Introduction to Epidemiology

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Lecture Contents….

1. Epidemiology defined.
2. The components of epidemiology
3. The basic tenets of epidemiology
4. Major Epidemiology cases
5. History of epidemiology
6. Theories of disease causation
7. Measuring disease occurrence (Prevalence and Incidence)

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 frequency, 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 epidemics

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

Epidemiology

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

What is the event? (The 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?**

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

Disease frequency:

The core characteristics of epidemiology are to measure the frequency 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 rate, 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…

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

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

1. Short term fluations: 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??

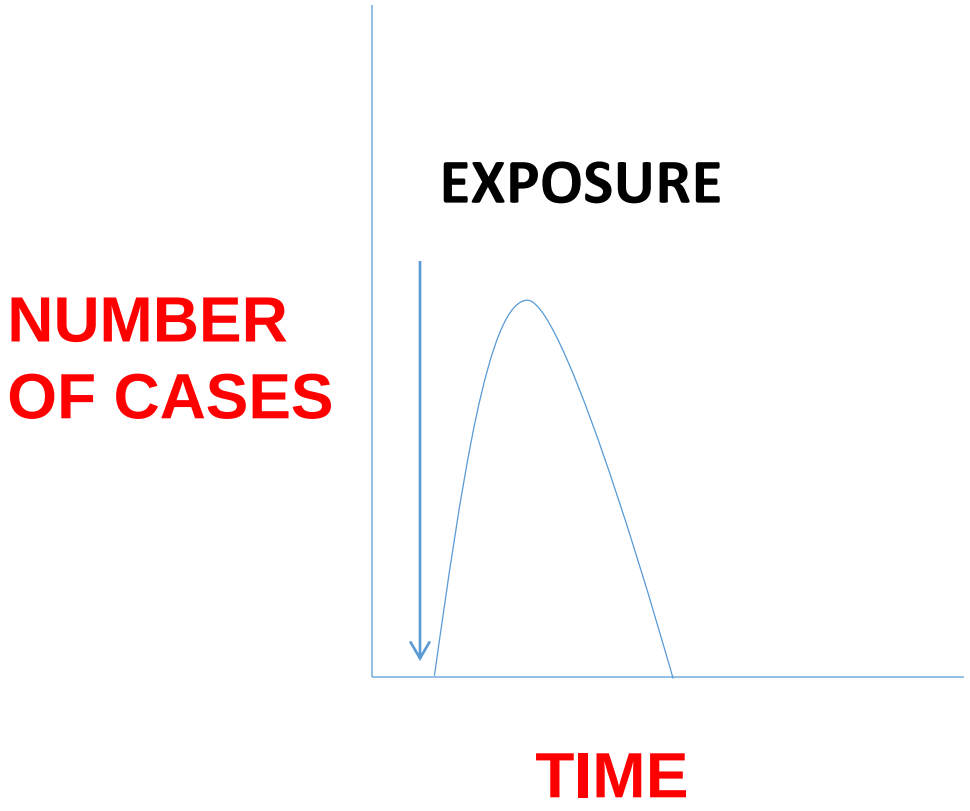
2. Periodic fluctuation:

   Seasonal: GI infection in Summer

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

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

EPIDEMIC CURVE



Components…

Determinants:

Factors the presence/absence of which affect the occurrence and level of an event

Epidemiology studies what determines or influences health events:

- ✓ **It answers the question: how and why?**
- ✓ **Epidemiology analyzes health events**

Components…

Determinants:

This aspect of epidemiology is known as "analytical epidemiology".

Analytical strategies help in developing scientifically sound health programmes, interventions & policies.

Components…

Diseases & other health related events

Epidemiology is not only the study of diseases.

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

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

Components…

Human population

Epidemiology diagnoses and treats communities/populations

- ✓ **Clinical medicine diagnoses and treats patients**
- ✓ **Epidemiology is a basic science of public health**

Components…

Application

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

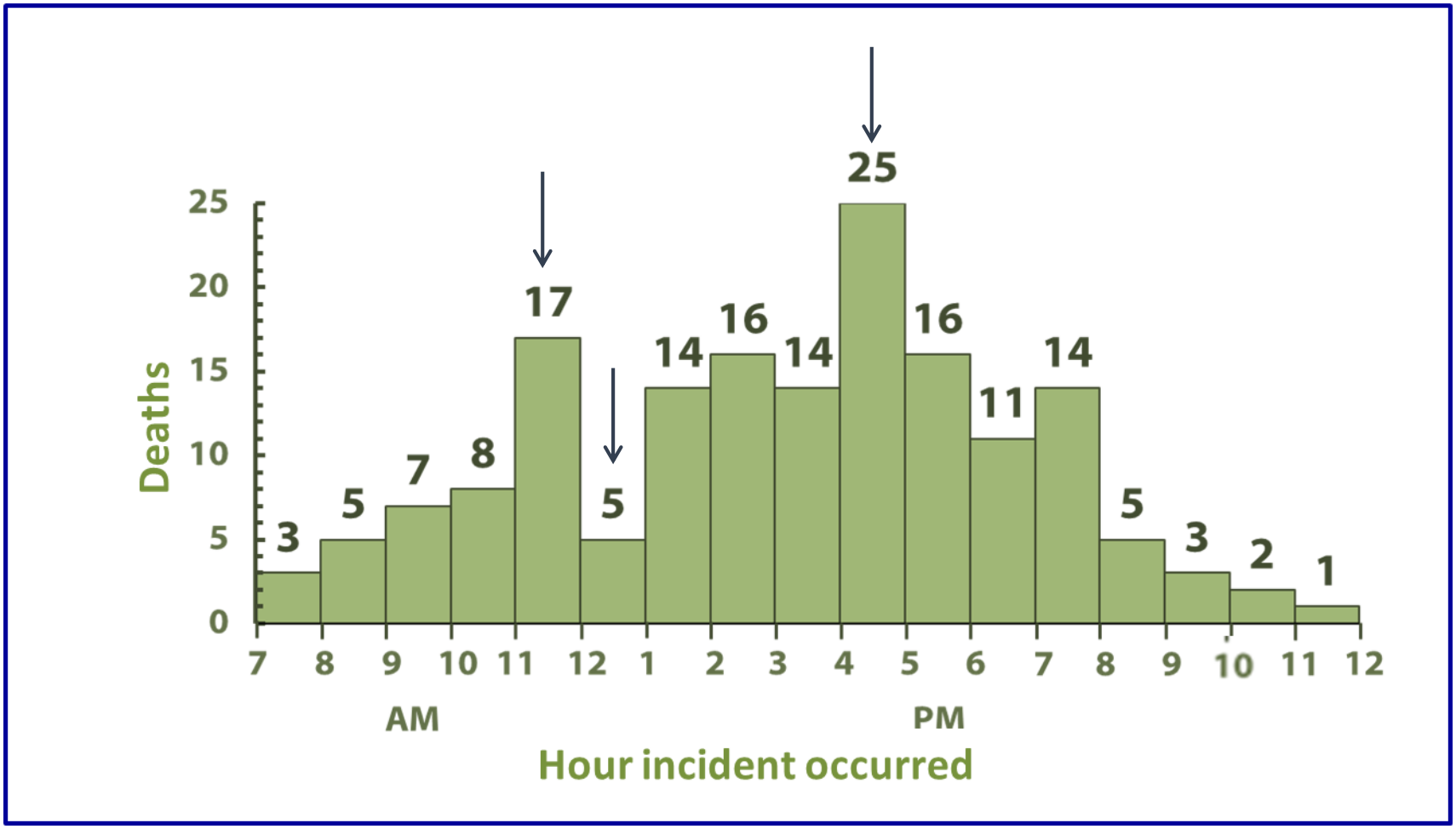
- ✓ **Epidemiology is a science and practice**
- ✓ **Epidemiology is an applied science**

