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Tools of measurement

The basic tools of measurement in epidemiology are :

1. Rates
2. Ratios, and
3. Proportions

1. RATE

- When we say there were 500 deaths from motor vehicle accidents in City A during 2018, it is just nothing more than counting deaths in that city during that particular year. Such a statement might be sufficient for the municipal administrator to provide necessary health services.

1. RATE

- But it conveys no meaning to an epidemiologist who is interested in comparing the frequency of accidents in City A with that in City B.
- To allow such comparisons, the frequency must be expressed as a rate.

1. RATE

- A rate measures the occurrence of some particular event (development of disease or the occurrence of death) in a population during a given time period.
- It indicates the change in some event that takes place in a population over a period of time.
- An example of a typical rate is the death rate.

1. RATE

- Death rate = $\frac{\text{Number of deaths in one year}}{\text{Mid-year population}} \times 1000$

1. RATE

A rate comprises the following elements –

- numerator,
- denominator,
- time specification and
- multiplier.
- The time dimension is usually a calendar year.
- The rate is expressed per 1000 or some other round figure (10,000; 100,000) selected according to the convenience or convention to avoid fractions.

1. RATE

The various categories of rates are :

- (1) Crude rates: These are the actual observed rates such as the birth and death rates. Crude rates are also known as unstandardized rates.
- (2) Specific rates: These are the actual observed rates due to specific causes (e.g., tuberculosis); or occurring in specific groups (e.g., age-sex groups) or during specific time periods (e.g., annual, monthly or weekly rates).
- (3) Standardized rates: These are obtained by direct or indirect method of standardization or adjustment, e.g., age and sex standardized rates

2. RATIO

- It expresses a relation in size between two random quantities. The numerator is not a component of the denominator. The numerator and denominator may involve an interval of time or may be instantaneous in time.
- Broadly, ratio is the result of dividing one quantity by another.

2. RATIO

- It is expressed in the form of:

x: y or x/y

Example 1: The ratio of white blood cells relative to red cells is 1 :600 or 1/600, meaning that for each white cell, there are 600 red cells

Example 2:

$$\frac{\text{The number of children with scabies at a certain time}}{\text{The number of children with malnutrition at a certain time}}$$

2. RATIO

Other examples include:

- sex-ratio,
- doctor-population ratio,
- child-woman ratio, etc

3. PROPORTION

- A proportion is a ratio which indicates the relation in magnitude of a part of the whole. The numerator is always included in the denominator. A proportion is usually expressed as a percentage.
- Example

$$\frac{\text{The number of children with scabies at a certain time}}{\text{The total number of children in the village at the same time}} \times 100$$

CONCEPT OF NUMERATOR AND DENOMINATOR

1. Numerator

- Numerator refers to the number of times an event (e.g., sickness, birth, death, episodes of sickness) has occurred in a population, during a specified time-period. The numerator is a component of the denominator in calculating a rate, but not in a ratio.

CONCEPT OF NUMERATOR AND DENOMINATOR

2. Denominator

- Numerator has little meaning unless it is related to the denominator, The epidemiologist has to choose an appropriate denominator while calculating a rate. It may be
- (a) related to the population, or
- (b) related to the total events

CONCEPT OF NUMERATOR AND DENOMINATOR

a. Related to the population

The denominators related to the population comprise the following:

- (i) MID-YEAR POPULATION: Because the population size changes daily due to births, deaths and migration, the mid-year population is commonly chosen as a denominator.
- The mid-point refers to the population estimated as on the first of July of an year.

CONCEPT OF NUMERATOR AND DENOMINATOR

- (ii) POPULATION AT-RISK: This is an important concept in epidemiology because it focuses on groups at risk of disease rather than on individuals. The term is applied to all those to whom an event could have happened whether it did or not.
- For example, if we are determining the rate of accidents for a town, the population at risk is all the people in the town.

CONCEPT OF NUMERATOR AND DENOMINATOR

- But sometimes, it may be necessary to exclude people because they are not at risk, as for example, in food poisoning, only those who ate the food are at risk of becoming ill.
- Similarly in calculating "general fertility rate", the denominator is restricted to women of child-bearing age (i.e., 15-49 years); older women and little girls are excluded because they are not "at risk" of becoming pregnant.

