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.

We knew about public health very well when we started dealing with COVID-19 in Jordan.Every country in the world started to work in a way to protect the public from exposure to a virus that is infectious and how to make people not transmit disease to others,it was a very good work of public health that we worked on in order to prevent the propagation of COVID-19

Public health

The science & art of

Preventing disease, public health prevention

prolonging life, and

promoting health & efficiency

through organized community effort

Public Health contains five main discplines:Epidemiology,Biostatistics,Environmental Occupational Health,Health Management,Health promotion.One of the most important of which is epidemiology

(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)

This definition is exteremely important to public health in epidemiology because we don't only study diseases that happen to people.Any thing that may affect human health,socially,psychologically,physically is our concern in public health and epidemiology

Disease: A physiological or psychological dysfunction

Illness: A subjective state of not being well

Subjective means it's different from one to another.It's from the person's point of view (how this person himself feels today,for example.So the person would say I feel ill today.Illness is from the person affected.His point of view,or how he feels.*What you feel in yourself is illness*

Sickness: A state of social dysfunction

While sickness is different because sickness is a state of social dysfunction.People around you don't see you ill,they see you sick.They say to you:"You look sick today.Are you OK?".So socially,people around you what they see in you is sickness

Definitions

Epidemiology

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

In the 30s,the definition extended more looking at the prevention of disease,how to prevent diseases after we know what causes these diseases

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

In the beginning of the last century (1927),it was all about the study of infectious diseases,as they were the most concern at that time.

Definitions…

Epidemiology

Eventually,these early definitions were followed by the last definition of epidemiology stated here under which we use until now.It was shaped in 1988 and is valid until now.

"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)

Let's analyze the definition word by word to see the implication of each word ,distribution (we'll see what's distribution),determinants(we'll see what are determinants) of health related states or events(See?it didn't say diseases because what we are concerned about is far more than diseases(health related states or events containing diseases);in specified populations-the unit of study of epidemiology is not a person like physicians do in clinical settings-we treat communities,we treat populations>groups of people, and then the application of this study to the control,controls mean prevention,prevention of health problems.

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

Biostatistics is a very important and pivotal tool in epidemiology to understand the associations between risk factors and diseases.Systematically,we subject the data and information we collect during our epidemiological study to statistical analysis to be able to come up with results and interpretations that can make us understand more the relationship between certain risk factors and diseases occurring,to be able to learn what causes these diseases

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.

We'll see what types of epidemiological studies that we can use to find out relationships between risk factors and diseases

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.

A term in mathematics that statistically calculates the number of times an event has happened by using tables (here the matter of the study is number of cases).In all countries in the world,particularly Jordan,we see reports that are published every day how many cases were discovered and admitted to hospital ,how many fatalities,etc.We should have these statistics as they are the beginning point of reference

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

Frequency is counting the number of cases of the disease,and from this number we can then calculate rates,when we divide the number of cases by the number of population,we can calculate the rate of the disease in this specific 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.

Distribution is concerned with:Who is getting the disease? Where is the disease happening more? When does it happen more?

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.

Ultimately,we describe the health problem analyzing data according to these effectors.That's the definition

An important outcome of this step is formulation of etiological hypothesis

Considering a new disease with no identified cause or risk factors,we start by analyzing who,where and when the disease happens in a descriptive way.From looking at this information,we can start to make some guess (for example:elderly seem to more likely get COVID-19 and die from it,consequently,this is a hypothesis we formulate and needs to be tested to see if its's right or wrong,to reject it or approve it

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.

Occupation:workers in health industries,getting disease more or at a higher risk compared to others

Smoking,better habits

- These host factors help us to understand the natural history of disease. **Everything related to describing a person**

So when reading any research about any subject,usually the first table it would have describes the sample in terms of age,gender,occupation,income,place of residence,… because they are usually the independent factors that can determine a lot about diseases that happen to people

PLACE DISTRIBUTION

- Study of the geography of the disease (geographical pathology) is one of the important dimensions of epidemiology. **Related to how diseases are distributed in a country according to region**
- 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

e.x:season in the year,month of the year,what time of the day?what days of the week?
Finding a certain pattern can help us discover why does it happen at that time,and this could lead to discovering the reason for it.

- 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).

Influenza cases peak in autumn-winter interval

- In contrast, diseases such as hepatitis B and salmonellosis can occur at any time.

Hepatitis B transmitted through blood exposure

- Day of the week or time of the day may be important.

For example,if we talk about car traffic (road traffic accidents),we usually find high increase in number of accidents at rush hours,at times with all people going to work,coming back from work

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??

Extra:A neurological disease caused by severe mercury poisoning

One accident.For example a group of people ate from a one shop that made contaminated food,this lead to one short term fluctuation,with all of them going to the same hospital.Incubation period and symptoms all happened together,in a one peak
***OR* it could be multiple fluctuations,for example if there is a well of contaminated water (by cholera),so a there will be a lot of people using water from it frequently,that every week you will have a fluctuation**

2. Periodic fluctuation:

Seasonal: GI infection in Summer

High temperatures,high proliferation of the bacteria or viruses

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

(e.g. SARS in 2003, MERS in 2012, COVID-19 in 2019).it is an epidemic

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

Notes about the periodic fluctuation:

- It could be seasonal like GI infection is summer because of high temperatures and high proliferation of the bacteria and viruses
- Or it has a cyclic type like influenza which goes through antigen variations every 7-10 years(Viruses mutate quickly and adapt to all medications that are discovered)

- Influenza has shown up in the last 20 years,there was SARS in 2003(Severe Acute Respiratory Syndrome),in fact it wasn't a pandemic which affected all part of the world like COVID-19,but a high increase in cases happened all over the world with no significant prevalence,and it was contained and ended
- Then the worse shown in 2012 located in the Middle East(Gulf), specially related to camels and it was in certain areas around the world

- Note the sequence:SARS 2003,MERS 2012(9 YEARS APART),and lastly COVID-19 2019(7 YEARS APART),it is very well-known that influenza every seven to 10 years has a large mutation that causes a new epidemic with a high number of cases,being an infectious disease and people travel all over the world,so they have to report this (e.x:COVID was transmitted by people coming from china then it was spread everywhere

Components of the Definition of Epidemiology

Determinants: **Causes/risk factors**

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

They could determine whether the disease happens or not,so this affects whether the disease happens in high rate or low rate

Epidemiology studies what determines or influences health events:

Later we will learn that we can't say causes of diseases since it is impossible to say that something causes a disease because that means in 100% of the time if this factor is present it will cause the disease and this is very rare but there is a percentage of people(high or low) that will be affected,so it is more accurate to say risk factors.People who have this factor have high probability,high risk of having the disease after a certain period of time

✓ It answers the question: how and why?