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

Fatalities Associated with Farm Tractors

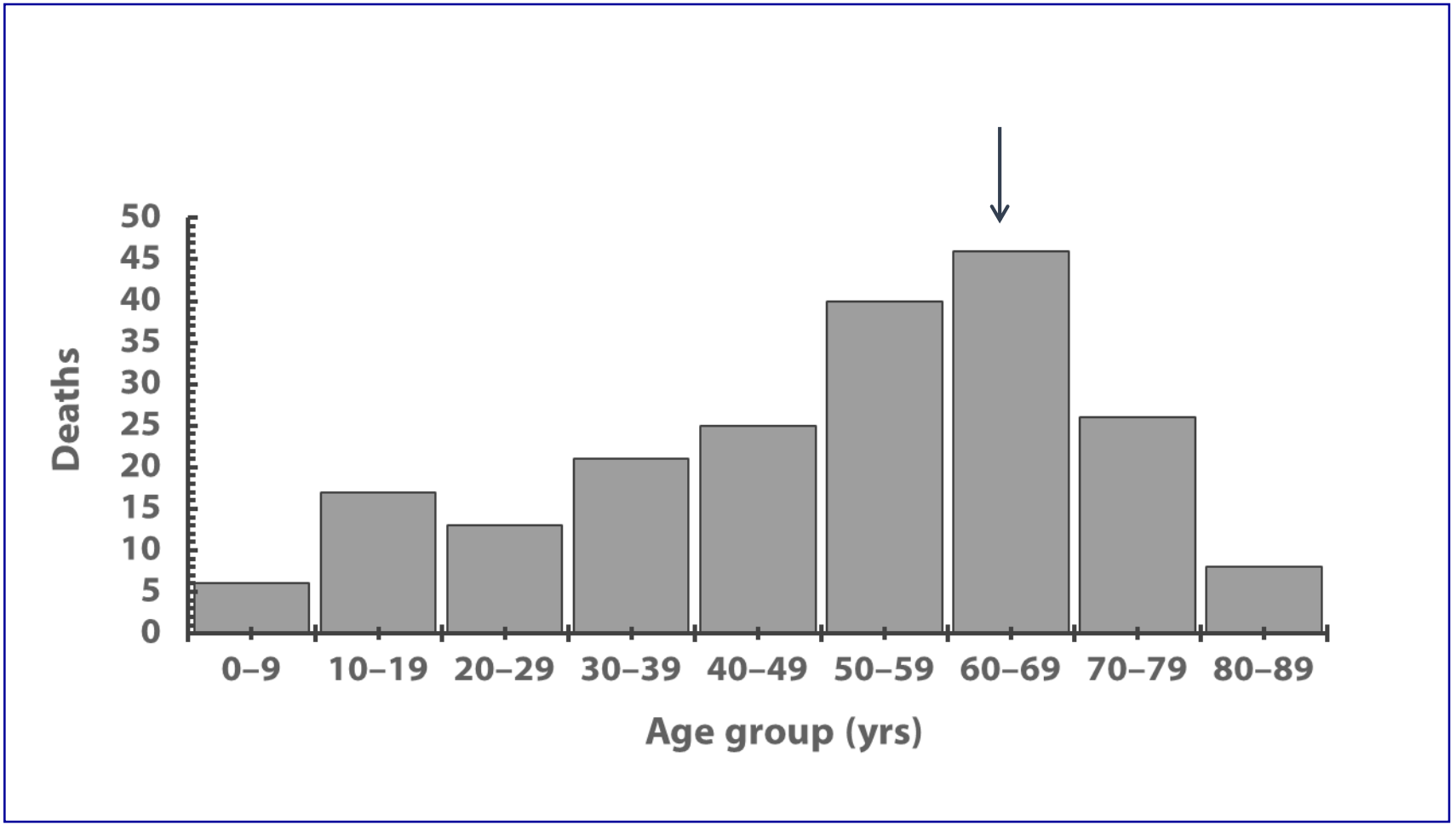
In 1982, the number of farm tractor-associated deaths in Georgia was described in terms of time, place, and person by using records from an existing surveillance system.

Fatalities Associated with Farm Tractors (time)



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 (person)



