NUR 627
"Advanced Epidemiology and Biostatistics for Nursing"

Session II: Incidence, Prevalence, and Mortality

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Objectives of the session

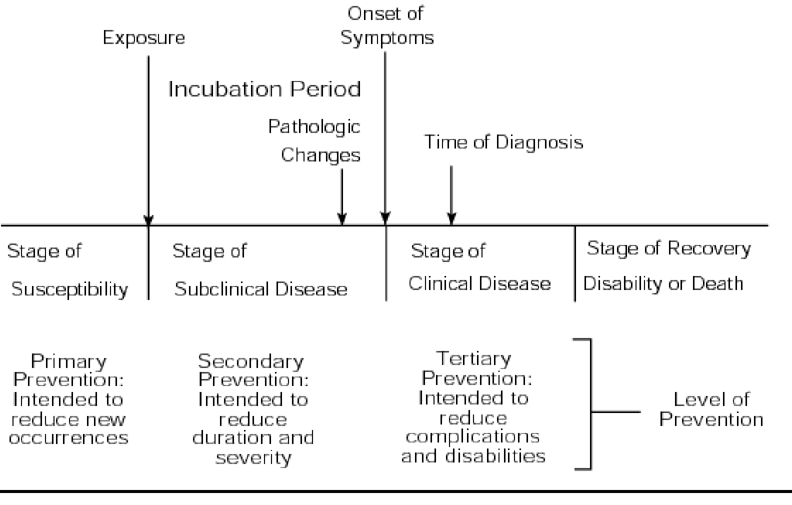
- Define dynamic of disease transmission
- Define and describe the clinical and non clinical disease
- Define, describe, and apply the measures of disease frequency
- Compare and contrast measures of disease occurrence
- Apply direct and indirect adjustment of disease measures
- Describe ways of expressing prognosis

Dynamics of disease transmission

- Human disease is an interaction between:
  - *Host: age, sex, race, immune status*
  - *Agent: biologic, chemical, physical, nutrition*
  - *Environment: temp, humidity, housing, water, milk, radiation*
- **Disease transmission**:
  - Direct
  - Indirect
    - Through common vehicle [e.g., Contaminated air or water]
    - Through vector [e.g., Mosquito]

Natural History of Disease

Progression of disease in an individual over time



Measuring Occurrence of Disease

- Disease occurrence: who, when, and where

- **Components:**
  - Classifying disease
  - Deciding what constitutes a case of disease in a study
  - Finding a source for ascertaining the cases
  - Defining the population at risk of disease
  - Defining the period of time of risk of disease
  - Making measurements of disease frequency

- **Factors Affecting Disease Frequency Measures**
  - Temporal Sequences
  - Disease Duration
  - Case Definition
  - Numerators [number of cases]
  - Denominator: Population at Risk
  - Characteristics of the test used for the diagnosis

Surveillance

- Monitor changes in disease frequency or monitor changes in the levels of risk factors.

- Much of our information about morbidity and mortality from disease comes from programs of systematic disease surveillance.

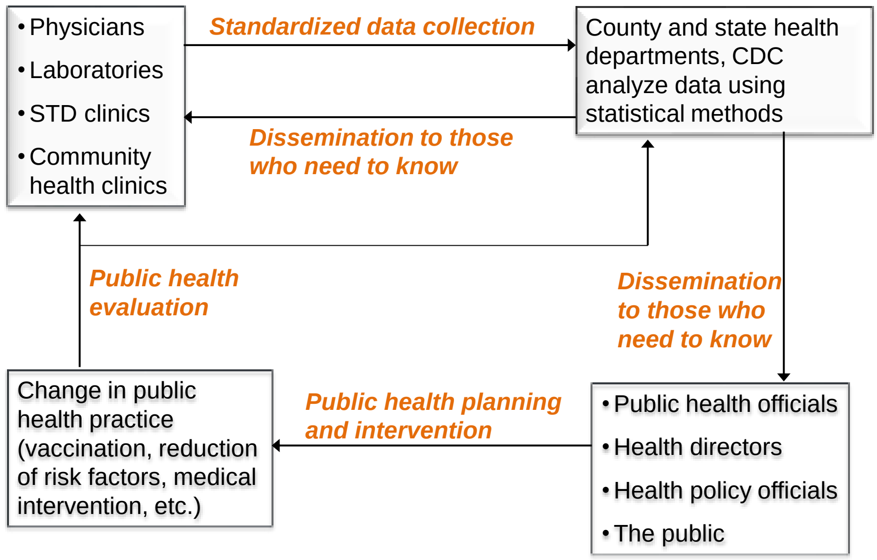
- *“The ongoing systematic collection, analysis, and interpretation of health data, essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination to those who need to know”.*

