EPI Case Study 1: Incidence, Prevalence, and Disease Surveillance; Historical Trends in the Epidemiology of *M. tuberculosis*

Estimated Time to Complete Exercise: 30 minutes

LEARNING OBJECTIVES

At the completion of this Case Study, participants should be able to:

- Explain why denominators are necessary when comparing changes in morbidity and mortality over time
- Distinguish between incidence rates and prevalence ratios
- Calculate and interpret cause-specific morbidity and mortality rates
- Describe how changes in mortality or morbidity could be due to an artifact rather than a real change

ASPH C. EPIDEMIOLOGY COMPETENCIES ADDRESSED IN THIS CASE STUDY

C. 3. Describe a public health problem in terms of magnitude, person, place, and time
C. 6. Apply the basic terminology and definitions of epidemiology
C. 7. Calculate basic epidemiology measures
C. 9. Draw appropriate inference from epidemiologic data
C. 10. Evaluate the strengths and limitations of epidemiologic reports

ASPH INTERDISCIPLINARY/CROSS-CUTTING COMPETENCIES ADDRESSED IN THIS CASE STUDY

F.1. [Communication and Informatics] Describe how the public health information infrastructure is used to collect, process, maintain, and disseminate data
J.1. [Professionalism] Discuss sentinel events in the history and development of the public health profession and their relevance for practice in the field
L.2. [Systems Thinking] Identify unintended consequences produced by changes made to a public health system

Please provide your evaluation of the usefulness of this material by clicking here:
http://www.zoomerang.com/Survey/?p=WEB229G8556MWC

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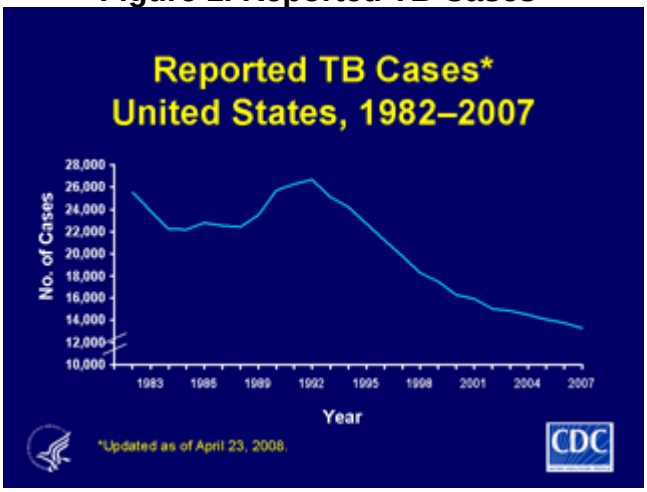
TB Surveillance

Since 1953, in cooperation with state and local health departments, the Centers for Disease Control and Prevention (CDC) has collected information on each newly reported case of tuberculosis (TB) disease in the United States. Currently, each TB case report (Report of Verified Case of Tuberculosis or RVCT) is submitted electronically to CDC's Division of Tuberculosis Elimination. Figure 1 depicts reported TB cases in the United States from 1982 to 2005.[1]

Figure 1. Reported TB Cases



Question 1

What factors might have contributed to the increase in TB cases from the mid 1980s to 1992? (See figure1 above.)

Answer Key

Students who have not had any exposure to TB information may have difficulty answering this question. They should be encouraged to propose a reasonable hypothesis.

There are a number of reasons that could explain this increase. The most important and most likely reason for this increase is the AIDS epidemic. In addition, inattention to the public health infrastructure needed to treat TB that was due to the prior decrease in TB rates is also believed to have played a role in the resurgence of TB.

Table 1 below presents the distribution of new cases of tuberculosis by age group and sex. Use this information to answer the next question.

