reduce this problem and its consequences?
- How can it be prevented in future?
- What action should be taken by the community? By whom should these activities be carried out?

Investigating an Outbreak

I Keep six honest serving-men:
(They taught me all I knew).
Their names are What and
Where and When And How and
Why and Who.

Rudyard Kipling (1865–1936)

Define **what** will be studied
Find out **where** the problem is
Who gets it , **When** it is occurring
Try to explain **why** the problem has such a distribution
Do specific studies to find out **how** the problem is occurring

Source: "The Elephant's Child" in Just So Stories by Rudyard Kipling

Photo source: http://www.online-literature.com/kipling

The Five Ws of Epidemiologic Studies

The Five Ws of Epidemiology Studies

- What = Clinical
- Who = Person
- Where = Place
- When = Time

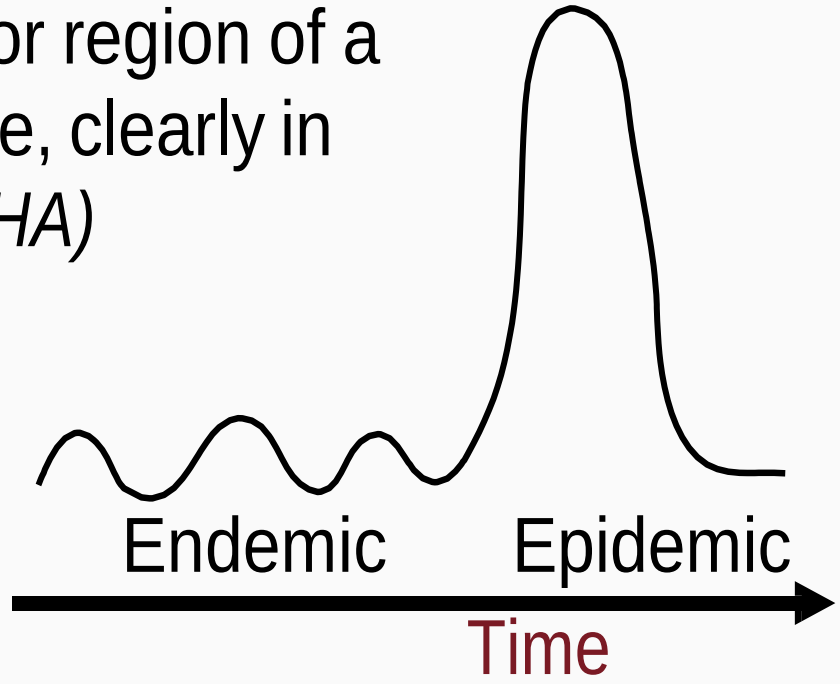
} Descriptive Epidemiology

- Why / How = Causes
  Risk factors
  Modes of transmission

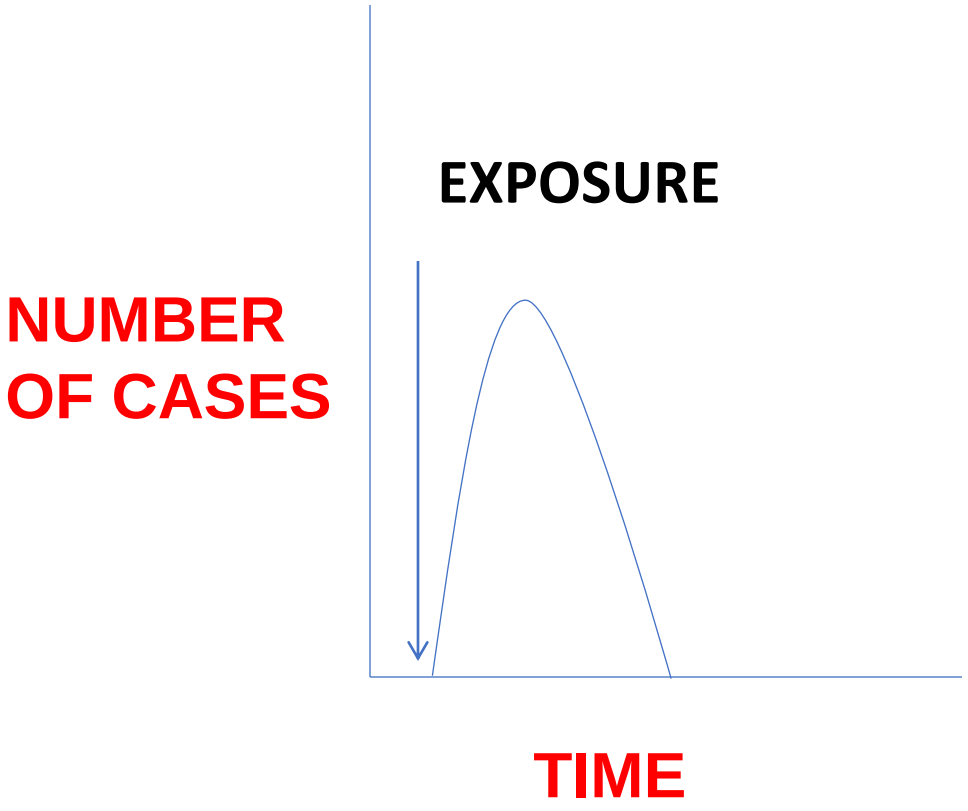
} Analytic Epidemiology

Definition of Endemic, Epidemic, and Pandemic

- **Endemic**
  - The habitual presence of a disease within a given geographic area
  - May also refer to the usual prevalence of a given disease within such an area *(APHA)*
- **Epidemic**
  - The occurrence in a community or region of a group of illnesses of similar nature, clearly in excess of normal expectancy *(APHA)*
  - Outbreak
- **Pandemic**
  - A worldwide epidemic



