

DESCRIPTIVE EPIDEMIOLOGY for Public Health Professionals Part 3

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Did you see **the Part I** and **the Part II** of this lecture?

MEASUREMENT

Central to epidemiology is measurement, the contribution that Major Greenwood credited to John Graunt.

**Health is a state of complete
physical, mental and social
well-being and not merely
the absence of disease or
infirmity**

World Health Organization, 1948

The 1948 World Health Organization definition of health is an ideal, and historically has been problematic to measure. For that reason, measurement has targeted ill-health rather than health. However, newer generations of health measures, such as healthy life expectancy, referred to near the end of the module, are beginning to correct the large imbalance in the orientation of epidemiologic measurement.

Purposes of Health-related Measurement

- **Disease and Injury Prevention**
- **Health Promotion**
- **Health Services Planning and Intervention Design**
- **Evaluation**

Measuring Mortality

The next five slides provide formulae and examples of well known mortality measures. They derive from the fourth international edition of the Population Handbook published by the Population Reference Bureau.

Crude Death Rate

The **DEATH RATE** (more correctly, the **Crude Death Rate**) can be measured as the number of deaths per 100,000 population in a given year.

$$\frac{\text{\# of deaths}}{\text{Total midyear population}} * k = \frac{471,000}{67,300,000} * 100,000 = 700$$

In 2002, the death rate in Turkey was 700 per 100,000 population.

In the same year, Guinea's death rate was 1,724/100,000 population and Singapore's rate was 400/100,000 population.

Where the population serves as the denominator for annualized mortality or morbidity rates, the midyear population serves as the best approximation of the population-at-risk for the event represented in the rate numerator, such as death by any cause. This makes allowance for changes in population due to births, deaths, or migration that occur over the year for which the measurement applies.

Age-Specific Death Rate

Death rates can be calculated for specific age groups in order to compare mortality across different ages or at the same age or in the same age group over time.

Comparisons also can be made across countries or other political or geographic entities.

Since mortality can vary considerably by sex, race, and ethnic group, separate age-specific death rates are often presented for males and females, and for different racial/ethnic groups.

Deaths of people ages

$$\frac{35 - 44}{\text{Total midyear population ages 35-44}} * k = \frac{663}{272,249} * 100,000 = 244$$

In West Virginia in 2000, the age-specific death rate for persons ages 35-44 was 244 per 100,000 population in those ages.

By comparison, the corresponding age-specific death rate in the United States' population was 200 per 100,000 people.

Cause-Specific Death Rate

Expressed as deaths per 100,000 for most causes of death, but sometimes per 1,000,000 when rates of occurrence are extremely low.

$$\frac{\text{Cancer deaths}}{\text{Mid-year total population}} * k ; \quad \frac{553,091}{275,264,999} * 100,000 = 200.9$$

In 2000, 201 persons per 100,000 population died of cancer in the United States.

Proportionate Mortality Rate

Deaths from a specific cause can be expressed as a percentage of all deaths

$$\frac{\text{\# of deaths from cancer}}{\text{Total deaths}} * k = \frac{553,091}{2,403,351} * 100 = 23\%$$

In 2000, 23% of all deaths in the United States were attributable to cancer.

Maternal Mortality Ratio

The **maternal mortality ratio** is the number of women who die as a result of complications of pregnancy or childbearing in a given year per 100,000 live births in that year. Deaths due to complications of spontaneous or induced abortions are included.

$$\frac{\text{\# of maternal deaths}}{\text{Total live births}} * k = \frac{185}{1,408,159} * 1,000 = 13.1$$

There were 13 maternal deaths per 100,000 live births in Russia in 1994.

This measure is sometimes referred to as the **maternal mortality rate**.

A valid maternal mortality rate would divide the number of maternal deaths by the population-at-risk; the number of pregnant women in the population. This information is typically unknown and inaccessible.

