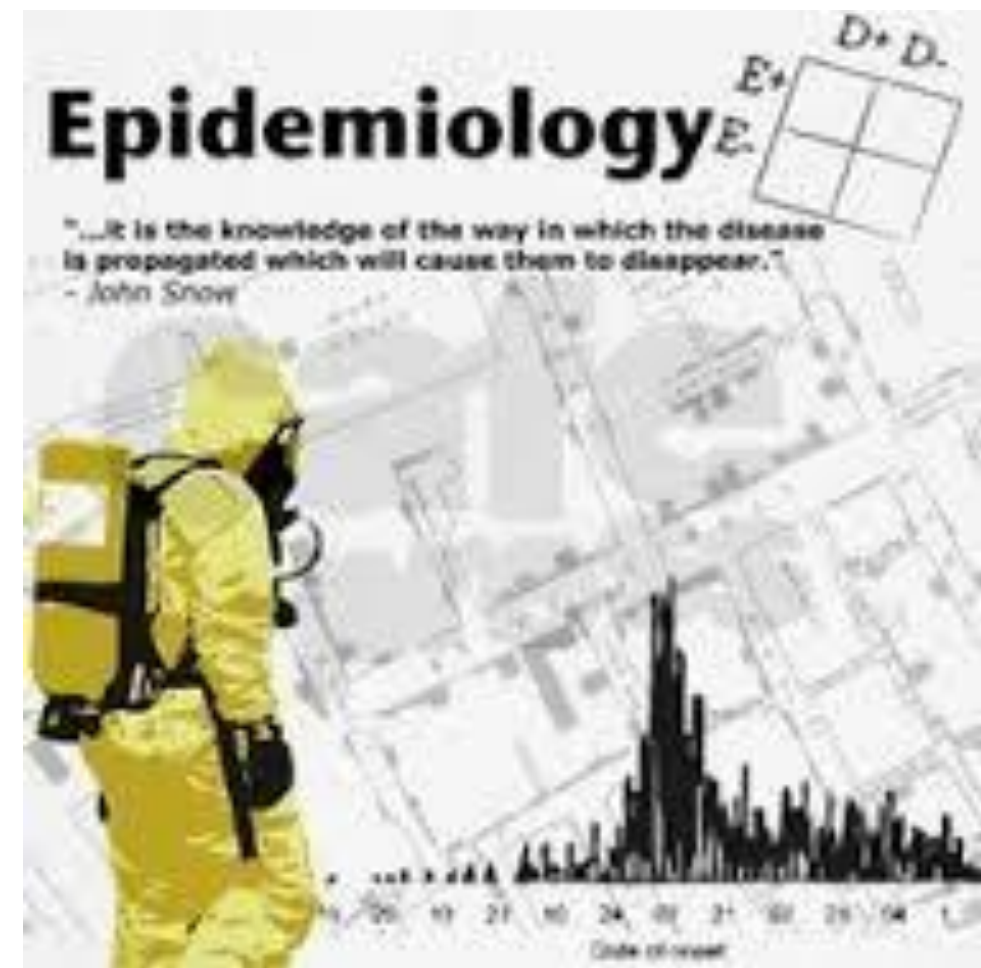


Introduction to and History of Epidemiology



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Lecture Contents....

1. Epidemiology defined.
2. The components of epidemiology
3. Major examples of epidemiologic investigations.
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. (Literally, disease, the opposite of ease, when something is wrong with a bodily function).

Illness: A subjective state of not being well (subjective state of a person who feels aware of not being well)

Sickness: A state of social dysfunction (i.e., a role that the individual assumes when ill).



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- demio- logy: The word itself comes from the Greek epi, demos, and Logos.....

literally translated it means the study (logos) of what is upon (epi) the people (demos).

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

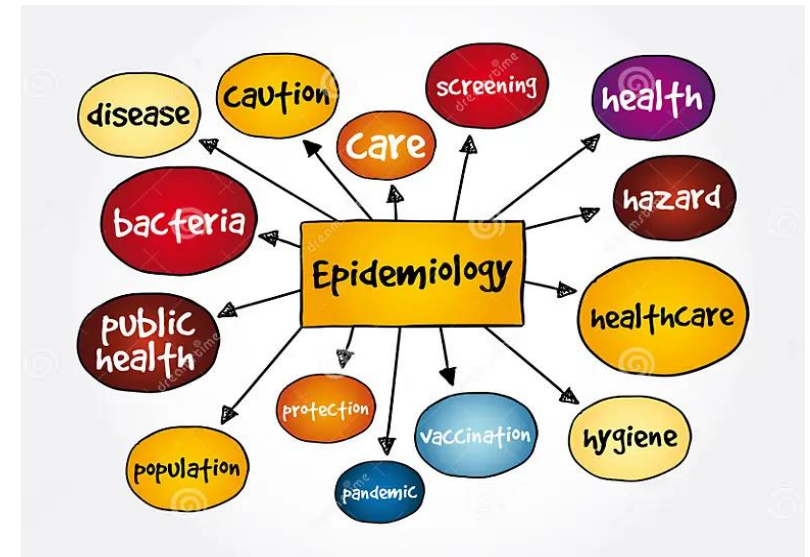


Components of the definition

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:

Frequency: A core characteristic of epidemiology is to measure the frequency (number of cases) of diseases, disability or death in a specified population.

It also refers to the relationship of that number to the size of the population.

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 different 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: Human coronavirus every 7-10 years..antigenic variations. (e.g. SARS-CoV in 2003, MERS-CoV in 2012, SARS-CoV-2 (COVID-19) in 2019).