EPIDEMIC CURVE

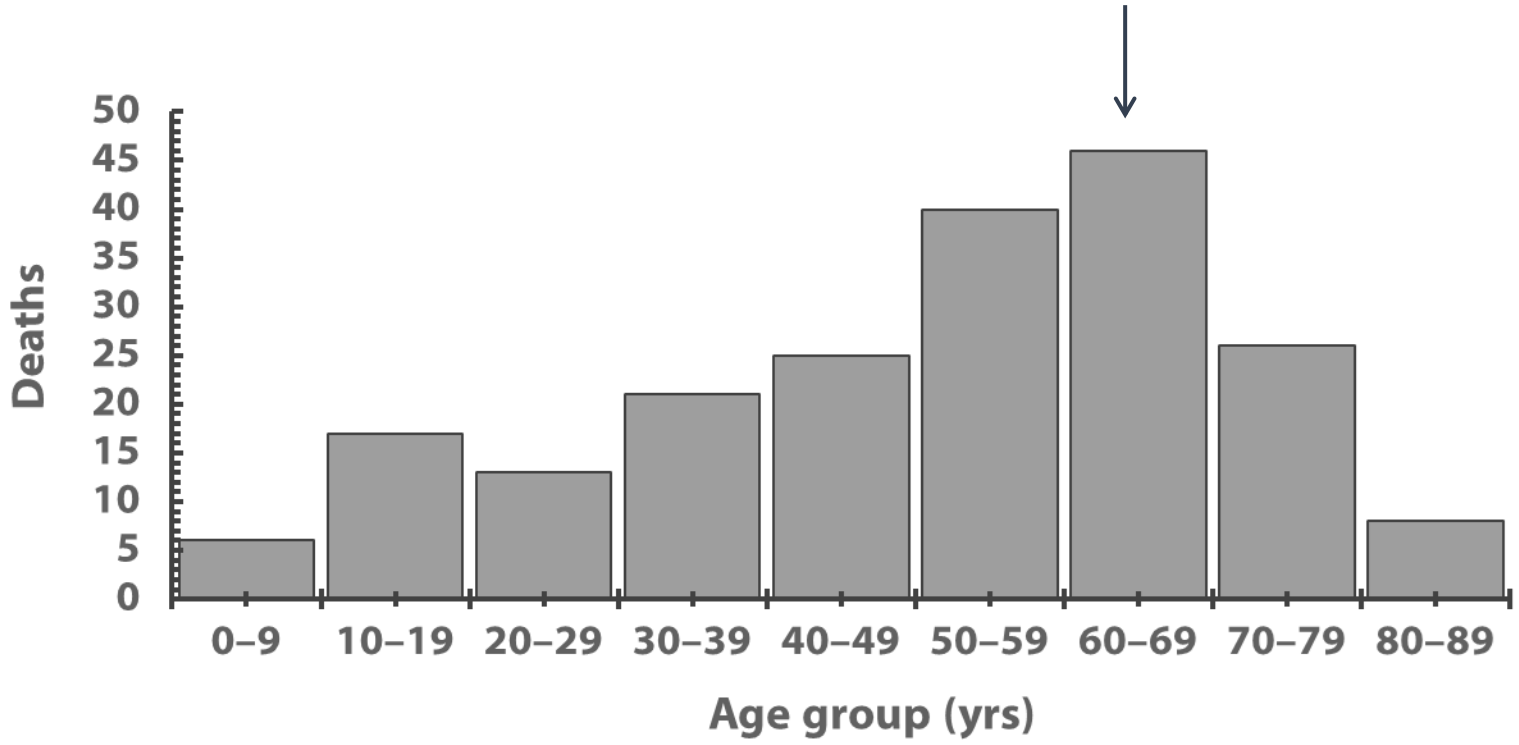


Fatalities Associated with Farm Tractors

In 1982, an epidemiologist studied the number of farm tractor-associated deaths in Georgia and described them in terms of time, place, and person by using death certificates and records from an existing surveillance system (All tractor related incidents between 1971-1981, N=166 cases).