Table 1. Number of TB Cases Reported to CDC by Age Group and Sex for 2007

Age	Sex	No. TB Cases
< 15	M	388
< 15	F	391
15-24	M	915
15-24	F	666
25-44	M	2557
25-44	F	1759
45-64	M	2747
45-64	F	1294
≥ 65	M	1502
≥ 65	F	1076

Source: **Table 15. Tuberculosis Cases by Hispanic Ethnicity and Non-Hispanic Race, Sex, and Age Group: United States, 2007**[2]

Question 2
A. In 2007, which group had the greatest number of TB cases?

Answer Key
According to this table, 45-64 year-old males had the greatest number of cases.

B. Does this mean that males 44-65 years of age are at greatest risk for developing TB?

Answer Key
Not necessarily. The numbers in Table 1 are only counts. We would need to look at the number of people within each group to calculate an incidence rate in order to get an estimate of the risk of developing the disease.

Estimating the Risk of Developing TB disease

The number of TB cases per 100,000 population, called the TB **case rate**, is determined by the following equation:

$$\frac{\text{number of } \textbf{new} \text{ TB cases that occur during a specified time period}}{\text{the population at risk}} \times 100{,}000$$

Also called cumulative incidence or an incidence rate, this formula provides an estimate of the risk for developing a disease. The population at risk information for the United States, which is needed to calculate the TB incidence (or case) rate, is collected by the US Census. Information on the US population by year can be found on the United States Census Bureau's American Factfinder website (http://factfinder.census.gov/home/saff/main.html?_lang=en).

Question 3

A. Estimated* population values and the number of new TB cases reported to the CDC appear in Table 2 below. Use this data to calculate the TB (incidence rates) case rates for years 2000 to 2007.

Table 2. TB Case Rates: 2000-2007

Year	New Cases	US Population Estimates	Case rate per 100,000 (incidence rate)
2000	16309	281,189,655	**5.8**
2001	15946	284,750,000	
2002	15056	289,538,462	
2003	14837	290,921,569	
2004	14501	295,938,776	
2005	14065	293,020,833	
2006	13754	299,000,000	
2007	13299	302,250,000	

Answer key

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2002	15056	289,538,462	5.2
2003	14837	290,921,569	5.1
2004	14501	295,938,776	4.9
2005	14065	293,020,833	4.8
2006	13754	299,000,000	4.6
2007	13299	302,250,000	4.4

* Estimated population values for this exercise were generated used the rates and cases that appear in the 2007 Surveillance Report (reference 2).

B. Describe the trend in TB incidence rates over time.

Answer Key
There has been a steady decline in TB incidence rates from 2000 to 2007 from 5.8 per 100,000 to 4.4 per 100,000.

Question 4
Use the CDC data and Table 3 below to calculate the age-specific incidence rates of TB for 2007. **EXAMPLE: 2007 <15 yr. old males = 245/10,652,174X 100,000= 2.3**

Table 3. Case Rates: 2007

Age	Sex	Cases	Estimated Population by Sex and Age Group	Incidence Rate per 100,000
<5	F	**245**	**10,652,174**	**2.3**
<5	F	**221**	**10,045,455**	
5-14	M	**143**	**20,428,571**	
5-14	F	**170**	**18,888,889**	
15-24	M	**915**	**21,785,714**	
15-24	F	**666**	**20,812,500**	
25-44	M	**2557**	**42,616,667**	
25-44	F	**1759**	**41,880,952**	
45-64	M	**2747**	**37,121,622**	
45-64	F	**1294**	**39,212,121**	
≥65	M	**1502**	**15,978,723**	
≥65	F	**1076**	**21,959,184**	

Answer Key: Table 3. Case Rates: 2007

Age	Sex	Cases	**Estimated Population by Sex and Age Group**	**Incidence Rate per 100,000**
<5	F	**245**	**10,652,174**	**2.3**
<5	F	**221**	**10,045,455**	**2.2**
5-14	M	**143**	**20,428,571**	**0.7**
5-14	F	**170**	**18,888,889**	**0.9**
15-24	M	**915**	**21,785,714**	**4.2**
15-24	F	**666**	**20,812,500**	**3.2**
25-44	M	**2557**	**42,616,667**	**6.0**
25-44	F	**1759**	**41,880,952**	**4.2**
45-64	M	**2747**	**37,121,622**	**7.4**
45-64	F	**1294**	**39,212,121**	**3.3**
≥65	M	**1502**	**15,978,723**	**9.4**
≥65	F	**1076**	**21,959,184**	**4.9**

Question 5
A. Which group has the highest incidence rate of TB in 2007?