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 (Risk Factor).

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 programmes, 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 prevents disease in 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.



Definition of Endemic, Epidemic, and Pandemic

- **Endemic**

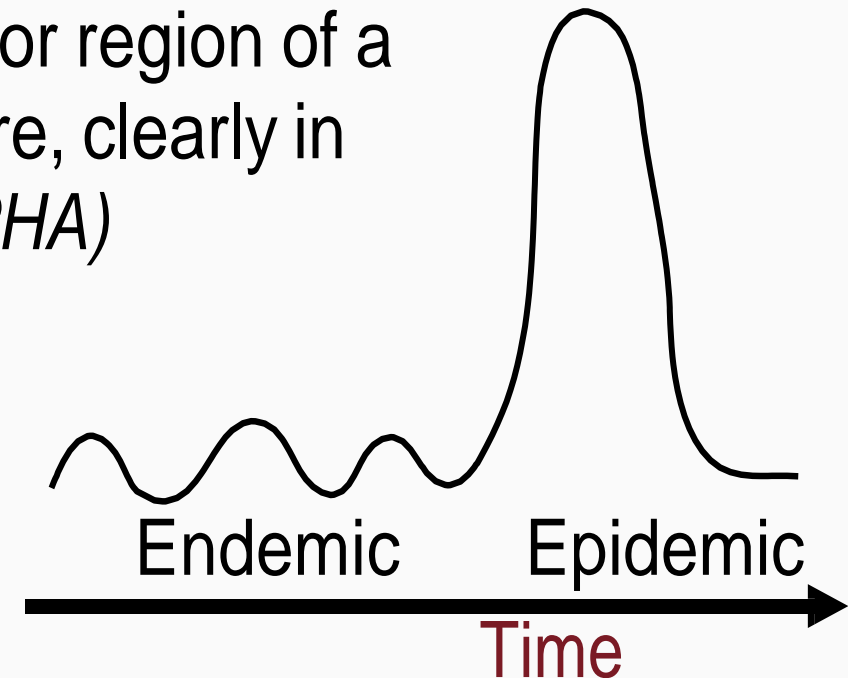
- The habitual presence of a disease within a given geographic area
- May also refer to the usual prevalence of a given disease within such an area (*APHA*)

- **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



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?



What Do Epidemiologists Do?

Count cases of disease or injury

Define the affected population

Compute rates of disease or injury in that population

Compare rates with those found in other populations

Make inferences regarding patterns of disease

Determine whether a problem exists

Fundamental assumptions in epidemiology

- **Human disease does not occur at random**
- **Disease has causal and preventive factors that can be identified using systematic investigations**

Epidemiologic Reasoning

There is a natural progression in epidemiologic reasoning:

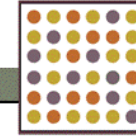
- **Begins with suspicion (clinical practice, descriptive epidemiology, laboratory research or theoretical speculation)**
- **Formulation of specific hypothesis**
- **Hypothesis is tested in epidemiologic studies using:**

Sources of information (data) in Epidemiology

- Registration of births, deaths and diseases
- Population censuses
- Routine health information systems
- Surveillance
- Investigation of epidemics
- Sample surveys

The Five Ws of Epidemiologic Studies

The Five Ws of Epidemiology Studies

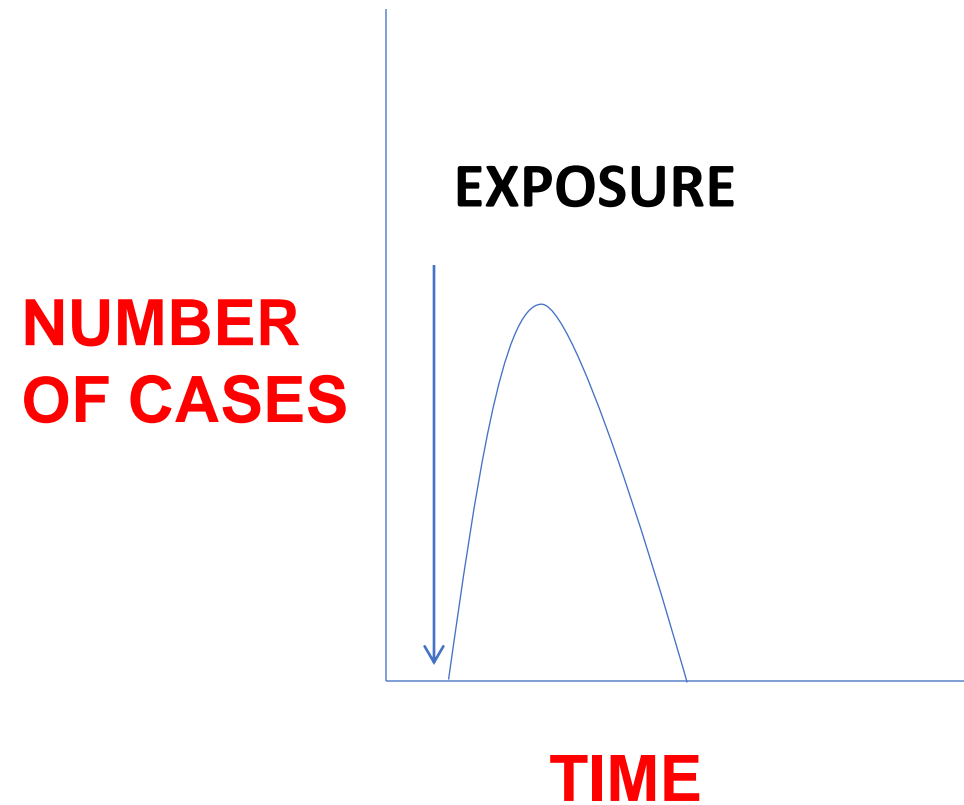


- What = Clinical
 - Who = Person
 - Where = Place
 - When = Time
- } Descriptive Epidemiology

