Introduction to Epidemiology

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Introduction

- Epidemiology – derived from Greek words – *Epi* (on/upon), *demos* (people) & *logos* (study)
- Last (2001) defines epidemiology as:
    - "**Study** of the **distribution** and **determinants** of **health-related states or events** in **specified populations**, and the **application** of this study to control of health problems"
- Study – Epidemiology is a scientific discipline – also called – the basic science of public health
    - Has at its foundation sound methods of scientific inquiry
- Distribution – Epi is concerned with *frequency* & *patterns* of health events in a population

Introduction

- *Frequency* refers not only to the number of health events in a population but also the rate/risk of disease in a pop (rate/risk being the no. of events divided by the pop size) – allows for comparisons between populations
- *Pattern* refers to occurrence of the events by time, place and person:
  - Time characteristics – annual, seasonal, daily occurrence during an epidemic
  - Place characteristics – geographical variation, urban-rural differences, locations
  - Personal characteristics – demographic factors e.g. age, sex, race, marital status, socioeconomic status and behaviours

Introduction

- The characterization of the **distribution** of health-related events falls under *descriptive epidemiology* – answers the question *who* (person) has *what* (outcome e.g. malaria, lung cancer etc.), *when* (time) and *where* (place)?
- Determinants – causes/factors that influence (increase/reduce) the occurrence of health-related events.
- Factors that *increase* risk (causal/risk factors) & those *reducing* risk (protective)

Introduction

- *Analytic epidemiology* – seeks to answer the *why* and *how* of epidemiology by comparing rates of disease occurrence in groups of individuals with & without determinants of interest:
  - E.g. **why** are smokers at an increased risk of lung cancer? (Demonstrate **association**)

    smoking **…………..**>Lung cancer (compare lung cancer rates in smokers & non-smokers since lung cancer does also occur amongst non-smokers)
  - E.g. By **how** much does cigarette smoking increase the risk of lung cancer? (Quantify **magnitude** of association)
- <u>Health-related states or events (outcomes) </u>– could be disease, injuries, birth defects, maternal-child health etc.

Introduction

- Specified populations – refers to target group – differ between clinicians & epidemiologists:
  - Clinicians are concerned with health of the individual – e.g. when faced with patient with diarrheal disease clinician focuses on *diagnosing*, *treating* and *caring* for the *individual* patient.
  - Epidemiologists are concerned with the collective health of the people in an area or community e.g. for the diarrheal patient the epidemiologist focuses on the "exposure" (action/source causing the illness), number of persons possibly exposed, potential for further spread in the community and measures to prevent new cases i.e. *diagnose* & *treat* (control disease) the *community*

Introduction

- Application – epidemiology generates knowledge (from descriptive & analytic epidemiology) for *action* – to direct public health policy i.e. control & prevent disease in community

Uses of Epidemiology:

- To investigate the aetiology of disease and modes of transmission
- To determine the extent (magnitude & space) of disease problems in the community
- To study the natural history of disease (course a disease takes in individual from its pathological onset until its eventual resolution through complete recovery or death) & prognosis of disease

Introduction

Uses of Epidemiology:

- To 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 (evidence-based medicine)

Descriptive & Analytic Epidemiology

Descriptive epidemiology

- Data are organised & summarised into *person*, *time* & *place* in order to:
    - Become intimately familiar with the data & extent of PH problem under investigation
    - Provide detailed description of the health of a population
    - Identify the pops at greatest risk of acquiring particular d'ses
    - Generate hypothesis which can be tested

