

Learning Resource:

## Measuring Disease Frequency and Association: Self Directed Tutorial

**PPH Domain:** Dr. David King, School of Population Health, [d.king@som.uq.edu.au](mailto:d.king@som.uq.edu.au)

**Learning Objectives:** Define, interpret and explain: incidence, prevalence

**Synopsis:** The following learning resource is designed as a self directed tutorial to help you understand measures used to describe disease, particularly prevalence and incidence, and associations between exposure and disease.

In clinical practice you will be faced with making many decisions about therapeutic alternatives. To make decisions based on sound clinical evidence you will require accurate information about the benefits and harms of the various alternatives. This evidence is normally in the form of quantitative estimates of the **probability** or **frequency** of clinical outcomes associated with the alternatives. This tutorial provides you with the skills to calculate these measures from the raw data.

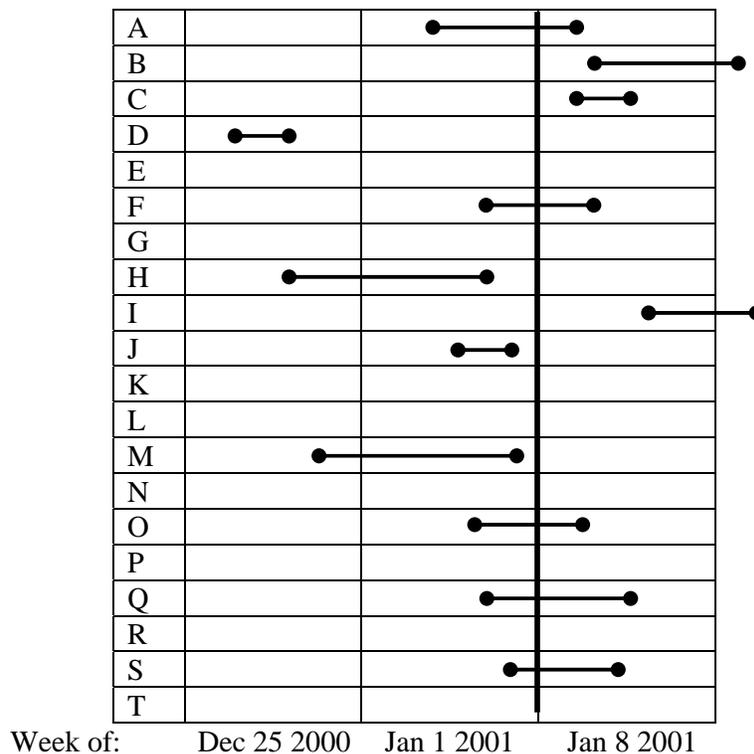
**Prevalence** - the proportion of a group of people possessing a clinical condition at a given point in time. It is related to the incidence and the duration of the condition.

**Incidence** - the proportion of a group initially free of the condition that develops it over a given period of time – refers to ‘new cases’. It is also called the ‘absolute risk’

**Relative risk** - the ratio of the incidence in exposed persons to nonexposed persons.

### Question 1

In the figure below each row represents a person (so there is a defined population of 20) and each heavy black line represents an episode of sore throat or flu-like symptoms.



**Figure 1:** Episodes of sore throat or flu-like symptoms in a population of 20 people.

- a) For the first two weeks of January 2001, compute the incidence and prevalence of sore throat or flu-like symptoms.
- b) Assume a survey is conducted on January 8, 2001 (heavy black vertical line). What is the 'point prevalence' on that day?

**Question 2**

- a) Of 1,500 middle-aged women, 30 had diabetes on January 1, 2002. What is the point prevalence of diabetes on that day?
- b) Of 20,000 middle-aged men (with no previous myocardial infarction), 60 developed a myocardial infarction during a 6-month period. What is the incidence of myocardial infarction during this 6-month period?

**Question 3**

Table 1 shows the number of cases of hepatitis B diagnosed in each of two hypothetical cities. Which city has the highest incidence of hepatitis B?

