

## Natality (Birth) Measures

Natality measures are population-based measures of birth. These measures are used primarily by persons working in the field of maternal and child health. Table 3.11 includes some of the commonly used measures of natality.

**Table 3.11 Frequently Used Measures of Natality**

| Measure                        | Numerator                                                                     | Denominator                                         | 10 <sup>n</sup> |
|--------------------------------|-------------------------------------------------------------------------------|-----------------------------------------------------|-----------------|
| Crude birth rate               | Number of live births during a specified time interval                        | Mid-interval population                             | 1,000           |
| Crude fertility rate           | Number of live births during a specified time interval                        | Number of women ages 15–44 years at mid-interval    | 1,000           |
| Crude rate of natural increase | Number of live births minus number of deaths during a specified time interval | Mid-interval population                             | 1,000           |
| Low-birth weight ratio         | Number of live births <2,500 grams during a specified time interval           | Number of live births during the same time interval | 100             |

## Measures of Association

The key to epidemiologic analysis is comparison. Occasionally you might observe an incidence rate among a population that seems high and wonder whether it is actually higher than what should be expected based on, say, the incidence rates in other communities. Or, you might observe that, among a group of case-patients in an outbreak, several report having eaten at a particular restaurant. Is the restaurant just a popular one, or have more case-patients eaten there than would be expected? The way to address that concern is by comparing the observed group with another group that represents the expected level.

A measure of association quantifies the relationship between exposure and disease among the two groups. Exposure is used loosely to mean not only exposure to foods, mosquitoes, a partner with a sexually transmissible disease, or a toxic waste dump, but also inherent characteristics of persons (for example, age, race, sex), biologic characteristics (immune status), acquired characteristics (marital status), activities (occupation, leisure activities), or conditions under which they live (socioeconomic status or access to medical care).

The measures of association described in the following section compare disease occurrence among one group with disease

occurrence in another group. Examples of measures of association include risk ratio (relative risk), rate ratio, odds ratio, and proportionate mortality ratio.

### ***Risk ratio***

#### ***Definition of risk ratio***

A risk ratio (RR), also called relative risk, compares the risk of a health event (disease, injury, risk factor, or death) among one group with the risk among another group. It does so by dividing the risk (incidence proportion, attack rate) in group 1 by the risk (incidence proportion, attack rate) in group 2. The two groups are typically differentiated by such demographic factors as sex (e.g., males versus females) or by exposure to a suspected risk factor (e.g., did or did not eat potato salad). Often, the group of primary interest is labeled the exposed group, and the comparison group is labeled the unexposed group.

#### ***Method for Calculating risk ratio***

The formula for risk ratio (RR) is:

$$\frac{\text{Risk of disease (incidence proportion, attack rate) in group of primary interest}}{\text{Risk of disease (incidence proportion, attack rate) in comparison group}}$$

A risk ratio of 1.0 indicates identical risk among the two groups. A risk ratio greater than 1.0 indicates an increased risk for the group in the numerator, usually the exposed group. A risk ratio less than 1.0 indicates a decreased risk for the exposed group, indicating that perhaps exposure actually protects against disease occurrence.

## EXAMPLES: Calculating Risk Ratios

**Example A:** In an outbreak of tuberculosis among prison inmates in South Carolina in 1999, 28 of 157 inmates residing on the East wing of the dormitory developed tuberculosis, compared with 4 of 137 inmates residing on the West wing.<sup>11</sup> These data are summarized in the two-by-two table so called because it has two rows for the exposure and two columns for the outcome. Here is the general format and notation.

**Table 3.12A General Format and Notation for a Two-by-Two Table**

|           | Ill           | Well          | Total         |
|-----------|---------------|---------------|---------------|
| Exposed   | a             | b             | $a + b = H_1$ |
| Unexposed | c             | d             | $c + d = H_0$ |
| Total     | $a + c = V_1$ | $b + d = V_0$ | T             |

In this example, the exposure is the dormitory wing and the outcome is tuberculosis) illustrated in Table 3.12B. Calculate the risk ratio.