✓ Epidemiology analyzes health events "analytical epidemiology". Here we test a hypothesis to prove right or wrong. **It needs more time and investigation**

✓Analytical strategies help in developing scientifically sound health programes, interventions & policies. **It has implications in the prevention of the disease**

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

Anything that affects human health physically,psychologically,socially,even if it's not a cause of the disease and only affects the level of health
It is important to conceptualize human health by knowing the level of health for everybody.It is like a battery,the more health behavior you do,the more you stuck up your battery with more credit of health,the more risky behaviours that you do(if you smoke more,if you eat unhealthy,if you don't do exercise),the level of health will start to diminish and deteriorate
so you become at more risk for lots of diseases
So it is anything that may affect the quality of life of life or the best functioning of a human body because the ultimate goal is having the optimum level of health and happiness for a human being

Components…

We don’t study individuals,we study populations(population of our country, group of university students,people who work in a certain industry)

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. **Usually treat individual**
- ✓ Epidemiology is a basic science of public health.

Components…

Application

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

Behaviours which can be applied by the population to prevent the disease

- ✓ 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.

Whenever we say control diseases,we mean prevent diseases

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?

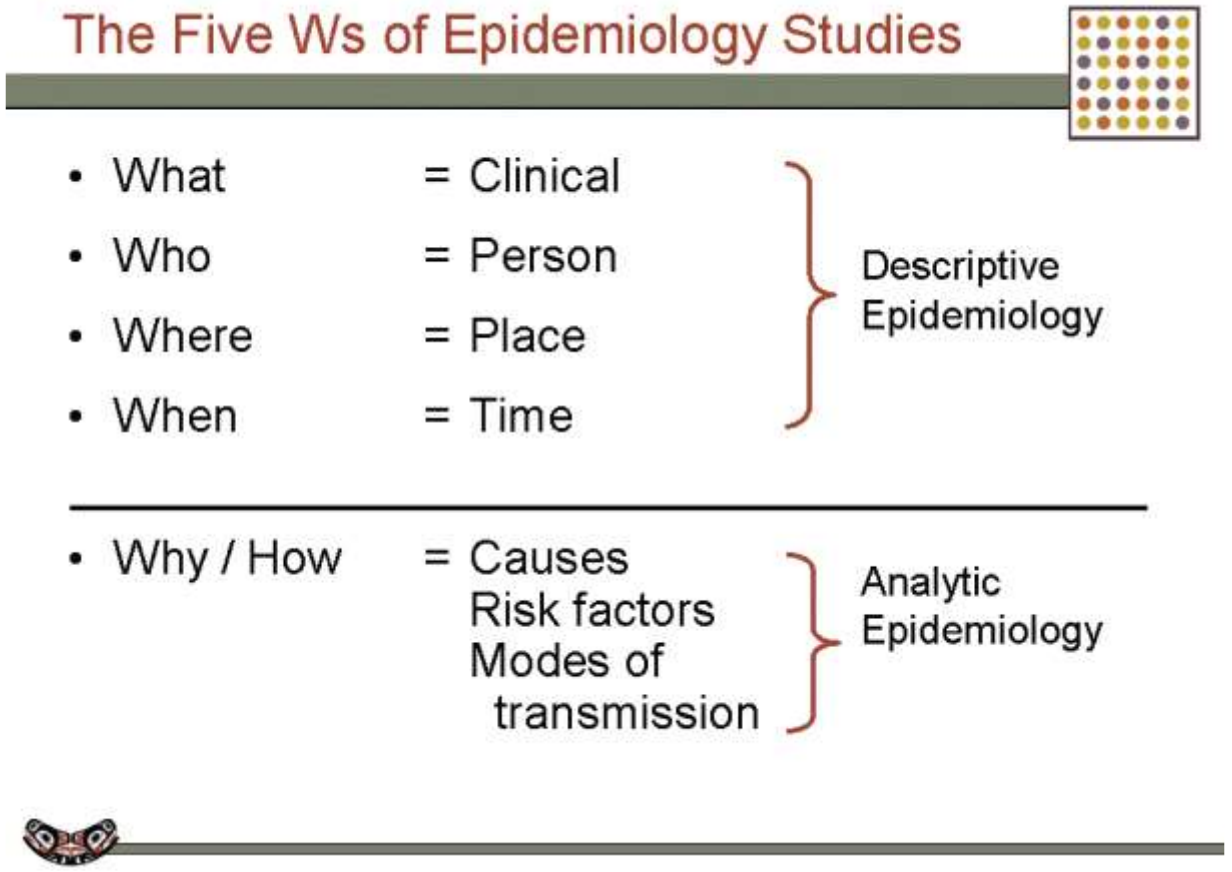
Why did it happen?

Epidemiology

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

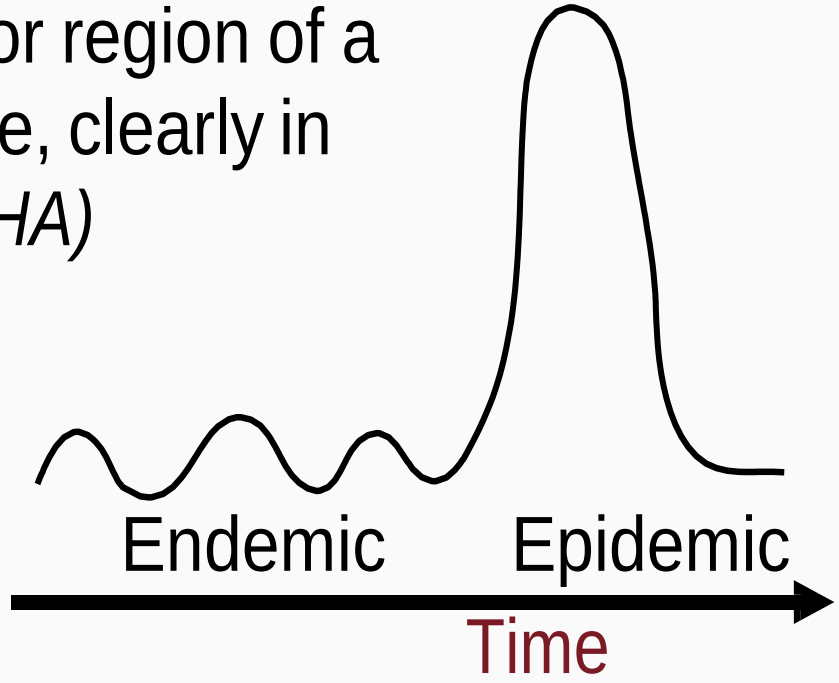
- What can be done to reduce this problem and its consequences?
- How can it be prevented in future?
- What action should be taken by the community? By whom should these activities be carried out?