Table 1. Hypothetical data on the incidence of hepatitis in two cities

Location	New cases of hepatitis B	Reporting period	Population
City A	58	1985	25,000
City B	35	1984-1985	7,000

**Question 4**

The following table shows special types of incidence and prevalence measures, which are commonly used in the medical literature. Fill in the missing cells following the example of 'Morbidity rate'.

Table 2. Special types of incidence and prevalence measures.

Rate	Type	Numerator	Denominator
Morbidity rate	Incidence	New cases of non-fatal disease	Total population at risk
Mortality rate		Number of deaths (from a disease or all causes)	
Case fatality rate	Incidence		Number of cases of that disease
Attack rate			Total population at risk, for a limited period of observation
Disease rate at autopsy		Number of cases of disease	Number of persons autopsied
Birth defect rate		Number of babies with a given abnormality	

### Question 5

Describe the effects that the following would have on (i) the incidence, (ii) the prevalence and (iii) the duration of the disease. State clearly any assumptions that you make.

- (a) The opening of a new specialist centre offering curative treatment for sufferers of a previously incurable chronic disease.
- (b) Development of a new drug that effectively prolongs survival but does not cure a previously fatal chronic disease.

### Question 6

Assume that the prevalence of a disease decreases after age 70, while its incidence continues to increase with age. What is the most probable explanation for the divergence of these measures of frequency?

### Question 7

Five years after the introduction of a vigorous detection and treatment program for a disease, the prevalence of the disease was found to be greater than in the year prior to the introduction of the program. What are the most probable reasons for this?

### Question 8

A recent randomised controlled trial was conducted to assess the safety and effectiveness of an intranasal influenza vaccine among healthy adults for reducing clinical illness. The following table is adapted from the original study. For teaching purposes, some of the numbers have been altered slightly. Examine the table and answer the following questions.

**Table 2.** Number of people experiencing various outcomes during the follow-up period

	Vaccine Group (n = 2833)	Placebo Group (n = 1420)
Sore throat during week following vaccination	754	231
Episode of febrile illness	373	207
Taking over-the-counter medications	1119	681

- a) What proportion of people in the vaccine group and the placebo group experienced sore throat during the week following vaccination? What is this measure of frequency called?
- b) What is the difference between the vaccine group and the placebo group in relation to experiencing a sore throat in the week following vaccination? What is this measure called?
- c) What is the ratio of experiencing sore throat in the vaccine group as compared to the placebo group. What is this measure called? Interpret the meaning of this measure in your own words.

- d) What proportion of people in the vaccine group and placebo group experienced an episode of febrile illness during the follow-up period?
- e) What is the difference between the vaccine group and the placebo group in relation to experiencing an episode of febrile illness during the follow-up period?
- f) What is the ratio of experiencing an episode of febrile illness during the follow-up period in the vaccine group as compared to the placebo group. Interpret the meaning of this measure in your own words.
- g) What proportion of people in the vaccine group and placebo group took over-the-counter medications during the follow-up period?
- h) What is the ratio of taking over-the-counter medications during the follow-up period in the vaccine group as compared to the placebo group. Interpret the meaning of this measure in your own words. How would your interpretation change if the number of people taking over-the-counter medications were 1700 in the vaccine group and 852 in the placebo group?

### Question 9

Table 3 shows some results from a recent prospective study of age and lifestyle factors in relation to community-acquired pneumonia. Examine the table and answer the following questions.

Table 3. Relative risks of community-acquired pneumonia for risk factors in men

Risk Factor	Incidence rate per 100 000/year	Relative Risk
<b>Age</b>		
≤49yr	92.7	1.00 (referent)
50-54	142.8	1.54 (142.8/92.7)
55-59	180.5	
60-64	263.8	
65-69	280.6	
≥ 70	404.9	
<b>Smoking status</b>		
Never smokers	150.3	1.00 (referent)
≤ 25 cigarettes/day	233.8	
> 25 cigarettes/day	392.7	