Descriptive Epidemiology

Time

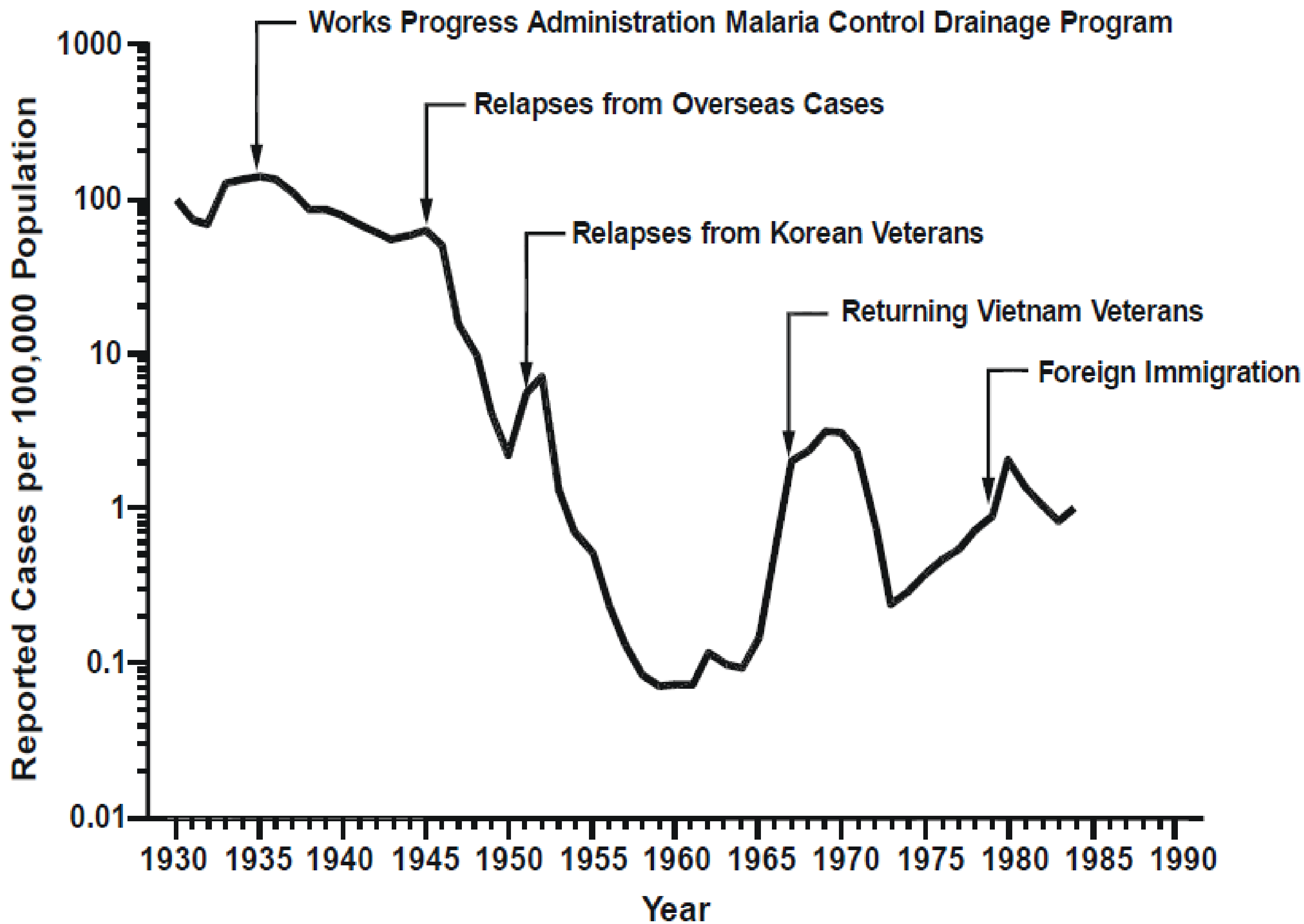
- D’se rates change over time – some changes occur regularly and are predictable and easily planned for e.g. seasonal increase of flu cases with onset of cold weather
- Time data are often graphed – no. of new cases/rate of disease (y-axis) is plotted against time periods (x-axis) – provides clues as to potential causes

Descriptive Epidemiology

- <u>Examples of time-graphs:</u>
  - a) Secular (long-term trends) – annual cases/rate of d'se is plotted over period of years to show long-term/secular trends in d'se occurrence. Used to:
    - Suggest/predict future incidence of d'se
    - Evaluate control programs/policies
    - Suggest causes of increases/decreases in d'se occurrence especially if graph shows when related events took place – see example

