Measures of Morbidity and Mortality

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Id number	Smoking status (yes =1, no =0)	Gender (male =1, female = 0)	Lung cancer (yes =1, no =2)
1	1	1	1
2	0	1	0
3	0	0	1
4	1	0	1
5	1	0	0
6	0	1	1
7	0	0	0
8	1	1	1
9	0	1	0
10	1	0	0
11	1	1	1
12	1	0	1
13	0	0	0
14	0	1	0
15	1	0	1

Ratio

$$\text{Ratio} = \frac{\text{Number or rate of events, items or persons etc. in one group}}{\text{Number or rate of events, items or persons etc. in another group}}$$

Proportion

$$\text{proportion} = \frac{\text{Number of persons or events with a particular characteristic}}{\text{Total number of persons or events, of which the numerator is a subset}}$$

Rate

- rate = $\frac{\text{numerator)}}{\text{denominator}}$ x K = $\frac{a}{a+b}$ x K

- Numerator
- Denominator
- Time

Person time at risk

Death Rate of rat in the last slide

$$\text{person time at risk} = \frac{\text{total number of rats that died during the month}}{\text{sum of the person times the 100 rats contribute}}$$

$$\text{Death proportion} = \frac{\text{total number of rats that died during the month}}{\text{number of rats alive in the beginning of the observe period}}$$

- Proportion of death = probability of dying during the month

  = 30/100 = 0.3 or 30%

- Death rate = average speed of dying

  $$= \frac{30}{85 \text{ rat months}} = 0.35 \text{ per rat month } (35\%)$$

Measures of morbidity

- Incidence
- Incidence rate
- Prevalence
- Prevalence rate

Numerator data:

Numerator data are information about persons without reference to the population from which the persons come.

Examples:

- Anecdotes “My grandfather smoked 3 packed of cigarettes a day, never exercised, and died when he was 93.”
- Commercials “Use our new diet sally lost 35 Kgs. in just 1 month.”
- Case studies “After just 2 month on the treatment Mr. Smith’s health improved dramatically.”

Incidence =

$$\frac{\text{Number of new cases of disease during specific time period}}{\text{Number of people free of disease at the beginning of the time period}}$$

= probability of developing the disease during the time interval

Ex.: On Jan 1, 1990 company X has 5000 employees free of cancer. During the course of the year 5 employees free of cancer. During the course of the year 5 employees are diagnosed with cancer.

Incidence = employees' probability of developing cancer

= 5/5000 =0.001 = 1 per 1000

Incidence rate =

$$\text{Incidence rate} = \frac{\text{Number of new cases of disease during specific time period}}{\text{Person time at risk accrued during the time period}}$$

If the occurrence of new cases is spread uniformly throughout the time period the incidence rate can be approximated by

$$\frac{\text{Number of new cases of disease during specific time period}}{\text{Number of people free of the disease in the middle of the time period}}$$

Note: When the development of the disease is rapid incidence and incidence rate may differ greatly

Example: on Jan 1, 1990, an accident happens in a chemical plant and 170 employees are exposed to toxic fumes known to cause skin lesions.

50 employees develop lesions after 1 month, 30 after 2 months, and 20 more after 3 months, but all of them are still able to come to work. The remaining employees do not develop any lesions. However, 2 of them die from other causes during the course of the year, one on March 1, and one on June 1, and 5 retire at the end of July.

Incidence = 50+30+20 = 0.59 =59%

Incidence rate =

$$\frac{50+30+20}{(50\text{x}1\text{mo.}) + (30\text{x}2\text{mo.}) + (20\text{x}3\text{ mo.}) + (1\text{x}2\text{mo.}) + (1\text{x}5\text{mo.}) + (68\text{x}1\text{yr})}$$

$$= \frac{100}{14\text{yrs.} + 9\text{ months} + 68\text{ yrs.}} = \frac{100}{82.75\text{ person years}} = 1.2/\text{person year}$$

- Note: Employees are at risk only until they develop the lesions or until they die from other causes. Retired workers are still at risk even after leaving the company.
- Note: The number of workers free of lesions on July 1 would not be a very good approximation of the person years at risk, since the development of the lesions was not uniformly spread throughout the year, but occurred during the first 3 months.