The Five Ws of Epidemiologic Studies



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** **Goes all over the world**
  - 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



Notes about the previous slide:

- **Endemic:Like Malaria in Africa.It's high in that population and that's normal for them,it's there every year every in a high rate**

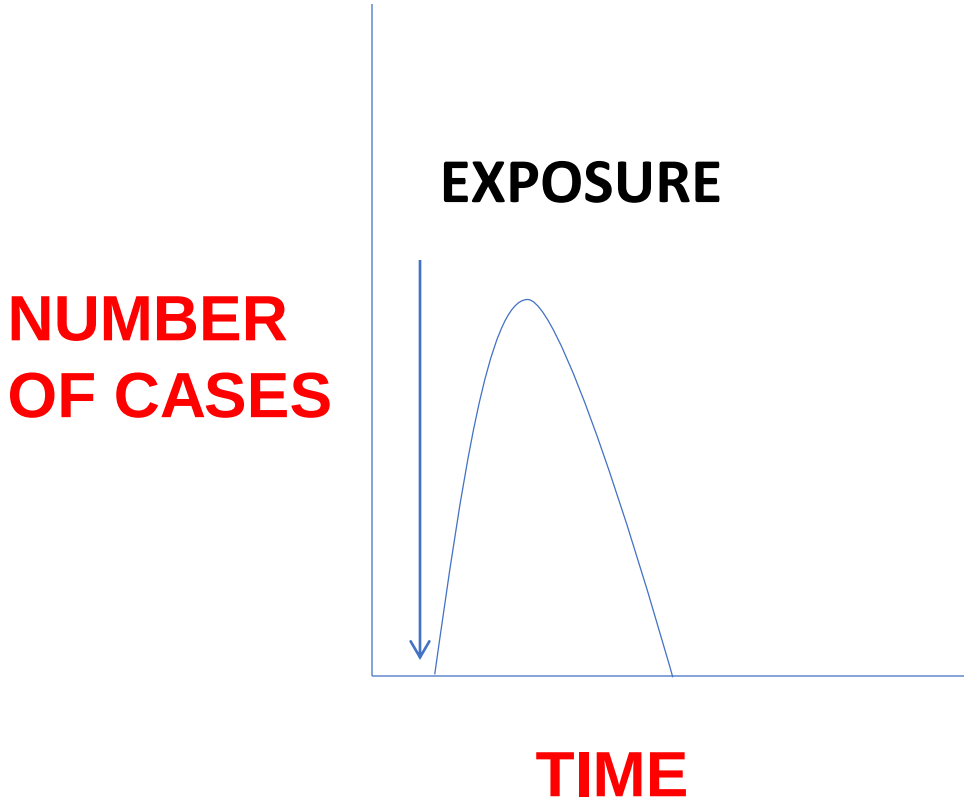
In Jordan we have no cases of malaria,if 5 cases of malaria were discovered in Jordan,it will be an emergency.

- **Epidemic:Every year people get infected with influenza and they get well and go back to work and school,so why we don't call it epidemic,like COVID-19 in Jordan for example?**

It's the number of cases,which has increased very much compared with previous years,so it became pandemic because it spread all over the world and all countries were affected

EPIDEMIC CURVE

On the Y-axis we have number of cases,on the x-axis we have time,we calculate its length and width to know types of epidemic

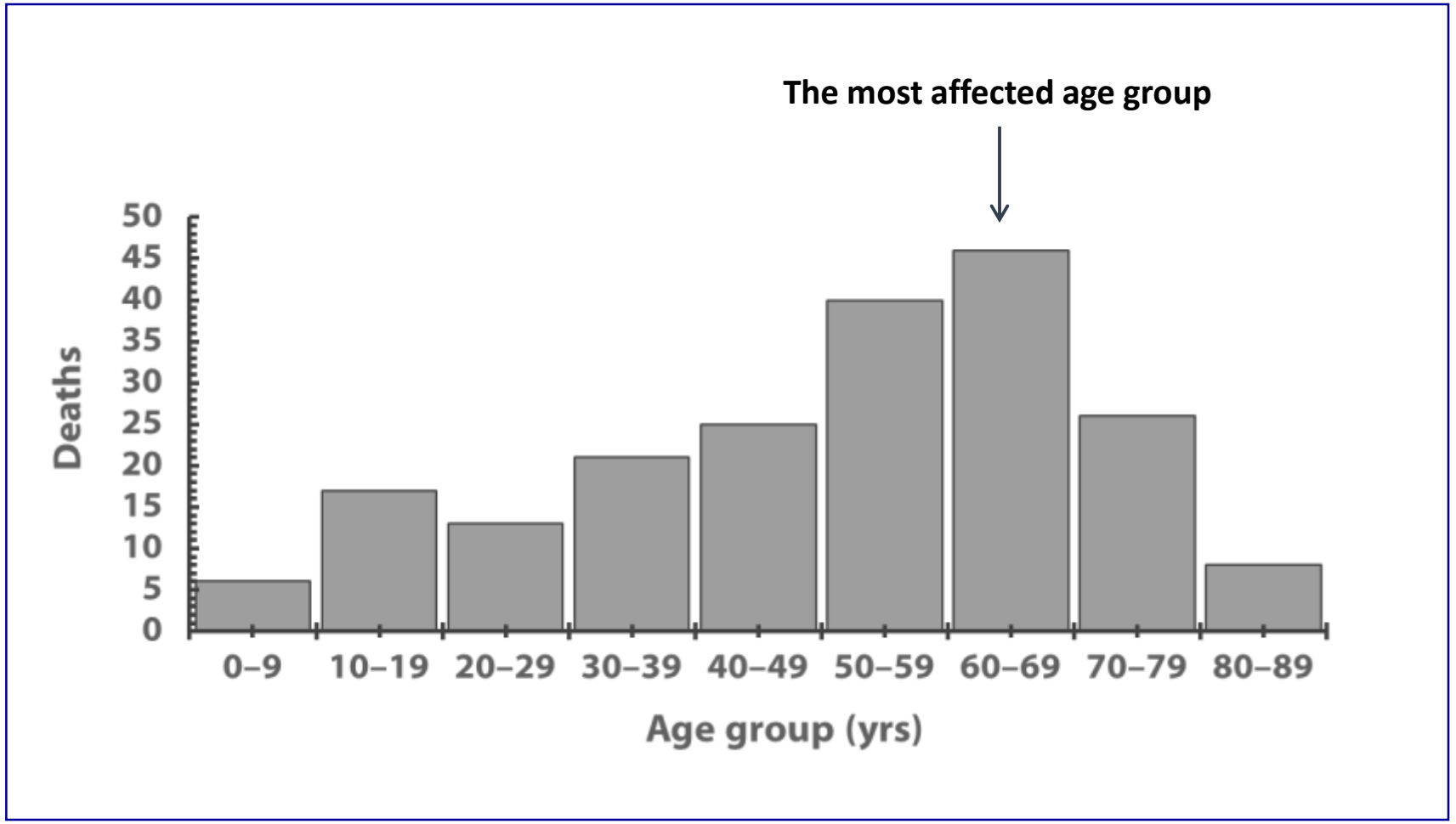


Fatalities Associated with Farm Tractors

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)