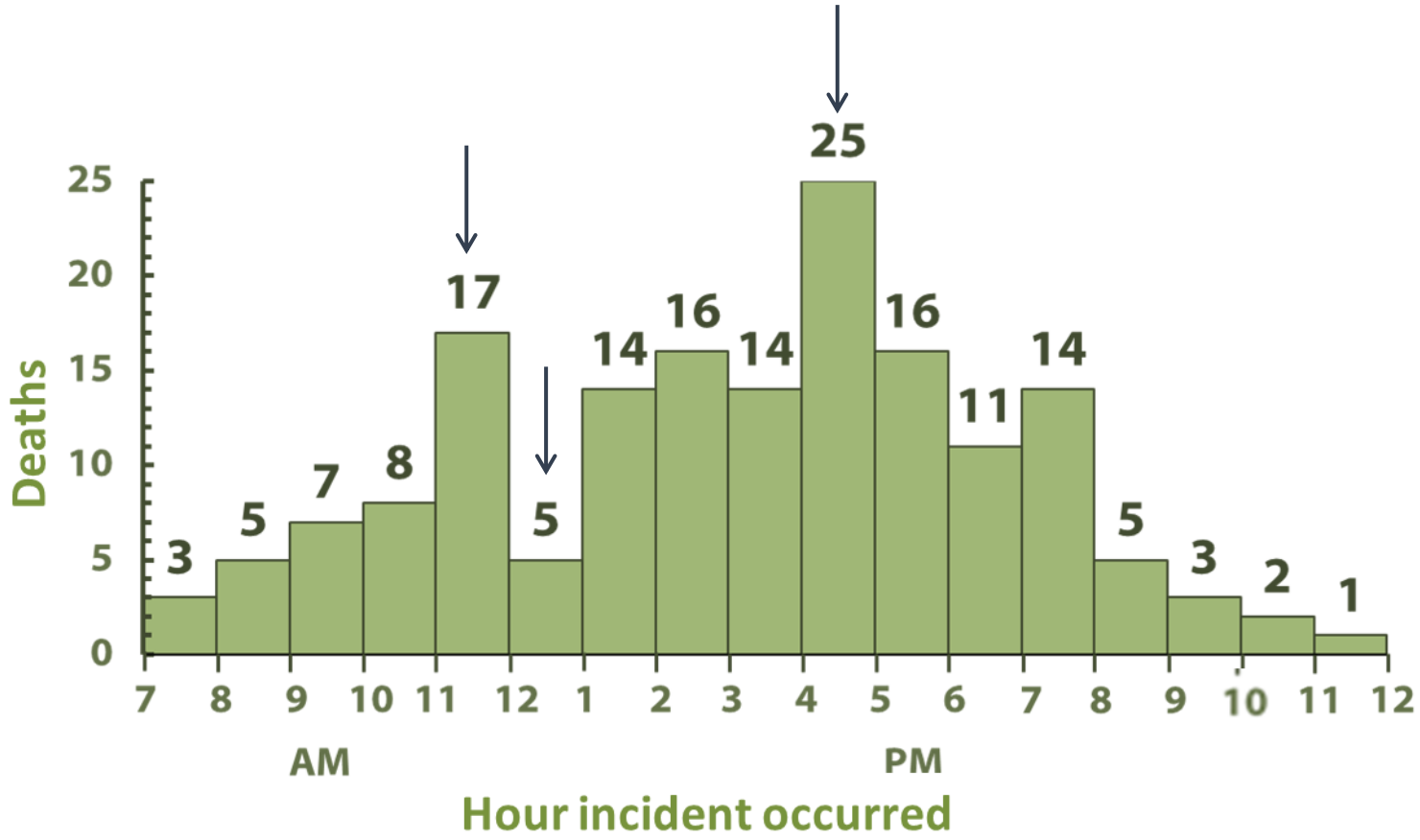
He then generated a hypothesis for further study. Let's look at the descriptive epidemiology (Who, When and Where….)

Fatalities Associated with Farm Tractors (person)



Goodman RA, Smith JD, Sikes RK, et al. Fatalities associated with farm tractor injuries: an epidemiologic study. Public Health Rep 1985;100: 329–33.

Fatalities Associated with Farm Tractors (time)



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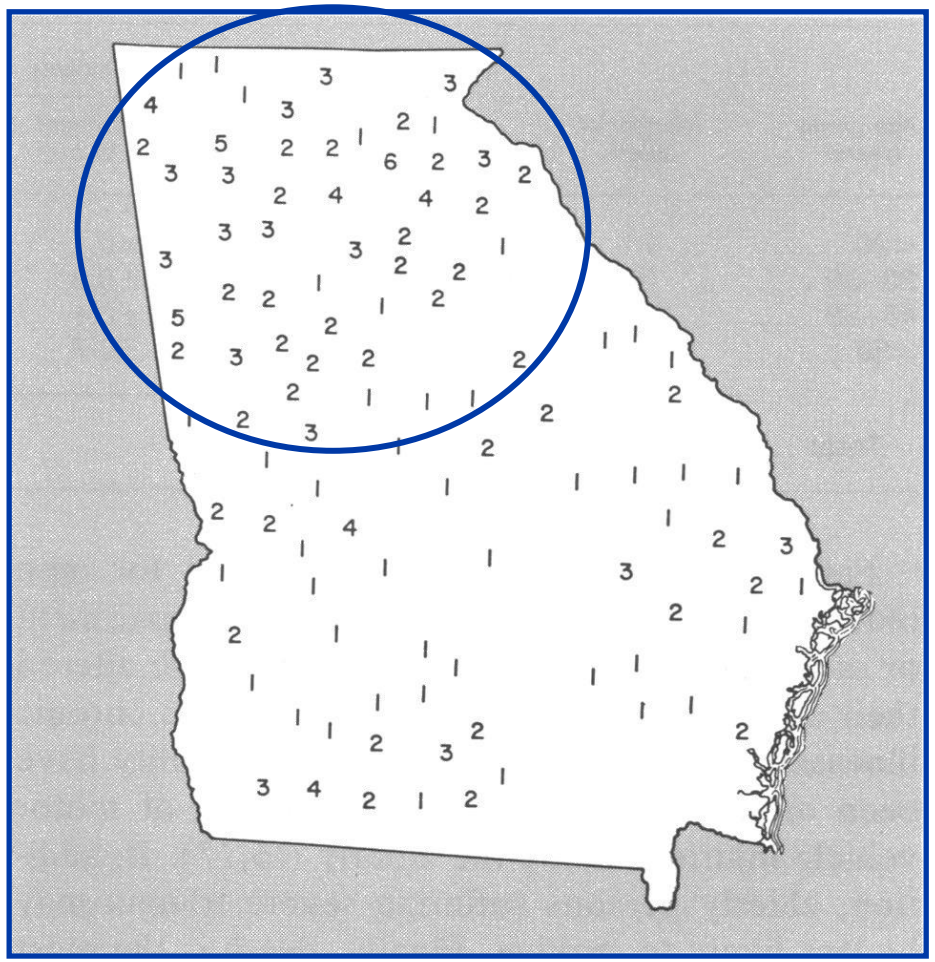
Fatalities Associated with Farm Tractors (place)