Descriptive Epidemiology

Malaria by year, United States, 1930-1990



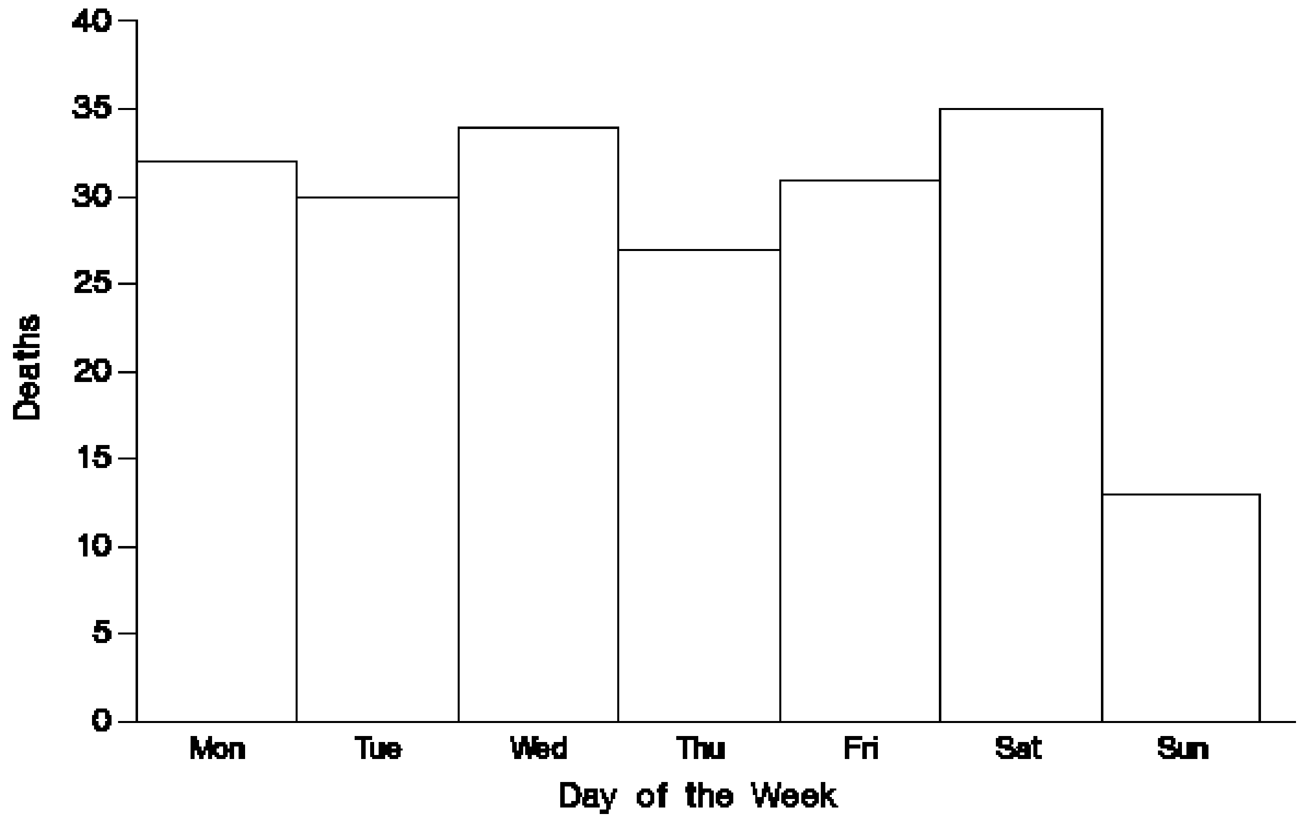
Descriptive Epidemiology

Descriptive epidemiology

- (b) Seasonality – involves graphing of d'se occurrence by week/month over the course of a year to reveal seasonal patterns – important for d'ses showing seasonal fluctuations e.g. flu cases typically increase in winter. Seasonal patterns may suggest how d'se is transmitted & what factors contribute to spread e.g. in next graph what factors contribute to its seasonal pattern?

Descriptive Epidemiology

Fatalities associated with farm tractor injuries by day of week, Georgia, 1971-1981



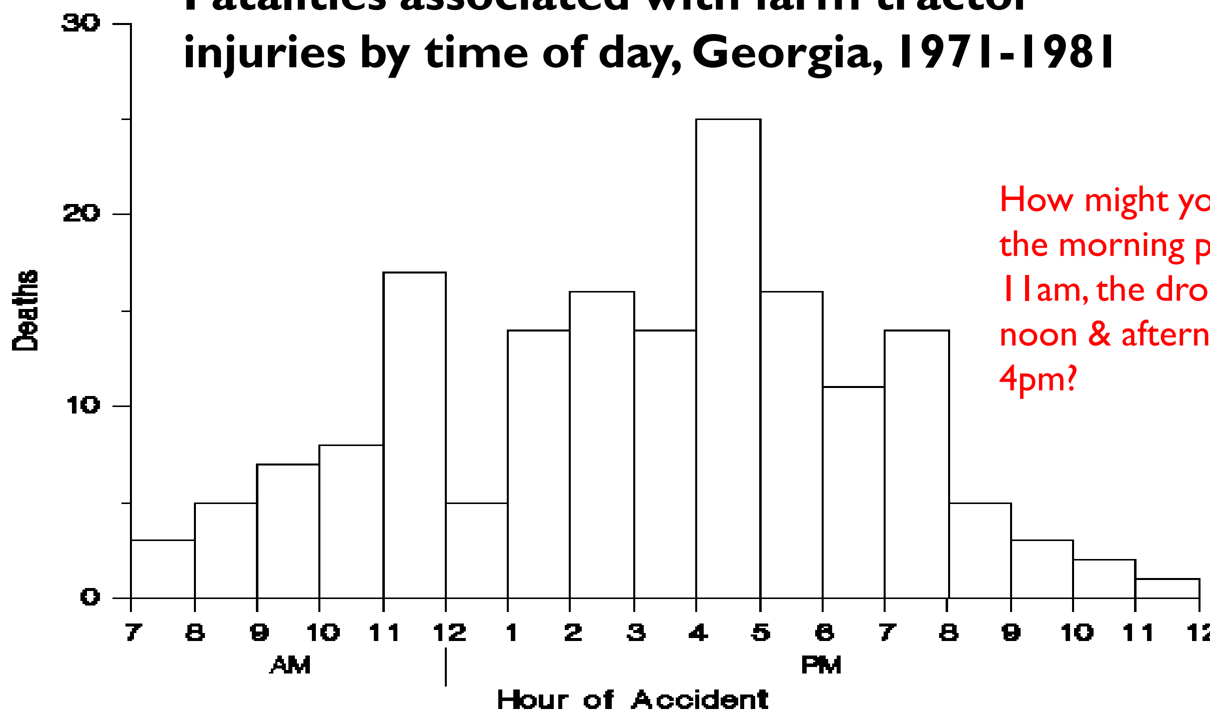
No. of farm tractor fatalities on Sundays is about half those in other days. Could be that farmers spend fewer hours on their tractors on Sundays than other days