-
- Why / How = Causes
Risk factors
Modes of transmission
- } Analytic Epidemiology



EPIDEMIC CURVE



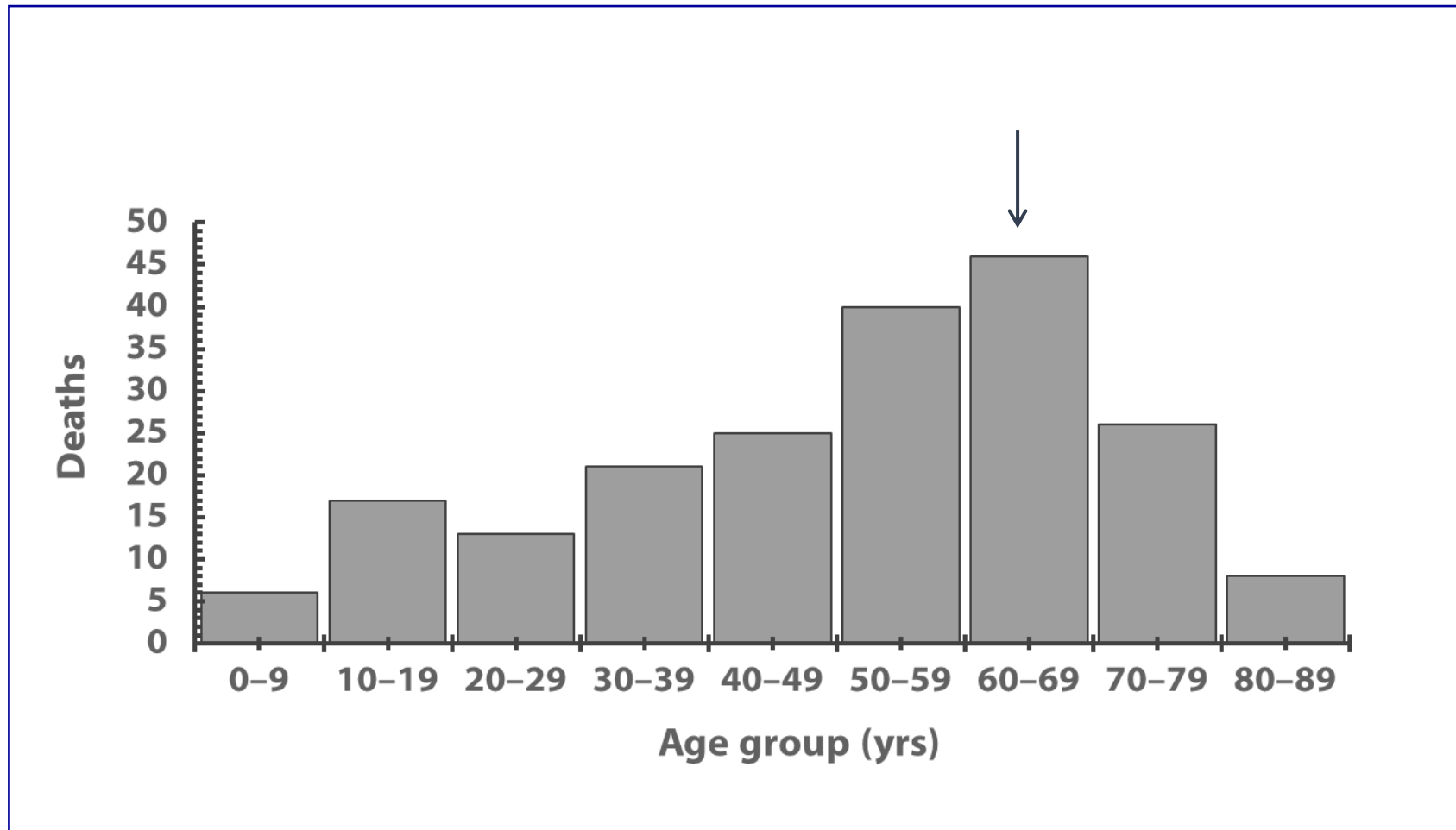
Fatalities Associated with Farm Tractors

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).