Answer Key
According to calculations above, males 65 years and older have the highest incidence rate in 2007 (9.4 per 100,000).

B. Why do you think this age group has the highest TB case (incidence) rate of TB?

Answer Key
The most likely reason is that this older group is the most immunocompromised. They may have been infected with TB when they were younger and as they got older their immune systems was weakened which can lead to progression to TB disease. It is also possible that they have been newly infected or reinfected.

C. Is your answer for question 5a different from your answer for question 2a? If so, justify why your answer is different.

Answer Key
Yes, the answer is different because crude numbers do not tell anything about the rate (or risk) of developing a disease. We need denominators or population at risk information to do that.

TB Incidence Rates and Mortality Rates

Look at Table 4 on the next page of this exercise. This table presents information on TB **morbidity (or illness)** by providing the number of cases and the **case (incidence) rates**. It also presents information on **mortality (or death)** associated with TB in the US by providing the number of deaths and the **death rates** from 1953 to 2006.

Question 6
Describe the change in TB case (incidence) rates presented in Table 4 below.

Answer Key
Overall, TB case (incidence) rates have been steadily declining since 1953. There was an increase in the late 1980s into the early 1990s due to the HIV/AIDS epidemic as well as inattention to the public health infrastructure needed to treat TB. TB case (incidence) rates began to decline in 1993.

Table 4.
Tuberculosis Cases, Case Rates per 100,000 Population, Deaths, and Death Rates per 100,000 Population, and Percent Change: United States, 1953–2007[2]