**Table 3.12B Incidence of Mycobacterium Tuberculosis Infection Among Congregated, HIV-Infected Prison Inmates by Dormitory Wing, South Carolina, 1999**

|           | Developed tuberculosis? |         | Total       |
|-----------|-------------------------|---------|-------------|
|           | Yes                     | No      |             |
| East wing | a = 28                  | b = 129 | $H_1 = 157$ |
| West wing | c = 4                   | d = 133 | $H_0 = 137$ |
| Total     | 32                      | 262     | $T = 294$   |

*Data source: McLaughlin SI, Spradling P, Drociuk D, Ridzon R, Pozsik CJ, Onorato I. Extensive transmission of Mycobacterium tuberculosis among congregated, HIV-infected prison inmates in South Carolina, United States. Int J Tuberc Lung Dis 2003;7:665-672.*

To calculate the risk ratio, first calculate the risk or attack rate for each group. Here are the formulas:

### Attack Rate (Risk)

Attack rate for exposed =  $a / a+b$

Attack rate for unexposed =  $c / c+d$

For this example:

Risk of tuberculosis among East wing residents =  $28 / 157 = 0.178 = 17.8\%$

Risk of tuberculosis among West wing residents =  $4 / 137 = 0.029 = 2.9\%$

The risk ratio is simply the ratio of these two risks:

$$\text{Risk ratio} = 17.8 / 2.9 = 6.1$$

Thus, inmates who resided in the East wing of the dormitory were 6.1 times as likely to develop tuberculosis as those who resided in the West wing.

### EXAMPLES: Calculating Risk Ratios

**Example B:** In an outbreak of varicella (chickenpox) in Oregon in 2002, varicella was diagnosed in 18 of 152 vaccinated children compared with 3 of 7 unvaccinated children. Calculate the risk ratio.

**Table 3.13 Incidence of Varicella Among Schoolchildren in 9 Affected Classrooms, Oregon, 2002**

|              | Varicella | Non-case | Total |
|--------------|-----------|----------|-------|
| Vaccinated   | a = 18    | b = 134  | 152   |
| Unvaccinated | c = 3     | d = 4    | 7     |
| Total        | 21        | 138      | 159   |

*Data Source: Tugwell BD, Lee LE, Gillette H, Lorber EM, Hedberg K, Cieslak PR. Chickenpox outbreak in a highly vaccinated school population. Pediatrics 2004 Mar;113(3 Pt 1):455–459.*

Risk of varicella among vaccinated children =  $18 / 152 = 0.118 = 11.8\%$

Risk of varicella among unvaccinated children =  $3 / 7 = 0.429 = 42.9\%$

Risk ratio =  $0.118 / 0.429 = 0.28$

The risk ratio is less than 1.0, indicating a decreased risk or protective effect for the exposed (vaccinated) children. The risk ratio of 0.28 indicates that vaccinated children were only approximately one-fourth as likely (28%, actually) to develop varicella as were unvaccinated children.

### Rate ratio

A rate ratio compares the incidence rates, person-time rates, or mortality rates of two groups. As with the risk ratio, the two groups are typically differentiated by demographic factors or by exposure to a suspected causative agent. The rate for the group of primary interest is divided by the rate for the comparison group.

$$\text{Rate ratio} = \frac{\text{Rate for group of primary interest}}{\text{Rate for comparison group}}$$

The interpretation of the value of a rate ratio is similar to that of the risk ratio. That is, a rate ratio of 1.0 indicates equal rates in the two groups, a rate ratio greater than 1.0 indicates an increased risk for the group in the numerator, and a rate ratio less than 1.0 indicates a decreased risk for the group in the numerator.

### EXAMPLE: Calculating Rate Ratios

*Public health officials were called to investigate a perceived increase in visits to ships' infirmaries for acute respiratory illness (ARI) by passengers of cruise ships in Alaska in 1998.<sup>13</sup> The officials compared passenger visits to ship infirmaries for ARI during May–August 1998 with the same period in 1997. They recorded 11.6 visits for ARI per 1,000 tourists per week in 1998, compared with 5.3 visits per 1,000 tourists per week in 1997. Calculate the rate ratio.*

$$\text{Rate ratio} = 11.6 / 5.3 = 2.2$$

Passengers on cruise ships in Alaska during May–August 1998 were more than twice as likely to visit their ships' infirmaries for ARI than were passengers in 1997. (Note: Of 58 viral isolates identified from nasal cultures from passengers, most were influenza A, making this the largest summertime influenza outbreak in North America.)