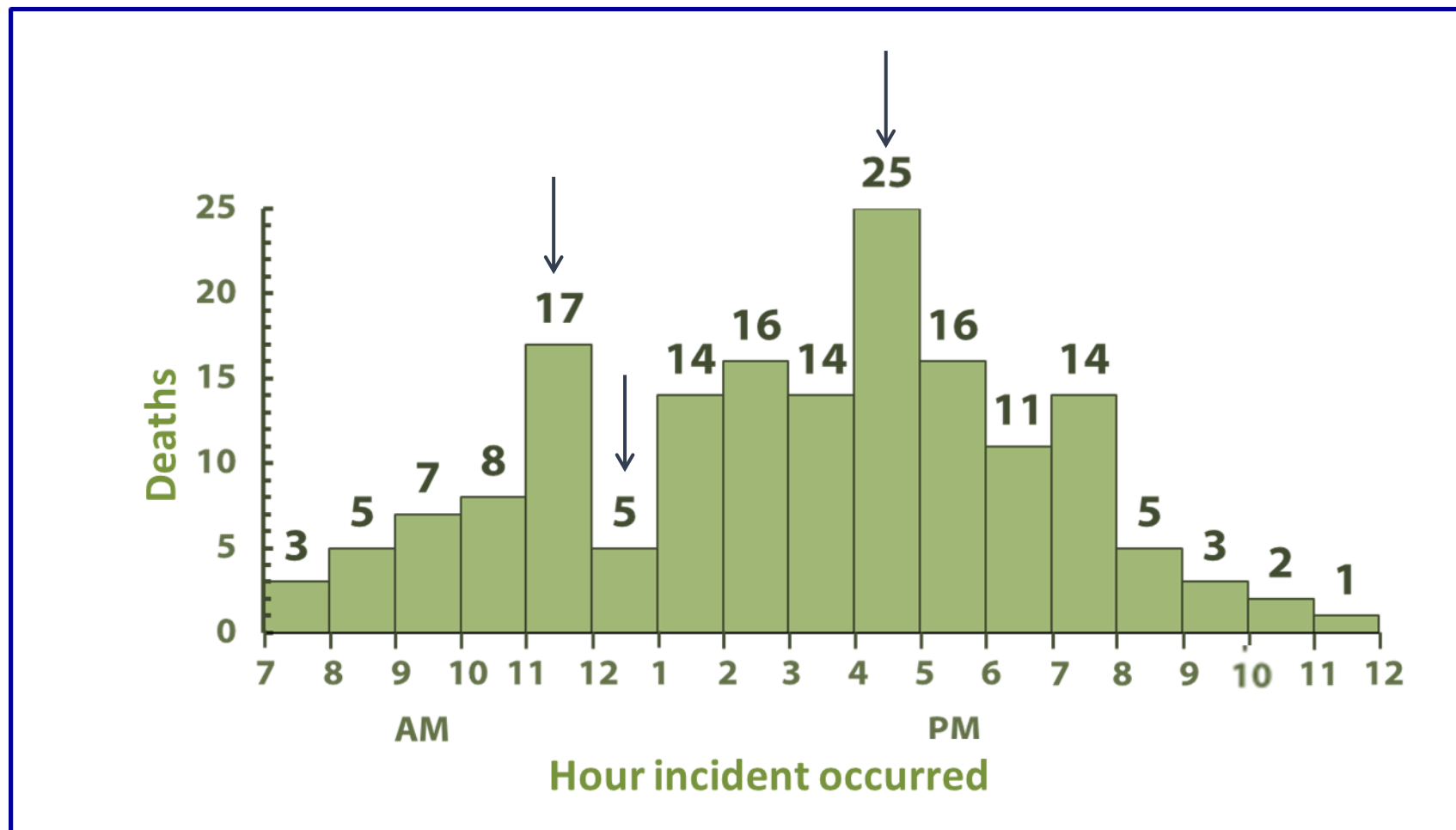
He then generated a hypothesis for further study. Let's look at the descriptive epidemiology (Who, When and Where....)



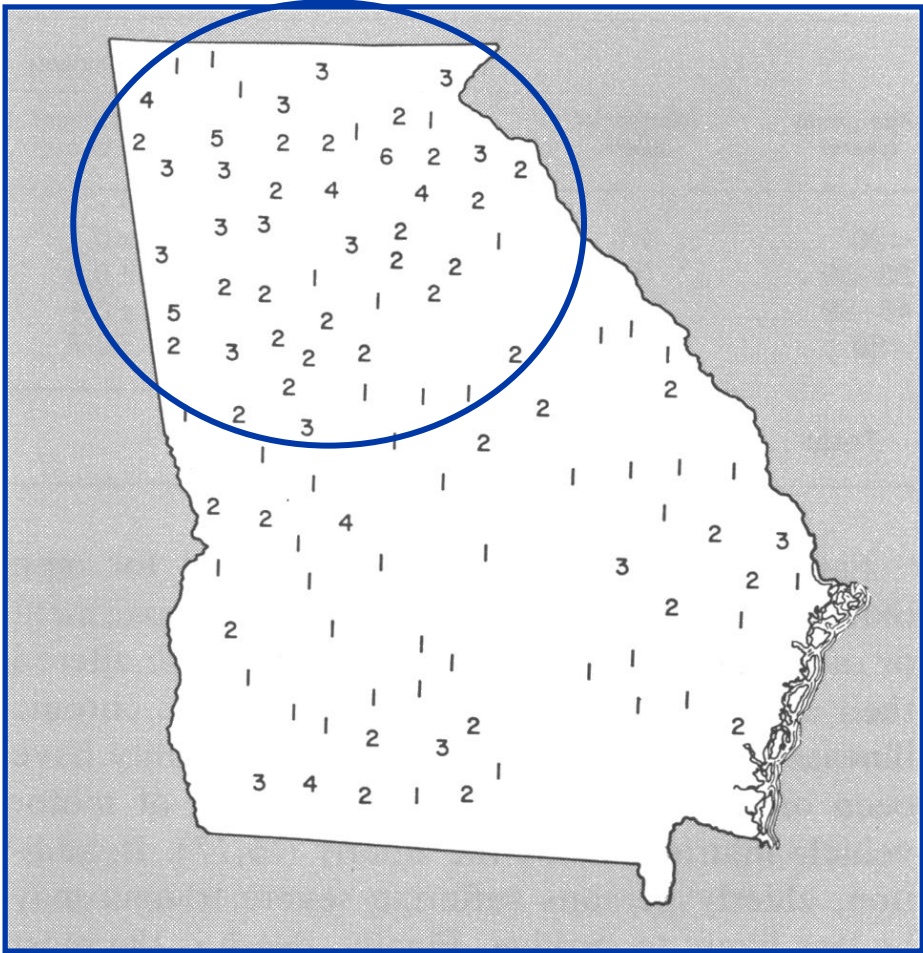
Fatalities Associated with Farm Tractors (person)