Descriptive Epidemiology

Descriptive epidemiology

- (c)Day of week and time of day – Analysis of these short time periods suitable for d'ses related to environmental/occupational exposures which may occur at regularly scheduled intervals e.g. see graph

Fatalities associated with farm tractor injuries by time of day, Georgia, 1971-1981

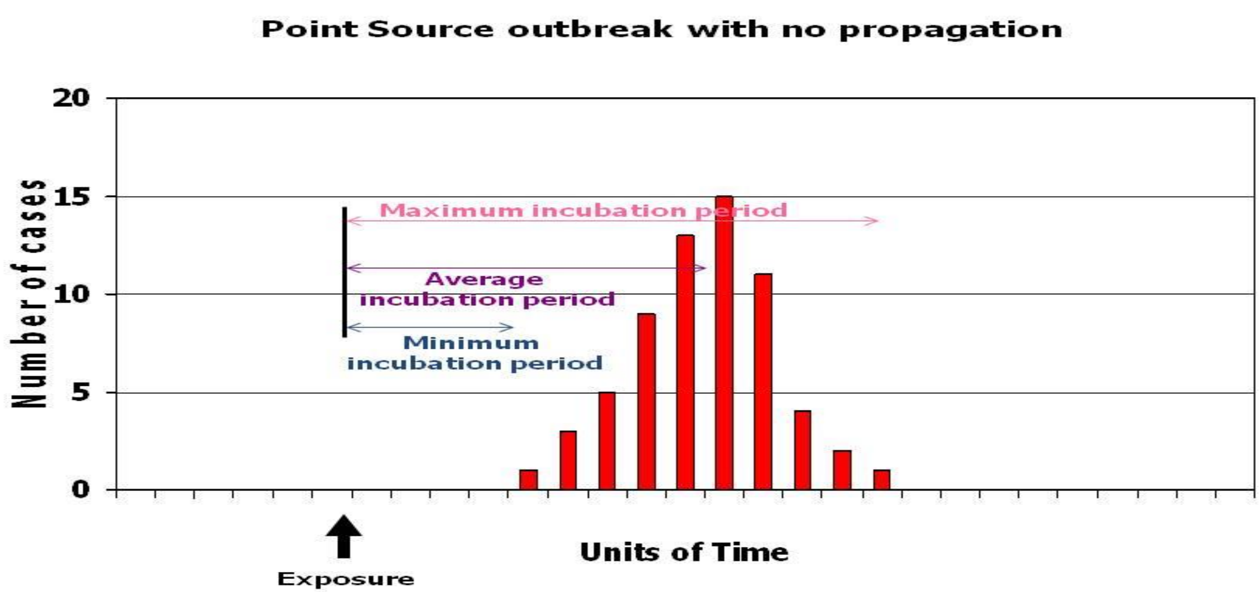


How might you explain the morning peak at 11am, the drop at 12 noon & afternoon peak at 4pm?

Descriptive Epidemiology

Descriptive epidemiology

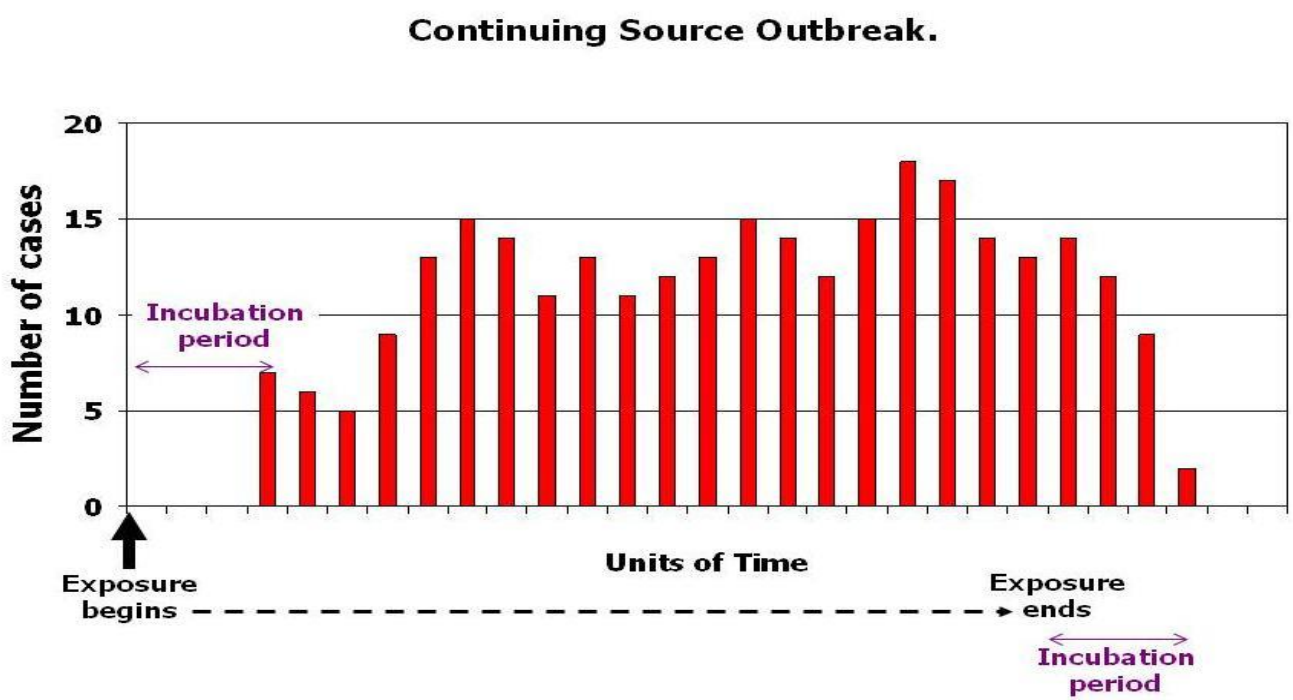
- Epidemic curves – no. of new cases plotted against time:
- Examples:
  - (a) Point source – all cases are exposed at a "point in time". Shape of curve reflects frequency distribution of incubation periods e.g. food-borne outbreaks



