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Epidemiological Methods for Determining Health in Populations

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Epidemiology: a definition

The 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 (Last, 2001)

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Objectives of Epidemiology

Determine the extent of disease found in the community

Identify risk factors and/or causes of disease,

Study natural history of disease & prognosis

Evaluate preventive & therapeutic methods

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Measuring Occurrence of Disease

Quantify how common a disease is in a specified population in a specified time-frame:-

INCIDENCE: occurrence of new cases

PREVALENCE: frequency of existing cases

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Measuring Incidence

Incidence

Number of ***new*** cases occurring in the population during a specified period of time in a population ***at risk*** for developing the disease

$$I = \frac{\text{Number of } \textit{new} \text{ cases of a disease during a specified time}}{\text{Number of persons } \textit{at risk} \text{ of developing the disease during a specified time}}$$

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Measuring Incidence

When calculating incidence:

Any individual included in the denominator must have the potential to become part of the group that is counted in the numerator

What is the population at risk for:

- Cervical cancer?
- Heart disease?

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Measuring Prevalence

Prevalence

- Number of affected persons present in the population at a specific time divided by the number of persons in the population at that time

$$P = \frac{\text{Number of cases during a specified time}}{\text{Number of persons in the population during a specified time}}$$

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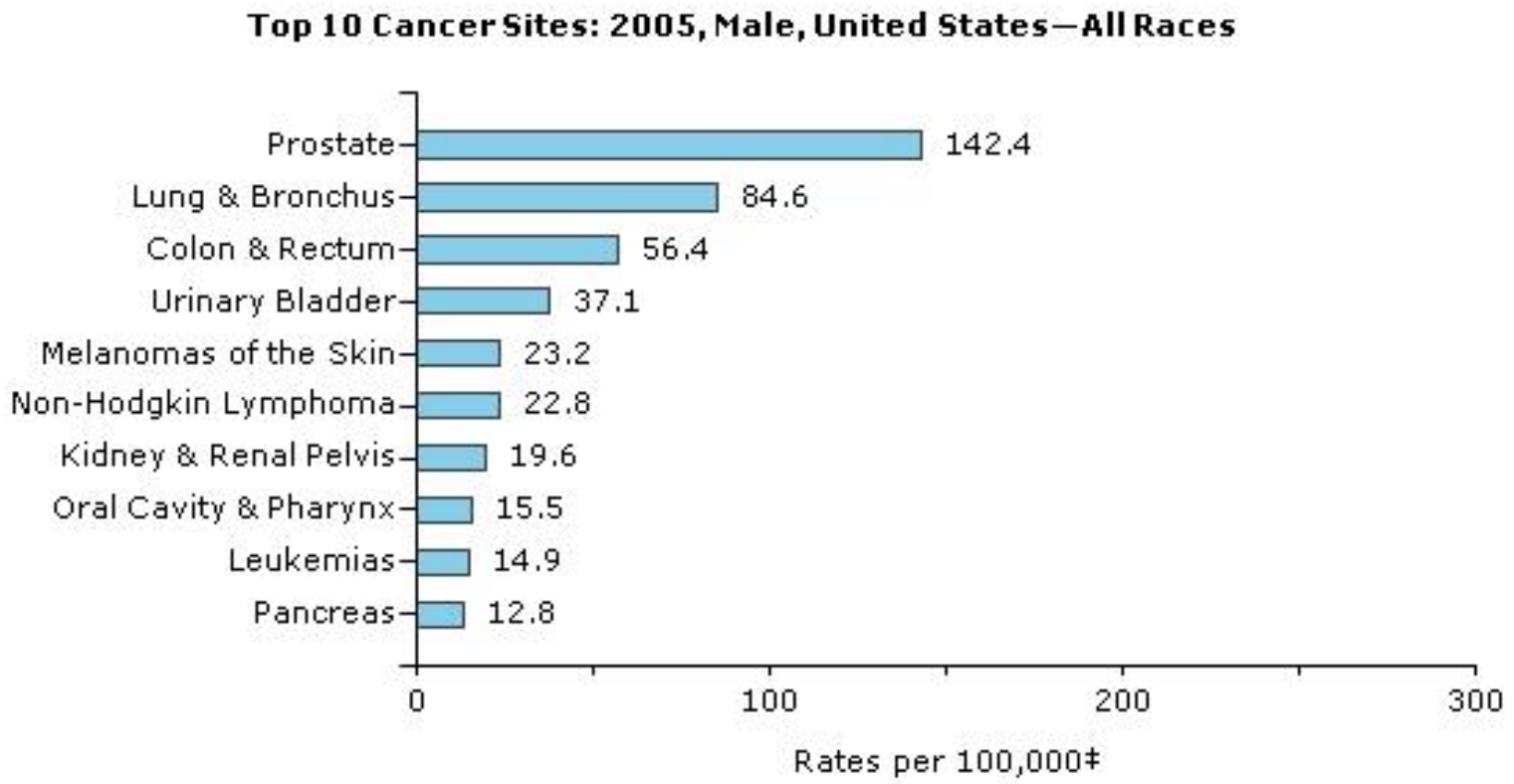
Interpreting Incidence and Prevalence Measures



