Measures of Morbidity and Mortality

Akhilesh Bhargava

MD, DHA, PGDHRM

Professor-Community Medicine

& Director-SIHFW, Jaipur

- The fundamental task in epidemiologic research is to quantify the occurrence of illness
- The goal is to evaluate causation of illness by relating disease occurrence to characteristics of people and their environment
- Rates, Ratios, and Standardized Rates are primary tools for quantifying occurrence of illness

What is a rate?

“a measure of speed with which events are occurring in a population in a specified time period.”

- Essentials
  - A numerator
  - A denominator that “appropriately” relates the numerator to population at risk
  - A “unit” such as per 1000, per 100,000 or per million

Why a rate?

- To ensure comparing apples with apples

Prevalence VS. Incidence

Prevalence:

A “snapshot” of disease at a point in time in a population

Relevant for planning of health services

Incidence:

A description of how new cases of disease are occurring. “force of morbidity” “rate of flow” of cases from non disease to disease state

Relevant for exploring causal theories

Prevalence (P) and Incidence (I)

P~I x d

d=duration

P= I x d

If the disease is stable, that is, if the incidence and duration remains constant over time.

Prevalence

$$P = \frac{\text{number of individuals with the disease}}{\text{number of individuals at risk}}$$

Prevalence can be expressed either as a proportion or as a rate

Expressed as a proportion, prevalence is a number between 0 and 1

As a rate, prevalence can be expressed as per 1000, per 100,000, or per whatever

Prevalence: Example

A sample of 1,000 women 70-74 years. 70 were found to have the diagnosis of rheumatoid arthritis.

The prevalence of arthritis is:

$$P = \frac{70}{1{,}000} = 0.07 \text{ for women age 70-74}$$

Or

P= 70 per thousand for women age 70-74

Or

P= 7 percent for women age 70-74

Or………

Prevalence

Choice of scale of rate usually depends on the ubiquity of the disease.

Thus, more common disease prevalence may be presented as percentage

Rare disease prevalence may be presented as per 100,000 or per million

Incidence Rate: Example

In 1973 there were 29 cases of MI in Jaipur among men 40-44 years. The number of person years was 41,532.

The incidence rate is:

$$I = \frac{29}{41{,}532} = 0.0007 \text{ per year}$$

= 0.7 per thousand per year

= 7 per 10 thousand per year

= 700 per million per year

To be more accurate, we must add another qualifier, namely, “for men 40-44 years of age”

Incidence Rate

$$I = \frac{\text{No. of new cases occurring during a period of time}}{\text{"total person time" at risk}}$$

What is "person time":

The duration of time a person is at risk

Usually expressed as person years <u>but</u> can be expressed as anything, e.g., person months, person weeks, etc.

"Total Person Time"