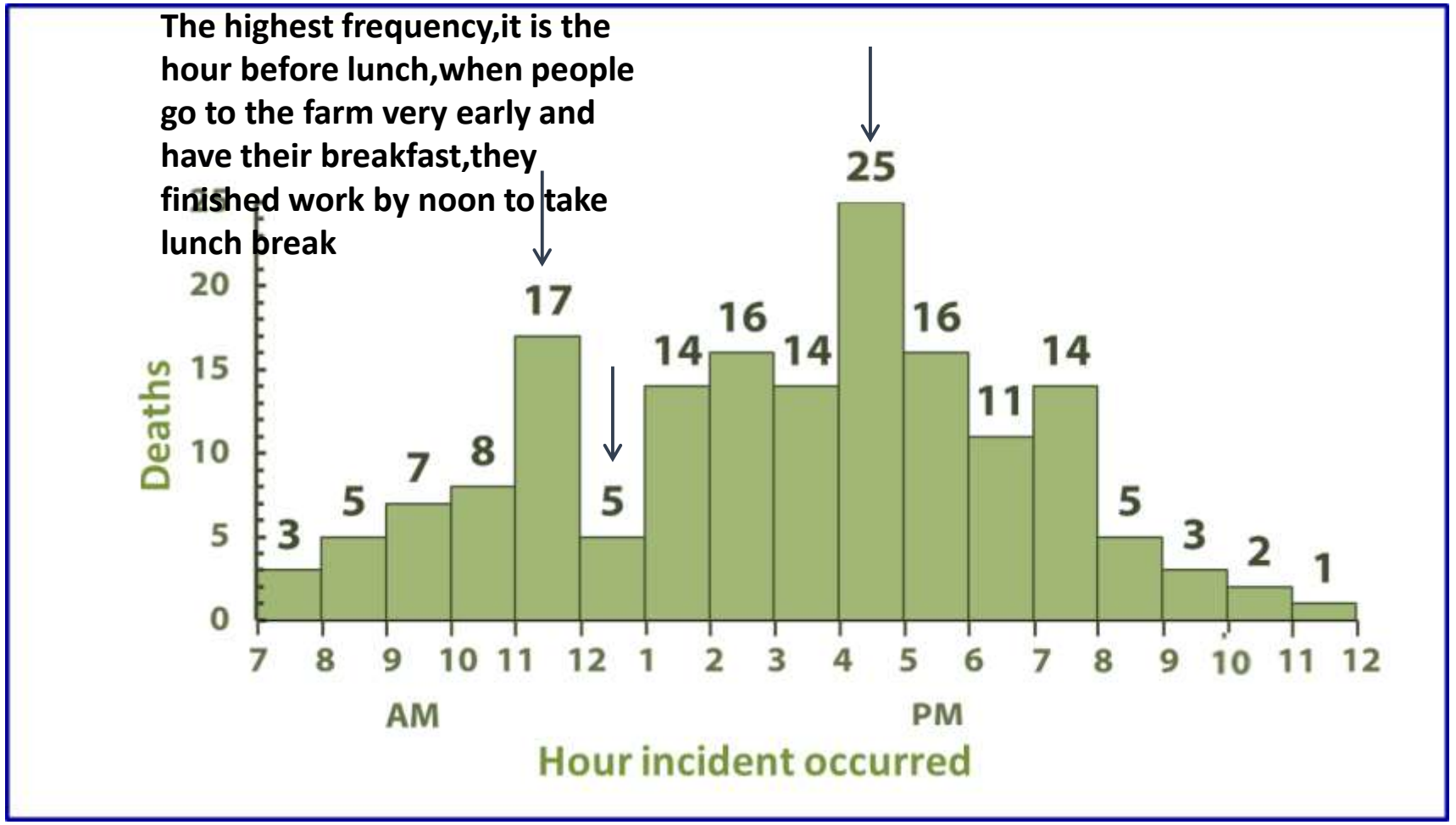
Firstly,He plotted fatalies in terms of person(age groups for people who died from farm tractor accidents).Very simple descriptive statistics
If we didn't draw a bar chart,we won't be able to know who's affected more(50s to 60s)



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)

Then he looked at the time distribution or time pattern,he tried to look at the hour of the day,to see the frequency