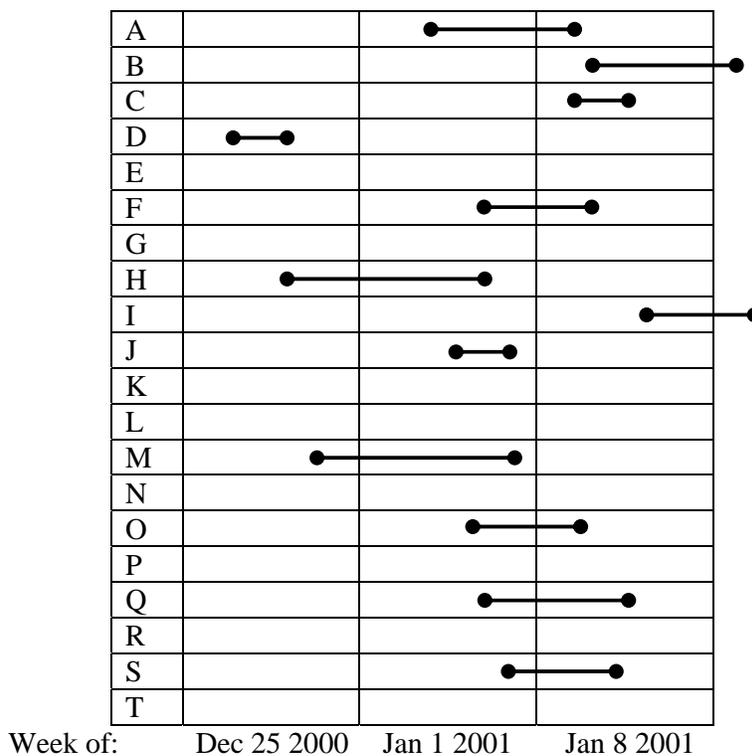
- a) Calculate the relative risks for community-acquired pneumonia in relation to age and smoking status (fill in table above) and interpret your findings.
- b) Of age and smoking, which is the more important risk factor?

# Answers

The answers are provided below for you to check once you've worked through the problems. **Remember that you will not benefit from this exercise if you look before you complete!**

### Question 1

In the figure below each row represents a person (so there is a defined population of 20) and each heavy black line represents an episode of sore throat or flu-like symptoms.



**Figure 1:** Episodes of sore throat or flu-like symptoms in a population of 20 people.

- c) For the first two weeks of January 2001, compute the incidence and prevalence of sore throat or flu-like symptoms.

*There are two possibilities here. If we assume that patients H and M (who developed a sore throat in December) are no longer at risk in the second week of January then they should be removed from the denominator and the incidence =  $9/18 = 0.5$  or 50% in 2 weeks*

*However, if we assume that H and M could get another sore throat in the second week of January, then the incidence =  $9/20 = 0.45$  or 45% in 2 weeks. You should review*

$$\text{incidence} = \frac{\text{number of new case of disease over a period of time}}{\text{population at risk of disease in the time period}}$$

Please Note: We have decided not to complicate things by differentiating between ‘cumulative incidence’ and ‘incidence rate’ or ‘incidence density’

*the prevalence =  $11/20 = 0.55$  or 55% ;*

$$\text{prevalence} = \frac{\text{number of cases of disease at a given time}}{\text{total population at risk at that given time}}$$

- d) Assume a survey is conducted on January 8, 2001. What is the ‘point prevalence’ on that day?  
*point prevalence = 5/20 = 0.25 or 25%*

**Question 2**

- c) Of 1,500 middle-aged women, 30 had diabetes on January 1, 2002. What is the point prevalence of diabetes on that day?  
*The prevalence = 30/1,500 = 0.02 = 2%*
- d) Of 20,000 middle-aged men (with no previous myocardial infarction), 60 developed a myocardial infarction during a 6-month period. What is the incidence of myocardial infarction during this 6-month period?  
*The incidence = 60/20,000 = 0.003 = 0.3%*

**Question 3**

Table 1 shows the number of cases of hepatitis B newly diagnosed in each of two hypothetical cities. Which city has the highest incidence of hepatitis B?