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Legionnaire's disease outbreak

- Members of the American Legion gathered for the annual American Legion Convention held July 21 through 24, 1976, in Philadelphia.
- Soon after the convention began, a substantial number of attendees were admitted to hospital emergency departments or were examined in doctors' offices with acute onset of fever, chills, headache, malaise, dry cough, and muscle pain.
- More troublesome is that during July 26 to August 1, a total of 18 conventioneers died, reportedly from pneumonia.
- On the morning of August 2, a nurse at a veterans' hospital in Philadelphia called CDC to report cases of severe respiratory illness among convention attendees.
- Subsequent conversations that day with public health officials uncovered an additional 71 cases among persons who had attended the convention.
- The goal was to find out why these conventioneers were becoming ill and, in some cases, dying!!!

Legionnaire's disease outbreak

American Legion Convention, Philadelphia, Pennsylvania

Health care provider at a veterans' hospital in Philadelphia calls CDC to report cases of severe respiratory illness among attendees of the American Legion Convention

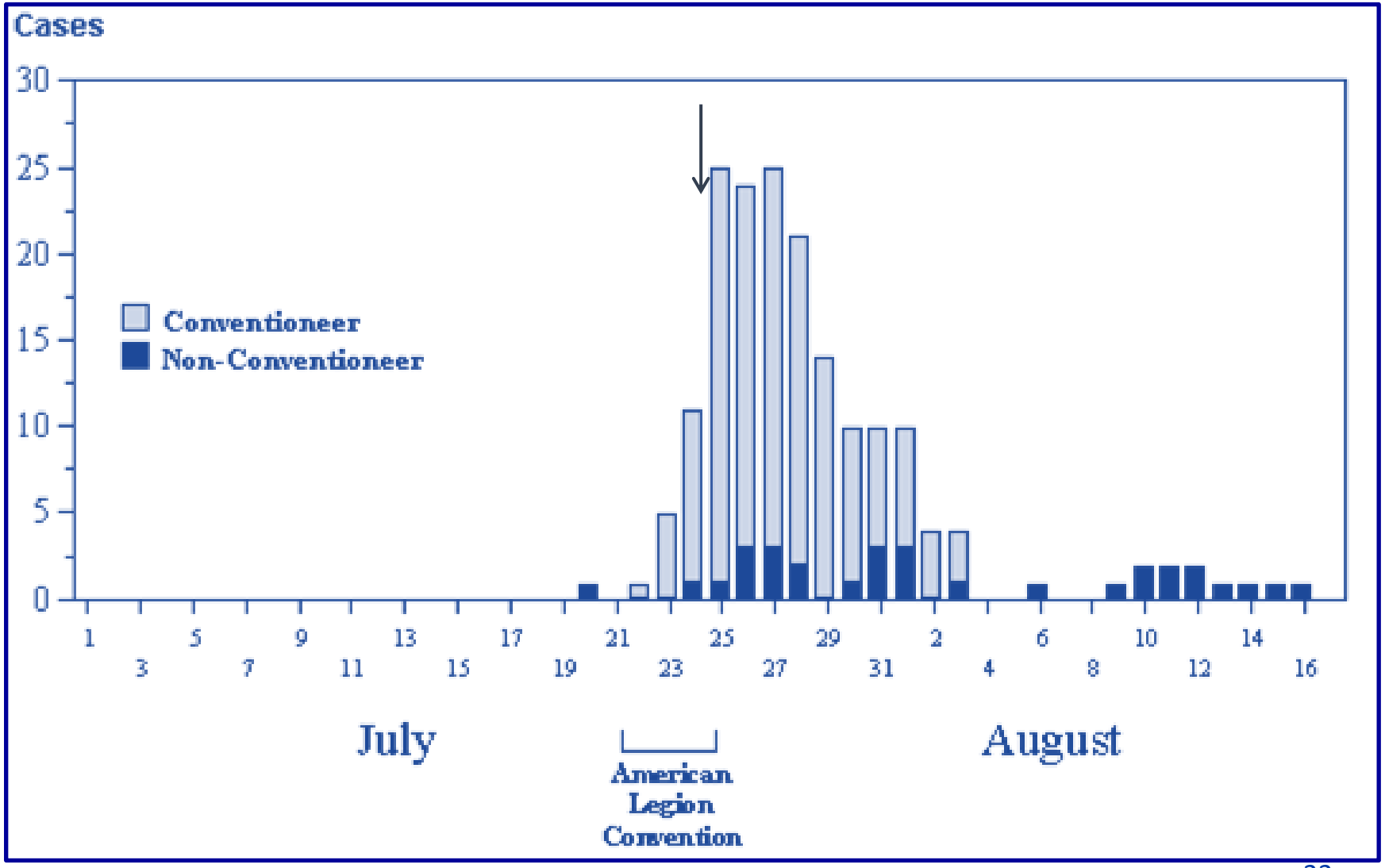
July 21–24 — July 26–Aug 1 — August 2 (Morning) — August 2 (Evening)