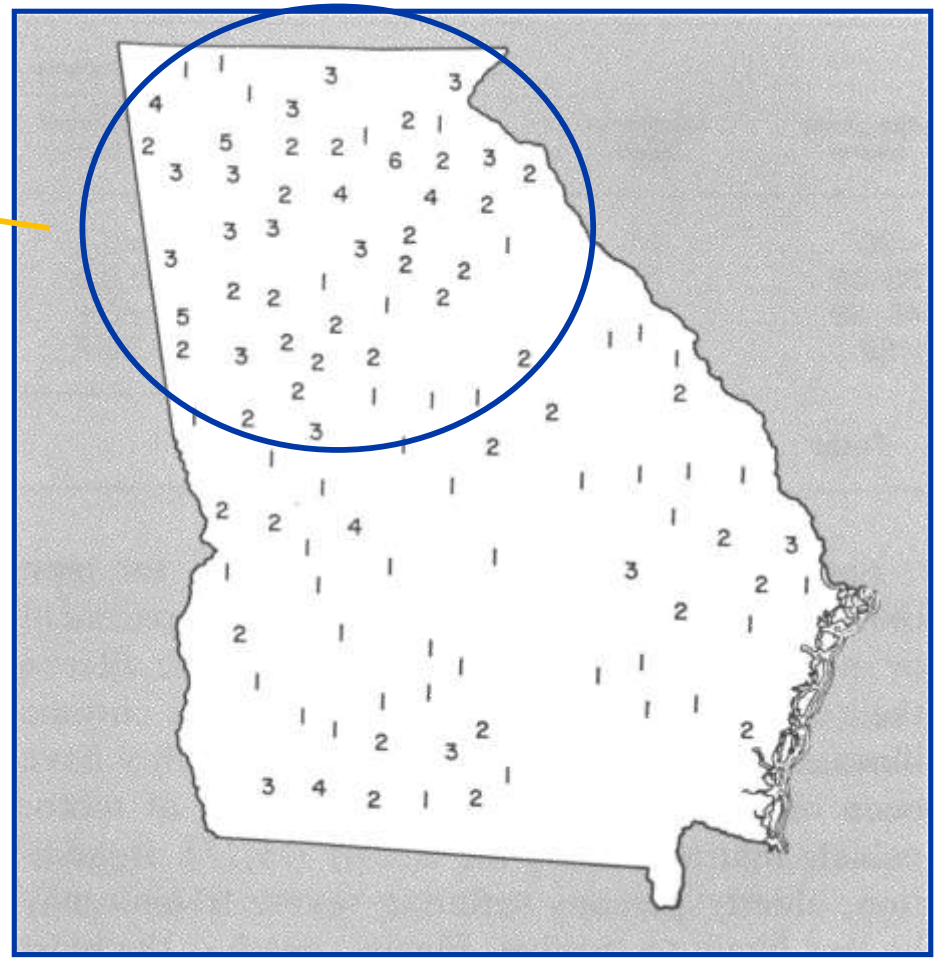


Goodman RA, Smith JD, Sikes RK, et al. Fatalities associated with farm tractor injuries: an epidemiologic study. Public Health Rep 1985;100:329–33.

Fatalities Associated with Farm Tractors (place)

When they tried to look at distribution by place,they found that the concetration was in this area,and prevention would be something more in this area

In order to understand a health problem,look at who's affected because numbers in tables aren't enough,you have to present them in a way to have a meaning out of them



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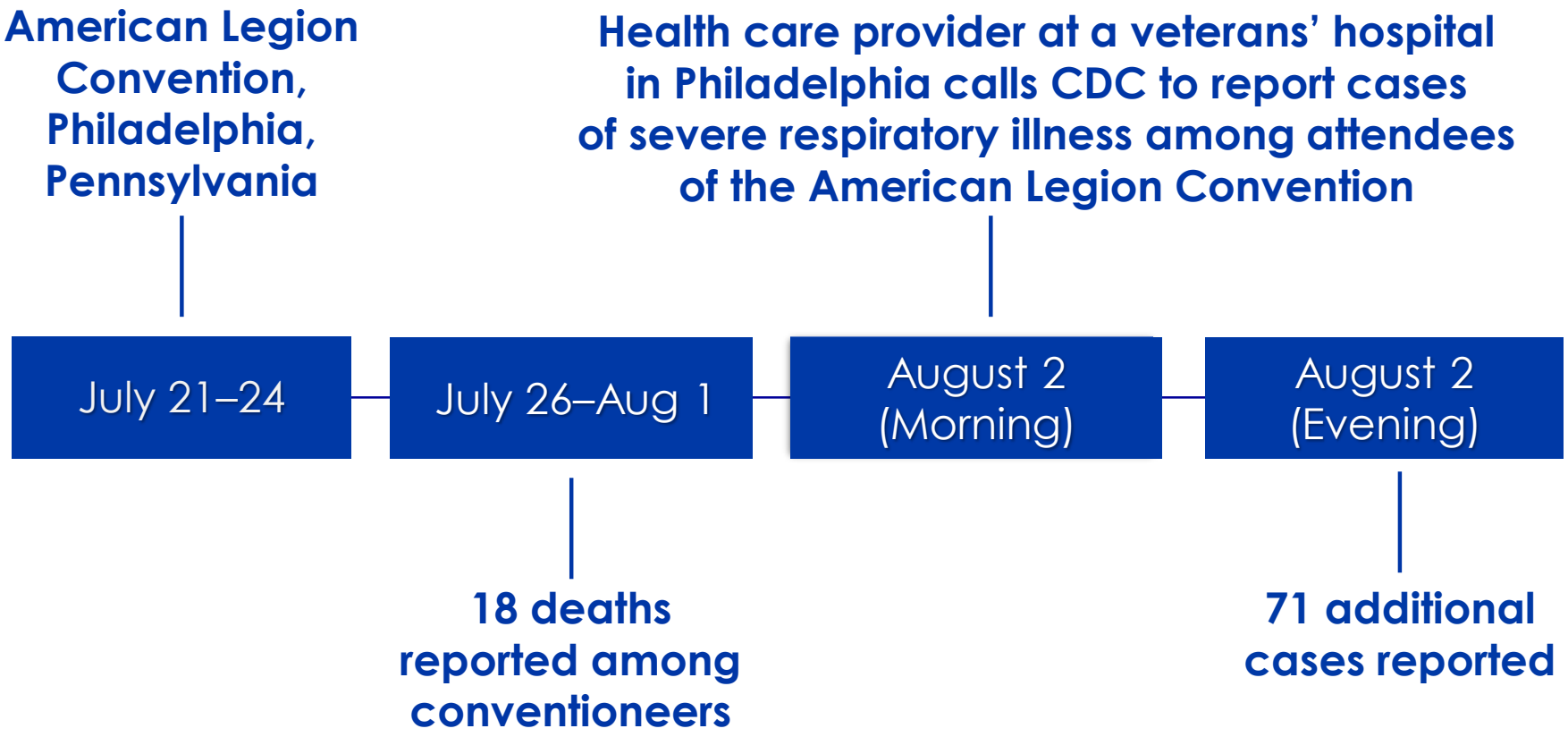
Legionnaire's disease outbreak