- Sum of person time of all individuals at risk

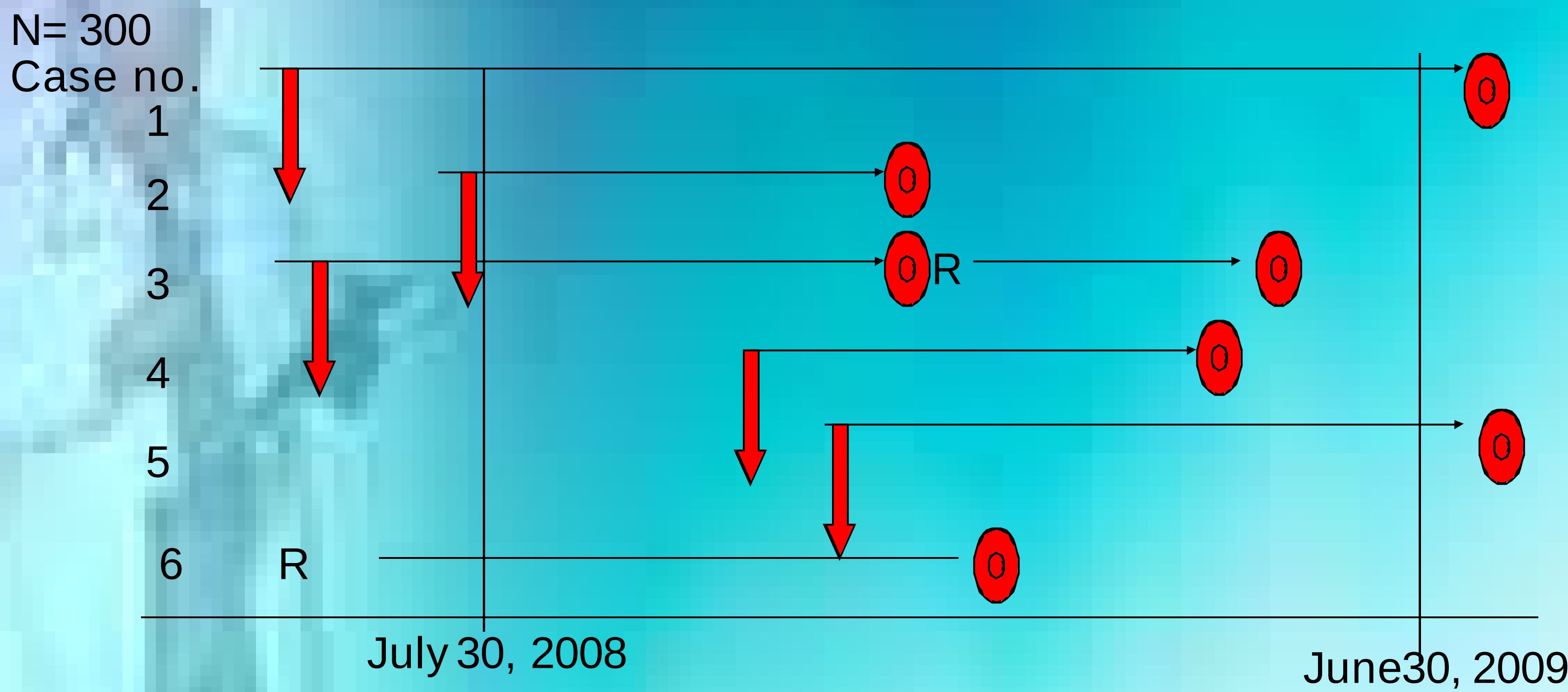
Equivalence of "total person time"

50,000 person years

= 5,000 persons observed for 10 years

= 1,000 persons observed for 50 years

= 10,000 persons observed for 5 years



R = Date of recurrence

Date of Onset of disease

Date of Termination or death

Point prevalence on July 30, 2003= 4 cases(1, 2, 3, 6)/ 300

Incidence rate on July 30, 2003= 2 cases (4, 5) /296

Period prevalence between July 30, 2003 to June 30, 2004= 6 /300

Crude and Specific Rates

"Crude": Rates calculated for the "entire" population

"Specific": Rates calculated for "specific" subpopulations.

Ex: Age-specific rates
Race-specific rates
Gender-specific rates

Comparing Apples with Apples

In comparing populations (groups) one should recognize that populations (groups) can differ in two important respects:

Subpopulation-specific rates

Distribution of subpopulations

Comparison of Death rates in two population by age

	Age	Population No.	proportion	Annual Age Specific Death Rate	Annual no. of deaths	CDR / 1000
Pop. A	< 15 15-44 45+ All ages	1500 2000 1500 5000	30 40 30 100	2 6 20	3 12 30 45	45 ----- = 9 5000
Pop. B	< 15 15-44 45+ All ages	2000 2500 500 5000	40 50 10 100	2 6 20	4 15 10 29	29 ----- = 5.8 5000

- **No difference in two population in risk of death**
- **Population A has higher crude death rate for large aged pop.**
- **CDR may not always reflect risk of death in a comparative study**

Standardization?

Standardized rate = “weighted” average of category-specific rates

Standardized rates can also be called Adjusted rates. For example, age adjusted, gender adjusted, race adjusted, etc.

Adjusted Rates are Created Through Standardization

- Standardization: The process by which you derive a summary figure to compare health outcomes of groups
  - The process can be used for mortality, natality, or morbidity data

.

Direct Adjustment

Rates of populations to be compared applied to the standard population

The question: What would be the number of events (deaths, births, etc.) in the standard population if events were happening at the category-specific rates in each population?