### Exercise 3.7

Table 3.14 illustrates lung cancer mortality rates for persons who continued to smoke and for smokers who had quit at the time of follow-up in one of the classic studies of smoking and lung cancer conducted in Great Britain.

Using the data in Table 3.14, calculate the following:

1. Rate ratio comparing current smokers with nonsmokers
2. Rate ratio comparing ex-smokers who quit at least 20 years ago with nonsmokers
3. What are the public health implications of these findings?

**Table 3.14 Number and Rate (Per 1,000 Person-years) of Lung Cancer Deaths for Current Smokers and Ex-smokers by Years Since Quitting, Physician Cohort Study, Great Britain, 1951–1961**

| Cigarette smoking status              | Lung cancer deaths | Rate per 1000 person-years | Rate Ratio            |
|---------------------------------------|--------------------|----------------------------|-----------------------|
| Current smokers                       | 133                | 1.30                       | _____                 |
| For ex-smokers, years since quitting: |                    |                            |                       |
| <5 years                              | 5                  | 0.67                       | 9.6                   |
| 5-9 years                             | 7                  | 0.49                       | 7.0                   |
| 10-19 years                           | 3                  | 0.18                       | 2.6                   |
| 20+ years                             | 2                  | 0.19                       | _____                 |
| Nonsmokers                            | 3                  | 0.07                       | 1.0 (reference group) |

Data Source: Doll R, Hill AB. Mortality in relation to smoking: 10 years' observation of British doctors. *Brit Med J* 1964; 1:1399–1410, 1460–1467.



**Check your answers on page 3-53**

### **Odds ratio**

An odds ratio (OR) is another measure of association that quantifies the relationship between an exposure with two categories and health outcome. Referring to the four cells in Table 3.15, the odds ratio is calculated as

$$\text{Odds ratio} = \left( \frac{a}{b} \right) \left( \frac{c}{d} \right) = ad / bc$$

where

- a = number of persons exposed and with disease
- b = number of persons exposed but without disease
- c = number of persons unexposed but with disease
- d = number of persons unexposed: and without disease
- a+c = total number of persons with disease (case-patients)
- b+d = total number of persons without disease (controls)

The odds ratio is sometimes called the **cross-product ratio** because the numerator is based on multiplying the value in cell “a” times the value in cell “d,” whereas the denominator is the product of cell “b” and cell “c.” A line from cell “a” to cell “d” (for the numerator) and another from cell “b” to cell “c” (for the denominator) creates an x or cross on the two-by-two table.

**Table 3.15 Exposure and Disease in a Hypothetical Population of 10,000 Persons**

|             | Disease | No Disease | Total  | Risk |
|-------------|---------|------------|--------|------|
| Exposed     | a=100   | b=1,900    | 2,000  | 5.0% |
| Not Exposed | c=80    | d=7,920    | 8,000  | 1.0% |
| Total       | 180     | 9,820      | 10,000 |      |

### EXAMPLE: Calculating Odds Ratios

Use the data in Table 3.15 to calculate the risk and odds ratios.

#### 1. Risk ratio

$$5.0 / 1.0 = 5.0$$

#### 2. Odds ratio

$$(100 \times 7,920) / (1,900 \times 80) = 5.2$$

Notice that the odds ratio of 5.2 is close to the risk ratio of 5.0. That is one of the attractive features of the odds ratio — when the health outcome is uncommon, the odds ratio provides a reasonable approximation of the risk ratio. Another attractive feature is that the odds ratio can be calculated with data from a case-control study, whereas neither a risk ratio nor a rate ratio can be calculated.

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In a case-control study, investigators enroll a group of case-patients (distributed in cells a and c of the two-by-two table), and a group of non-cases or controls (distributed in cells b and d).

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The odds ratio is the measure of choice in a case-control study (see Lesson 1). A case-control study is based on enrolling a group of persons with disease (“case-patients”) and a comparable group without disease (“controls”). The number of persons in the control group is usually decided by the investigator. Often, the size of the population from which the case-patients came is not known. As a result, risks, rates, risk ratios or rate ratios cannot be calculated from the typical case-control study. However, you can calculate an odds ratio and interpret it as an approximation of the risk ratio, particularly when the disease is uncommon in the population.