Measures of Disease Frequency

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Introduction

- Measures of d'se frequency are tools to describe how common an illness (or other outcome event) is with reference to the size of pop at risk.
- Are used to quantify cases in relation to a pop and a measure of time
- Outcome events of interest: infection, d'se (morbidity), disability, death (mortality), recovery, presence of antibodies & usage of health services
- Two main measures: Prevalence & incidence

Introduction

- The measures can take various mathematical forms:
  - *Count* – Enumeration of the no. of cases of d'se or no. of persons affected with a condition in a given population. Often pop size is not accounted for hence counts are of limited use
  - *Proportion* – Ratio in which numerator is a subset of denominator e.g. if 200 persons are tested for TB and 40 are positive, the proportion positive is 40/200 = 0.2 (20%). Prevalence & risk are both proportions.
  - *Odds* – Ratio in which numerator is not a subset of denominator e.g. 3 stillbirths and 120 live births, odds of stillbirth is 3:120 = 0.025:1 or 25 stillbirths to 1000 live births. Odds of TB above is 40:160 or 1:4

Introduction

- The measures can take various mathematical forms:
  - *Rate* – Ratio in which denominator is the number of person-time units at risk e.g. 30 cases of pneumonia in an office of 100 people over a 3-month period, incidence rate is 30/(100*3) = 0.1 cases per person-month. NB: 100*3 = 300 person-months at risk. *Rate is generally used to refer to all types of measures of d'se frequency but should strictly be used to only refer to measures based on person-time units* e.g. prevalence "rate"

Incidence

- Concerned with quantifying the occurrence of *new cases*
- Two main measures of incidence – *risk* & *rate*

Incidence risk (cumulative incidence)

- Probability of occurrence of d'se in a d'se free population during a specified time period
- Given as: $\frac{No.of\ new\ cases\ (d) in\ a\ defined\ period}{population\ at\ risk\ at\ \textbf{start of study period}\ (N)}$
- Since risk is a probability it ranges between 0 – 1 (0% –100%)
- Used for non-recurrent d'ses or applied to the 1st episode of a recurrent d'se

Incidence

Incidence risk (cumulative incidence)

- Restricted to closed populations (pop with no additions for duration of study and few to no losses [withdrawals])
- People lost to follow-up (withdrawals) are dealt with by subtracting half of no. of losses from pop at risk (assumed to be lost half-way through study period):

$$Risk = \frac{d}{N - (0.5 \times withdrawals)}$$

Examples:

- 15 out of 100,000 women developed cancer of the cervix in England in 1998
- A study in Nairobi found 4 deaths of diarrhoea per 1,000 children per year

- Two other measures of risk:
  - *Attack rate* - defined as no. of new cases (d) occurring during duration of outbreak among a pop at risk at start of outbreak (N)
    - used in context of outbreaks/epidemics of infectious d'ses

Incidence

- *Secondary attack rate* - defined as proportion of those exposed to the primary case that develop d'se as a result of the exposure
  - Used in study of spread of infectious d'ses in small communities e.g. households or schools

Incidence rate (incidence density)

- Refers to no. of new cases of d'se in a population per person-time at risk
- It takes into account changes in size of pop at risk during the follow-up period
- Calculated as: Rate = $\frac{No.of\ new\ cases\ of\ d'se\ in\ a\ defined\ time\ period}{No.of\ person-time\ units\ at\ risk\ during\ the\ time\ period}$

Incidence

Incidence rate (incidence density)

- Rate of new cases is hence related to a more precise measure of pop at risk during study period i.e. the *person-time units*
- The denominator thus accounts for the fact that some people who start at risk *do not remain* at risk during whole period because they develop the disease, or die or leave the pop by migrating, refusing to continue to participate in study etc.
- Others may join pop at risk after beginning of the period e.g. by birth, migration into area, recruitment into study etc.
- Can be calculated for d'ses with multiple episodes (recurrent)

Incidence

Incidence rate (incidence density)

- Appropriate for open populations – pop in which people are entering & leaving pop throughout study period
- Open pops can be stable if rates of additions and withdrawals are relatively constant over time

Example:

- Rate of diarrhoea in Ethiopia was 3.6 episodes per child-year

- The inverse of rate is an estimate of average time to occurrence of d'se if pop is closed or open & stable : $\frac{1}{Rate}$
- Exact & approximate methods available for calculating rate