18 deaths reported among conventioneers

71 additional cases reported

Fraser DW, Tsai, T, Orenstein W, et al. Legionnaires' disease: description of an epidemic of pneumonia. New Engl J Med 1977;297:1189–97.

Legionnaires' Disease Cases, by Day



Fraser DW, Tsai, T, Orenstein W, et al. Legionnaires' disease: description of an epidemic of pneumonia. New Engl J Med 1977;297:1189–97.

Legionnaires' Disease Attack Rates by Place

	Hotel A			Hotel B			Hotel C		
Age (yrs)	Ill	Total	Percent ill	Ill	Total	Percent ill	Ill	Total	Percent ill
≤39	3	44	6.8	3	116	2.6	6	160	3.7
40–49	9	160	5.6	11	232	4.7	20	392	5.1
50–59	27	320	8.4	25	523	4.8	52	843	6.2
60–69	12	108	11.1	19	207	9.1	31	315	9.8
≥70	11	54	20.4	5	76	6.5	16	130	12.3
Unknown	0	2	0	0	7	0	0	9	0
Total	62	688	9.0	63	1,161	5.4	125	1,849	6.8

Those who stayed in Hotel A have the highest percentage of illness — 9.0% versus 5.4% and 6.8 at other hotels (% Ill in Hotel A= 62 / 688 = 9.0%).

The age group that has the highest percentage of ill persons is those aged 70 years or older (% Ill in >70y in Hotel A = 11 / 54 = 20.4%)

Legionnaires' Disease Rate by Age Group

Hotel A Residents

Time: July 21–24, 1976

	Frequency	Unit	Rate
Age (yrs)	Sick	Total	Percentage
≥39	3	44	6.8
40–49	9	160	5.6
50–59	27	320	8.4
60–69	12	108	11.1
≥70	11	54	20.4
Unknown	0	2	0

Those who stayed in Hotel A have the highest percentage of illness — 9.0% versus 5.4% and 6.8 at other hotels (% Ill in Hotel A= 62 / 688 = 9.0%)..

The age group that has the highest percentage of ill persons is those aged 70 years or older (% Ill in >70y in Hotel A = 11 / 54 = 20.4%)

Legionnaires' Disease

The age group that has the highest percentage of ill persons is those aged 70 years or older, regardless of where they were staying.

Combining all age groups, those who stayed in Hotel A have the highest percentage of illness — 9.0% versus 5.4% at other hotels.