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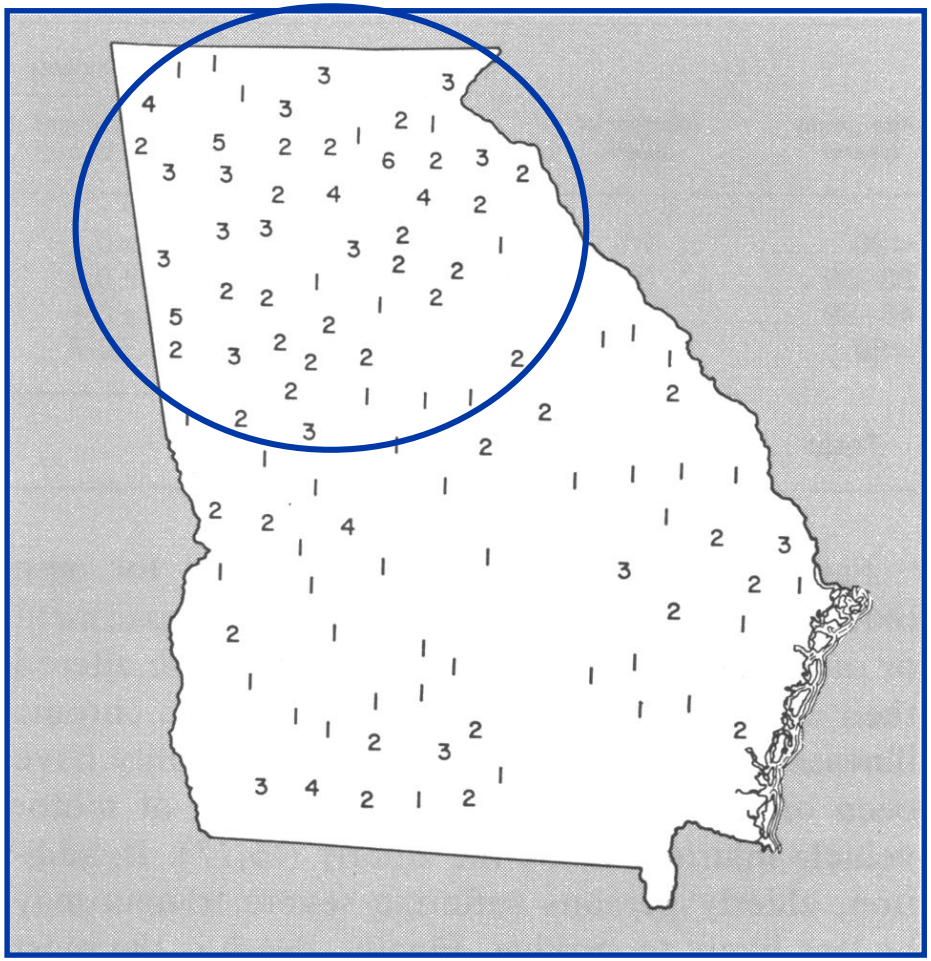
Fatalities Associated with Farm Tractors (place)



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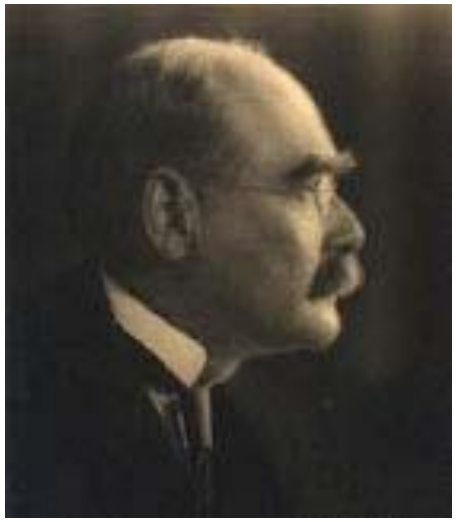
Data Sources and Collection Methods

Source	Method	Example
Individual persons	• Questionnaire • Survey	• Foodborne illness outbreak • CDC's National Health and Nutrition Examination Survey • Health data on U.S. residents
Environment	• Samples from the environment (river water, soil) • Sensors for environmental changes	• Collection of water from area streams — check for chemical pollutants • Air-quality ratings
Health care providers	• Notifications to health department if cases of certain diseases are observed	• Report cases of meningitis to health department
Nonhealth–related sources (financial, legal)	• Sales records • Court records	• Cigarette sales • Intoxicated driver arrests

Epidemiology Purposes in Public Health Practice

- Discover the agent, host, and environmental factors that affect health
- Determine the relative importance of causes of illness, disability, and death
- Identify those segments of the population that have the greatest risk from specific causes of ill health
- Evaluate the effectiveness of health programs and services in improving population health

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

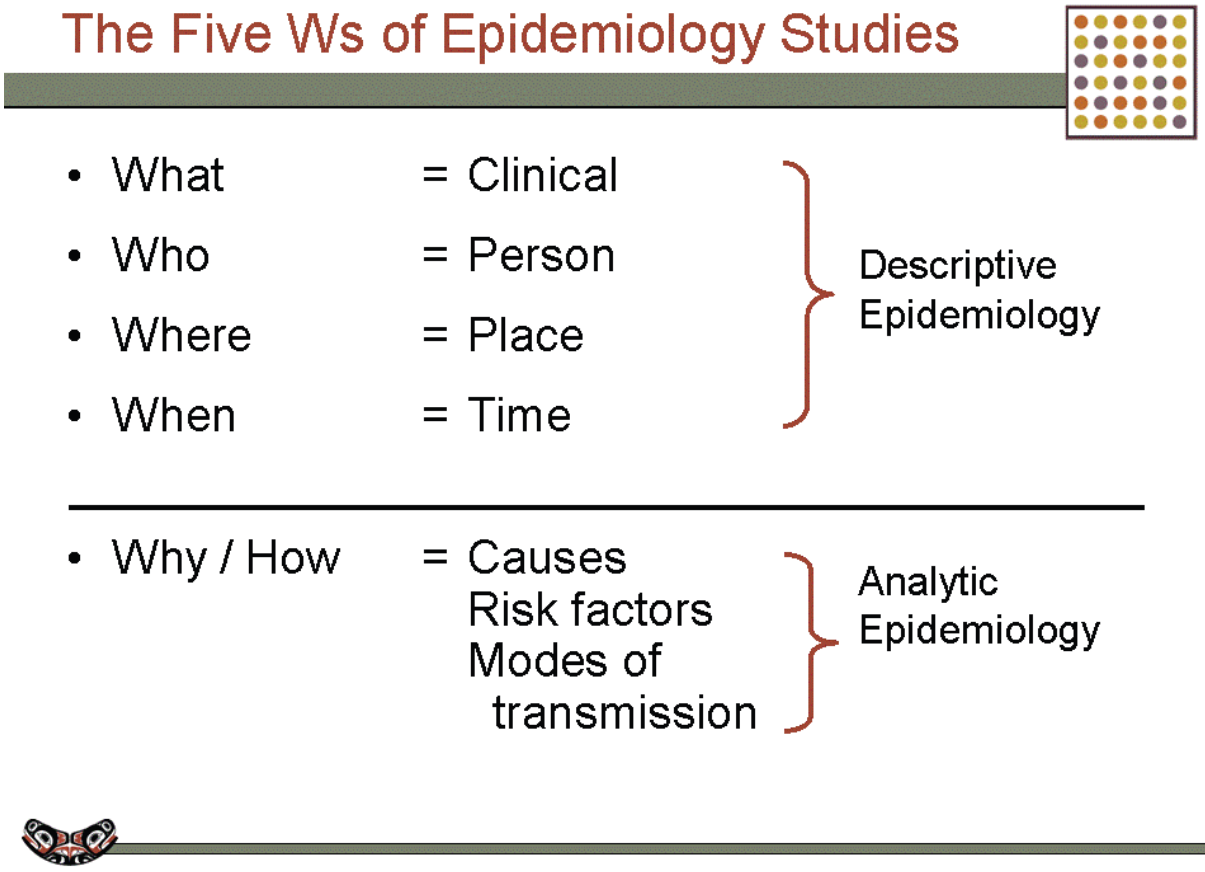
Try to explain **why** the problem has such a distribution