Source: The Centers for Disease Control and Prevention (CDC)

Types:
- Active: project staff recruited to carryout the program

- Passive: Available data on reportable diseases are used [health care provider or district health officer]

Surveillance Information, Dissemination, and Reporting

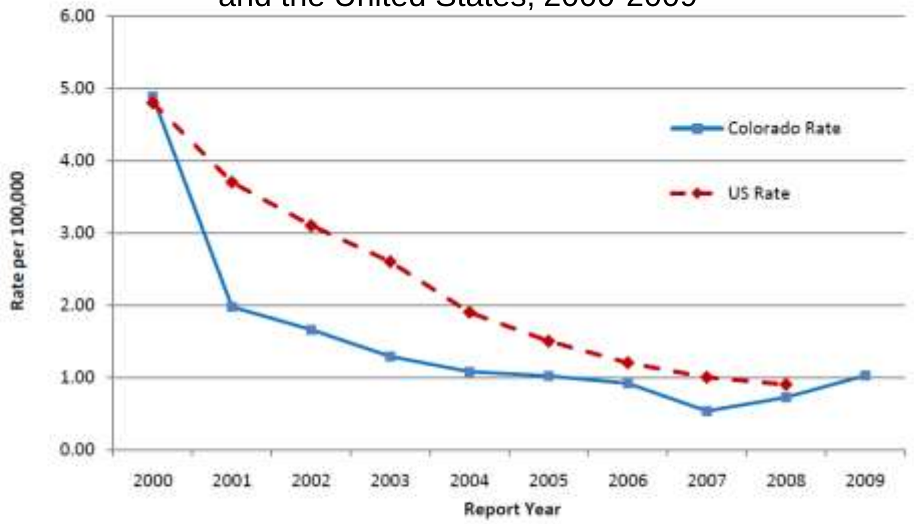


Surveillance Data as a Tool

- Establish baseline rate of disease
- Detect epidemics
- Estimate magnitude of a health problem
- Determine geographic distribution
- Facilitate planning

Surveillance Data Graphs

Incidence rates of reported hepatitis A infections in Colorado and the United States, 2000-2009



Surveillance Data Maps

North Carolina Salmonella Rates by County: 2002

Rate numerators: NC Communicable Disease Data for 2000

Rate denominators: U.S. Census population data, by county, for 2000

CDC: Surveillance and Reporting

- Office of Surveillance, Epidemiology, and Laboratory Services
  - Gulf States Population Survey (GSPS)
  - National Electronic Disease Surveillance System (NEDSS)
  - National Electronic Telecommunications System for Surveillance (NETSS)
  - Behavioral Risk Factor Surveillance System (BRFSS)

- MMWR
  - Publication public health information and recommendations

Presentation of Epidemiological Outcomes

- Ratio: Relationship between two numbers
  - Example: males/females
- Proportion: A ratio where the numerator is included in the denominator
  - Example: males/total births
  - tell us what fraction of the population is affected.
- Rate: A proportion with the specification of time
  - Example: (deaths in 1999/population in 1999) x 1,000
  - Tell us how fast the disease is occurring in a population.