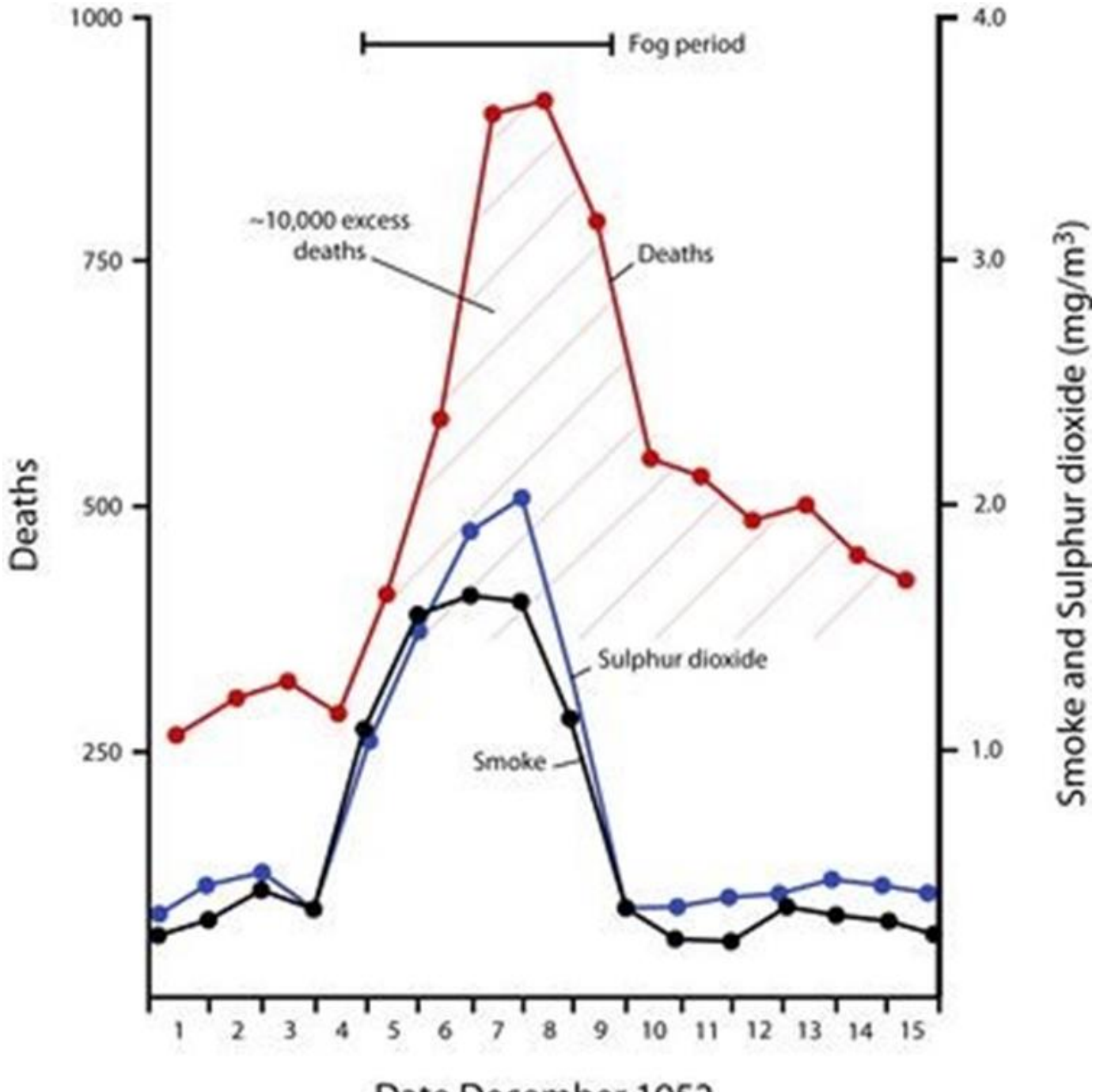
We can infer, therefore, that a connection exists between staying in Hotel A and becoming ill; we can also infer that older persons are somehow more susceptible to the disease.

Legionnaires' Disease

- Five months after the first cases of Legionnaires' disease occurred, results of the case-control study indicated that spending time in the lobby of Hotel A was a risk factor for illness
- In January 1977, the *Legionella* bacterium was finally identified and isolated and was found to be breeding in the cooling tower of the hotel's air-conditioning system; the bacteria then spread through the building whenever the system was used.
- Similar bacteria grew in warm waters in nature, such as hot springs, and also had been identified in air-conditioning cooling towers.
- The finding from this outbreak investigation lead to development of new regulations worldwide for air conditioning systems.

London Smog Disaster, 1952

- Air pollution causes respiratory illnesses and death.
- When fog and soot from coal burning created a dense smog in Winter, 1952, in London, the smog was around for five days from December 5–10.
- There was a substantial increase in mortality
- The death rate in London in the previous week was around 2,062
- In the week of the smog, 4,703 died


Fog period
~10,000 excess deaths
Deaths
Sulphur dioxide
Smoke
Deaths
Smoke and Sulphur dioxide (mg/m3)
1000
750
500
250
4.0
3.0
2.0
1.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Epidemiology and Polio Vaccine

In April, 1955, Dr. Thomas Francis, director of Poliomyelitis Vaccine Evaluation Center at the University of Michigan, announced that the two-year field trial of the Salk vaccine against polio was up to 90% effective

“The results announced by Francis effectively marked the beginning of the end of polio as the most life-threatening and debilitating public health threat to the children of the United States“.

Scope of Epidemiology

Originally, Epidemiology was concerned with investigation & management of ***epidemics*** of communicable diseases

Lately, Epidemiology was extended to endemic communicable diseases and non-communicable diseases

Recently, Epidemiology can be applied to ***all*** diseases and other health related events

History of Epidemiology

Seven land marks in the history of Epidemiology:

1) Hippocrates (460BC): Environment & human behaviors affects health
2) John Graunt (1662): Quantified births, deaths and diseases.
3) Lind (1747): Scurvy could be treated with fresh fruit
4) William Farr (1839): Established application of vital statistics for the evaluation of health problems.

History…

5) John Snow (1854): tested a hypothesis on the origin of an epidemic of cholera in London.
6) Alexander Louis (1872): Systematized application of numerical thinking (quantitative reasoning).
7) Bradford Hill (1937): Suggested criteria for establishing causation.