Fatalities Associated with Farm Tractors (time)



Fatalities Associated with Farm Tractors (place)



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



Epidemiological contributions to medical science and humanity

Doll & Bradford-Hill smoking and carcinoma of the lung:
preliminary report, BMJ 1950;II:739-48

- **Patients with lung cancer more likely to have smoked**
- **85-90% of cases are due to tobacco”**

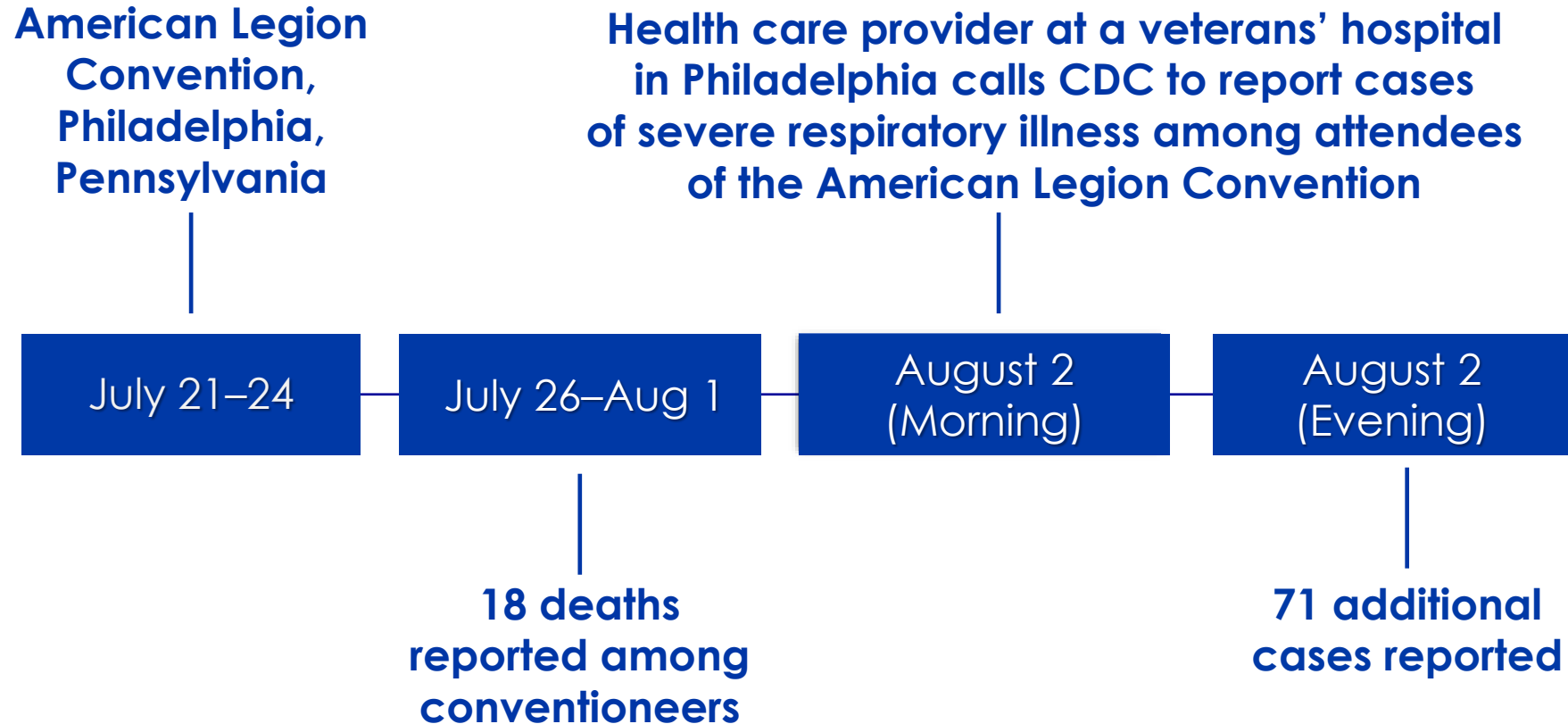
Breast cancer screening (Swedish two country trial)

- Screening with mammography was started in 1977 in the counties of Kopparberg and Ostergotland.
- The results at 29-year follow-up: A substantial and significant reduction in breast cancer mortality was associated with an invitation to screening (31% lower mortality rate in women diagnosed via mammography).
- At 29 years of follow-up, the number of women needed to undergo screening for 7 years to prevent one breast cancer death was 414

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 conventioners 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 conventioners were becoming ill and, in some cases, dying!!!