Measuring Morbidity

The Dictionary of Epidemiology (4th edition), edited by John Last, defines morbidity as “any departure, subjective or objective, from a state of physiological or psychological well-being.” Thus, this definition allows for self-reported ill-health as well as classification supported by a physician’s diagnosis.

Prevalence and Incidence

Prevalence and Incidence form the core of epidemiologic measurement

Prevalence

Prevalence measures the number of cases (new and old) of the disease (or other health-related phenomenon) at a point or period in time

Prevalence *(not actually a rate as it ignores the duration of exposure to the hazard; that is, the time dimension)*

Point Prevalence (as a percentage) =

Number of cases of a disease present in the population at a specified time

 * 100

Number of persons in the population at that specified time

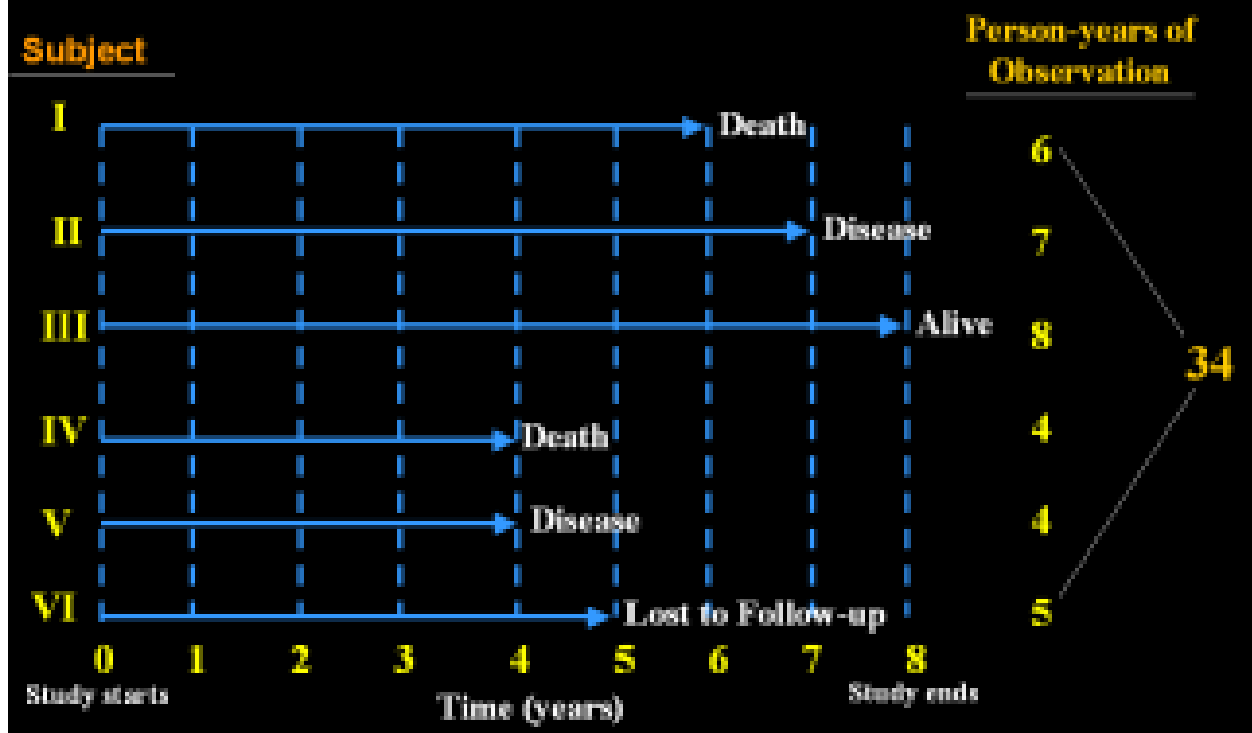
If prevalence is measured for a period of time, say three months, rather than at a point in time, the population denominator should represent the average population during that period. Care needs to be taken in selecting or estimating the denominator for any epidemiologic measure to avoid overestimation or underestimation of rates or proportions, and to make sure that events are correctly matched to a population-at-risk.