History…

- ✓ **Epidemiological thought emerged in 460 BC**
- ✓ **Epidemiology flourished as a scientific discipline in 1940s**

John Snow (1813–1858)

- An English physician and modern-day father of epidemiology
- He used scientific methods to identify the cause of the epidemic of cholera in London in 1854
- He believed that it was the water pump on Broad Street that was responsible for the disease
  - The removal of the pump handle ended the outbreak

Photo source of two color images: Sukon Kanchanaraksa
Photo source of portrait: http://www.ph.ucla.edu/epi/snow/fatherofepidemiology.html. Public Domain

History of epidemiology

John Snow conducted a series of investigations in London. Snow conducted his classical study in 1854 when an epidemic of cholera developed in the golden square of London.

During the time of microscope development, snow conducted studies of cholera outbreak both to discover the cause of cholera and how to prevent its recurrences.

During that time Farr and Snow had major disagreement about the cause of cholera. Farr adhered to what was called the miasmatic theory of diseases, according to this theory, which was commonly held at that time, diseases were transmitted by a miasma or a cloud with bad smell that clung low on the earth surface.

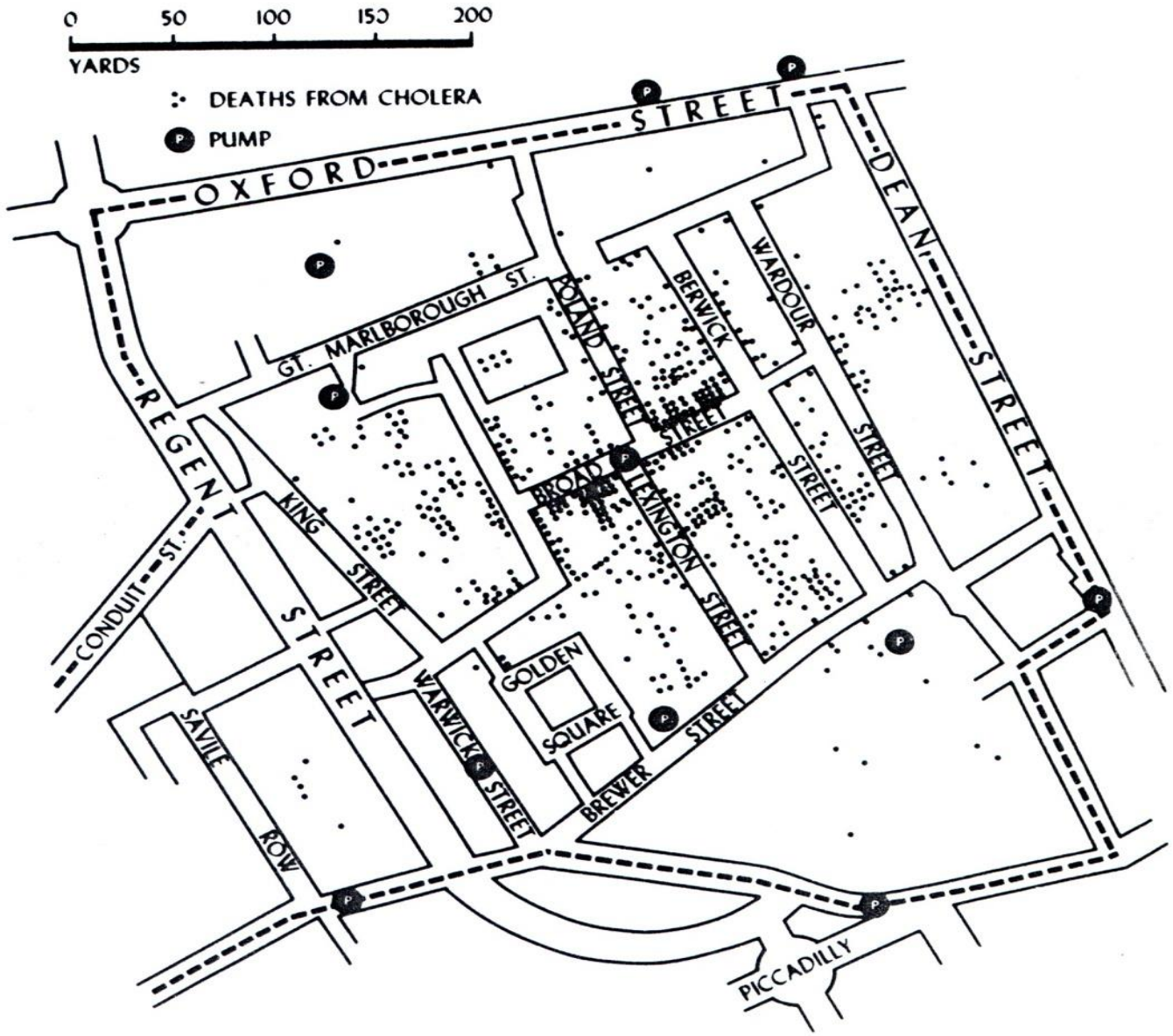
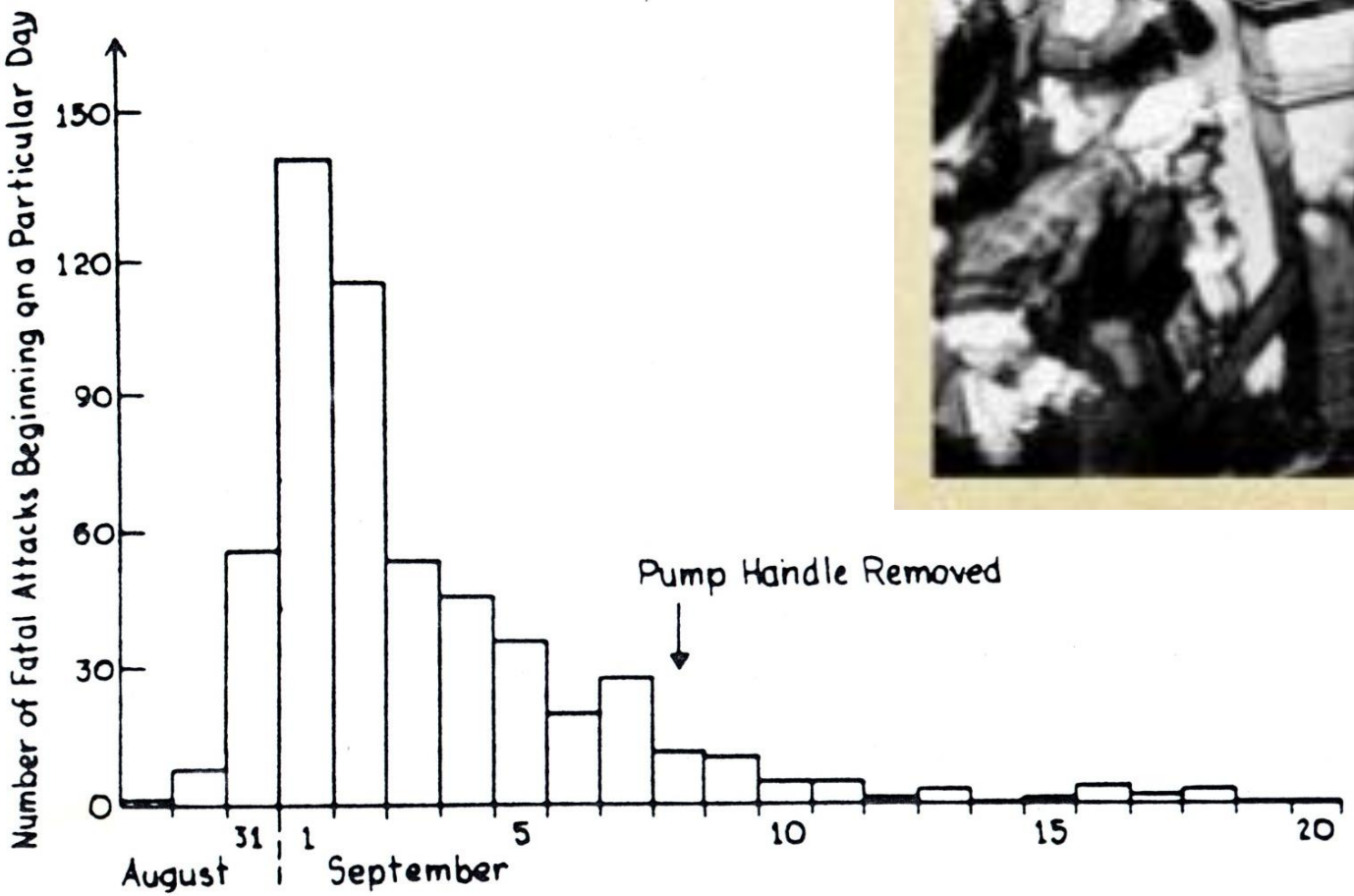