	Tuberculosis Cases				Tuberculosis Deaths			
			Percent Change				Percent Change	
Year	Number	Rate	Number	Rate	Number[1]	Rate[1]	Number	Rate
1953	84,304	52.6	--	--	19,707	12.4	--	--
1954	79,775	48.9	-5.4	-7.0	16,527	10.2	-16.1	-17.7
1955	77,368	46.6	-3.0	-4.7	15,016	9.1	-9.1	-10.8
1956	69,895	41.4	-9.7	-11.1	14,137	8.4	-5.9	-7.7
1957	67,149	39.0	-3.9	-5.8	13,390	7.8	-5.3	-7.1
1958	63,534	36.3	-5.4	-6.9	12,417	7.1	-7.3	-9.0
1959	57,535	32.4	-9.4	-10.7	11,474	6.5	-7.6	-8.5
1960	55,494	30.7	-3.5	-5.2	10,866	6.0	-5.3	-7.7
1961	53,726	29.2	-3.2	-4.9	9,938	5.4	-8.5	-10.0
1962	53,315	28.6	-0.8	-2.1	9,506	5.1	-4.3	-5.6
1963	54,042	28.6	+1.4	0.0	9,311	4.9	-2.1	-3.9
1964	50,874	26.5	-5.9	-7.3	8,303	4.3	-10.8	-12.2
1965	49,016	25.2	-3.7	-4.9	7,934	4.1	-4.4	-4.7
1966	47,767	24.3	-2.5	-3.6	7,625	3.9	-3.9	-4.9
1967	45,647	23.0	-4.4	-5.3	6,901	3.5	-9.5	-10.3
1968	42,623	21.2	-6.6	-7.8	6,292	3.1	-8.8	-11.4
1969	39,120	19.3	-8.2	-9.0	5,567	2.8	-11.5	-9.7
1970	37,137	18.1	-5.1	-6.2	5,217	2.6	-6.3	-7.1
1971	35,217	17.0	-5.2	-6.1	4,501	2.2	-13.7	-15.4
1972	32,882	15.7	-6.6	-7.6	4,376	2.1	-2.8	-4.5
1973	30,998	14.6	-5.7	-7.0	3,875	1.8	-11.4	-14.5
1974	30,122	14.1	-2.8	-3.4	3,513	1.7	-9.3	-5.6
1975	33,989	15.7	--	--	3,333	1.6	-5.1	-5.9
1976	32,105	14.7	-5.5	-6.4	3,130	1.5	-6.1	-6.3
1977	30,145	13.7	-6.1	-6.8	2,968	1.4	-5.2	-6.7
1978	28,521	12.8	-5.4	-6.6	2,914	1.3	-1.8	-7.1
1979	27,669	12.3	-3.0	-3.9	2,007[2]	0.9[2]	-31.1[2]	-30.8[2]
1980	27,749	12.2	+0.3	-0.7	1,978	0.9	-1.4	0.0
1981	27,373	11.9	-1.4	-2.3	1,937	0.8	-2.1	-11.1
1982	25,520	11.0	-6.8	-7.7	1,807	0.8	-6.7	0.0
1983	23,846	10.2	-6.6	-7.4	1,779	0.8	-1.5	0.0
1984	22,255	9.4	-6.7	-7.5	1,729	0.7	-2.8	-12.5
1985	22,201	9.3	-0.2	-1.1	1,752	0.7	+1.3	0.0
1986	22,768	9.5	+2.6	+1.6	1,782	0.7	+1.7	0.0
1987	22,517	9.3	-1.1	-2.0	1,755	0.7	-1.5	0.0
1988	22,436	9.2	-0.4	-1.3	1,921	0.8	+9.5	+14.3
1989	23,495	9.5	+4.7	+3.7	1,970	0.8	+2.6	0.0
1990	25,701	10.3	+9.4	+8.2	1,810	0.7	-8.1	-12.5
1991	26,283	10.4	+2.3	+0.9	1,713	0.7	-5.4	0.0
1992	26,673	10.4	+1.5	+0.1	1,705	0.7	-0.5	0.0
1993	25,107	9.7	-5.9	-7.1	1,631	0.6	-4.3	-14.3
1994	24,205	9.2	-3.6	-4.8	1,478	0.6	-9.4	0.0
1995	22,728	8.5	-6.1	-7.2	1,336	0.5	-9.6	-16.7
1996	21,210	7.9	-6.7	-7.8	1,202	0.5	-10.0	0.0
1997	19,751	7.2	-6.9	-8.0	1,166	0.4	-3.0	-20.0
1998	18,287	6.6	-7.4	-8.5	1,112	0.4	-4.6	0.0
1999	17,501	6.3	-4.3	-5.4	930	0.3	-16.4	-25.0
2000	16,309	5.8	-6.8	-7.9	776	0.3	-16.6	0.0
2001	15,946	5.6	-2.2	-3.2	764	0.3	-1.6	0.0
2002	15,056	5.2	-5.6	-6.5	784	0.3	+2.6	0.0
2003	14,837	5.1	-1.5	-2.3	711	0.2	-10.2	-33.3
2004	14,501	4.9	-2.3	-3.2	662	0.2	-6.9	0.0
2005	14,065	4.8	-3.0	-3.9	648	0.2	-2.1	0.0
2006	13,754	4.6	-2.2	-3.1	644	0.2	-0.6	0.0
2007	13,299	4.4	-3.3	-4.2	…	…	…	…

[1] Official tuberculosis mortality statistics were compiled by the National Center for Health Statistics, CDC, National Vital Statistics Reports.
[2] The large decrease in death rate in 1979 occurred because late effects of tuberculosis (e.g., bronchiectasis or fibrosis) and pleurisy with effusion (without mention of cause) are no longer included in tuberculosis deaths.

Source: CDC. *Reported Tuberculosis in the United States, 2007*. Atlanta, GA: U.S. Department of Health and Human Services, CDC, September 2008. Table 1, page 15.

Question 7
Table 4 includes the cause-specific death rates associated with TB.

Definition: $\frac{\text{number of deaths associated with TB each year}}{\text{Mid-period population}} \times 100{,}000$

The rates for 1977, 1978 and 1979 are repeated below.