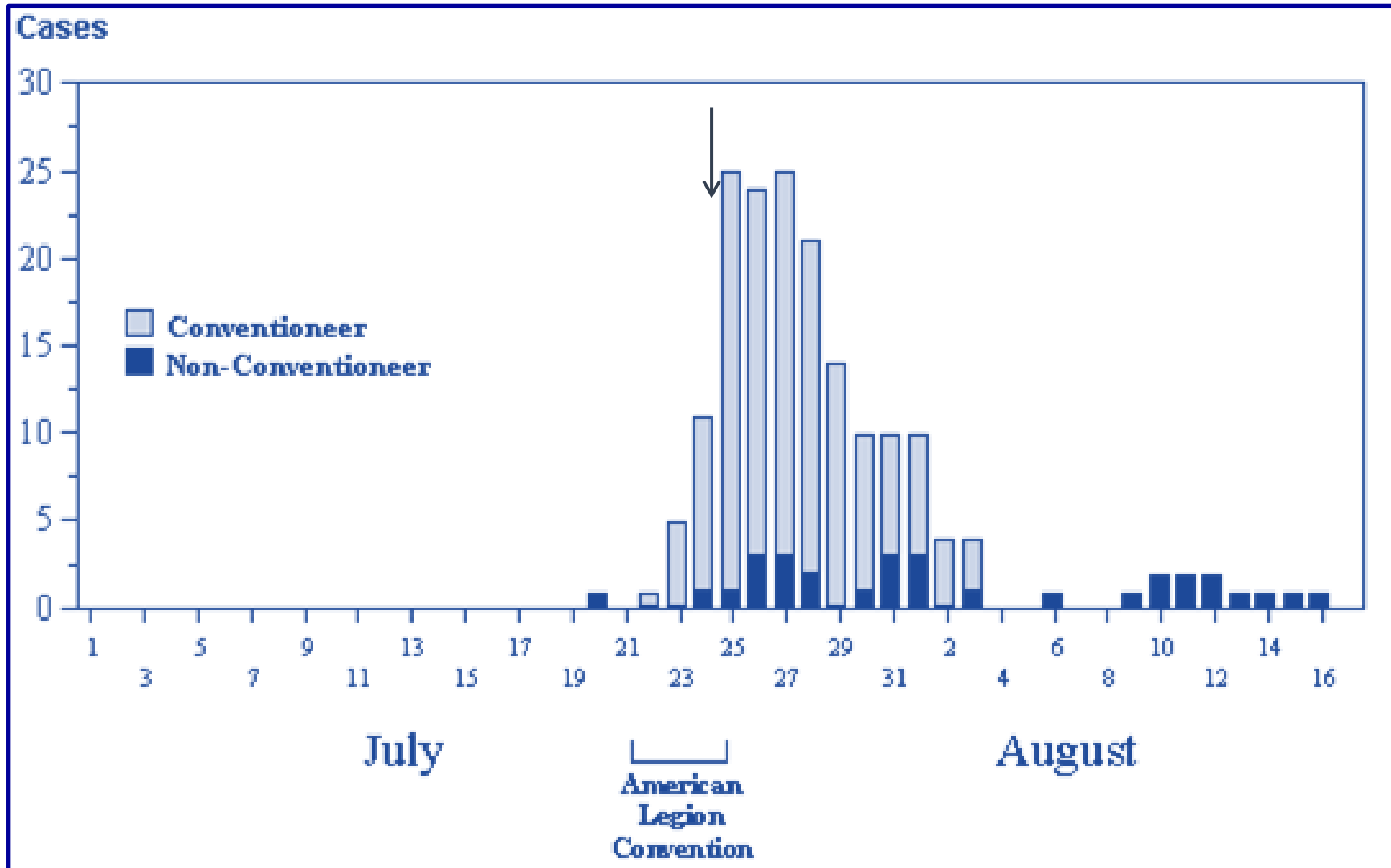
Legionnaire's disease outbreak



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



Legionnaires' Disease Attack Rates by Place

Age (yrs)	Hotel A			Hotel B			Hotel C		
	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