Example: Age-Adjustment

A. Direct Method requires -

1. Age-specific rates in the sample population
   - a) The age of each case
   - b) The population-at-risk for each age group in the sample
2. Age structure (percentage of cases in each age group) of a standard population

Summary figure is an Age-adjusted rate

Calculation of expected no of deaths by direct method:

Same age specific rates

	Standard Pop. A & B combined	Pop. A Age specific death rate	Expected deaths	Pop. B Age specific death rate	Expected deaths
< 15	3500	2	7	2	7
15-44	4500	6	27	6	27
45+	2000	20	40	20	40
All ages	10000		74		74

- While crude deaths were different, adjusted deaths are same for two pop.
- Risk of death is identical in Pop. A & B
- Age adjustment has removed distortion in risk of death from crude death rate

Calculation of expected no of deaths by direct method:

different age specific rates

	Standard Pop. A & B combined	Pop. A Age specific death rate	Expected deaths	Pop. B Age specific death rate	Expected deaths
< 15	3500	2	7	2	7
15-44	4500	6	27	10	45
45+	2000	20	40	20	40
All ages	10000		74		92

Adjusted rate for Pop. A= 74/ 10000 X 1000= 7.4
Adjusted rate for Pop. B= 92/ 10000 X 1000= 9.2
Different risk of death in two pop. Are preserved by age adjustment

Direct Age Adjustment

1995-2000			2001-2005		
Population	No. of Deaths	Death rate/ 100000	Population	No. of Deaths	Death rate/ 100000
900000	862	**96**	900000	1130	**126**

Direct Age Adjustment: Comparison of Age specific death rates

	1995-2000			2001-2005		
Age Gr.	popula tion	No. of Deaths	Death Rate/ 100000	popula tion	No. of Deaths	Death Rate/ 100000
All ages	900000	862	96	900000	1130	126
30-49	500000	60	12	300000	30	10
50-69	300000	396	132	400000	400	100
70+	100000	406	406	200000	700	350

Direct Age Adjustment:
Age adjustment using total of two pop. As standard

Age Group	Standard Population	1996-2000 Age specific mortality rates	Expected no. of deaths	2001-2005 Age specific mortality rates	Expected no. of deaths
All Ages	1800000				
30-49	800000	12	96 (8 x 12)	10	80
50-69	700000	132	924 (7 x 132)	100	700
70+	300000	406	1218	350	1050
Total			2238		1830

Age adjusted Rate= $\dfrac{2238}{1800000}$ = 24.3 $\dfrac{1830}{1800000}$ =101.7

Indirect Adjustment

Rates of standard population applied to populations to be compared.

The question: What would be the number of events (deaths, births, etc.) if the particular population was having events at the same category specific rates as the standard population?

Indirect method requires

1. Age structure (percentage of cases in each age group) of the sample population
2. Total deaths in the sample population
3. Age-specific rates for the standard population

Summary figure is a

Standardized Mortality ratio

Indirect Standardization

- Instead of a standard population structure, you utilize a standard rate to adjust your sample
- Indirect standardization does not require that you know the stratum-specific rates of your cases
- The summary measure is the **SMR** or standardized mortality/morbidity ratio

$$\textbf{SMR} = \frac{\textbf{Observed}}{\textbf{Expected}} \times \textbf{100}$$

- An SMR of 100 means no difference between the number of outcomes in the sample population and that which would be expected in the standard population

Indirect Standardization (cont.)

Calculation of the SMR for Male Farmers for All Causes of Death:

Age Group	Number of Factory workers & Managers (Census, 2001) (1)	Standard Death Rates per 1,000,000 (All Causes of Death) (2)	Expected Number of Deaths for Factory workers & Managers per 1,000,000 (3) = (1) X (2)
20-24	7,989	1,383	11
25-34	37,030	1,594	59
35-44	60,838	2,868	174
45-54	68,687	8,212	564
55-64	55,565	22,953	1,275

Total expected deaths per year: 2,083 Total observed deaths per year: 1,464

SMR = 1,464 / 2,083 x 100 = 70.3%

Indirect Standardization (cont.)