Incidence

Incidence measures the number of new cases of a disease (or other health-related phenomenon) that occur during a specified period of time in a population at risk

The specified period of time pertaining to the population-at-risk for the health related phenomenon in question is referred to as person-time-at-risk. This is the time study subjects, as a group, are exposed to the risk under investigation.

Accumulation of person-years observed in an eight-year cohort study of six subjects



This diagram illustrates how person-time-at-risk is calculated for a cohort of subjects, where the cohort is the group of individuals who share a common putative risk exposure like work in a coal mine or tobacco smoking.

Incidence Rate

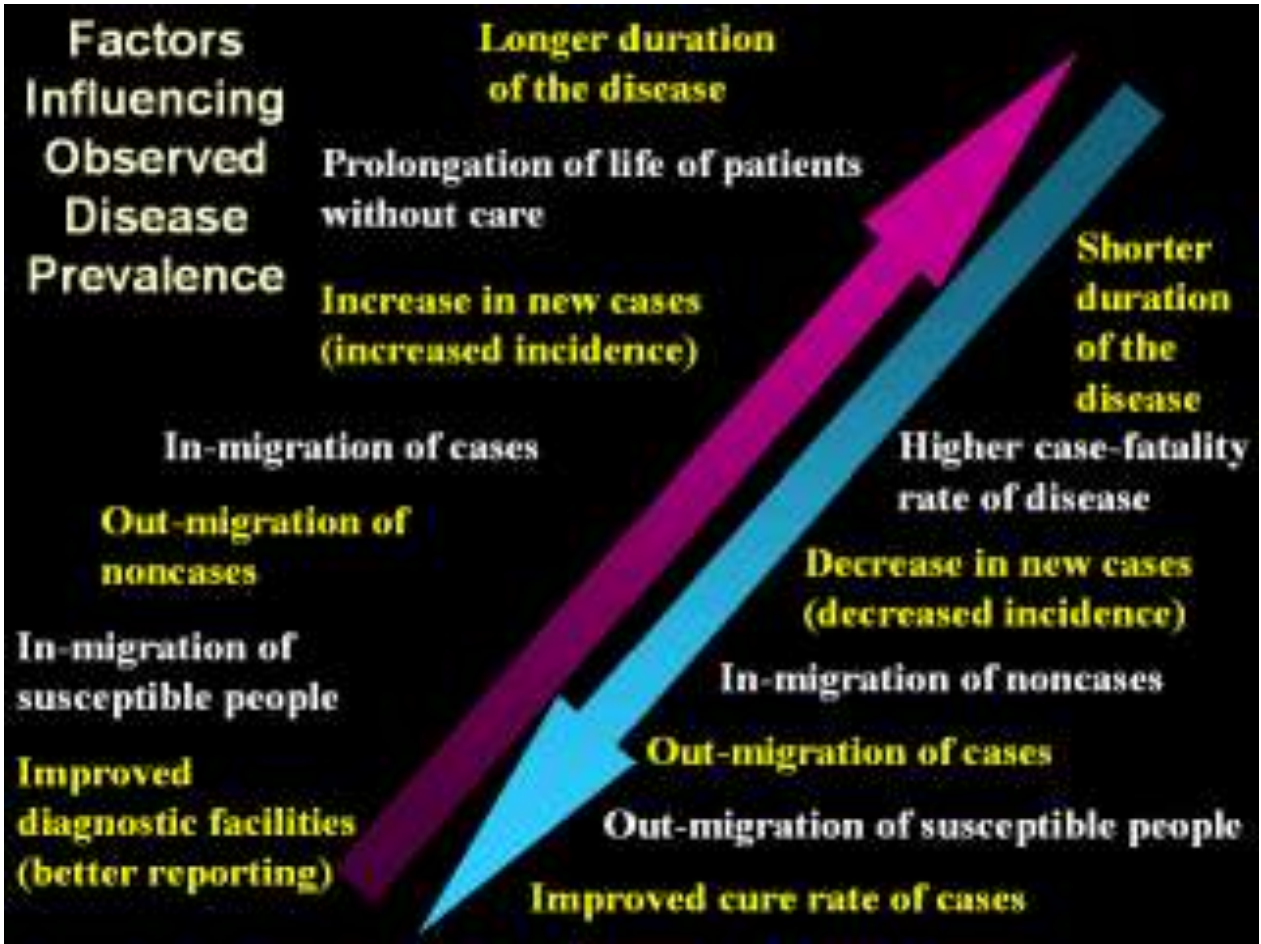
$$\frac{\text{Number of new events in specified period}}{\text{Person-time exposure to risk during this period}} * k$$