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



Basic tenets of epidemiology

- ✓ **The target of a study in epidemiology is human Population: the most common population in epidemiology is the population in a given area or country at a given time.**
- ✓ **Since the structure of population varies at each time such variations also have to be taken in to consideration during data analysis.**

Basic tenets of epidemiology

- ✓ **Diseases do not occur randomly.**
- ✓ **Conclusions are based on comparisons: comparing the rates of disease frequency among the exposed and unexposed is an important epidemiological method.**
- ✓ **Description of events by time, place and person. Getting answer for when, where and who are affected is very important in epidemiology to formulate hypothesis about its causation. Other important aspects are what, why and how of the events.**

Definition of Epidemic, Endemic, 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)***

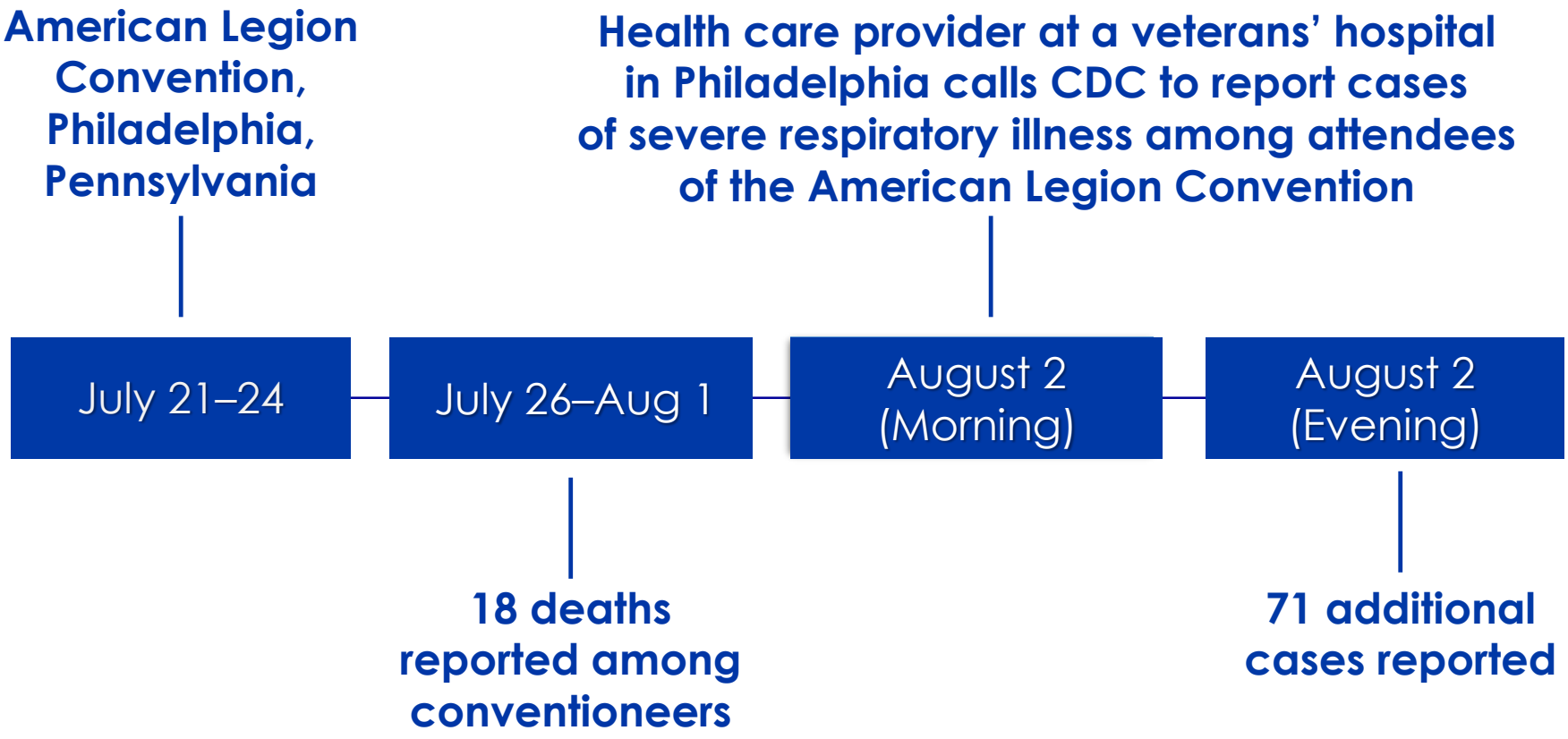
Epidemic or outbreak:

The occurrence of a disease in a community or region, clearly in excess of normal expectancy (APHA)