Year	Cause-Specific Death Rate for TB
1977	**1.4 per 100,000**
1978	**1.3 per 100,000**
1979	**0.9 per 100,000**

What is the TB mortality rate percent change between 1977 and 1978?
Remember: Percent change formula: $\frac{\text{Time2-Time1}}{\text{Time 1}} \times 100$

Answer Key

$\frac{1.3-1.4}{1.4} \times 100 = -7.1\%$, so TB death rate decreased by approximately 7%.

Question 8
What is the TB death rate percent change between1978 and 1979?

Answer Key

$\frac{0.9-1.3}{1.3} \times 100 = -30.8\%$, so TB death rate decreased by approximately 31%.

Question 9
What are the possible reasons there was such a large difference between the rates for these years?

Answer Key
When looking at changes over time, we know that the differences could be real or artifacts. A real change might be the result of a change in the population or in the treatment of the disease; in this case it seems unlikely to have occurred in a 1 year period. An artifact, such as a change in the way the disease is classified, is a more likely explanation. This is in fact the case. Footnote #2 that appears at the bottom of this table states "The large decrease in death rate in 1979 occurred because late effects of tuberculosis (e.g., bronchiectasis or fibrosis) and pleurisy with effusion (without mention of cause) are no longer included in tuberculosis deaths."

TB Morbidity (Incidence Rates vs. Prevalence Ratios)

Tuberculosis is a disease where people can become infected and remain infected without symptoms for many years. **TB infection (without active disease) is called latent TB infection**. The identification and treatment of people with latent TB infection is an important goal of TB control, because successful treatment of TB infection will prevent progression from infection to active disease. TB infection can be detected using a skin test and more recently through a blood test.

An epidemiologic measure that can be used to measure the proportion of a population with a specific **infection or disease** is called the prevalence ratio. For example, conducting tuberculin skin testing in a homeless shelter would provide a measure of the proportion of residents who have been infected with TB. This would include both old and new infections.

The following formula can be used to determine the **prevalence ratio**:

number of **new and old** TB infections during a specified time period x 100,000
total (usually mid-period population) during the same time period

Note: incidence rates and prevalence ratios may be expressed per 100 or per 1,000. They are commonly presented per 100,000.

Question 10
Suppose that a county TB controller would like to know how many people currently living in a local nursing home are infected with TB. After receiving the appropriate approval and consent from the nursing home residents and administration, she has a trained nurse administer and read the results of tuberculin skin tests. Of the 100 nursing home residents who were tested, 30 had positive tuberculin skin test results during July of that year.

What is the prevalence ratio of TB infection in this nursing home during the month of July? Provide your answer per 100.

Answer Key

The prevalence ratio of TB infection during July would be 30/100 or 30%. This means that 30% of these nursing home residents were exposed to TB at some point in their lives; some may be "new" or recent infections and some may be "old" infections which occurred earlier in the lives of these residents.

Question 11

In this particular nursing home, all 100 residents remained in this nursing home for the next year at which time only those who did not have an initial positive tuberculin skin test result were tested again. Among these 70 residents who were tested again, 5 had a positive tuberculin skin test result.

What is the incidence rate of TB infection in this nursing home during the next year?

Answer Key

The incidence rate of TB infection during this 1-year period would be 5/70 or approximately 7%. Since all of the 70 residents who were tested during the one year period had an initial negative tuberculin skin test result the prior July, we can assume that the 5 individuals who had positive skin tests during the next year were "new" or recent TB infections.

Works Cited

1. Centers for Disease Control and Prevention. Division of Tuberculosis Elimination 2007 Slide Set. [Online]. http://www.cdc.gov/tb/statistics/surv/surv2007/default.htm Last accessed June 17, 2009.

2. CDC. Reported Tuberculosis in the United States, 2007. Atlanta, GA: U.S. Department of Health and Human Services, CDC, September 2008. http://www.cdc.gov/tb/statistics/reports/2007/default.htm Last accessed June 17, 2009.