The incidence rate is commonly expressed as the number of cases of disease or injury per 100,000 person-years of exposure to the risk or putative hazard under investigation. With very rare conditions the rate may be expressed per million person-years to avoid the awkwardness of decimals.

**Relationship *between* Incidence
and
Prevalence**



A waterfall metaphor can be helpful in illustrating the concepts of incidence and prevalence. Commencing at the top of the falls, we see the new cases flowing into the prevalence pool below. The water flowing out of this pool reflects the individuals who die, recover, or migrate out of that population for which the prevalence is measured.



This diagram shows factors that alternatively can increase or decrease the magnitude of the observed prevalence of a disease. This diagram is a modified version of one published in the teachers' guide to *Basic Epidemiology*, a textbook published under the sponsorship of the World Health Organization.

Mortality
meets
Morbidity

Case-Fatality Rate

$$\frac{\text{Number of deaths due to a disease}}{\text{Number of people with the same disease}} * 100$$

Example:

- 600 people have disease
- 9 of them die
- $CFR = (9/600) * 100 = 1.5 \%$

An important question concerns the proportion of cases of a particular disease which end in death. Epidemiologists label this proportion the case-fatality rate.

Example: Infant Mortality Rate

The Infant Mortality Rate is the number of deaths of infants (that is, children less than age one) per 1,000 live births in a given year.

$$\frac{\text{\# of deaths of infants under age 1 in a given year}}{\text{Total live births in that year}} \times k = \frac{27,960}{4,058,882} \times 1,000 = 24.6$$

There were an estimated 25 deaths of infants per 1,000 live births in Venezuela in 2002. The lowest estimated rate in that year was for Sweden, at 3.4 per 1,000 live births. A very high national rate would be Angola's, estimated at 192 per 1,000 live births in 2002.

A special example of the case-fatality rate is the Infant Mortality Rate. The decision to use the live births as the rate denominator instead of the 0-1 population stems from the fact that this population historically was poorly enumerated in the census. Babies were too easy to overlook in the count.