This led to discovery of a new type of microrganism named a legionella bacteria

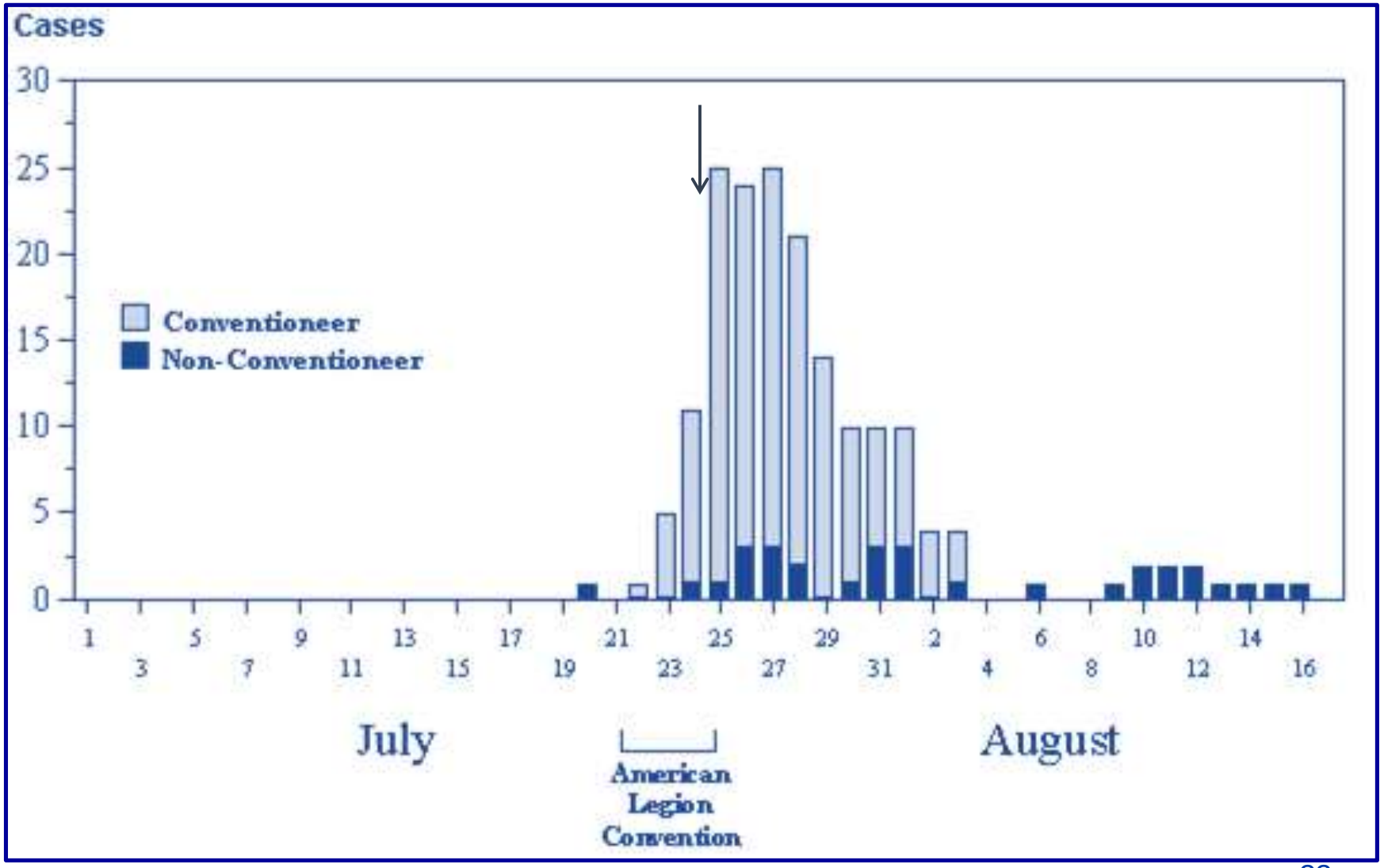
- Members of the American Legion gathered for the annual American Legion Convention held July 21 through 24, 1976, in Philadelphia.
- Soon after the convention began, a substantial number of attendees were admitted to hospital emergency departments or were examined in doctors' offices with acute onset 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. this was an epidemic
- 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



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.

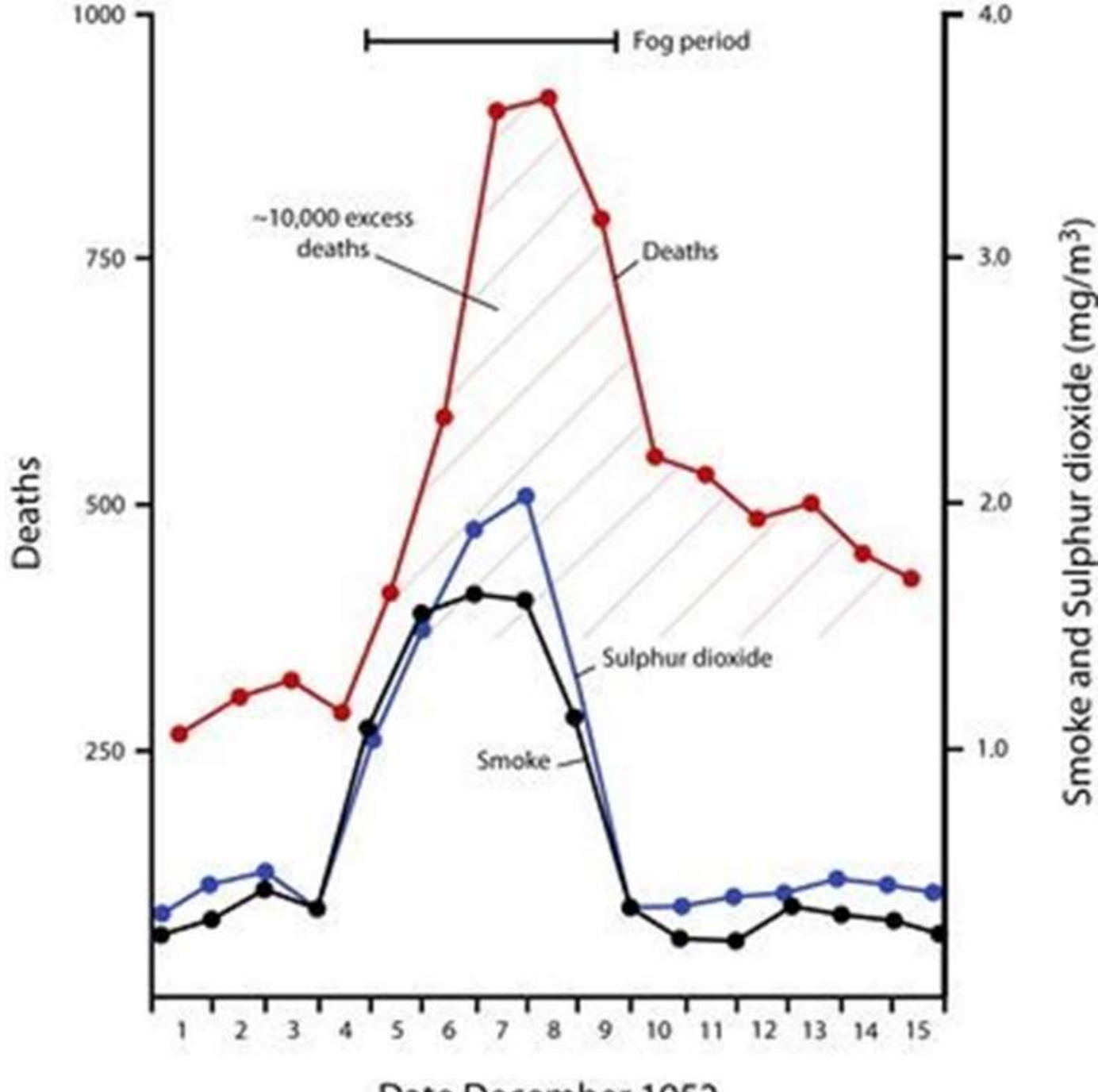
We can infer, therefore, that a connection exists between staying in Hotel A and becoming ill; we can also infer that older persons are somehow more susceptible to the disease.