Table 1. Hypothetical data on the incidence of hepatitis in two cities

Location	New cases of hepatitis B	Reporting period	Population
City A	58	1985	25,000
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*Annual incidence of hepatitis:*

*City A: 58/25,000/1 year = 0.23% or may be expressed per 100,000 (eg. 232/10<sup>5</sup>/year)*

*City B : 35/7,000/2 years = 17.5/7,000/1year = 0.25% (250/10<sup>5</sup>/year)*

*Please reinforce the idea that for ease of comparing rates directly, the same unit of population in the denominator of each rate is often used. This is usually expressed as a power of 10 (eg. 10<sup>5</sup>) and it is preferable to maintain whole numbers (eg. 6 cases/10<sup>5</sup>/year rather than 0.06 cases/10<sup>3</sup>/year).*

*Overall, the question highlights two important aspects of measuring disease:*

- 1. The raw numbers of cases can often be misleading. For example, at first glance it might seem that hepatitis is more common in City A than in City B because there were more reported cases in half the time period. The fallacy in this line of thinking is that, as shown in the table, the population of City A is much larger than that of City B. Thus, to compare disease frequency in different populations it is necessary to account for both the difference in population sizes and the different lengths of the reporting periods.*
- 2. The raw numbers can still be useful, particularly for health administrators to plan for personnel and services necessary to treat affected individuals.*

#### Question 4

The following table shows special types of incidence and prevalence measures, which are commonly used in the medical literature. Fill in the missing cells following the example of 'Morbidity rate'.

Table 2. Special types of incidence and prevalence measures.

Rate	Type	Numerator	Denominator
Morbidity rate	Incidence	New cases of non-fatal disease	Total population at risk
Mortality rate	<i>Incidence</i>	Number of deaths (from a disease or all causes)	<i>Total population</i>
Case fatality rate	Incidence	<i>Number of deaths from a disease</i>	Number of cases of that disease
Attack rate	<i>Incidence</i>	<i>Number of cases of a disease (often used for infectious diseases)</i>	Total population at risk, for a limited period of observation
Disease rate at autopsy	<i>Prevalence</i>	Number of cases of disease	Number of persons autopsied
Birth defect rate	<i>Prevalence</i>	Number of babies with a given abnormality	<i>Total population</i>

#### Question 5

Describe the effects that the following would have on (i) the incidence, (ii) the prevalence and (iii) the duration of the disease. State clearly any assumptions that you make.

- (c) The opening of a new specialist centre offering curative treatment for sufferers of a previously incurable chronic disease.

*Prevalence = Incidence x Duration (approximately)*

*Curing a previously incurable disease would reduce the duration. This would reduce the prevalence but not the incidence. However, if the disease was contagious then it may be assumed that the incidence could also decrease because there is a smaller pool of contagion.*

- (d) Development of a new drug that effectively prolongs survival but does not cure a previously fatal chronic disease.

*Prevalence = Incidence x Duration (approximately)*

*Prolonging survival increases the duration, which would increase the prevalence. Incidence would not be affected unless the disease was contagious - then it may be assumed that the incidence could also increase because there is a larger pool of contagion.*

#### Question 6

Assume that the prevalence of a disease decreases after age 70, while its incidence continues to increase with age. What is the most probable explanation for the divergence of these measures of frequency?

*The most probable explanation is that patients over 70 who develop the disease have shorter survival times than the younger patients. A good example of such a disease would be coronary heart disease.*

### Question 7

Five years after the introduction of a vigorous detection and treatment program for a disease, the prevalence of the disease was found to be greater than in the year prior to the introduction of the program. What are the most probable reasons for this?

*This is a commonly found phenomenon and there are several reasons for this. The most obvious one is that because of the vigorous detection program, there is an increase in previously undetected cases. Secondly, with improved treatment you would expect a decrease in the number of people dying due to the disease. Increased detection and improved treatment and survival would increase disease prevalence. An example you could use here is diabetes.*

### Question 8

A recent randomised controlled trial was conducted to assess the safety and effectiveness of an intranasal influenza vaccine among healthy adults for reducing clinical illness. The following table is adapted from the original study. For teaching purposes, some of the numbers have been altered slightly. Examine the table and answer the following questions.