Morbidity Measures

$$\textbf{Incidence Rate} = \frac{\text{Number of } \textbf{\textit{new}} \text{ events during a time period}}{\text{Population at risk during that period of time}} \times 1{,}000$$

- Incidence is always calculated for a given period of time
  - *An attack rate is an incidence rate calculated for a specific disease for a limited period of time during an epidemic*

Morbidity Measures (Cont.)

$$\textbf{Prevalence} = \frac{\text{Number of } \textbf{\textit{existing}} \text{ events, old and new}}{\text{Population at risk}} \times 1{,}000$$

- Prevalence is not a rate
  - *Point prevalence* measures the frequency of all current events at a given instant in time
  - *Period prevalence* measures the frequency of all current events for a prescribed period of time

Relationship Between Incidence and Prevalence

Interrelationship: *Prevalence ≅ Incidence X Duration*

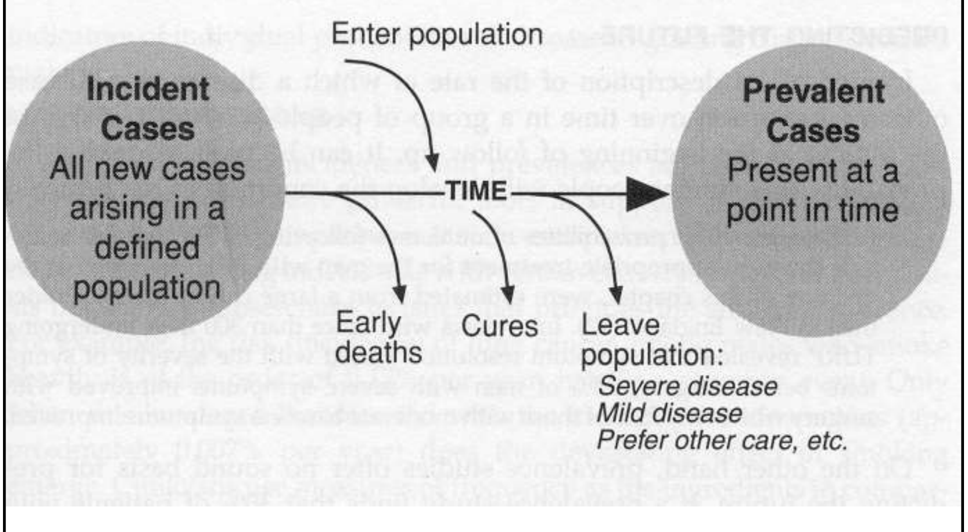
High prevalence may reflect:

- High risk
- Prolonged survival without cure

Low prevalence may reflect:

- Low risk
- Rapid fatal disease progression
- Rapid cure

Examples: Ebola, Common cold



Relationship Between Incidence and Prevalence (cont.)

- Cancer of the pancreas
  - Incidence low
  - Duration short
  - Prevalence low
- Adult onset diabetes
  - Incidence low
  - Duration long
  - Prevalence high
- Roseola infantum
  - Incidence high
  - Duration short
  - Prevalence low
- Essential hypertension
  - Incidence high
  - Duration long
  - Prevalence high

Incidence Density (ID)

- "Force of morbidity or mortality" ; "Incidence density (ID)"
  - It is a measure of the instantaneous rate of development of disease in a population
    - ID=number of new cases during given time period / total person time of observation
      - » the sum of the time that each person remained under observation and free from disease

- **Example:**
  - Five subjects, two developed the disease over 5 year follow-up period
  - **The cumulative incidence**= (2/[5*5]*100)= 8 /100 over 1 year
  - Details for each subject of the follow-up time:
    - One subject was followed for 5 years
    - One subject was observed for 2 years
    - one subjects was followed for 3 years
    - one subjects was followed for 4 years
    - one subjects was followed for 2.5 years
  - **Total time at risk for 5 subjects=16.5** person-years
  - **ID** = 2 cases / 16.5 person-year = 12.1/100 person-years

Incidence Density Example

- In the Women's Health Study (WHS), 37,105 women contributed 276,453 person-years of follow-up

- Because there were 1,085 incident cases, the rate of breast cancer using the incidence density method is:

  1,085/276,453 = 392.5/100,000 person-years

- If each woman had been followed for the entire 8-year period of the study, the total person-years would have been 296,840 and the rate would have been lower (assuming the number of incident cancers was the same)