Prevalence and Prevalence rate

- Proportion
- Prevalence
- Duration of disease
- Virulence

point prevalence rate

Amount of disease in the population at given point in time

$$\frac{\text{Number of cases of the disease present at given point in time}}{\text{total population at that time}}$$

Ex.: on Jan , 2004 company X has 5000 employees, 100 of which have cancer

Point prevalence = 100/5000 = 0.02 = 20 per 1000

Period prevalence rate

Amount of disease in the population during a specific time period

Number of cases of the disease present during specific time interval

average population during the time interval

Ex.: In 2000 company X has 5000 employees. Of these 105 have cancer, 100 were diagnosed prior to Jan 1, 2000 and 5 were diagnosed in 2000.

Period prevalence = 105/5000 = 0.021 = 21 per 1000

Note: prevalence ≈ incidence x duration

(if short duration of diseases and prevalence very similar)

Secondary attack rate

$$= \frac{\text{number of additional cases among contacts of primary case}}{\text{number of contacts of primary case}}$$

Question: It is generally impossible to find all contacts of the primary case. Does this affect this rate much?

Answer: No…It is often safe to assume that the contacts who weren't found developed the disease at the same rate as those who were found.

Relationship of incidence and prevalence

$P = I \times D$

P= Prevalence

I = Incidence

D = Duration of the disease

Relationship of mortality and incidence rate)

Mortality rate = Incidence rate x Case fatality rate

Case fatality rate = Mortality rate / Incidence rate

$$\text{Case fatality rate} = \frac{\text{Mortality rate}}{\text{Incidence rate}} \times 100\% = \frac{31.3}{32.5} \times 100\% = 96\%$$

Crude death rate

total number of deaths during calendar year

total population as of July 1

Ex.: 1991, Florida: 131,044 deaths; total population = 12,335,000

Crude death rate = 131,044/ 12,335,000 = 0.01062

or 10.62 deaths per 1,000

or 1062 deaths per 100,000

Specific death rate

$$\frac{\text{total number of deaths in specific group during calendar year}}{\text{total midyear population in specific group}}$$

Ex.: 1991, Florida: 242,617 deaths from malignant neoplasms among people 65 and older; population in that age group = 29,840,000

Specific death rate = 242,617 / 29,840,000 = 0.008131

or 8.131 deaths per 1,000

or 813.1 deaths per 100,000

Cause-of-death ratio

total number of deaths due to specific disease during calendar year

total deaths due to all causes during calendar year

Ex.: Country A: 400 deaths from all causes, 60 deaths from cancer,

population = 1,000,000

Country B: 200 deaths from all causes, 60 deaths from cancer,

population = 1,000,000

Specific cancer death rate = 6 per 100,000 for both countries

Cause of death ratio = 60/400 = 0.15 or 15% for country A

Cause of death ratio = 60/200 = 0.3 or 30% for country B

Question

- Does the cause-of-death ratio reflect the probability of dying from cancer in country A?
- No, it reflects the probability of dying from cancer rather than other causes in country A, such as it reflects the relative importance of cancer as a cause of death in country A

Case-fatality rate/ratio (or sometime proportion)

$$\frac{\text{number of deaths due to the disease during specific time period}}{\text{number of new cases of the disease during specific time period}}$$

Ex.: 1981, US: 23,400 leukemia cases, 15,900 deaths from leukemia

Case fatality rate = 15,900/23,400 = 0.679 = 67.9%

It would be a proportion when short time interval between onset and death (dead are part of the cases)

It would be a ratio when long time interval between onset and death (numerator and denominator do not necessarily reflect the same cases)

Measure of mortality

Adjusted or standardized mortality rate

1. direct method
2. indirect method

Adjustment of Rates

Why do we adjust?

Rates may depend on factors such as age. If the groups differ with respect to this factor rates cannot be correctly compared unless the factor is adjusted for.

Ex.: We cannot directly compare mortality rates between Florida and Alaska since the average age of Floridians is much higher than the average age of Alaskans.

Problem: It might be difficult to think of every possible factor the rates may depend on.