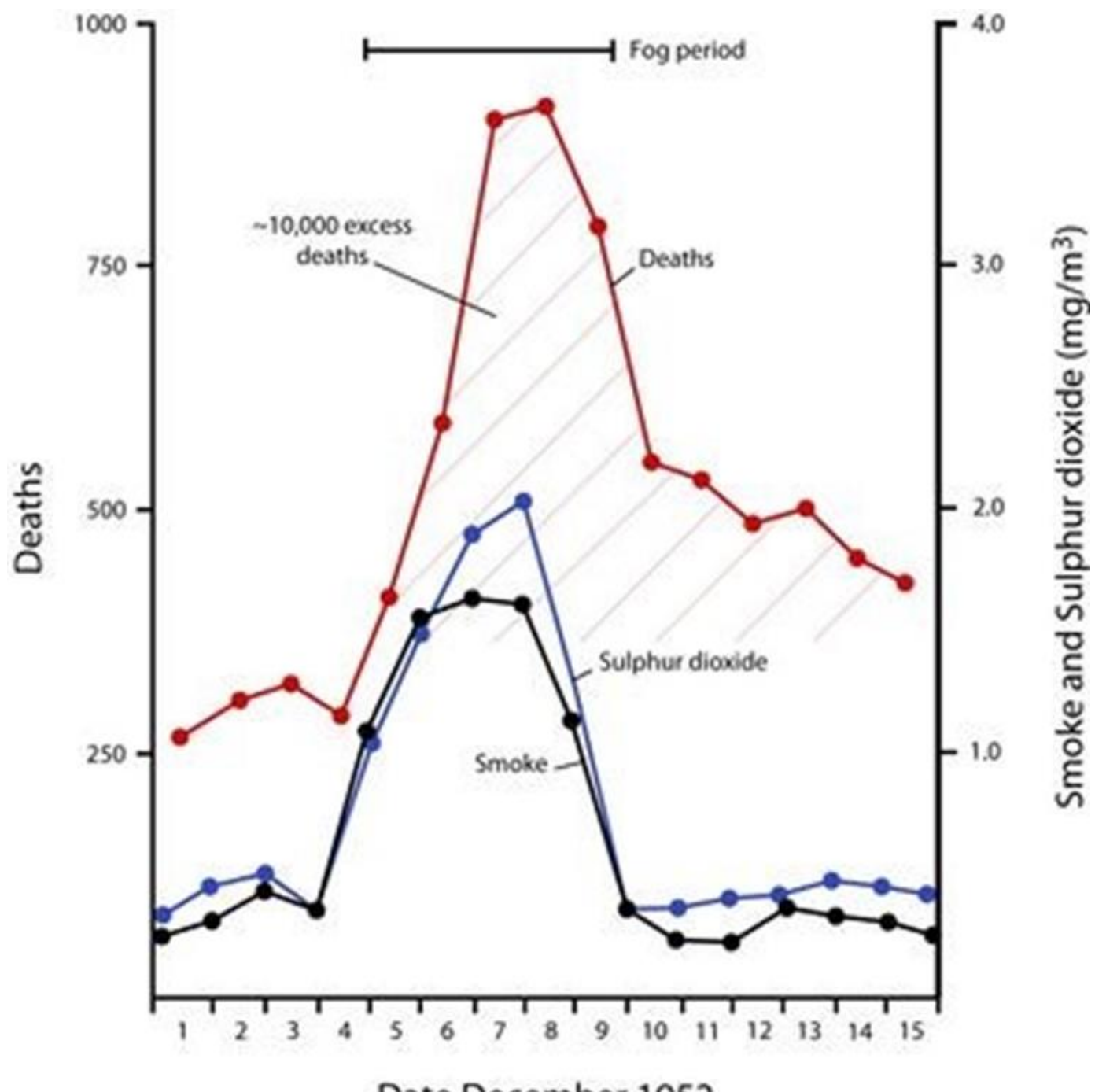
- Five months after the first cases of Legionnaires' disease occurred, results of the case-control study indicated that spending time in the lobby of Hotel A was a risk factor for illness
- In January 1977, the Legionella bacterium was finally identified and isolated and was found to be breeding in the 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





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 affect health: “healthy mind in health body”.**
- 2) **John Graunt (1662): Quantified births, deaths and diseases (Statistician, founder of demography in London).**
- 3) **James Lind (1747): Scottish Doctor, treated scurvy among sailors with fresh fruit (lemons)...first Clinical trial in history**
- 4) **William Farr (1839): Established application of vital statistics to evaluate health problems...Founder of medical statistics.**



History...

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

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.