Descriptive Epidemiology

Descriptive epidemiology

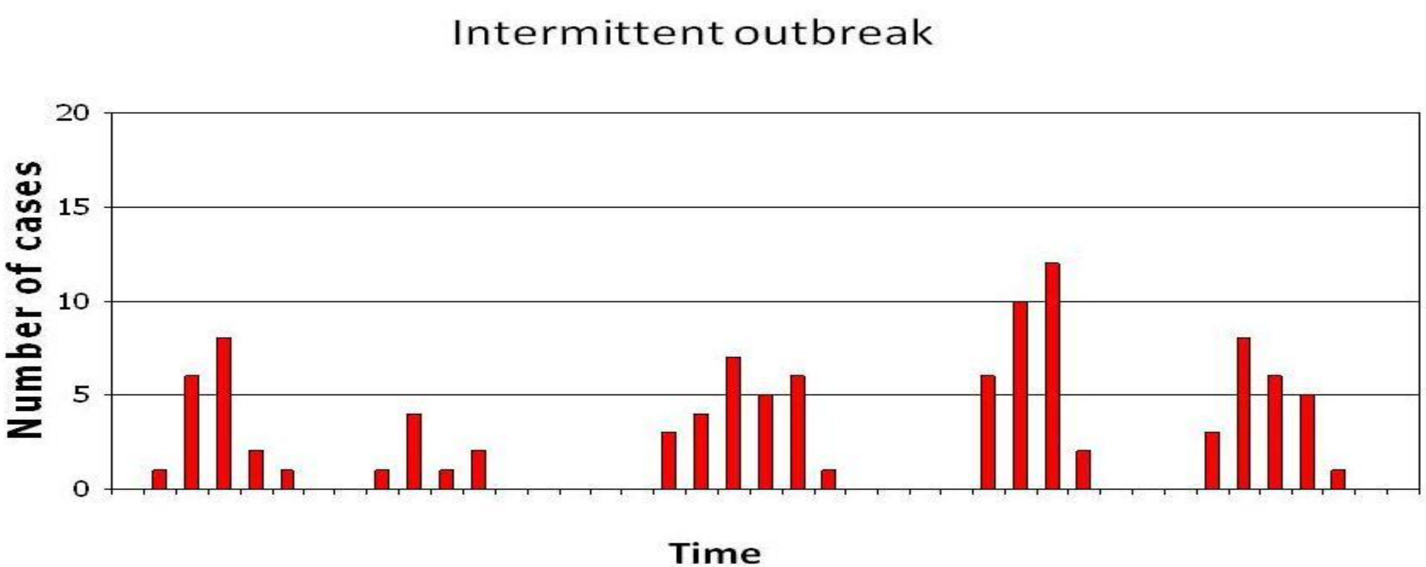
- (b) Extended source – onset & continuation of exposure to an environmental source of infection. 1st case may appear from *one minimum incubation period* from start of exposure & last case may appear up to *one maximum incubation period* from the end of exposure



Descriptive Epidemiology

Descriptive epidemiology

- (c) Propagated source – indicates successive generations of cases (1st, 2nd, 3rd etc) after introduction of an index case into a susceptible pop. Time between successive peaks is a measure of the (average) serial interval (time between homologous stages (e.g. onset of symptoms) of two successive cases in the chain of transmission e.g. measles or chicken pox in institutions. Shows person-to-person transmission