Example: Population and number of deaths from malignant neoplasm by age class, Florida and Alaska, 1999

Age class	Population		Deaths from malignant neoplasm	
	Alaska	Florida	Alaska	Florida
<5	60,000	812,000	0	24
5-44	368,000	6,543,000	52	1,077
45-64	78,000	2,528,000	180	7,464
>65	19,000	2,140,000	210	21,599
Total	525,000	12,023,000	442	30,164

Example: Age specific death rates from malignant neoplasm and expected deaths for Florida and Alaska, 1999

Age class	Standard population U.S 1999 (x 1000) (A)	Alaska		Florida	
		Age specific death rates (per 100,000) (B)	Expected deaths (AxB per 100,000)	Age specific death rates (per 100,000)	Expected deaths
<5	18,250	(0/60,000) 0.0	0.0	(24/812,000) 3.0	547.5
5-44	150,020	(52/368,000) 14.1	21,152.8	(1077/6,543,000) 16.5	24,753.3
45-64	42,300	230.8	97,628.4	295.3	124,911.9
>65	29,840	1,105.3	329,821.5	1009.3	301,175.1
Total	243,400	-	448,602.7		451,387.8

- age adjusted rate Alaska

  448,602.7/243,400,000 = 0.00184 or 184 per 100,000.

- The age adjusted rate ของ Florida คือ

  451,387.8/243,400,000 = 0.00185 or 185 per 100,000.

age adjusted death rate malignant neoplasm Florida Alaska

Question: Are the age adjusted rates the correct probabilities for the actual age distribution in the two states.

Answer: No…The adjusted rates reflect the probability of dying from cancer if the age distribution in the two states were like the age distribution in the standard population.

Example: Age specific U.S. death rates for malignant neoplasm and expected number of deaths from malignant neoplasm in Alaska and Florida, 1990

Age class	U.S death rate (per 100,000) (A)	Population		Expected deaths	
		Alaska (B)	Florida (C)	Alaska (A x B)/100,000	Florida (A x C)/100,000
<5	2.6	60,000	812,000	1.6	21.1
5-44	11.4	368,000	6,543,000	42.0	745.9
45-64	244.7	78,000	2,528,000	190.9	6,186.0
>65	813.1	19,000	2,140,000	154.5	17,400.3
Total	149.4	525,000	12,023,000	389.0	24,353.3

Age adjusted rate for

- Alaska: 389/525,000 = 0.00074 or 74 per 100,000
- Florida: 24,353.3/12,023,000 = 0.0020 or 202 per 100,000

Total observed number of malignant neoplasm:

422 for Alaska and 30,164 for Florida (slide 44)

- SMR for Alaska = $\frac{442}{389} \times 100 = 113.6$
- SMR for Florida = $\frac{30,164}{24,353.3} \times 100 = 123.9$

Question: The SMR's are greater than 100. What can we conclude?

Answer: Residents of Florida and Alaska have a higher risk of dying from cancer than the general population.

Interpreting the SMR (using the Alaska example)

- The SMR is 100 times the number of observed deaths divided by the number of expected deaths.
- The observed deaths are the deaths that actually occurred among residents of Alaska.
- The expected deaths are the deaths we would expect to have occurred (given the age distribution in Alaska) if the age specific death rates in Alaska were the same as in the standard population.

Interpreting the SMR

Observed vs. expected	SMR	Cancer death risk in Alaska vs. the general population
Observed = expected	100	Same
Observed > expected	>100	Higher
Observed < expected	<100	Lower

Question: How do the SMR's of Florida and Alaska compare?

Answer: We cannot compare the SMR's between Florida and Alaska.

We have to use direct method to compare Florida to Alaska.

Recall: The direct method uses the age distribution in the standard population. Thus, if we also calculated the indirectly adjusted cancer death rate for Florida we could only compare the rates to the standard population, but not compare between the two states.

Note: the indirect method uses the age distribution in Alaska rather than in the standard population. Thus, if we also calculated the indirectly adjusted cancer death rate for Florida we could only compare the rates to the standard population, but not compare between the two states.

Reference

- ไพบูลย์ โล่ห์สุนทร บทบรรณาธิการ วิทยาการระบาดคลินิก จุฬาลงกรณ์เวชสาร กรกฎาคม 2528; 29(4): 415-420
- ไพบูลย์ โล่ห์สุนทร บทบรรณาธิการ ประโยชน์ของวิทยาการระบาดต่อชุมชน จุฬาลงกรณ์เวชสาร กรกฎาคม 2529; 30(7): 603-605
- ไพบูลย์ โล่ห์สุนทร ระบาดวิทยา ภาควิชาเวชศาสตร์ป้องกัน คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย 2540
- Annette Bachand, Introduction to Epidemiology: Colorado State University, Department of Environmental Health
- Kenneth J.Rothman and Sander Greenland (1998) Modern Epidemiology, Lippincott Williams and Wilkins, USA.