CONCEPT OF NUMERATOR AND DENOMINATOR

- (iii) PERSON-TIME: In some epidemiological studies (e.g., cohort studies), persons may enter the study at different times. Consequently, they are under observation for varying time periods. In such cases, the denominator is a combination of persons and time. The most frequently used person-time is person-years. Sometimes, this may be person-months, person-weeks or man-hours.

CONCEPT OF NUMERATOR AND DENOMINATOR

- For example, if 10 persons remain in the study for 10 years, there are said to be 100 person-years of observation. The same figure would be derived if 100 persons were under observation for one year.
- These denominators have the advantage of summarizing the experience of persons with different durations of observation or exposure.

CONCEPT OF NUMERATOR AND DENOMINATOR

- (iv) PERSON DISTANCE: A variant of person-time is person-distance, as for example passenger-miles.
- (v) SUB-GROUPS OF THE POPULATION: The denominator may be subgroups of a population, e.g., age, sex, occupation, social class, etc

CONCEPT OF NUMERATOR AND DENOMINATOR

b. Related to total events

- In some instances, the denominator may be related to total events instead of the total population, as in the case of infant mortality rate and case fatality rate.

CONCEPT OF NUMERATOR AND DENOMINATOR

- In the case of accidents, the number of accidents "per 1000 vehicles" or "per million vehicle-miles" will be a more useful denominator than the total population, many of them may not be using vehicles.

MORTALITY RATES AND RATIOS

- The commonly used measures are described below;
- 1. Crude death rate
- It is defined as "the number of deaths (from all causes) per 1000 estimated mid-year population in one year, in a given place". It measures the rate at which deaths are occurring from various causes in a given population, during a specified period.

Crude death rate

- The crude death rate is calculated from the formula:

$$\frac{\text{Number of deaths during the year}}{\text{Mid-year population}} \times 1000$$

SPECIFIC DEATH RATES

The specific death rates may be –

- (a) cause or disease specific - e.g., tuberculosis, cancer, accident;
- (b) related to specific groups e.g., age specific, sex-specific, age and sex specific, etc.
- Rates can also be made specific for many other variables such as income, religion, race, housing, etc.

SPECIFIC DEATH RATES

- Specific death rates are obtained mainly in countries in which a satisfactory civil registration system operates and in which a high proportion of deaths is certified medically.

1. Specific death rate due to tuberculosis

Number of deaths from tuberculosis during a calendar year

---x 1000

Mid-year population

2. Specific death rate for males

Number of deaths among males during a calendar year

- ---x 1000

Mid-year population of males

3. Specific death rate in age group 15-20 years

Number of deaths of persons aged 15-20 during a calendar year

- ---x 1000

Mid-year population of persons aged 15-20

4. Death rate for January

- (Note: The deaths are multiplied by 12 in order to make the monthly death rate comparable with the annual death rate)

$$\frac{\text{Deaths in January} \times 12}{\text{Mid-year population}} \times 1000$$

5. Weekly death rate

$$\frac{\text{Deaths in the week} \times 52}{\text{Mid-year population}} \times 1000$$

3. Case fatality rate (Ratio)

$$\frac{\text{Total number of deaths due to a particular disease}}{\text{Total number of cases due to the same disease}} \times 100$$

Case fatality rate

- Case fatality rate represents the killing power of a disease. It is simply the ratio of deaths to cases. The time interval is not specified. Case fatality rate is typically used in acute infectious diseases (e.g., food poisoning, cholera, measles). Its usefulness for chronic diseases is limited, because the period from onset to death is long and variable. The case fatality rate for the same disease may vary in different epidemics because of changes in the agent, host and environmental factors. Case fatality is closely related to virulence.

4. Proportional mortality rate (Ratio)

- It is sometimes useful to know what proportion of total deaths are due to a particular cause (e.g., cancer) or what proportion of deaths are occurring in a particular age group (e.g., above the age of 50 years). Proportional mortality rate expresses the "number of deaths due to a particular cause (or in a specific age group) per 100 (or 1000) total deaths".