Source: U.S. Cancer Statistics Working Group. United States Cancer Statistics: 1999–2005 Incidence and Mortality Web-based Report. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention and National Cancer Institute; 2009. Available at: www.cdc.gov/uscs

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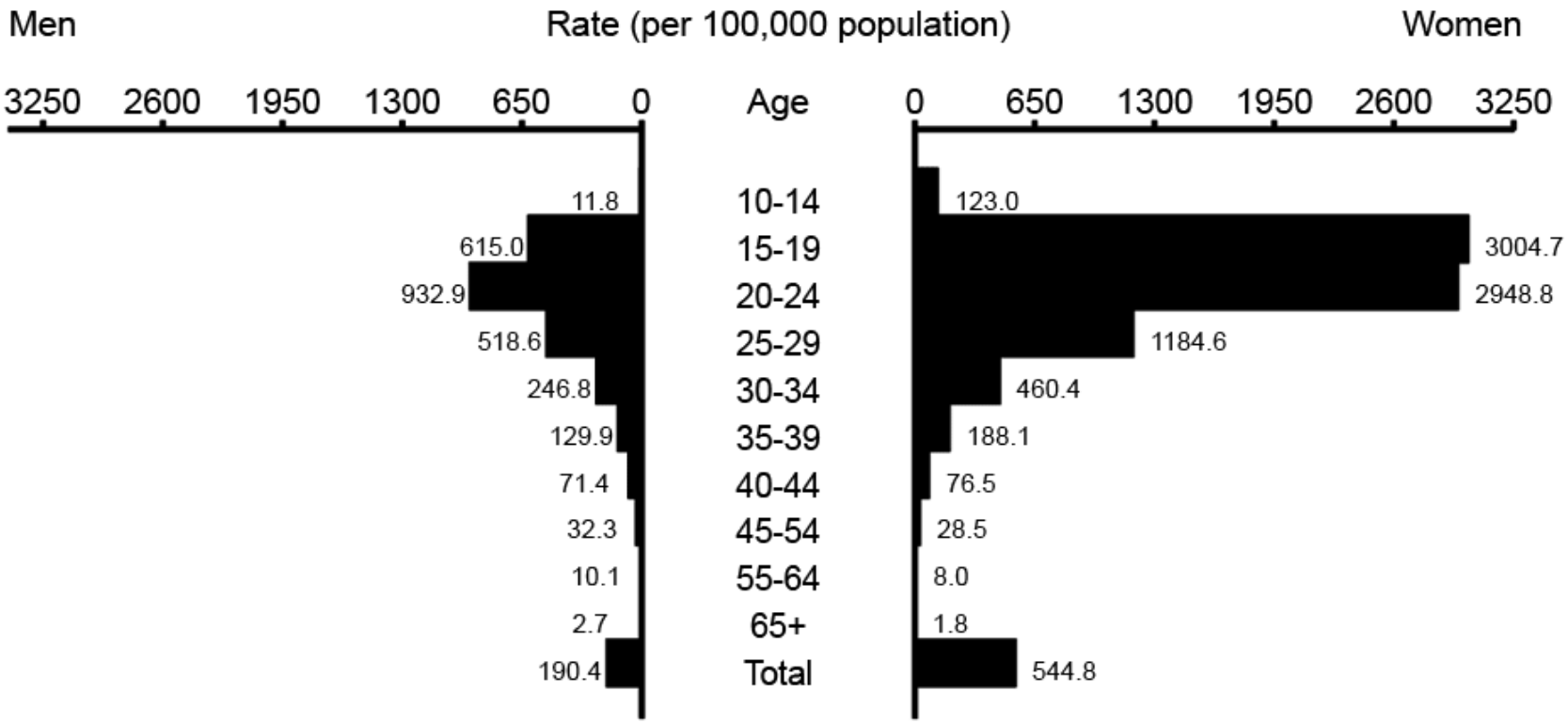
Chlamydia Incidence, United States 2007