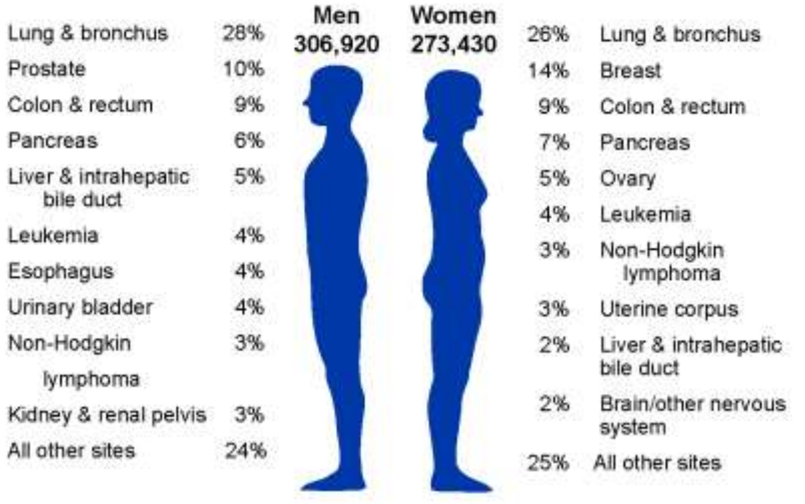
- The incidence density method yielded a <u>*higher and more accurate*</u> estimate

Mortality

- **Annual <u>mortality rate</u> from all causes**:
  - Numerator: total number of deaths from all causes in 1 year
  - Denominator: number of persons in the population at midyear (approximation because population changes over time)

  - Annual mortality rate from all causes for children younger than 10 years: (<u>age specific rate</u>)
    - Numerator: total number of deaths from all causes in 1 year in children younger than 10 years
    - Denominator: number of children <10 years in the population at midyear

Estimated Cancer Deaths in the US in 2013



Measures of mortality (Cont.)

- **Case Fatality**:
  - Percent of people diagnosed as having certain disease who died within a certain time after diagnosis
  - Numerator: number of subjects dying during a specific period of time after disease onset or diagnosis
  - Denominator: number of subjects with the specified disease
- Example:
  - Population of 100,000
  - 20 are sick with disease X
  - In one year, 18 die from disease X
  - Mortality = 18/100,000X100 = 0.018% → low
  - Case fatality = 18/20 X 100 = 90% → very high

Measures of mortality (Cont.)

- **Proportionate mortality**
  - Of all deaths in the population, what proportion were due to specific disease
  - Numerator: number of subjects dying during a specific period of time (e.g., 1999) from a specified disease
  - Denominator: total number of deaths in the population in the same period of time (1999)

- Example:
  - Population of 1,000
  - 30 died from all causes
  - Mortality = **30**/1,000
  - Mortality from heart disease = **3**/1,000
  - Proportionate mortality = 3/30X100 = 10%

Potential Problems with Mortality

- Death certificate
- Underlying cause of death is used
  - It excludes information pertaining to immediate cause of death
- Countries and regions vary greatly in quality of data
- Validity of death certificate data: Autopsy; Hospital records
- ICD code (international code of disease)
  - Revisions
  - Mortality overtime
    - ICD revision code
  - Change in disease definition

Comparison of mortality in different populations.

Population may differ in regard to many characteristics that can affect mortality [e.g., Age; Gender; Race/ethnicity]

- White 14.3/1,000
- Black 10.2/1,000
- *Let us look at the data by age group*

	<1	1-4	5-17	18-44	45-64	>65
W	23	0.7	0.4	2.5	15.2	69.3
B	*31*	*1.6*	*0.6*	*4.8*	*22.6*	*75.9*

- Higher in black than white in all age group
  - mortality increase in both groups in older age group.
  - *White population is older than black population*
  - Overall mortality in white is heavily weighted by high rate in old age group
  - The rate reflected difference in mortality and difference in age composition of the population.