- **Pandemic:**

A worldwide epidemic

Legionnaire's disease outbreak

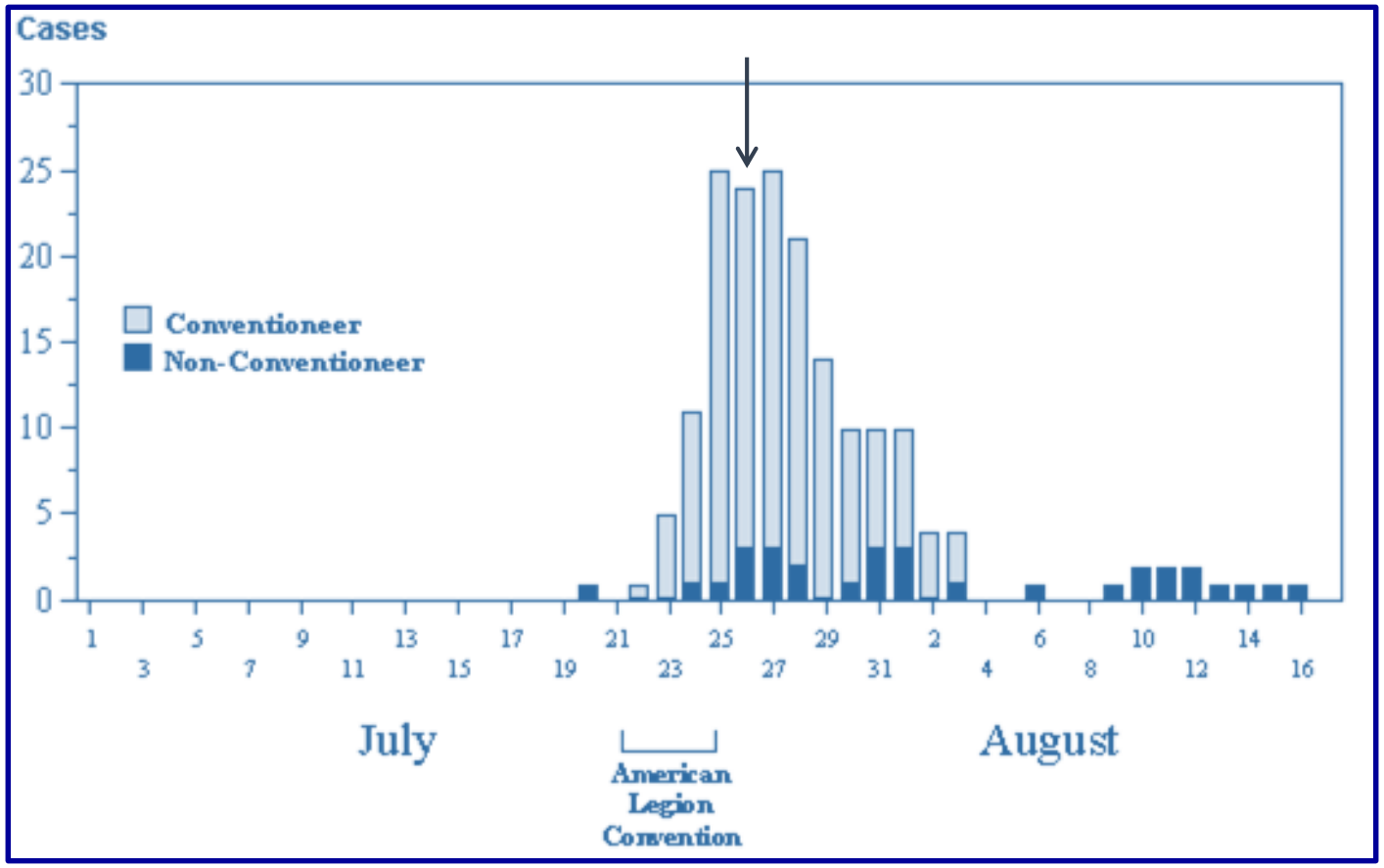


Fraser DW, Tsai, T, Orenstein W, et al. Legionnaires' disease: description of an epidemic of pneumonia. New Engl J Med 1977;297:1189–97.

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!!!

Legionnaires' Disease Cases, by Day



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Legionnaires' Disease Attack Rates

	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

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, by Age Group

Hotel A Residents

➡ Time: July 21–24, 1976

	Frequency	Unit size	
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

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 Rate

Hotel A Residents

Time: July 21–24, 1976

	Frequency	Unit	Rate
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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

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 engaged.
- 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 climate control systems.

London Smog Disaster, 1952

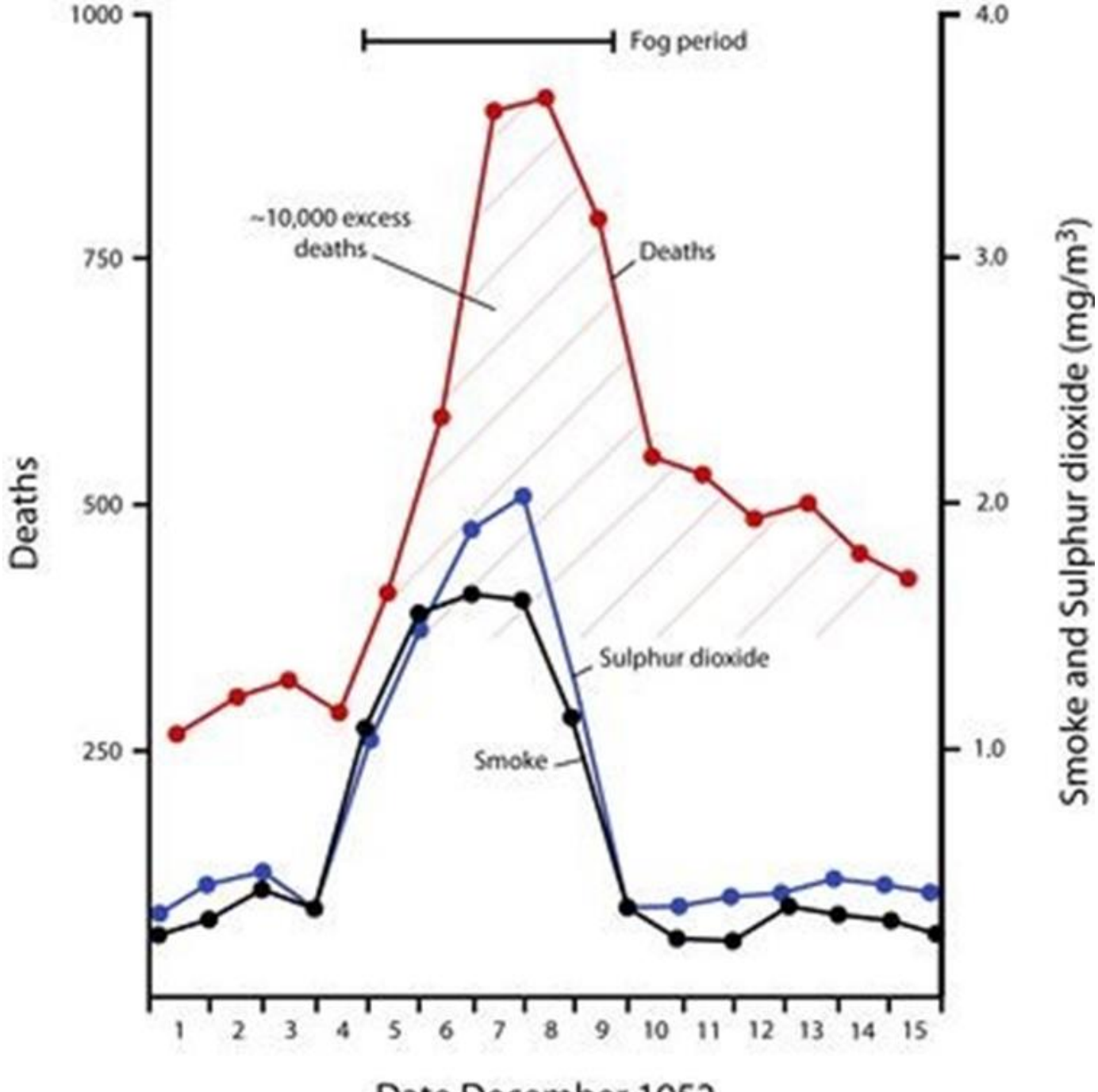
Air pollution causes respiratory illnesses and death …