Source: US Centers for Disease Control and Prevention. Sexually Transmitted Disease Surveillance, 2007. www.cdc.gov/std

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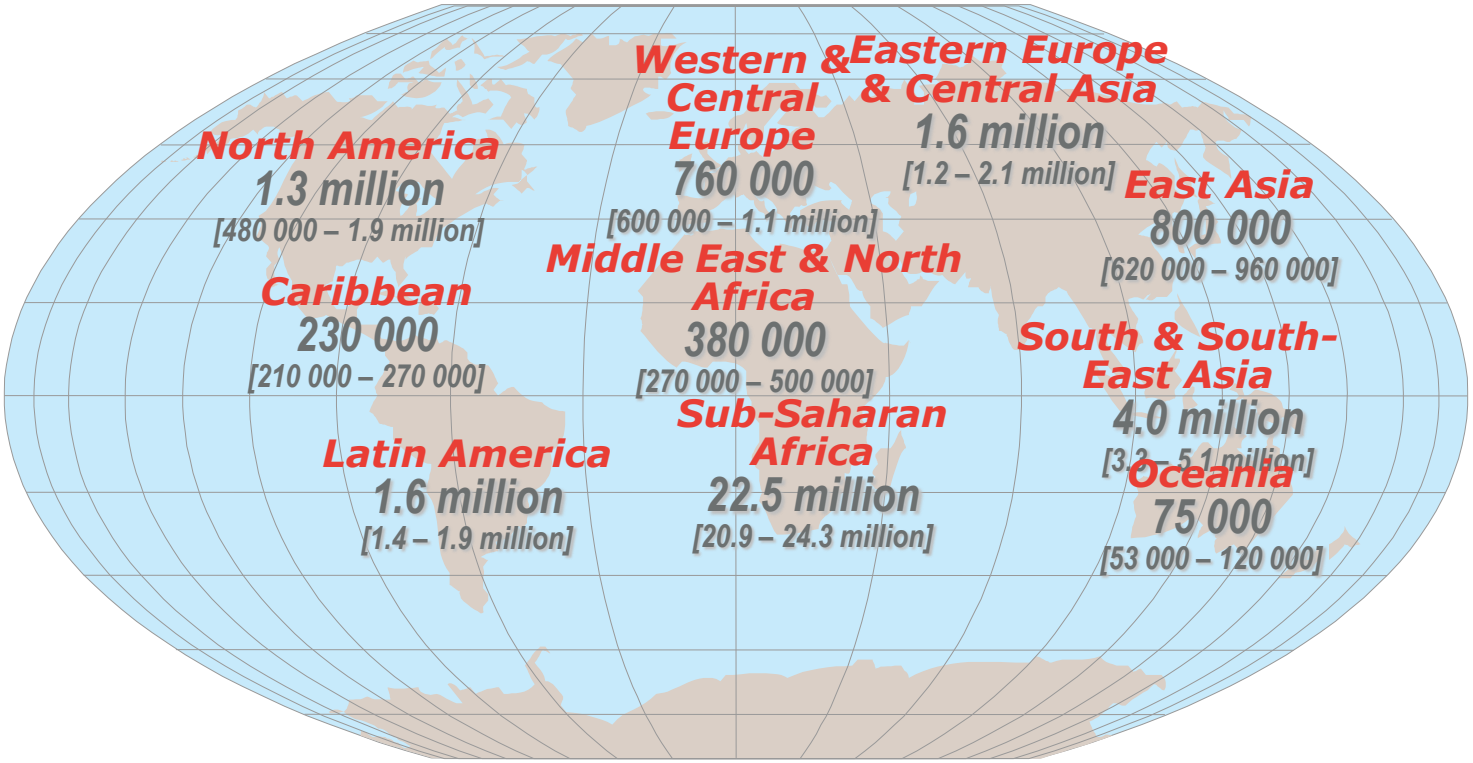
Estimated Persons living with HIV/AIDS, 2007