**Selected Rounded Annual Crude
Death Rates per 100,000
population, 2001**

Algeria	600
Mexico	500
The Netherlands	900
United States	900

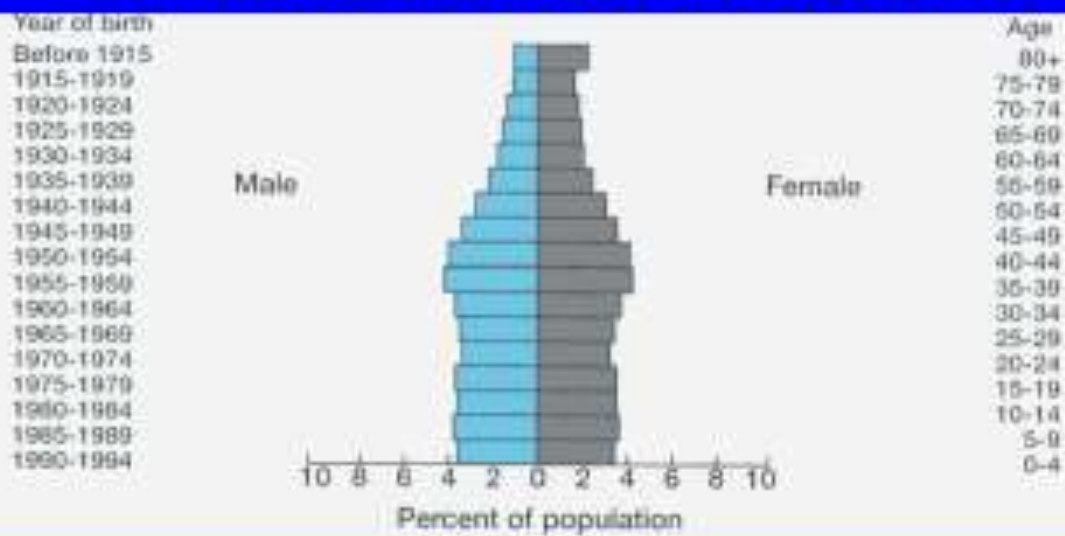
Comparison of these national crude death rates reveals differences that are not intuitive. Assuming that the rates are accurate, and actually this is a solid assumption, then how is it that the rates displayed are higher in the two more developed countries, the United States and The Netherlands, than in the two less developed countries, Algeria and Mexico?

The answer to the question posed by the preceding paradox lies in differences in the age distributions of the various populations – age is a confounding variable. The less developed countries have much younger populations than the more developed countries, as a result of having much higher fertility rates. In our contemporary world younger people, especially those who aren't infants, are much less likely to die than older people. We take this as a given, but this was not always the case as John Graunt's life table data attest.

Population Pyramids

Crucial to rate calculation is the determination of an appropriate denominator. For many mortality rates, such as the crude death rate and age- and cause-specific death rates, and also some incidence rates, denominators typically derive from the census. However, population census data perform another very useful function in descriptive epidemiology. They furnish the building blocks for constructing population pyramids. Valuable for comparisons, population pyramids graphically display the composition of a population broken down by age and sex. Although a pyramid is a cross-sectional snapshot of a population, it also reflects that population's history.

United States Population, 1995



Source: Joseph A. McFallis, Jr. Population: A Lively Introduction. Population Bulletin 46(2); 1995: 22.

This slide shows the US population depicted as a pyramid. Please move to the next slide to learn how to construct such a population pyramid.

Population Pyramid

Really an age-sex pyramid. Can be graphed in two ways:

