EPI Case Study 3: Cross-Sectional, Case-Control, and Cohort Studies– Identification of TB Risk Groups and TB Risk Factors in Epidemiologic Studies

Time to Complete Exercise: 60 minutes

LEARNING OBJECTIVES

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

- Describe recent trends in tuberculosis (TB) incidence rates by race and ethnicity
- Distinguish between cross-sectional, case-control, and cohort study designs
- Describe the advantages and disadvantages of these epidemiologic study designs
- Understand and identify TB risk groups (demographic and occupational)
- Calculate and interpret odds ratios, relative risks, and attributable risks
- Understand the difference between an odds ratio and a relative risk
- Interpret data from a contact investigation

ASPH EPIDEMIOLOGY COMPETENCIES ADDRESSED

C. 3. Describe a public health problem in terms of magnitude
C. 6. Apply the basic terminology and definitions of epidemiology
C. 7. Calculate basic epidemiologic 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

I.8. [Public Health Biology] Apply biological principles to development and implementation of disease prevention, control, or management programs
L.10. [Systems Thinking] Analyze the impact of global trends and interdependencies on public-health–related problems and systems

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Introduction

Statistical output provided in this exercise was generated using JMP 7.0, SAS Institute Inc. Some modifications of headings were made to clarify output for this exercise.

In 2007, the number of TB cases reported (13,299) and case rate (4.4 cases per 100,000) both decreased; this represented declines of 3.3% and 4.2%, respectively, compared to 2006. Since the 1992 TB resurgence peak in the United States, the number of TB cases reported annually has decreased by 50%. However, the trend of the declining annual case rate has slowed, from an annual average decline of 7.3% for 1993 through 2000 to an annual average decline of 3.8% for 2000 through 2007.

The proportion of total cases occurring in foreign-born persons has been increasing since 1993. In 2007, 58% of TB cases occurred in foreign-born persons. Foreign-born persons have accounted for the majority of TB cases in the United States every year since 2001. Moreover, the case rate among foreign-born persons in 2007 was nearly 10 times higher than among U.S.-born persons.[1]

The table presented below summarizes data from the national TB surveillance system for 2003 and describes trends during a 5-year period.

TABLE 2. Number and rate* of tuberculosis cases and percentage change in rate in U.S.-born and foreign-born persons, by race/ethnicity — United States, 1998 and 2003†

	U.S.-born					Foreign-born					Total§				
	1998		2003		% change 1998–2003	1998		2003		% change 1998–2003	1998		2003		% change 1998–2003
Race/Ethnicity	No.	Rate	No.	Rate		No.	Rate	No.	Rate		No.	Rate	No.	Rate	
Hispanic	1,282	6.6	1,025	4.4	-33.3	2,785	26.0	3,035	19.3	-25.8	**4,091**	**13.5**	**4,108**	**10.5**	**-22.2**
Non-Hispanic															
Black	4,968	16.0	3,041	9.1	-43.1	841	48.5	1,033	51.3	5.8	**5,816**	**17.8**	**4,099**	**11.5**	**-35.4**
Asian/Pacific Islander¶	213	5.8	201	5.3	-8.6	3,411	55.4	3,241	40.6	-26.7	**3,637**	**36.9**	**3,466**	**29.4**	**-20.3**
Asian	—	—	154	4.4	—	—	—	3,205	40.5	—	—	—	**3,383**	**29.7**	—
Native Hawaiian or Other Pacific Islander	—	—	47	15.1	—	—	—	36	48.6	—	—	—	**83**	**21.5**	—
White	3,914	2.1	2,328	1.2	-42.9	550	8.5	437	6.3	-25.9	**4,473**	**2.3**	**2,784**	**1.4**	**-39.1**
American Indian/ Alaska Native	248	12.6	169	7.9	-37.3	—	—	—	—	—	**254**	**12.7**	**175**	**8.0**	**-37.0**
Total**	**10,633**	**4.3**	**6,873**	**2.7**	**-37.2**	**7,598**	**30.2**	**7,845**	**23.4**	**-22.5**	**18,287**	**6.8**	**14,871**	**5.1**	**-25.0**

* Per 100,000 population.
† Data for 2003 are provisional.
§ Includes persons for whom country of birth was unknown: 56 in 1998 and 153 in 2003.
¶ For comparison with 1998, data for 2003 for Asian/Pacific Islanders include Asians plus Native Hawaiians or Other Pacific Islanders.
** Includes persons for whom race/ethnicity was unknown: 16 for total, eight for U.S-born, and five for foreign-born persons in 1998; 201 for total, 99 for U.S-born, and 66 for foreign-born persons in 2003. In 2003, persons were included who selected multiple races: 38 for total, 10 for U.S.-born, and 28 for foreign-born persons.

Source: Centers for Disease Control and Prevention. Trends in tuberculosis—United States, 1998–2003. *MMWR Morb Mortal Wkly Rep*. 2004;53:209-214.

Question 1

Describe the trends in TB incidence rates over time for US-born and foreign-born populations.