Source: WHO www.who.int

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Relationship Between Incidence and Prevalence

When a disease is rare, prevalence and incidence can be described by the following relationship:

$$\text{Prevalence} \sim \text{Incidence} \times \text{Duration}$$

What factors determine duration of disease?

- *natural history*
- *death*
- *treatment*

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Interpreting Incidence and Prevalence

Population	Number Persons Positive for TB on Chest X-Ray	Point Prevalence (per 1000 persons)	Duration of TB (years)	Incidence (Cases per Year)
Town A (1000 persons)	100	100	25	4
Town B (1000 Persons)	60	60	3	20

**Example From Gordis Epidemiology 2nd Edition*

*** This is hypothetical data*

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Assessing Disease and Mortality

All Cause Mortality Rate

- "Incidence of Death": Total number of deaths from all causes during a specified period of time in a population
- Also simply referred to as the mortality rate

$$\text{Annual Mortality Rate} = \frac{\text{Number of Deaths in one year}}{\text{Number of persons in the population at mid-year}}$$

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Assessing Disease and Mortality

Disease-Specific Mortality Rate or Cause-Specific Mortality Rate

- Total number of deaths from a specific disease during a specified period of time in the total population

$$\text{Disease X Specific Mortality} = \frac{\text{Number dying from disease X over a specific time period}}{\text{Total in the population over a specific time period}}$$

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Assessing Disease and Mortality

Case-Fatality Rate

- The percent of people diagnosed with a certain disease who die within a certain time after diagnosis

$$\text{Case Fatality Rate} = \frac{\text{Number dying within a certain time period after disease onset}}{\text{Number with a specified disease}}$$

Assessing Disease and Mortality

- In 2010, Healthy Land has 100,000 people:
  - 20 are sick with malaria
  - 18 die from malaria

- What is the malaria-specific mortality rate?
  - 18/100,000 = 0.00018 = 0.18%

- What is the malaria case-fatality rate?
  - 18/20 = 0.9 = 90%

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Estimating Disease Burden

Determining the burden of disease

Endemic

- Habitual presence of a disease with a given geographical area or the usual occurrence of a disease within a certain area – i.e., diarrheal diseases in developing countries

Epidemic

- Occurrence of disease in a community or region in excess of normal expectancy – i.e., cholera in Zimbabwe; Ebola in DRC

Pandemic

- Worldwide epidemic – i.e., HIV

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Estimating Disease Burden

Disability-adjusted life year (DALY)

- Measure of the burden of disease on a defined population and the effectiveness of interventions.
- Based on an adjustment of the life expectancy to allow for long-term disability: “healthy life years lost”.
- Calculated using a disability weight (proportion less than one) that reflects the burden of disability.
  - limited by lack of necessary data to calculate the disability weight.
  - postulates a continuum from disease to disability to death that is not universally accepted

Last (2001)