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, 1952

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

History…

4) **William Farr (1839): Established application of vital statistics for the evaluation of health problems.**
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 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

History of epidemiology

John Snow conducted the series of investigations in London that later earned him the title father of field epidemiology. 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 causes of diseases and prevent its recurrences.

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

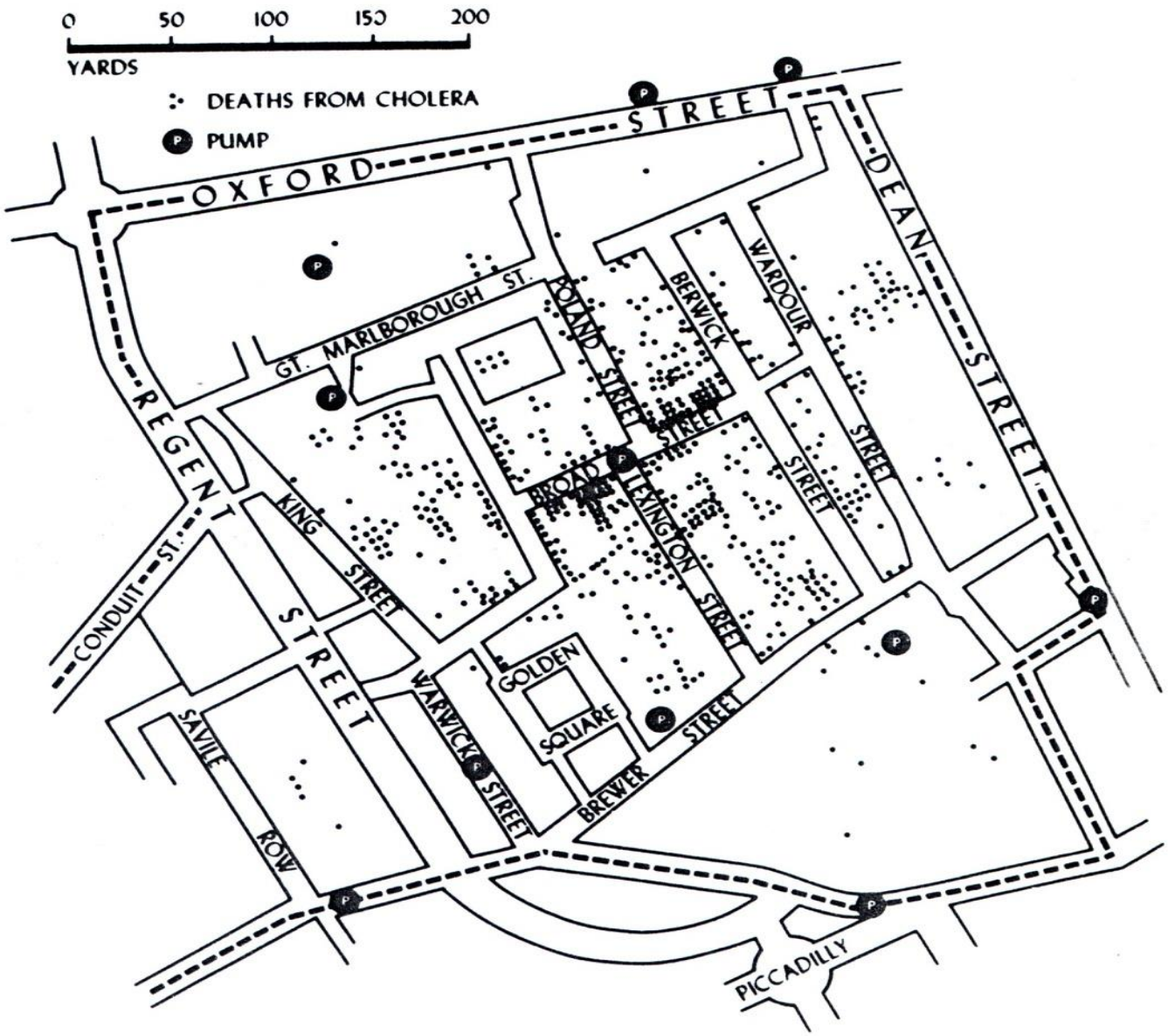
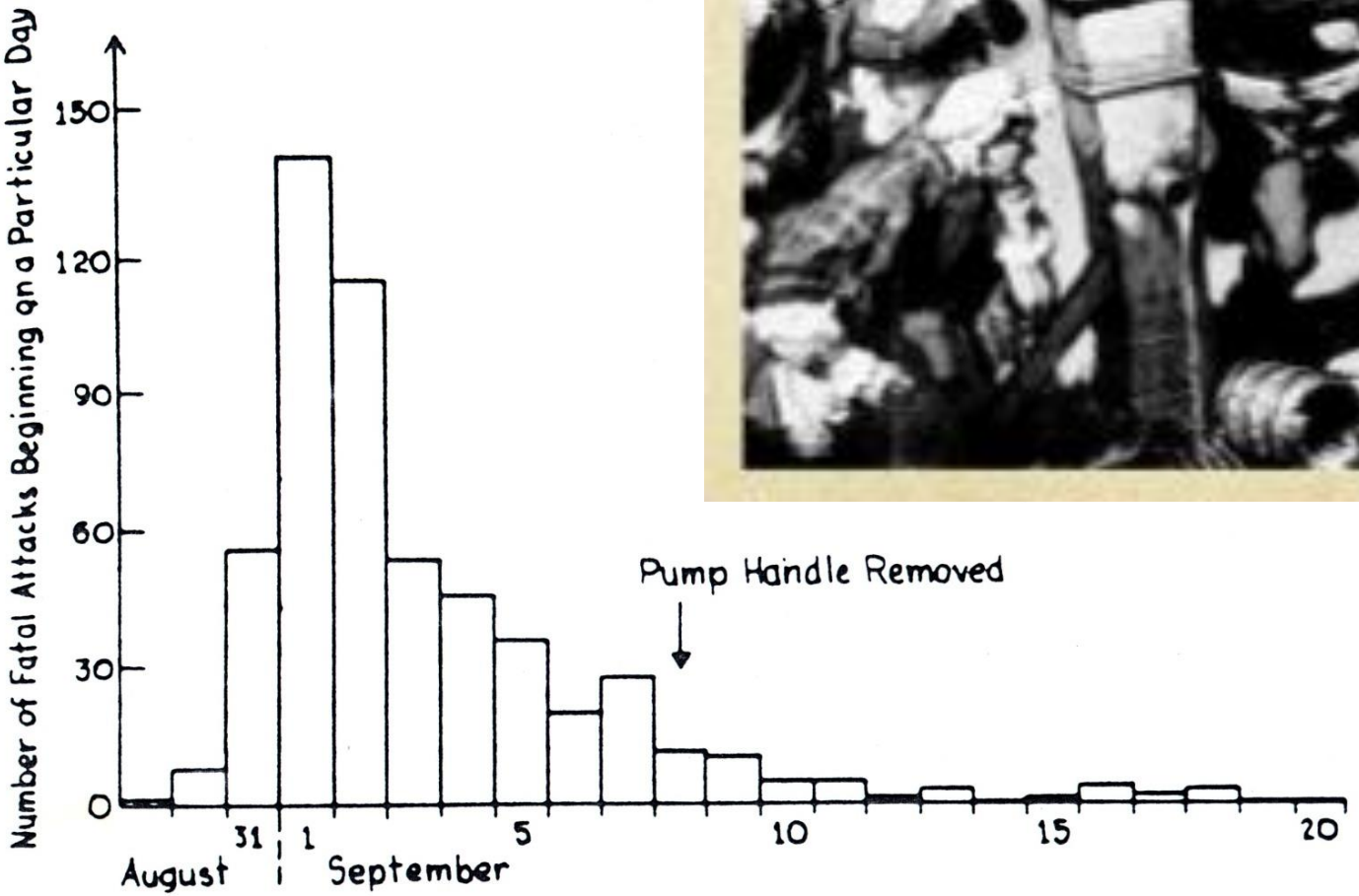