Incidence

Incidence rate (incidence density)

- *Exact method* (exact amount of person-time at risk required) is preferred but info often unavailable

Example

- Assuming 4 previously healthy people were observed for exactly 1 month (30 days). The history for each individual was as follows:

1 person not sick at all	**1.00 person-month at risk**
1 person sick on day 10	0.33 person-months at risk
1 person sick on day 20	0.67 person-months at risk
1 person moved away on day 15 (and lost to follow-up)	0.50 person-months at risk
Total population at risk	**2.50 person months at risk**
Total new cases of disease	**2**
Incidence rate = $\frac{2}{2.5}$	**0.80 cases per person-month**

Incidence

Incidence rate (incidence density)

- In general: if risk period < study period use risk and if risk period > study period rate is appropriate
- Risk can be estimated from rate as follows:

$$\text{Risk} = 1 - \exp(-\sum rates * t)$$

Example

- Calculations based on deaths among 100 people in a nursing home experiencing a norovirus outbreak over 6 weeks are shown in the below table:

Week	Population at risk	Cases	Weekly incidence rate
1	100	1	0.0100 per person-week
2	99	2	0.0202 per person week
3	97	1	0.0103 per person week
4	96	3	0.0313 per person week
5	93	1	0.0108 per person week
6	92	0	0.0000 per person week
Total		**8**	**0.0826**

The estimate of the 6-week risk is:

$1 - \exp(-\sum rates * t)$

$= 1 - e^{(-0.0826)}$

$= 0.079$ **per 6 weeks**

Prevalence

- Proportion of persons in a defined pop that have outcome of interest (existing cases) at a defined *instant* (*point*) in time (called **point prevalence**):

$$\text{Point prevalence} = \frac{No.\ of\ existing\ cases\ at\ point\ in\ time}{Total\ pop\ at\ risk\ at\ same\ point\ in\ time}$$

- We can also have **period prevalence** – calculated the same way as point prevalence except that:

$$\text{Period prevalence} = \frac{No.\ of\ existing\ cases\ at\ any\ time\ during\ a\ specified\ time\ period}{Total\ pop\ at\ risk\ during\ the\ stated\ period}$$

Prevalence

- Examples:
  - 1% of women having baby in a maternity hospital in Sao Paulo Brazil in 1999 were infected with HIV
  - The proportion of the population in India that has diabetes today

Relationship between Incidence & Prevalence

- If d'se is stable i.e. both incidence & duration of d'se are stable/constant over time, then prevalence is derived as:

$$\frac{p}{1-p} = incidence * ave.duration\ of\ d'se$$

- However, if prevalence is low (<10% of pop has d'se):

$$p = incidence * ave.duration\ of\ d'se$$

Relationship between Incidence & Prevalence

- Factors related to *duration* of d'se: subject's constitution, access to care, availability of treatment, social support & severity of d'se
- **NB:** Prevalence reflects factors not only related to d'se incidence but also those related to duration of d'se (survival with the disease) – so not appropriate for examining causal relationships

Uses of Incidence & Prevalence

- *Incidence:*
  - Estimate risk of d'se development
  - Study causal factors
  - Evaluate the effectiveness of primary prevention programs
- *Prevalence:*
  - Assist health care providers plan to deliver services
  - Indicate groups of people who should be targeted for control measures
  - May signal causal relationships, but also reflects determinants of survival with d'se

Other measures of d'se frequency

- Other than *attack rates* & *secondary attack rates* (described):
  - *Case fatality rate* – proportion of people with specific d'se that die from it (actually a risk)
  - *Infant mortality rate* – no. of deaths in children under one year of age divided by no. of live births in the same period in a specified pop (actually a ratio)
  - *Maternal mortality rate* – no. of maternal deaths divided by no. of women of reproductive age (15-49) in a specified year (also a ratio)
  - *Odds of d'se* – **no. of cases** in a defined pop and time period divided by no. of people who **did not become** a *c*ase (**non-cases**) in the time period
  - *Proportional morbidity/ mortality* – used when appropriate denominator is unknown: no. of cases/deaths due to *specific d'se* divided by no. of cases/deaths from *all d'ses* diagnosed