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 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.

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.

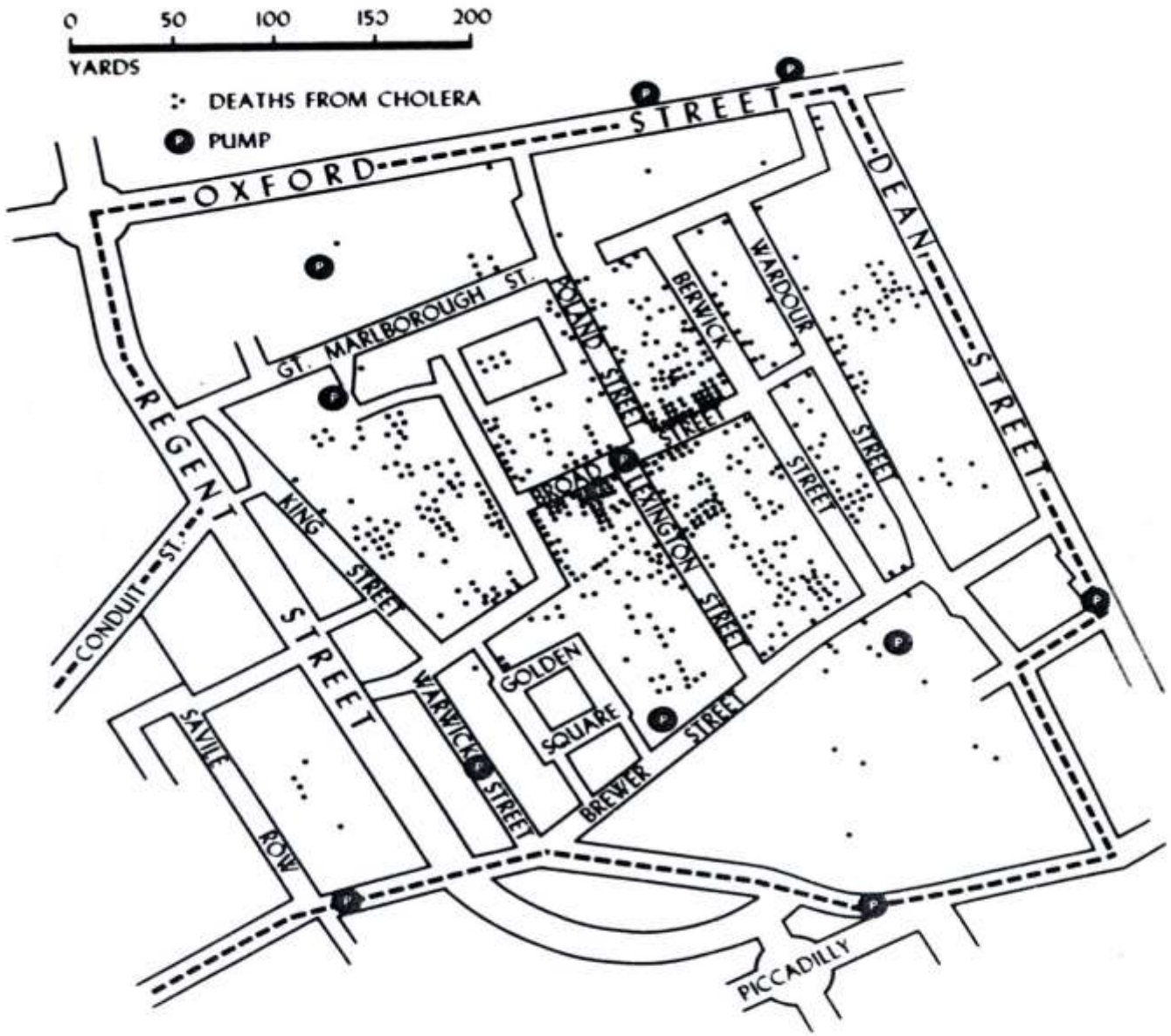
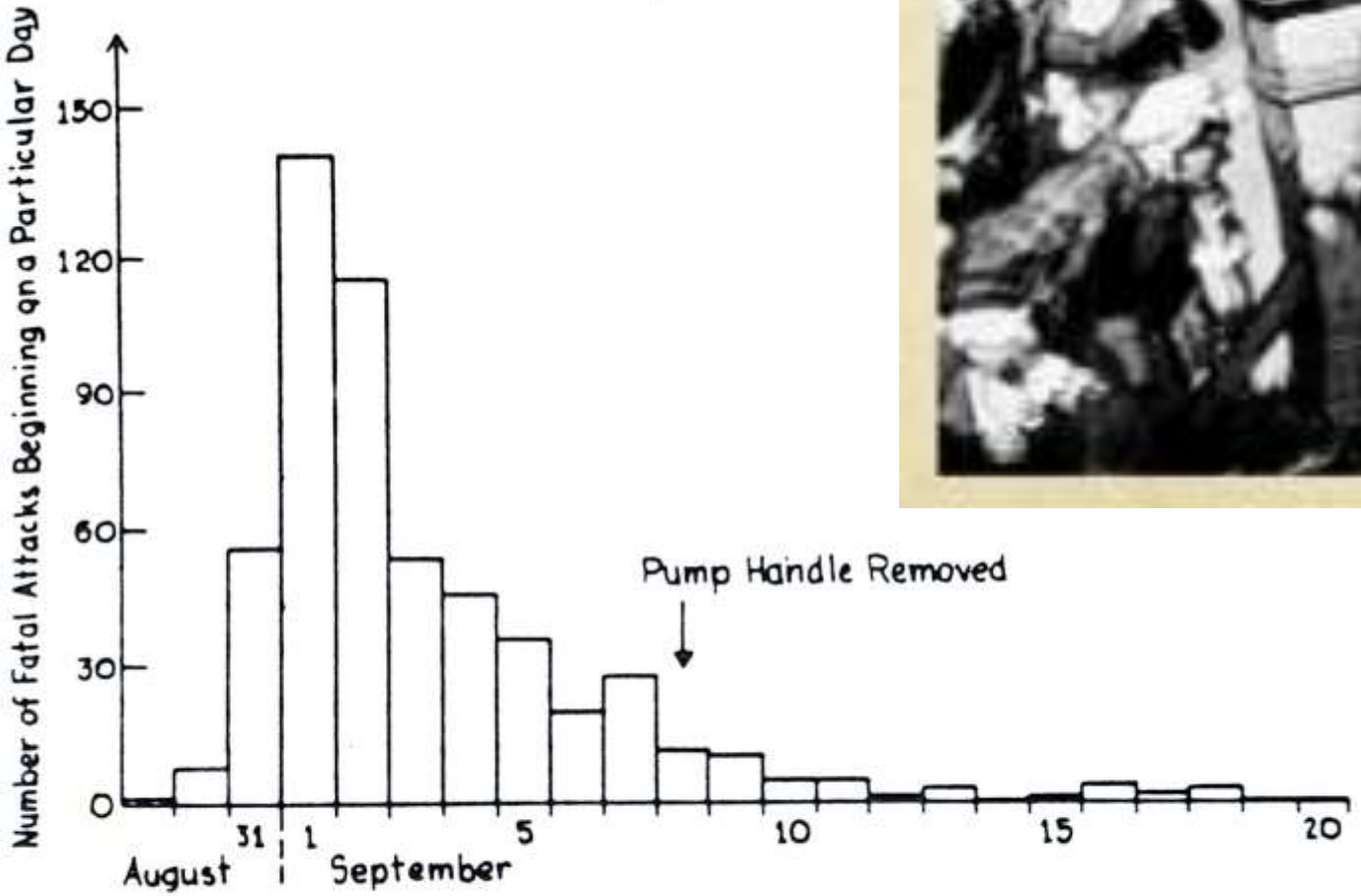