Figure 5-4 John Snow's Map of Cholera Deaths in the Soho District of London, 1848. *Source:* Adapted from *Health Care Delivery: Spatial Perspectives* by G. Shannon and G.E.A. Dever, p. 3, McGraw-Hill Book Company, 1974, and from *Some Aspects of Medical Geography* by L.D. Stamp, p. 16, Oxford University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

Board Office, Wine Office Court, Fleet Street, E.C.

John Snow


JOHN SNOW
JOHN SNOW


Dr John Snow and the Broad Street Pump
DEATH


PRET A MANGER

Theories of Disease Causation

What causes a disease?

Nineteenth century theories

1. **Contagion theory**
2. **Supernatural theory**
3. **Personal behavior theory**
4. **Miasma theory**

Theories …..

Twentieth century theories

1. Germ theory
2. Lifestyle theory
3. Environmental theory
4. Multi-causal theory

How do we measure diseases occurrence?

Four *quantitative* descriptors:

- Numbers
- Ratios
- Proportions
- Rates

Numbers: Use of actual number of events

e.g 100 cases of TB in community A

Ratios: Quantifies the magnitude of one occurrence X, in relation to another event Y as X/Y (quantities X and Y are random).

The numerator is not a part of the denominator.

e.g Ratio of TB cases in community A to B is 1:10

***Proportions*: a ratio in which the numerator is included in the denominator**

e.g proportion of TB cases in community A is 10%

***Rates*: a proportion with time element**

It measure the occurrence of an event overtime (usually with a multiplier: 1000 or 100,000)

e.g US measles cases in 2000/US population in 2000

Types of rates

1. **Crude rates**: Apply to the total population in a given area

2. **Specific rates**: Apply to specific subgroups in the population (age, sex etc) or specific diseases

3. **Standardized rates**: used to permit comparisons of rates in populations which differ in structure (e.g age structure), we can calculate age or sex- standardized rates.

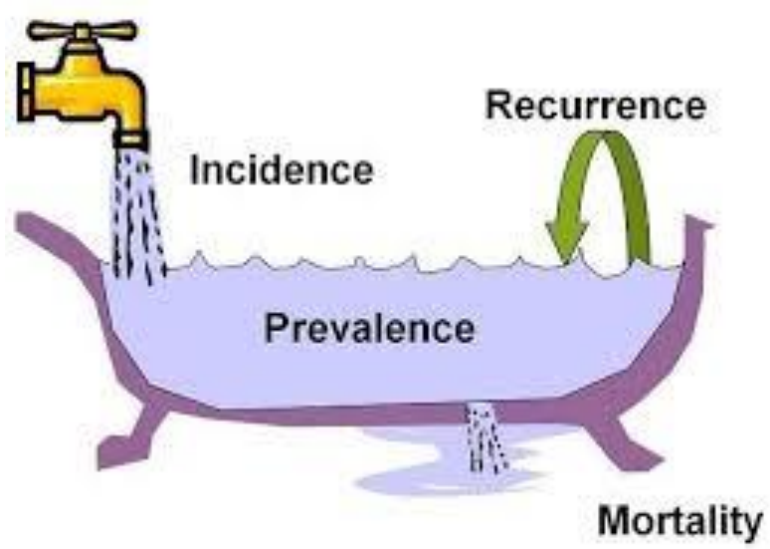
Two methods of standardization: Direct, indirect