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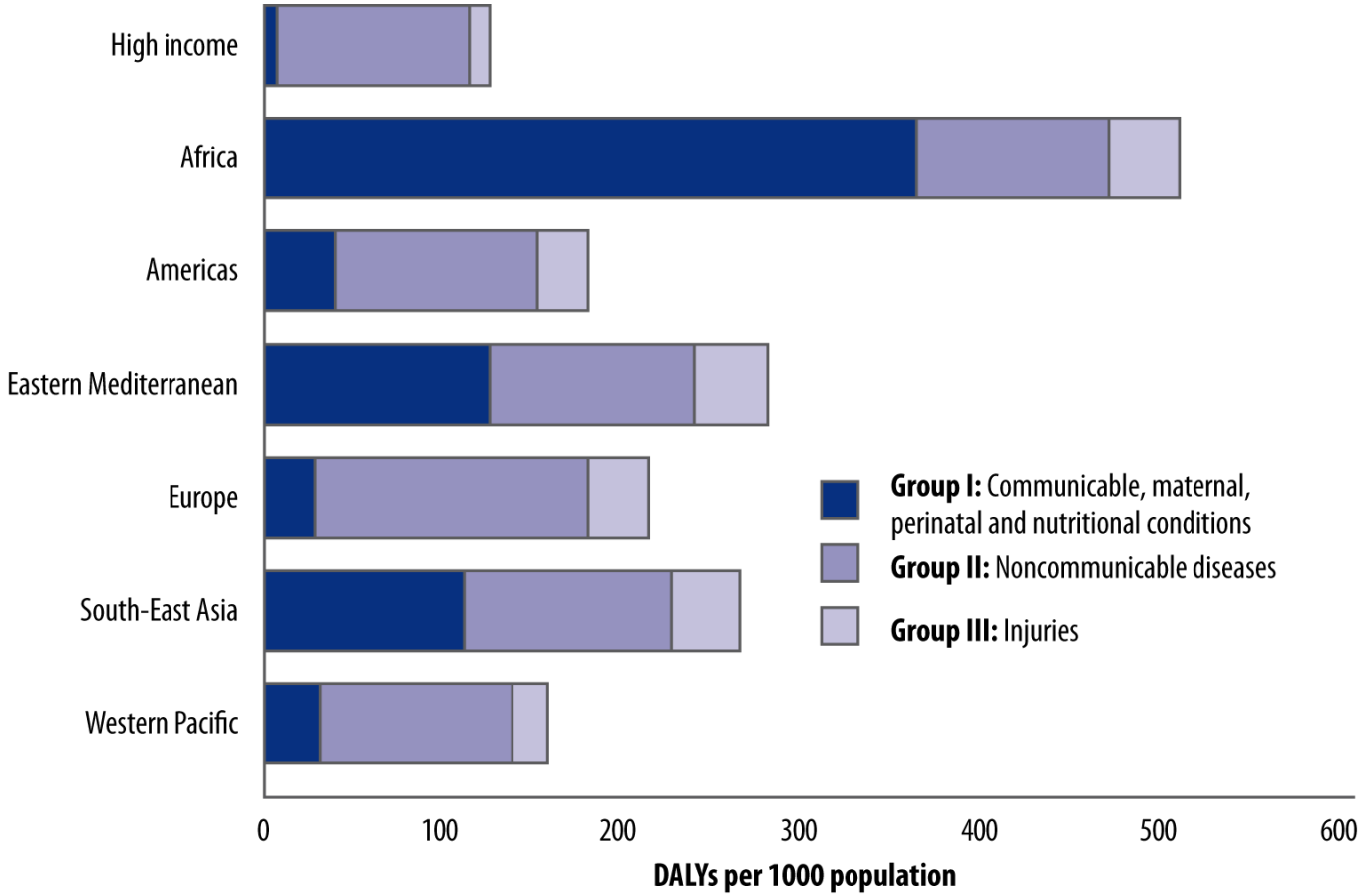
Estimating Disease Burden

Burden of disease by broad cause group and region, 2004



Source: WHO.Global Burden of Disease: 2004 Update.
http://www.who.int/healthinfo/global_burden_disease/2004_report_update/en/index.html