Direct Age Adjustment

- **Standard population**
  - is used in order to eliminate the effects of any differences in age between two or more populations being compared
- *By applying the rates from populations to a single standard population*
  - we eliminate the possibility that observed differences could be a result of age difference in the population

Direct Age Adjustment (example)

- Population A:
  - N=900,000
  - Number of deaths=862
  - Rate= ???/100,000
- Population B:
  - N=900,000
  - Number of deaths=1,130
  - Rate= ???/100,000

Direct Age Adjustment (example)

- Population A: for each age group

Age gp	Pop.	Deaths	Rate/100,000
– ***Total***	***900,000***	***862***	***96***
– 30-49	500,000	60	12
– 50-69	300,000	396	132
– 70+	100,000	406	406

- Population B: for each age group

– ***Total***	***900,000***	***1,130***	***126***
– 30-49	300,000	30	10
– 50-69	400,000	400	100
– 70+	200,000	700	350

Direct Age Adjustment (example)

- Population A:

Age gp	Standard Pop.	Rate in pop. **A**/100,000	*Expected*
– *Total*	*1,800,000*		
– 30-49	800,000	12	*96*
– 50-69	700,000	132	*924*
– 70+	300,000	406	*1,218*

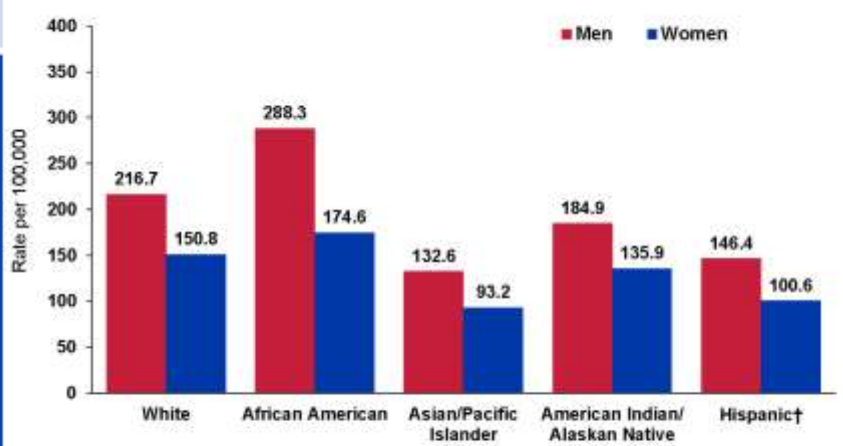
  - ***Total number of death in standard population = 2,238***
  - ***Age adjusted rate in population A = 2,238/1,800,000 = 124.3***

- Population B:

Age gp	Standard Pop.	Rate in pop. **B**/100,000	*Expected*
– *Total*	*1,800,000*		
– 30-49	800,000	10	*80*
– 50-69	700,000	100	*700*
– 70+	300,000	350	*1,050*

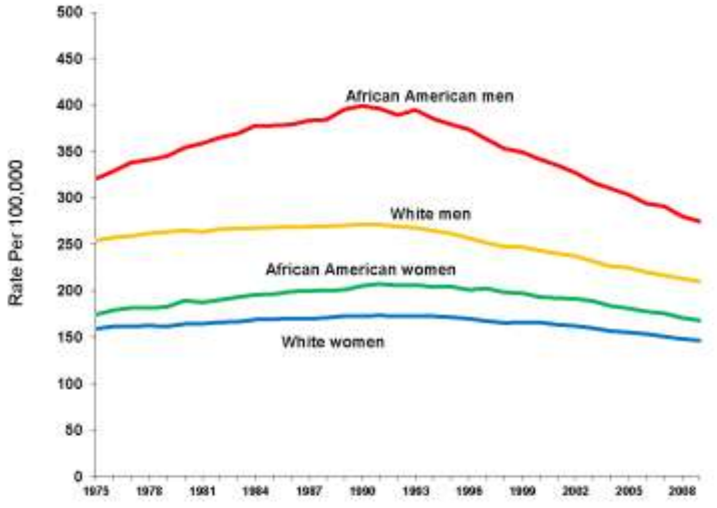
  - ***Total number of death in standard population = 1,830***
  - ***Age adjusted rate in population B = 1,830/1,800,000 = 101.7***