Descriptive Epidemiology

Place

- We describe a health event by place to gain insight into the geographical extent of the problem
- Could be large/small geographical units e.g. country, county, ward, street address etc
- Could analyse data by place categories e.g. rural vs urban – provides info as to ease of spread (overcrowding in urban areas). Also zoonotic diseases spread easily in semi-urban and rural areas due to animal contacts
- E.g. by analysing malaria cases by place of acquisition we can see where the risk of acquiring malaria is high
- Analysis of data by place could also reveal where a d'se agent lives, what may transmit it and how it spreads

Descriptive Epidemiology

Place

NUMBER OF IMPORTED MALARIA CASES IN U.S. AND FOREIGN CIVILIANS, BY AREA OF ACQUISITION -- UNITED STATES, 1993

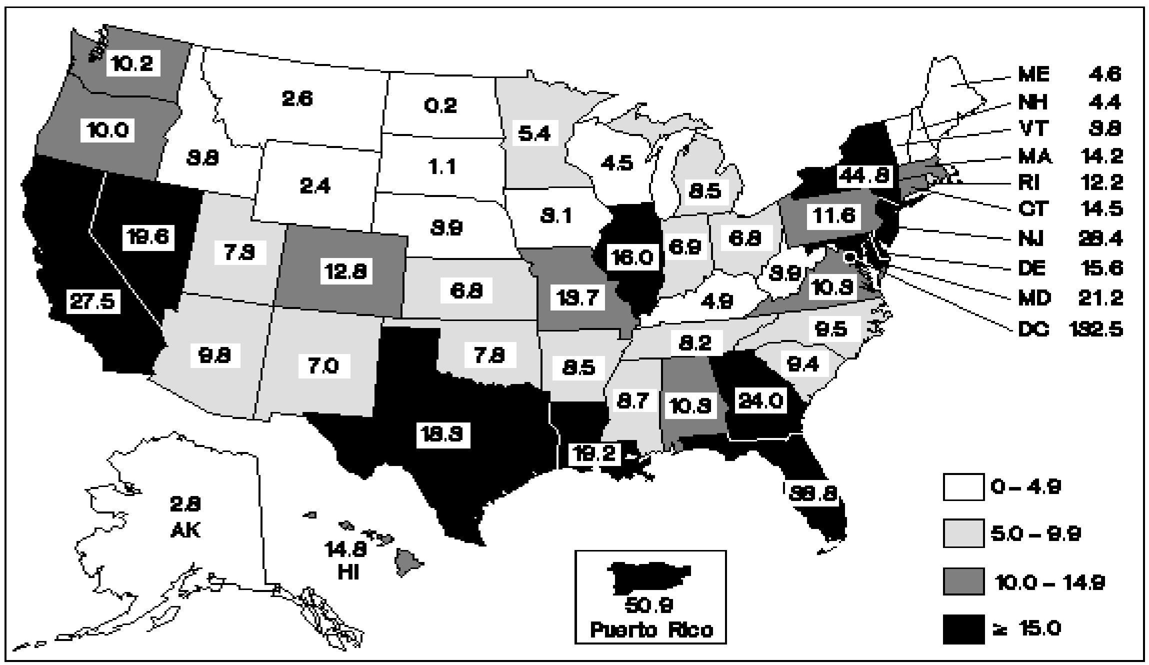
	U.S. civilians		Foreign civilians		Total	
Area of acquisition	No.	(%)	No.	(%)	No.	(%)
Africa	276	(54.3)	213	(47.0)	489	(50.9)
Asia	91	(17.9)	157	(34.7)	248	(25.8)
Caribbean	11	(2.2)	12	(2.6)	23	(2.4)
Central America	54	(10.6)	46	(10.2)	100	(10.4)
Mexico	5	(1.0)	7	(1.5)	12	(1.2)
Oceania	38	(7.5)	2	(0.4)	40	(4.2)
South America	17	(3.3)	2	(0.4)	19	(2.0)
Unknown	16	(3.1)	14	(3.1)	30	(3.1)
Total	508	(100.0)	453	(100.0)	961	(100.0)

- Data could also be displayed on a map – shows rates of d’se occurrence in different areas