SMR for Tuberculosis for Miners Ages 20 to 59 Years

Age (yr)	Estimated Population of Miners (1)	Death Rate (per 100,000) for TB in Males in the General Population (2)	Expected Deaths From TB in Miners if they Had the Same Risk as the General Population (3) = (1) X (2)	Observed Deaths from TB in Miners (4)
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			181.09	436

SMR = Observed / Expected X 100

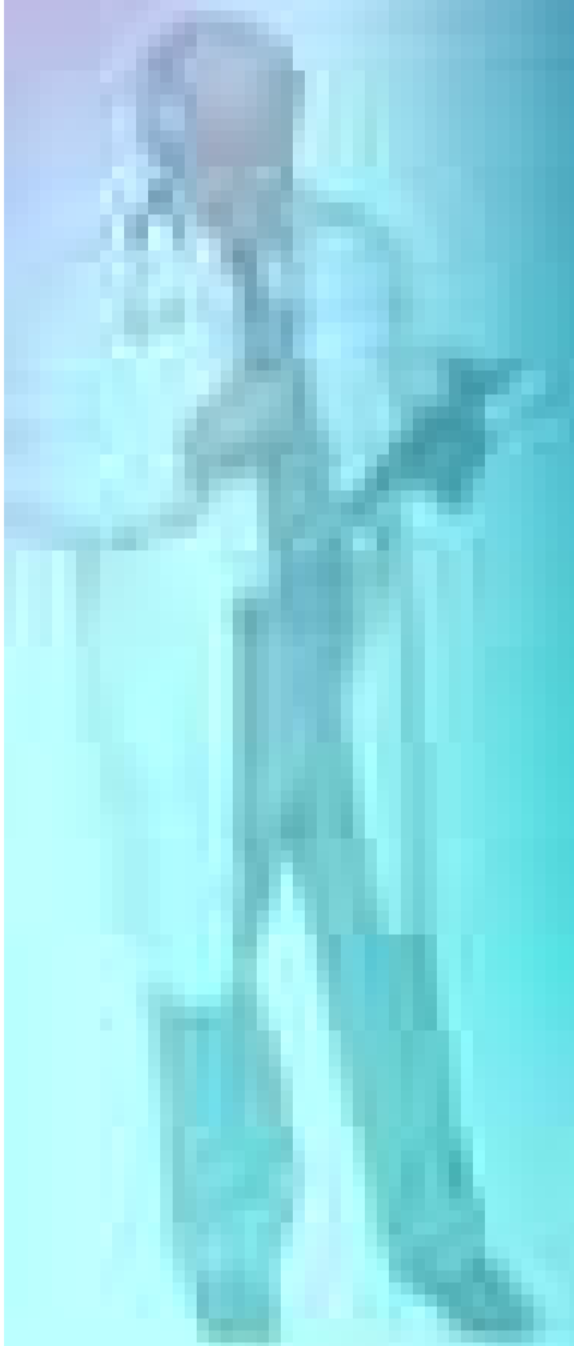
SMR (for 20–59 yr olds) = 436 / 181.09 X 100 = 241

Indirect Standardization (cont.)

Some individuals contribute different amounts of risk due to length of exposure

Hypothetical Example Illustrating Calculation of stratum-specific SMRs

Age (Yrs.)	Study Cohort				
	Obs	Person-Years	Reference Population Rate per 1,000	Exp	SMR =
	(1)	(2)	(3)	(4) = (2) X (3)	(1) / (4)
40-49	6	1,200	2.5	3.00	2.00
50-59	27	2,340	6.1	14.27	1.89
60-69	98	3,750	12.4	46.50	2.11
70-79	48	975	25.0	24.38	1.97
Totals	179			88.15	2.03



Vital Statistics

Indicators of Public Health

- Mortality statistics
  - Age specific mortality rates
  - Disease specific mortality rates
  - Case-fatality
  - Life Expectancy
  - Maternal mortality rates
  - Infant mortality rates
- Morbidity statistics
- Fertility rates
- Vaccination coverage
- Health care utilization
- Health status indicators

Vital Statistics

- Systems for collecting vital statistics
  - Civil registration system
    - Advocated by the United Nations
    - Present in industrialized countries
    - Costly to develop and maintain
  - Alternative methods
    - Probability area samples
    - Purposeful area samples
    - Records-based surveys

Vital Statistics

- Priority in Vital Statistics Collection – based on UN criteria
  - Births and deaths
  - Marriages
  - Divorces
  - Fetal deaths
  - Annulments
  - Judicial separations
  - adoptions

Vital Statistics

- Legal documentation
- Assessment
  - Demography
  - Health

Vital Statistics

- History
  - U.S. census every 10 years since 1790
  - Mid-point census since 1976
- Census
  - Latin – to estimate or assess
  - Enumerating the number of people in a given population
    - Age, sex, race, household relationships, marital status, number of rooms in house, length of time in residence, rental or ownership, value of home
  - Sampling strategies for difficult to reach populations