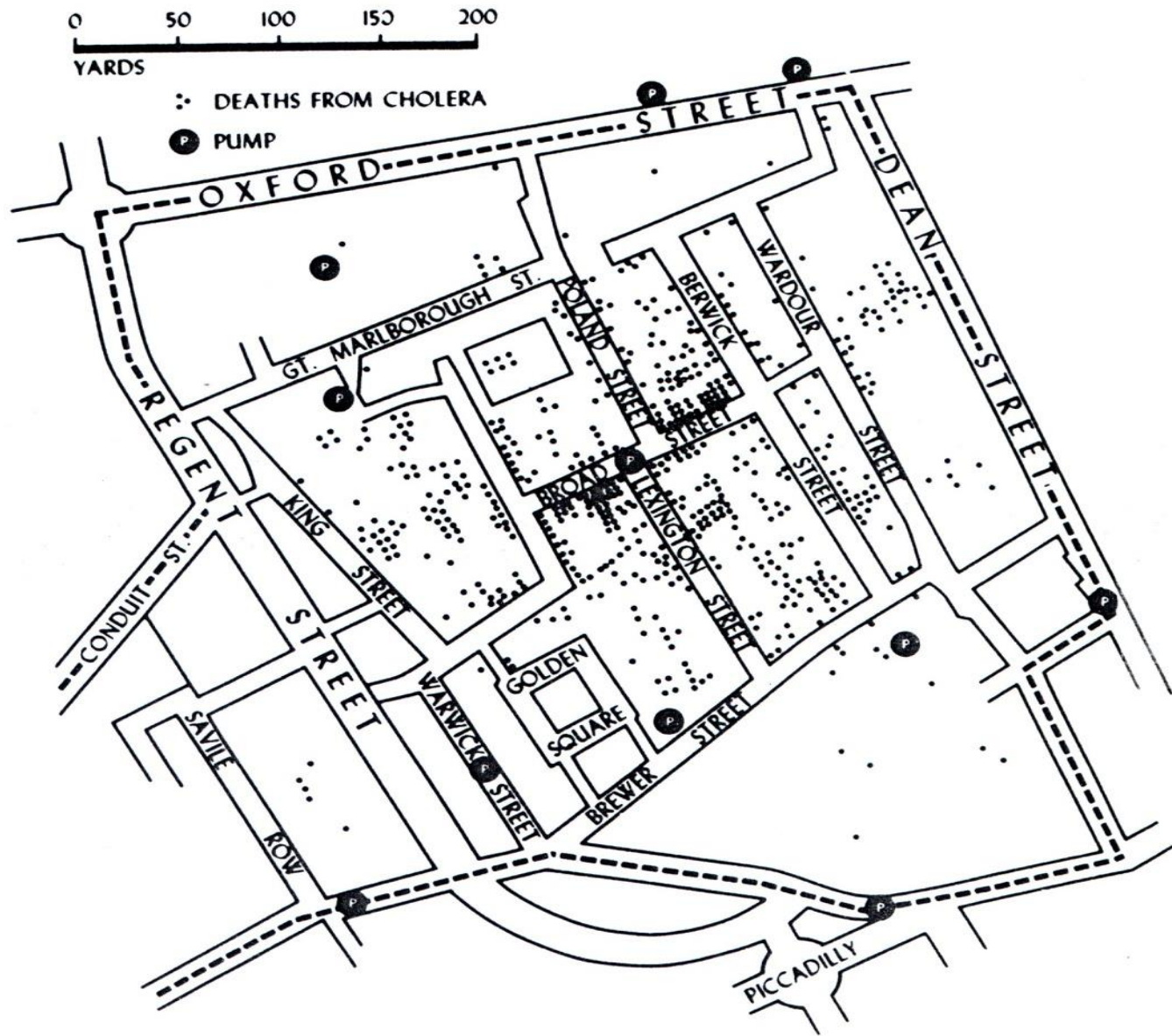
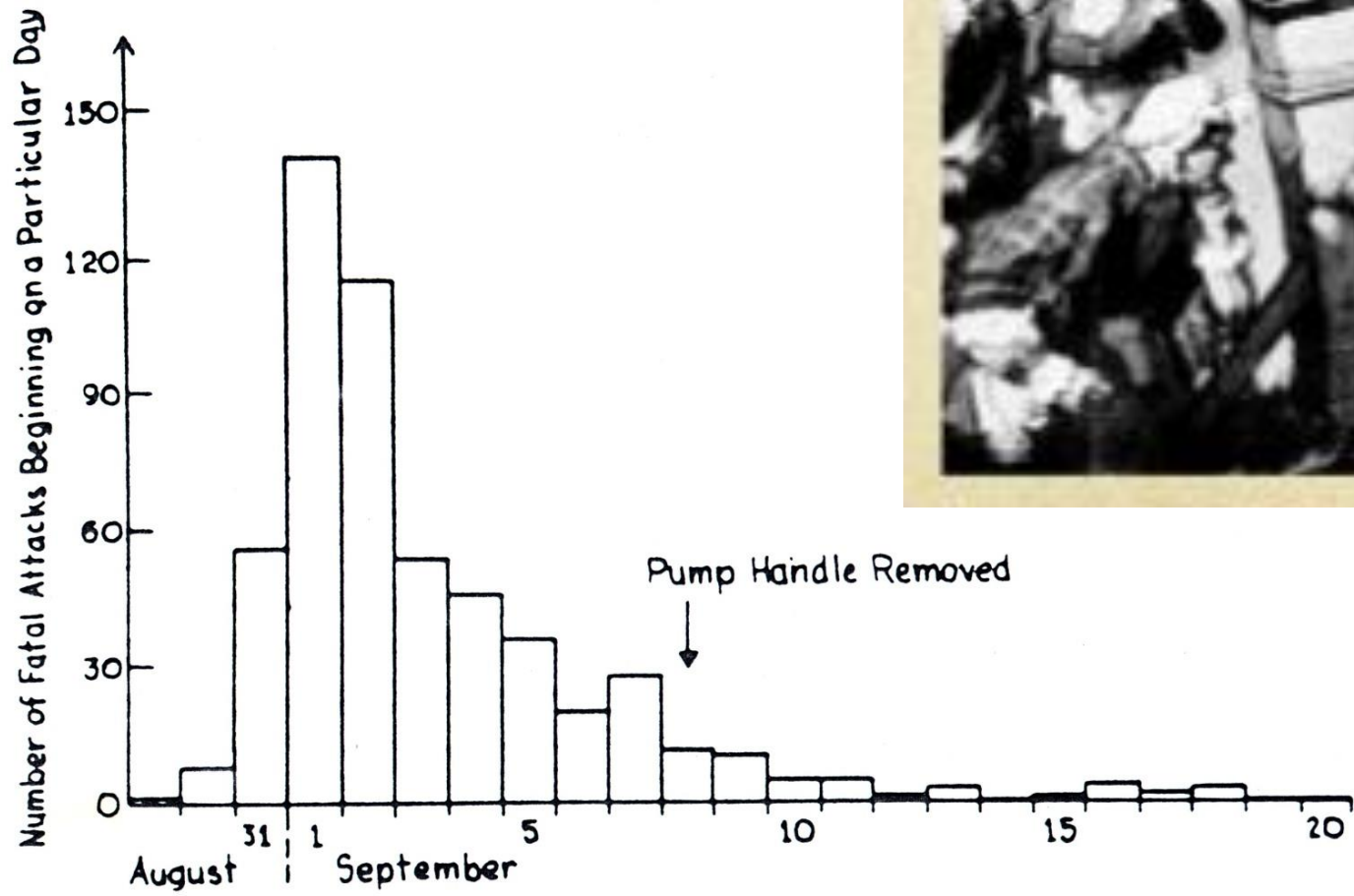


Figure 5-4 John Snow's Map of Cholera Deaths in the Soho District of London, 1848. *Source:* Adapted from *Health Care Delivery: Spatial Perspectives* by G. Shannon and G.E.A. Dever, p. 3, McGraw-Hill Book Company, 1974, and from *Some Aspects of Medical Geography* by L.D. Stamp, p. 16. Oxford University 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 stopped the outbreak.
- He found that cholera was transmitted through contaminated water. This was a major achievement in epidemiology.



Snow's Epidemic Curve



CHOLERA AND WATER.

BOARD OF WORKS

FOR THE LINEHOUSE 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.

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John Snow