Descriptive Epidemiology

Place

AIDS cases per 100,000 population, United States, July 1991-June 1992



Descriptive Epidemiology

Person

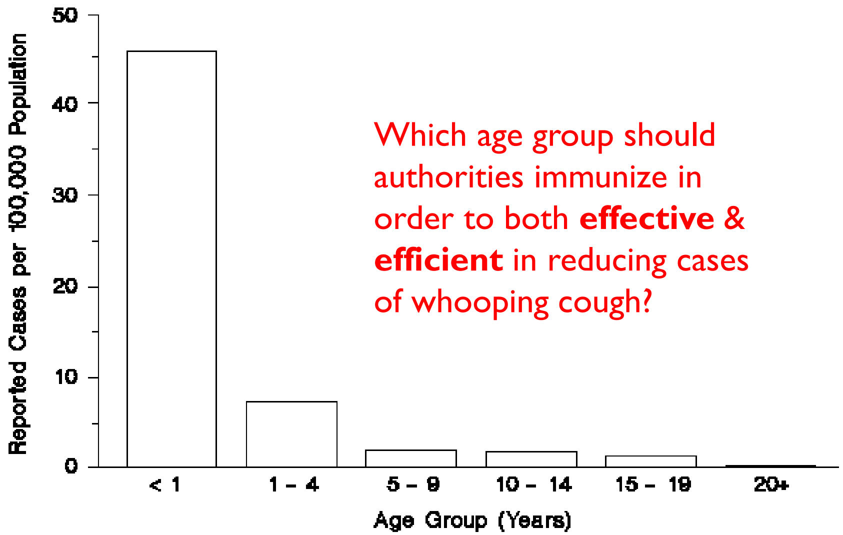
- Analysis of data by person involves use of:
  - Demographic characteristics – age, sex, race, immune or marital status
  - Socio-economic traits – occupation, income, education
  - Access to medical care etc.
- Such analysis assists in identifying who is at greatest risk of contracting specific d'ses
- Person data may be displayed on tables or graphs
- *Age:*
  - Single most important "person" attribute as most events vary by age
  - Other factors also associated with age e.g. susceptibility, opportunity of exposure, incubation period of d'se etc.

Descriptive Epidemiology

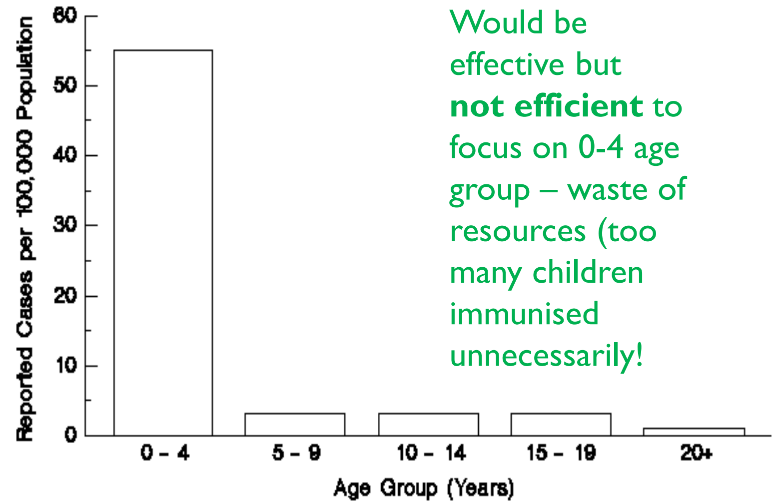
Person

- Often narrow age groups are used so as to detect any age-related patterns present in data e.g. 5-year intervals. Larger intervals e.g. 10-yrs could conceal variations related to age
- However, sometimes, it may be important to consider smaller intervals in analysis of data for some specific d'ses

Pertussis (whooping cough) incidence by age group, United States, 1989



Which age group should authorities immunize in order to both **effective** & **efficient** in reducing cases of whooping cough?



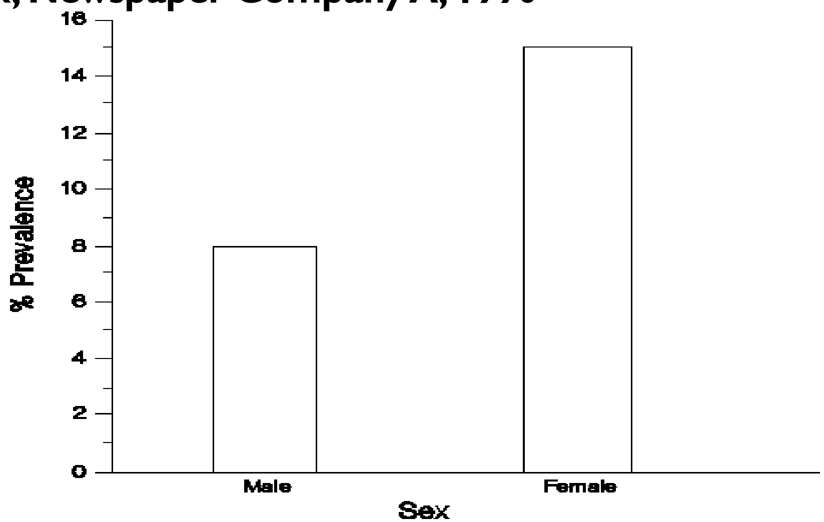
Would be effective but **not efficient** to focus on 0-4 age group – waste of resources (too many children immunised unnecessarily!