Figure 5-4 John Snow's Map of Cholera Deaths in the Soho District of London, 1848. *Source:* Adapted from *Health Care Delivery: Spatial Perspectives* by G. Shannon and G.E.A. Dever, p. 3, McGraw-Hill Book Company, 1974, and from *Some Aspects of Medical Geography* by L.D. Stamp, p. 16, Oxford University Press, 1964.

History of epidemiology

- However, Snow did not agree, he believed that cholera is transmitted through contaminated water. He began his investigation by determining where in this area in London persons with cholera lived and worked. He then used this information to map for distribution of diseases.
- Snow believed that water was the source of infection for cholera. He marked the location and searched the relationship between cases and water sources (water pumps).
- He found most cases clustered around the Broad Street pump.
- So, he decided to break the pump handle, which stoped the outbreak.
- He found that cholera was transmitted though contaminated water. This was a major achievement in epidemiology.



Snow's Epidemic Curve

CHOLERA AND WATER.

BOARD OF WORKS

FOR THE LIMEHOUSE DISTRICT,

Comprising Limehouse, Ratcliff, Shadwell, and Wapping.

The INHABITANTS of the District within which CHOLERA IS PREVAILING, are earnestly advised

NOT TO DRINK ANY WATER

WHICH HAS NOT

PREVIOUSLY BEEN BOILED.

Fresh Water ought to be Boiled every Morning for the day's use, and what remains of it ought to be thrown away at night. The Water ought not to stand where any kind of dirt can get into it, and great care ought to be given to see that Water Butts and Cisterns are free from dirt.

BY ORDER,

THOS. W. RATCLIFF,
CLERK OF THE BOARD.


JOHN SNOW
JOHN SNOW
SALOON
SALOON


Dr John Snow and the Broad Street Pump
DEATH


POET A MANCER