(a) Proportional mortality from a specific disease

$$\frac{\text{Number of deaths from the specific disease in a year}}{\text{Total deaths from all causes in that year}} \times 100$$

(b) Under-5 proportionate mortality rate

Number of deaths under 5 years of age in the given year

- ---x100

Total number of deaths during the same period

(c) Proportional mortality rate for aged 50 years and above

Number of deaths of persons aged 50 years and above

- ---x 100

Total deaths of all age groups in that year

5. Survival rate

- It is the proportion of survivors in a group, (e.g., of patients) studied and followed over a period (e.g., a 5-year period). It is a method of describing prognosis in certain disease conditions. Survival experience can be used as a yardstick for the assessment of standards of therapy. The survival period is usually reckoned from the date of diagnosis or start of the treatment. Survival rates have received special attention in cancer studies.

Survival rate

$$\text{Survival rate} = \frac{\text{Total number of patients alive after 5 years}}{\text{Total number of patients diagnosed or treated}} \times 100$$

6. Adjusted or standardized rates

- If we want to compare the death rates of two populations with different age-composition, the crude death rate is not the right yardstick. This is because, rates are only comparable if the populations upon which they are based are comparable.

Adjusted or standardized rates

- The answer is "age adjustment" or "age standardization", which removes the confounding effect of different age structures and yields a single standardized or adjusted rate, by which the mortality experience can be compared directly. The adjustment can be made not only for age but also sex, race, parity, etc. Thus one can generate age-sex, and race-adjusted rates.

Adjusted or standardized rates

- Standardization is carried out by one of two methods direct or indirect standardization. Both the methods begin by choosing a "standard population", not the age-structures of the populations.

DIRECT STANDARDIZATION

- First, a "standard population" is selected.
- A standard population is defined as one for which the numbers in each age and sex group are known. A frequently used standard age-composition is shown in Table . The standard population may also be "created" by combining 2 populations;

DIRECT STANDARDIZATION

- The next step is to apply to the standard population, the age-specific rates of the population whose crude death rate is to be adjusted or standardized.

DIRECT STANDARDIZATION

- As a result, for each age group, an "expected" number of deaths (or events) in the standard population is obtained; these are added together for all the age groups, to give the total expected deaths. The final operation is to divide the "expected" total number of deaths by the total of the standard population, which yields the standardized or age-adjusted rate.

DIRECT STANDARDIZATION

- Example 1
- (a) the computation of age-specific death rates per 1000 population for city X (Table); and
- (b) application of these rates to a standard population to obtain the "expected deaths" and the standardized or age adjusted death rate (Table).

Age	Mid-year population	Deaths in a year	Age specific death rates
0	4000	60	60/4000x1000=15.0
1—4	4500	20	4.4
5—14	4000	12	3.0
15—19	5000	15	3.0
20—24	4000	16	4.0
25—34	8000	25	3.1
35—44	9000	48	5.3
45—54	8000	100	15.5
55—64	7000	150	21.4
	53500	446	

Crude death rate per 1000=8.3

Age	Standard population	Age specific death rates	Expected deaths
0	2400	15.0	15/1000x2400 = 36
1—4	9600	4.4	42.24
5—14	19000	3.0	57
15—19	9000	3.0	27
20—24	8000	4.0	32
25—34	14000	3.1	43.4
35—44	12000	5.3	63.6
45—54	11000	15.5	137.5
55—64	8000	21.4	171.2
	93000		609.93

DIRECT STANDARDIZATION

- It can be seen from Tables that standardizing for age distribution has reduced the crude death rate from 8.3 to 6.56.

INDIRECT AGE STANDARDIZATION

- Standardized mortality ratio (SMR)
- The simplest and most useful form of indirect standardization is the Standardized Mortality Ratio (SMR).
- Standard mortality ratio is a ratio (usually expressed as a percentage) of the total number of deaths that occur in the study group to the number of deaths that would have been expected to occur if that study group had experienced the death rates of a standard population

INDIRECT AGE STANDARDIZATION

- In other words. SMR compares the mortality in a study group (e.g., an occupational group) with the mortality that the occupational group would have had if they had experienced national mortality rates. In this method, the more stable rates of the larger population are applied to the smaller study group. It gives a measure of the likely excess risk of mortality due to the occupation.

INDIRECT AGE STANDARDIZATION

$$SMR = \frac{\text{Observed deaths}}{\text{Expected deaths}} \times 100$$

If the ratio had value greater than 100, then the occupation would appear to carry a greater mortality risk than that of the whole population. If the ratio had value less than 100, then the occupation risks of mortality would seem to be proportionately less than that for the whole population


Thanks