**Table 2.** Number of people experiencing various outcomes during the follow-up period

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Sore throat during week following vaccination	754	231
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Taking over-the-counter medications	1119	681

- i) What proportion of people in the vaccine group and the placebo group experienced sore throat during the week following vaccination? What is this measure of frequency called?  
*vaccine group –  $754/2833 = 26.6\%$ ; placebo group =  $231/1420 = 16.3\%$  - incidence or 'absolute risk'*
- j) What is the difference between the vaccine group and the placebo group in relation to experiencing a sore throat in the week following vaccination? What is this measure called?  
*difference =  $26.6\% - 16.3\% = 10.3\%$  - risk difference*
- k) What is the ratio of experiencing sore throat in the vaccine group as compared to the placebo group. What is this measure called? Interpret the meaning of this measure in your own words.  
 *$26.6\%/16.3\% = 1.63$  – relative risk – The people who took the vaccine were about 1.6 times more likely to develop a sore throat compared with people who took the placebo*
- l) What proportion of people in the vaccine group and placebo group experienced an episode of febrile illness during the follow-up period?  
*incidence in vaccine group =  $373/2833 = 13.2\%$ ; incidence in placebo group =  $207/1420 = 14.6\%$*

- m) What is the difference between the vaccine group and the placebo group in relation to experiencing an episode of febrile illness during the follow-up period?

$$\text{risk difference} = 13.2 - 14.6 = 1.4\%$$

- n) What is the ratio of experiencing an episode of febrile illness during the follow-up period in the vaccine group as compared to the placebo group. Interpret the meaning of this measure in your own words.

*relative risk = 13.2/14.6 = 0.90 – The people who took the vaccine were about 0.9 times as likely to develop a febrile illness compared to those who did not have the vaccine, thus the vaccine is protective for febrile illness*

- o) What proportion of people in the vaccine group and placebo group took over-the-counter medications during the follow-up period?

$$\text{incidence in vaccine group} = 1119/2833 = 39.5\%; \text{ placebo group} = 681/1420 = 47.9\%$$

- p) What is the ratio of taking over-the-counter medications during the follow-up period in the vaccine group as compared to the placebo group. Interpret the meaning of this measure in your own words. How would your interpretation change if the number of people taking over-the-counter medications were 1700 in the vaccine group and 852 in the placebo group?

*relative risk = 39.5/47.9 = 0.82 – The people who took the vaccine were about 0.8 times as likely to take over-the-counter medications compared to those who did not have the vaccine.*

*Hypothetical situation - vaccine group = 1700/2833 = 60% and placebo group = 852/1420 = 60%; thus, the RR = 60/60 = 1 – we would say that there is no difference between the vaccine group and the placebo in terms of over-the-counter medication usage.*

## Question 9

Table 3 shows some results from a recent prospective study of age and lifestyle factors in relation to community-acquired pneumonia. Examine the table and answer the following questions.

- c) Calculate the relative risks for community-acquired pneumonia in relation to age and smoking status and interpret your findings.

Table 3. Relative risks of community-acquired pneumonia for risk factors in men

Risk Factor	Incidence rate per 100 000/year	Relative Risk
<b>Age</b>		
≤49yr	92.7	1.00 (referent)
50-54	142.8	1.54
55-59	180.5	1.95
60-64	263.8	2.85
65-69	280.6	3.03
≥ 70	404.9	4.37

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<b>Smoking status</b>		
Never smokers	150.3	1.00 (referent)
≤ 25 cigarettes/day	233.8	1.56
> 25 cigarettes/day	392.7	2.61

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*Age is positively associated with CAP. Risk increases markedly with increasing age. Smoking also shows a positive association with CAP with risk increasing with the number of cigarettes smoked.*

- d) Of age and smoking, which is the more important risk factor?

*There is no right or wrong answer here. The question has been asked to generate some discussion. In numerical terms it appears that age is a much stronger risk factor than smoking. However, age is a non-modifiable risk factor whereas smoking is definitely modifiable. This is an important distinction and should be discussed.*