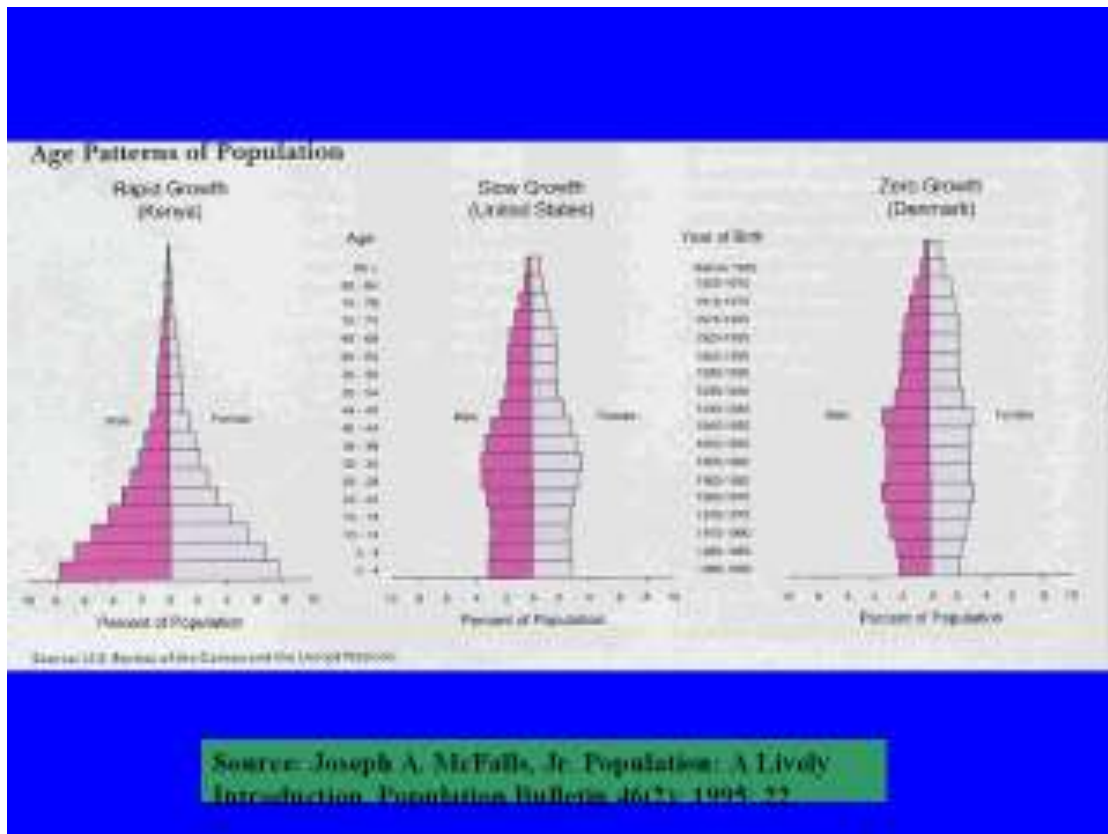
- in absolute numerical terms
- **(better)** as percentage distribution
- gives comparability across time and space

$$N = \Sigma (\text{males} + \text{females}) \longrightarrow 100\%$$

Note that the percentages for each age and sex-specific population segment should total 100. In other words, the cumulations should not be performed separately for each sex lest a misleading picture of the population emerge.