Mortality Data

- Comprehensive
- Measure of community health
- Track trends over time by region
- Proportionate mortality
- Infant death
- Applies to men and women
- Cohort analysis
- Standardization for comparison across populations
- Demography

Mortality Rate

$$\text{Annual Mortality Rate} = \frac{\text{Total number of deaths from all causes in 1 yr}}{\text{Number of persons in the population at mid-year}} \times 1000$$

Mortality Rates
Age Specific

$$\text{Age-specific Annual Mortality Rate} = \frac{\text{Total number of deaths from all causes in 1 yr per age group}}{\text{Number of children in the population at mid-year per age group}} \times 1000$$

Mortality Rates: Disease Specific

$$\text{Annual Mortality Rate for Lung Cancer} = \frac{\text{Total number of deaths from lung cancer in 1 yr}}{\text{Number of persons in the population at mid-year}} \times 1000$$

Total and Age-Specific Mortality Rate (deaths/1000)

Age Group (yrs)	Population	Deaths	Rate*
0 – 4	97,870	383	3.9
5 – 9	221,452	75	0.3
10 – 24	284,956	440	1.5
25 – 34	265,885	529	2.0
35 – 44	207,564	538	2.6
45 – 54	193,505	1,107	5.7
55 – 64	175,579	2,164	12.3
65 – 74	152,172	3,789	24.9
≥ 75	107,114	7,834	73.1
Total	1,706,097	16,859	9.9

Infant Mortality Rate

$$\text{IMR} = \frac{\text{Number of deaths in a year of live-born infants less than 1 year of age}}{\text{Number of live births in the same year}} \times 1000$$

Source of Error in Mortality Statistics

- Facts inaccurate
  - Demographic- age, sex, race, ethnicity
  - Marital status
  - Occupation
- Place of residence, not occurrence recorded
- Cause of death - very inaccurate
  - Immediate cause
  - Underlying condition
- Changing taxonomy

Sources of Information

- Deaths
  - Death certificate
  - Clinical records
  - Autopsy
  - Surveillance programs
  - Village recorders
- Population
  - Census
  - Hospital admissions
  - Fixed cohorts
  - Estimates

Case Fatality Rate

$$\text{Case-Fatality Rate} = \frac{\text{Total number of individuals dying during a specified period of time after disease onset}}{\text{Number of individuals with the disease of interest}} \times 100$$

Proportionate Mortality

$$\text{Proportionate Mortality For a Disease} = \frac{\text{Total number of deaths from the Disease in given yr}}{\text{Total number of deaths in the population during that year}} \times 100$$

Comparing Mortality in Different Populations

- Crude
- Age Adjustment
  - Direct
  - Indirect (Standardized Mortality Ratio)
- Cohort Analysis
- Life-table Analysis
  - Median survival
  - Life expectancy

Trends in Mortality: Artifactual

Numerator
- Errors in diagnosis
- Errors in age
- Changes in coding
- Changes in classification

Denominator
- Errors in counting population
- Errors in classifying by demographic characteristics
- Differences in proportion of population at risk

Measures of Mortality:

- Mortality rate
  - Cause specific
  - Age specific
- Case-fatality rate
- Proportionate mortality rate
- Standardized Mortality Rates

Why study Mortality-

- Eternal, ultimate experience
- A measure of disease severity
- Effectiveness of treatment
- Surrogate for incidence (in severe, fatal diseases)
- Comparison of rates in two or more population or one population at different times

Mortality Data- Problems

- Change in coding of ICD revisions
- Changes in definitions of diseases
- Underlying cause of death excludes Information on immediate Cause & those in between two.
- Denominator may not be available
- Numerator alone does not give rates and calls for standardization

Comparison of Rates

	Advantages	**Disadvantages**
<u>Crude</u>	Actual Summary rates	Difficult to interpret because of differences in population structures
	Readily calculable	
<u>Specific</u>	Controls for homogeneous subgroups	Cumbersome if there are many subgroups
	Provides detailed information	No summary figure
<u>Adjusted</u>	Provides a summary figure	Fictional rate
	Controls confounders	Magnitude depends on population standard
	Permits group comparison	Hides subgroup differences