Figure 5-4 John Snow's Map of Cholera Deaths in the Soho District of London, 1848. *Source:* Adapted from *Health Care Delivery: Spatial Perspectives* by G. Shannon and G.E.A. Dever, p. 3, McGraw-Hill Book Company, 1974, and from *Some Aspects of Medical Geography* by L.D. Stamp, p. 16, Oxford University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

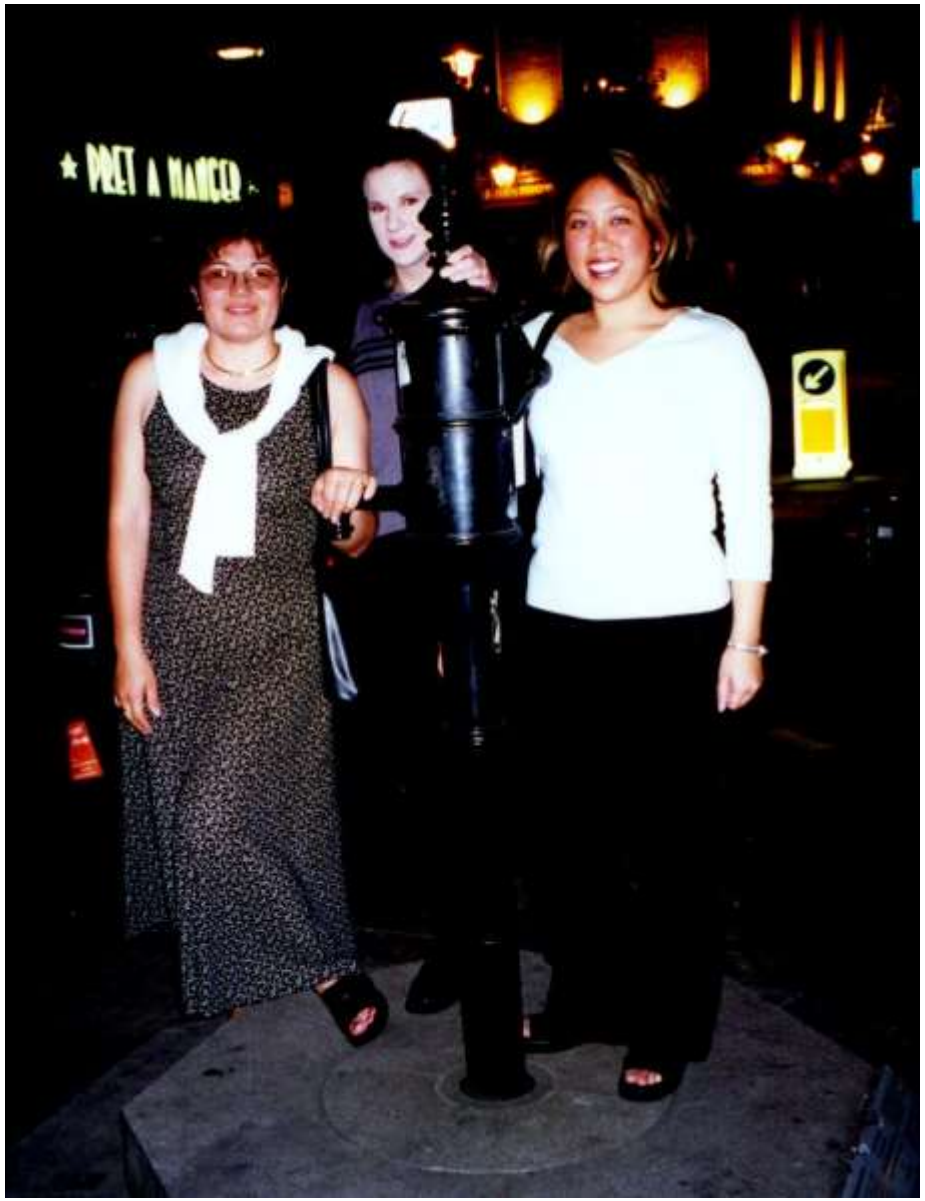
Fresh Water ought to be Boiled every Morning for the day's use, and what remains of it ought to be thrown away at night. The Water ought not to stand where any kind of dirt can get into it, and great care ought to be given to see that Water Butts and Cisterns are free from dirt.

BY ORDER,

THOS. W. RATCLIFF,
CLERK OF THE BOARD.


JOHN SNOW
JOHN SNOW


Dr John Snow and the Broad Street Pump
DEATH


★ POET A MARCO