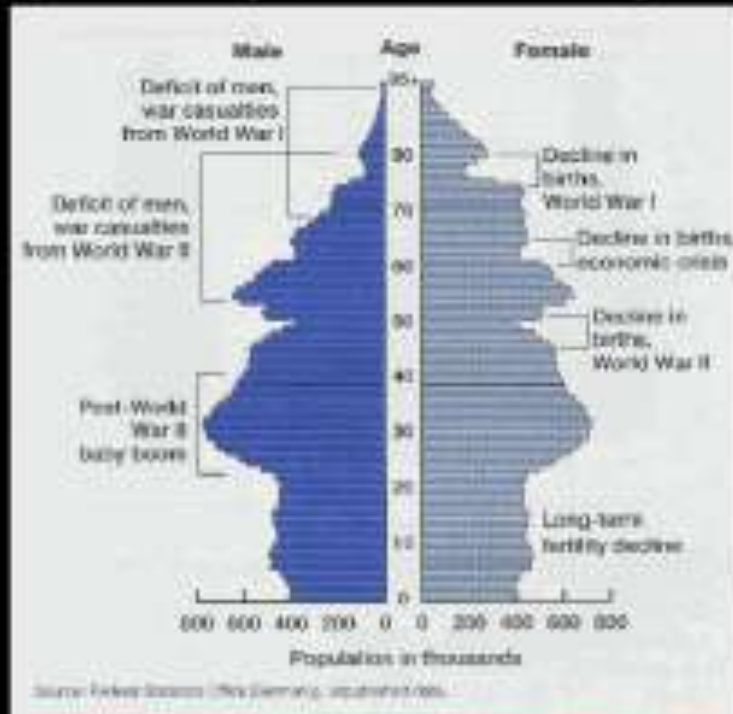
Bases for Comparison

- **variation across age groups**
- **variations within age group by sex**



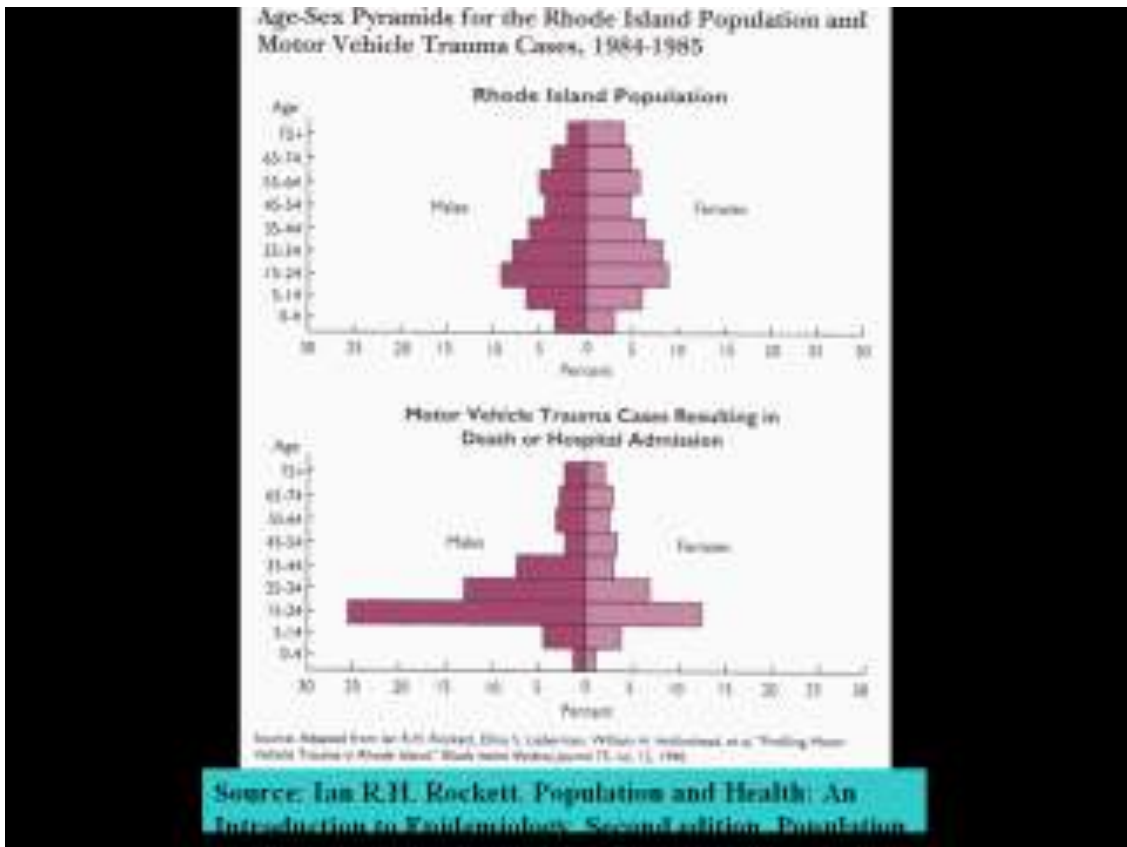
This slide displays pyramids for three populations exhibiting very different age distributions. Kenya's pyramid is typical of pyramids for populations in less developed countries. The US population pyramid would resemble Denmark's much more closely than it does if not for its heavy immigration that is highly selective of younger adults and children.

Population Pyramid of Germany, 1996



Source: Joseph A. McFalls, Jr. Population: A Lively Introduction, Third edition. Population Bulletin.

While a population pyramid represents a cross-sectional view of a population, its bumps and indentations do reflect the past as the German pyramid vividly illustrates.



Population pyramids are versatile comparative tools. The two pyramids constructed using the Rhode Island population and serious motor vehicular trauma cases, respectively, show how Rhode Island's teens and young adults are highly over-represented among the severely and fatally injured. In the second pyramid, morbidity and mortality data were combined.