Measurement of Disease Occurrence

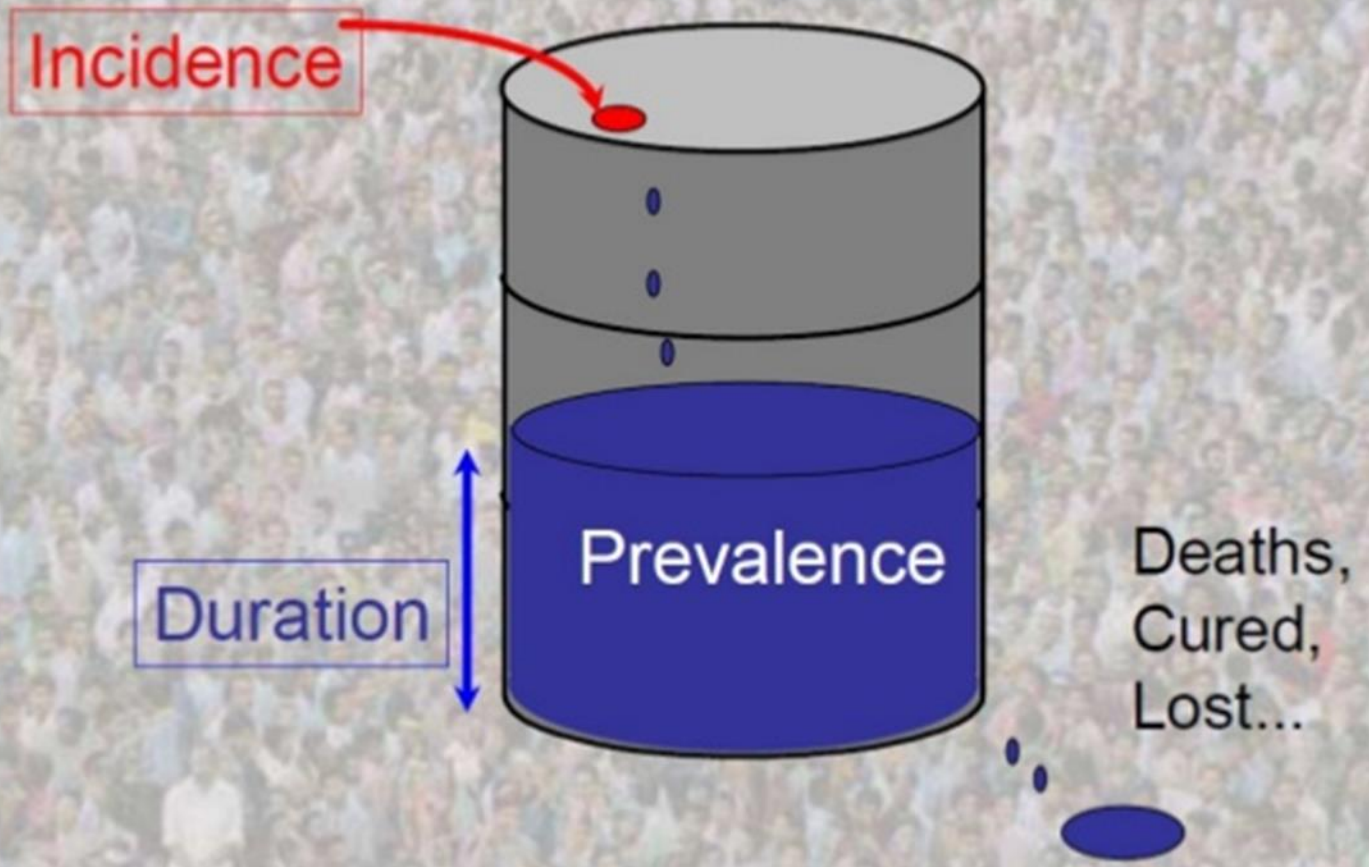
Morbidity rates

Morbidity rates are rates that are used to quantify the magnitude/frequency of diseases.

1. **Incidence rates** (Cumulative incidence, incidence density).
2. **Prevalence** (Period prevalence, point prevalence).



Prevalence vs. Incidence



Incidence rate

- ✓ The proportion of a population that develops a disease overtime
- ✓ The risk/probability of an individual developing a disease overtime
- ✓ The rapidity with which new cases of a disease develop overtime
- ✓ The proportion of unaffected individuals who on average will contract the disease overtime

Cumulative incidence

$$\text{Cumulative Incidence} = \frac{\text{Number of new cases of a disease during a specified period}}{\text{Population at risk in the same Period of time}}$$

Practical challenges in measuring incidence rate

1. Identification of population at risk

   Population at risk constitutes all those free of the disease and susceptible to it

2. Population is not static/it fluctuates/as a result of births, deaths and migration

3. People are at risk only until they get the disease and then no more at risk

Prevalence rate

It measures the proportion of a population with a disease during a specified period or at a point in time.

There is Point prevalence and Period prevalence.

Point prevalence rate

Measures the proportion of a population with a disease at a point in time

Point prevalence rate=All persons with a disease at a point in time/Total population

It is not a rate, but a true proportion.

Incidence Vs prevalence

Prevalence measures all of the current cases of the disease in the community.

- ✓ It depends on the duration of the disease process
- ✓ It depends on the incidence of the disease
- ❖ It can be used to determine the health care needs of a community.

$$P = I \times D$$

where P = Prevalence rate, I = Incidence rate, D = Duration of the disease.

- ✓ Prevalence rate is equal to Incidence rate in case of diseases with short duration or highly fatal such as Rabies.

Relationship between prevalence & incidence rates

An increase in prevalence rate may not necessarily be due to an increase in incidence rate, it could be due to an increase in average duration of a disease due to decrease in death and/or recovery rates.

Calculations …

A survey of respiratory disease was conducted and the results are presented in the table below.

Calculate the prevalence of chronic bronchitis in each age group and in the total group.

Prevalence of chronic bronchitis, by age, in a sample of 2383 employed men: , 1981.			
Age (years)	Number Surveyed	Frequency	Prevalence (%)
45-49	496	18	3.6
50-54	672	18	2.7
55-59	1215	18	1.5
Total	2383	54	2.3
$\chi^2 = 0.983$, p = 0.612			

Prevalence = 54 / 2383 = 0.0226 x 100% = 2.3%

= 0.0226x 1000= 22.6 cases/1000 pop.

A study was conducted to examine the incidence of Carpal Tunnel Syndrome (CTS) among computer operators in a certain corporation. An initial survey was given to 12 administrative assistants. Two of the 12 administrative assistants had symptoms and 10 did not reveal signs or symptoms equivalent to CTS. The administrative assistants who did not reveal signs or symptoms equivalent to CTS were then recruited into a study and followed for 4 years. The findings are listed below

3 of the 10 administrative assistants developed CTS during the 4 year follow-up period

Subjects	Follow-up Time(yrs)	CTS
1	1	yes
1	2.5	yes
1	3	yes
2	2	fired
1	1	transferred
4	4	no

Calculate Cumulative Incidence (per 1,000?)

Cumulative Incidence= 3/ 10 = 0.3 x 100% = 30%

= 0.3 x 1000 = 300 cases per 1,000 population