Cancer Death Rates* by Race and Ethnicity, US, 2005-2009



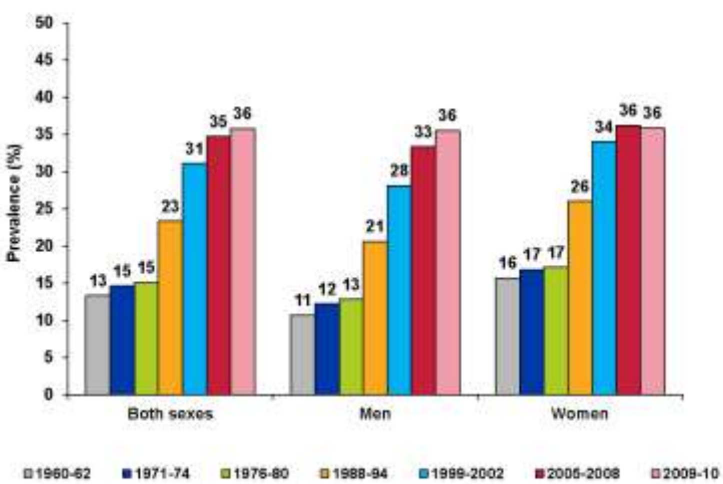
*Per 100,000, age-adjusted to the 2000 US standard population.
†Persons of Hispanic origin may be of any race.

Cancer Death Rates* by Sex and Race, US, 1975-2009



*Age-adjusted to the 2000 US standard population.
Source: Surveillance, Epidemiology, and End Results Program, 1975-2009, Division of Cancer Control and Population Sciences, National Cancer Institute, 2012.

Trends in Obesity* Prevalence, Adults Aged 20 to 74, US, 1960-2010



*Obesity=body mass index ≥ 30 kg/m²; estimates are age adjusted to the 2000 US standard population.
Source: National Health and Nutrition Examination Survey, National Center for Health Statistics, Centers for Disease Control and Prevention.

Indirect Age Adjustment

- Used when number of deaths for each age specific group are not available
- Used to study mortality in occupationally exposed population
  - Example: do people that work in mining industry have higher mortality than people of same age in the general population?

Indirect Age Adjustment

- Standardized mortality **ratio** (SMR) for TB for Miners age 20-59 years

Age (yr)	Pop. Of Miners	**Deaths Rate/100,000 in the general pop**	Expected death	**Observed death**
20-24	74,598	12.26	9.14	10
25-29	85,077	16.12	13.71	20
30-34	80,845	21.54	17.41	22
35-44	148,870	33.96	50.55	98
45-54	102,649	56.82	58.32	174
55-59	42,494	75.23	31.96	112
Total	534,533		181.09	436

SMR = observed/expected = 436/181.09 = 2.41

i.e., observed number of death exceeds the expected number of death

Ways of Expressing Prognosis

- WHY?
  - Once a person is identified as having a disease, it is necessary to describe severity of a disease
      - Establish priorities for clinical services
    - Patients often ask questions about prognosis
    - Establish baseline
      - New treatment effect can be compared with the expected outcome
    - Compare effectiveness of the various types of therapy
- Prognosis is described in quantitative terms
    - Prognosis can be expressed in terms of:
      - Death from a disease
      - Survival
    - End point commonly used:
      - death
      - Interval from diagnosis to recurrence of disease
      - Interval from diagnosis to the time of functional impairment
      - Interval from diagnosis to the time of change in quality of life

Ways of Expressing Prognosis (Cont.)

- **Case-Fatality:**
  - The number of subjects who died of a disease divided by the number of subjects who have the disease
    - Used for <u>acute diseases</u> in which death occurs relatively soon after diagnosis
- **Five-Year Survival**
  - Frequently used in clinical medicine
    - Evaluating treatment for cancer
  - It is the percentage of patients who are alive 5 years after treatment begins or 5 years after diagnosis
    - Most deaths from cancer occur during 5 years after diagnosis