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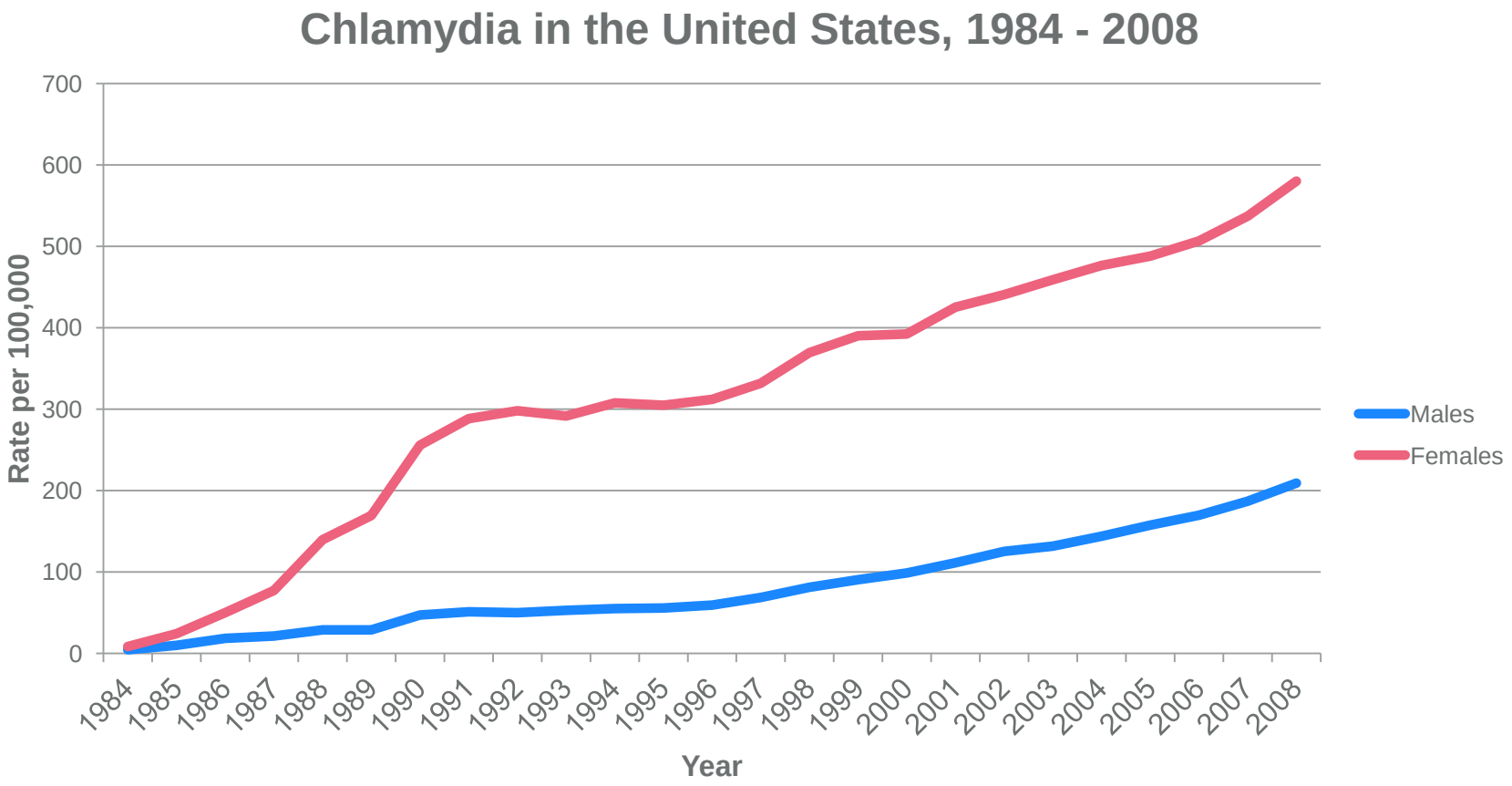
Evaluating Trends in Incidence and/or Prevalence



Source: US Centers for Disease Control and Prevention. Extracted from www.wonder.cdc.gov

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Data Used to Assess Health in Populations

- Surveillance Data
  - Passive Surveillance
  - Active Surveillance
  - Sentinel Surveillance
- Observational Data
  - Cross Sectional Surveys
  - Case Control Studies
  - Cohort Studies

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Surveillance Data

The ongoing systematic collection, analysis, interpretation and dissemination of data reflecting the current health status of a community or population

- Monitor implementation of health programs
- Understand local epidemiology
- Assessing changes in trend of disease or its distribution
- Identifying specific groups at risk
- Predict patterns in occurrence of diseases