Descriptive Epidemiology

Person

- *Sex:*
  - Males generally have higher rates of illness than females for wide range of d'ses due to either anatomical, hormonal, genetic differences e.g. albinism (recessive trait carried on X chromosome) and heart d'se (less common in premenopausal women due to oestrogen levels)
  - Some sex-related disorders are occupation-related

Prevalence of hand/wrist cumulative trauma disorder by sex, Newspaper Company A, 1990



Prevalence differences due to increased hand/wrist motions in females e.g. in typing or data entry

Analytic Epidemiology

- Analytic epi is concerned with the search for <u>causes</u> & <u>effects</u> i.e. seeks to answer the *why* & *how* in d'se causation.
- Analytic epi helps to test hypothesis about causal relationships (identify factors associated with d'se - **why**) & also quantify these relationships – the **how** much aspect
- However, it doesn't prove that a factor causes d'se but could provide evidence for which control actions could be taken
- Analytic studies categorised into:
  - Experimental (allocation of exposure) – intervention studies (clinical/field or community trials)
  - Observational (observer) – Cross sectional, cohort, case control studies

Historical developments in Epidemiology

- History of Epi has involved many key players who sought to understand and explain illness, injury & death from a purely observational standpoint – purpose being to provide info for the control & prevention of health-related events
- They advanced study of disease from a supernatural to a scientific-based viewpoint:
  - From no approach to assessment to systematic methods for summarising & describing public health problems
  - From unclear understanding of the natural course of a disease to knowledge of probable causes & modes of transmission
  - From no means to preventing and controlling diseases to effective approaches of solving public health problems

Key figures in advancement of Epidemiology

Hippocrates

- Physician – became known as father of medicine and 1st epidemiologist
- His 3 books – *Epidemic I*, *Epidemic III* & *On Airs, Waters & Places* - attempted to describe disease from a rational rather than a supernatural basis
- His major contribution to epi was on the concept of epidemiologic observation (still sound epi concept) – observations of contributing/causal factors of d'ses
- E.g. he observed that different d'ses occurred in different locations – malaria & fever common in swampy areas – unknown then that mosquitoes were responsible for the d'ses
- Also introduced terms like epidemic & endemic e.g. advised physicians to be familiar with local d'ses and nature of these prevailing d'ses as well as when seasons when epidemic d'ses might strike

Key figures in advancement of Epidemiology

Hippocrates

- Identified *hot* and *cold* diseases & *hot* and *cold* treatments – *hot* d'ses were treated with *cold* treatments and vice versa e.g. diarrhoea considered as *hot* d'se and treated with fruit (*cold* treatment) – rational approach as loss of electrolytes throu' diarrhoea could be replenished by electrolytes in fruit
- Also theorised that the body was composed of 4 humours: phlegm, yellow bile, blood & black bile – imbalance of these resulted in sickness
- Fever thought to be as a result of too much blood whose treatment was through bloodletting or use of bloodsuckers (leeches) – again a rational approach as leech extract has antibacterial properties

Key figures in advancement of Epidemiology

James Lind

- Scottish naval surgeon (1716-1794)
- Contributed to epidemiology of scurvy:
  - Observed that scurvy was more common in sailors on long ocean voyages
  - D'se marked by bleeding gums, skin and extreme lethargy
  - Scurvy began to occur 4-6 weeks at sea with d'se commonest in April, May & June
  - Also present were cold, rainy, foggy and thick weather – thought air as source of d'se
  - Compared sick with those healthy in attempts to understand causes
  - He performed an experimental study to elucidate cause:
    - Took 12 sailors all with clinical scurvy (putrid gums, spots and weakness)
    - Put the sailors in 6 groups of two each – which in addition to common "hard" diet of water-gruel, fresh mutton, boiled biscuit with sugar, barley, raisins etc , received a dietary intervention – 1st grp (quart of cider a day), 2nd (2 spoonfuls of vinegar twice a day), 3rd (half-pint of sea water), 4th (lemons & oranges), 5th (an elixir [medicinal potion] recommended by hospital surgeon), 6th (garlic, mustard seed & horseradish)
    - Observed that in 6 days those eating citrus fruits were free of symptoms and fit for duty
  - Thus discovered that oranges and lemons were effective remedies for scurvy
  - Following his epidemiologic work, the British Navy in 1895 required lime juice to be included in diet of seamen

Key figures in advancement of Epidemiology

John Snow

- British physician (1813-1858)
- Studied cholera throughout his medical career especially outbreak in 1840s in Soho and Golden Square (London)
- Used both descriptive & analytic epidemiologic techniques to investigate the d'se:

Observational studies

- Descriptive – he identified incubation times of the d'se, length of time from infection to death, modes of d'se transmission, sources of water contamination, plotted mortality rates (epidemic) against time and mapped cases (spot map). Found that nearly all deaths had taken place near the Broad Street pump
- Analytic epidemiology – compared death rates from d'se to where sufferers got their water – Lambeth Water Company (upstream) vs. Southwark & Vauxhall Water Company (downstream where contaminated by sewage water)

Experimental study

- Performed an intervention study by removal of the Broad Street pump handle (removal of exposure) to control spread of the d'se

- By calculations, he showed that mortality at height of epidemic was 8-9 times higher in h/holds supplied by S-V companies than those supplied by Lambeth
- He proved hypothesis that contamination of water by sewers led to cholera and hence cholera was a water-borne disease