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Surveillance Data

- Passive Surveillance
  - Monitoring of disease through routinely collected reports sent to government agencies/Ministries of Health/NGOs
    - Reportable diseases (i.e., measles, influenza, syphilis)
    - Disease registries – usually clinical data
    - Birth and death certificates
  - Relatively inexpensive and easy to develop
  - Allows for comparison of trends over time, across communities and across countries
  - Underreporting often a problem
  - Lack of completeness of data

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Surveillance Data

- Active Surveillance
  - Case-finding activities – often done after an index case identified, but can be done routinely
    - Field visits to health care facilities (clinics/hospitals)
    - Interviewing physicians and patients
    - Reviewing medical records
    - Surveying villages
  - More accurate data than passive surveillance
  - Resource intensive

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Surveillance Data

- Sentinel Surveillance
  - Use of community-based health or occupational sites to monitor for a specific disease activity
    - Monitoring ANC clinics for maternal and child health outcomes
    - Monitoring rural clinics for malaria
    - Monitoring of drug treatment centres for HIV
  - Often used in developing countries where passive surveillance incomplete
  - If medical facility used as surveillance site, tends to identify only sickest of cases
  - Tends to overestimate population prevalence if surveillance site is among high-risk individuals (i.e. HIV in IDUs)

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Cross Sectional and Case Control Studies

• Cross Sectional Study: Select a sample of persons from the population of interest and measure disease and an exposure simultaneously

• Case Control Study: Select a sample of persons from the population with a disease and a sample of persons from the population without a disease and measure rates of exposure in each group

- Can calculate the prevalence of disease of interest in total study population
- If study population is representative of underlying population (i.e., random sample of adults in UK) can infer prevalence in underlying population
- Can be used to identify groups at higher risk for a particular disease (though difficult to infer causes of disease)
- Cannot be used to calculate incidence!

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Cohort Studies

•Cohort Study – Select a sample of persons from the population with a certain exposure and a sample of persons without exposure and compare rates of development of a disease over time in each group

- Can calculate incidence and prevalence of disease in total study population
- If study population is representative of the underlying population, can infer incidence and prevalence of disease in underlying population
- Can identify groups at higher risk for developing disease and make more robust inferences regarding causation.

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Strengths and Limitations of Surveillance Data

- Estimates disease in community rather than a population sample
- In many areas, conducted routinely over long time periods - so compare trends over time

- Reporting often falls to health care providers or district health officers
  - Underreporting
  - Inconsistencies in diagnostic tools or reporting between clinics/districts
- Incomplete reporting from areas difficult to reach or lacking resources for surveillance (e.g., rural areas lacking paved roads)
- Resource constraints may affect type of diagnostic criteria used
  - Laboratory confirmed diagnoses vs. syndromic diagnoses
  - Less sensitive monitoring of environmental risk factors (i.e., particulate air pollution)

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Strengths and Limitations of Observational Study Data

- If representative population sample used can be used to estimate incidence and/or prevalence of disease in areas where health data is not routinely collected or where routine monitoring data are incomplete

- Generally, observational studies for research purposes often use more accurate laboratory tests than clinics to assess disease status
  - Use of NAATs to identify gonorrhoea or chlamydia in research study vs. syndromic diagnostics in a rural clinic

- Since population sampling is used, using results to estimate population prevalence/incidence subject to sampling errors and selection biases

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General Cautions

- Frequency at which data is routinely collected and/or reported
- How disease reporting/status determined
  - Laboratory tests
  - Clinical Diagnoses
  - Self report (Have you ever received a diagnosis of or do you currently have *Disease X*?)
- Representativeness of clinics/districts reporting data to central health authority
- Representativeness of population samples used in research studies

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Common Data Sources

- Demographic and Health Surveys (DHS) www.measuredhs.come
- Doctors Without Borders/Médecins Sans Frontières www.doctorswithoutborders.org or www.msf.org.uk
- Path www.path.org
- Population Services International www.psi.org
- RTI International www.rti.org
- US National Library of Medicine - PubMed http://www.ncbi.nlm.nih.gov/pubmed
- UNAIDS www.unaidstoday.org
- UNICEF www.unicef.org
- USAID http://www.usaid.gov/our_work/global_health/
- US Centers for Disease Control and Prevention www.cdc.gov/globalhealth
- World Bank www.worldbank.org
- World Health Organization: www.who.int

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