Study Design

There are 3 major types of epidemiologic studies that appear in medical and public health literature:

- Cross-sectional studies
- Case-control studies
- Cohort studies

Cross-Sectional Studies

In a cross-sectional study, data on possible risk factors and disease outcomes are collected at the same time. These studies are sometimes called **prevalence studies** since the information collected can be used to provide prevalence ratios (the proportion in a population with a particular outcome). The data collected present a picture of what is occurring at a specific time. Cross-sectional studies cannot provide information on causes of diseases because it is unclear in these studies whether the disease or the supposed risk factor occurred first. [2]

The following abstract provides an example of a cross-sectional or prevalence study.

Study Design: Cross-Sectional Study

"**Objective:** To determine the prevalence of and risk factors for tuberculin skin test positivity and conversion among New York City Department of Health and Mental Hygiene employees.

Design: Point-prevalence survey. Sentinel surveillance was conducted from March 1, 1994 to December 31, 2001.

Participants: HCWs in high-risk and low-risk settings for occupational TB exposure.

Results: Baseline tuberculin positivity was 36.2% (600 of 1,658), 15.5% (143 of 922) among HCWs born in the United States, and 48.5% (182 of 375) among HCWs not born in the United States."

Source: Cook S, Maw KL, Munsiff SS, Fujiwara PI, Frieden TR. Prevalence of tuberculin skin test positivity and conversions among healthcare workers in New York City during 1994 to 2001. *Infect Control Hosp Epidemiol*. 2003;24:807-813. Reprinted here with permission.

Question 2

Based on this abstract, describe the relationship between place of birth and tuberculin skin test (TST) results among these health care workers (HCW). Can it be said that there is a causal relationship between being born outside the United States and TST positivity?

The following study explores the relationship between a possible risk factor and TB infection. This hypothetical study was inspired by a study conducted by Lobato and Hopewell,[3] but the study design and the data presented are hypothetical.

METHODS

Study Population and Design

In this hypothetical community, all 1000 healthy children entering kindergarten in a particular year were required to receive a TST prior to school entrance. Overall, 80 of these children had a positive TST result, meaning that they were infected with TB. Additional tests were done to rule out active TB disease.

A random sample of 220 children, among all those who had a negative TST result was identified by the study team. Parents of all 300 of these children were contacted and interviewed by a trained public health worker who was unaware of the TST status of the child. Parents were asked to provide information about any travel that the child experienced during the 12 months prior to the TST. Information was gathered on the length and number of trip(s) and the country that was visited. Travel locations were classified as being to a high-burden country (yes or no) according to the designation assigned by the World Health Organization (WHO). The WHO has identified the following 22 countries as high-burden TB countries: Afghanistan, Bangladesh, Brazil, Cambodia, China, DR Congo, Ethiopia, India, Indonesia, Kenya, Myanmar, Mozambique, Nigeria, Pakistan, Philippines, Russian Federation, South Africa, Tanzania, Thailand, Uganda, Vietnam, and Zimbabwe because they account for 80% of TB globally.[4]

Question 3
What type of study is this? Please explain.

Results for travel to a high-burden TB country

Parents of all 300 children consented to be in this study. Of these 300 children, 22 had traveled to a high burden TB country during the 12 months prior to their TST. Twelve of the 80 children with a positive skin test had traveled to a high-burden TB country during the 12 months before their skin test.

Question 4 A-B

A. Using the information provided in the above paragraph, create a 2 x 2 table for the group of children who had traveled to a high-burden TB country during the 12 months prior to their TST.

Group: All children

		TST Results		Totals
		Positive	Negative	
Travel to a high-burden country	Yes			
	No			
	Total			300

B. Calculate the odds ratio (OR) and provide an interpretation of the findings.

Question 5

Can a relative risk (RR) be calculated for this study? Please explain why or why not.

Question 6

Under what circumstances is an OR a good estimate of RR (Hint: See reference 5)?

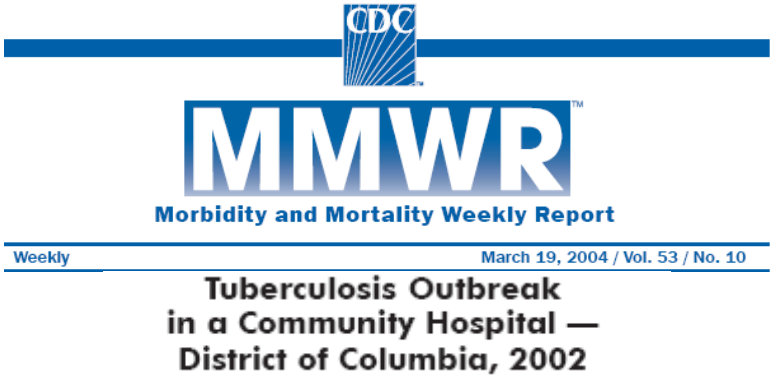
Question 7

The public health workers who interviewed the parents of these children did not know the TST status of these children. Why is this important?

Question 8

When conducting any study, researchers must be concerned about other possible biases. What is recall bias?

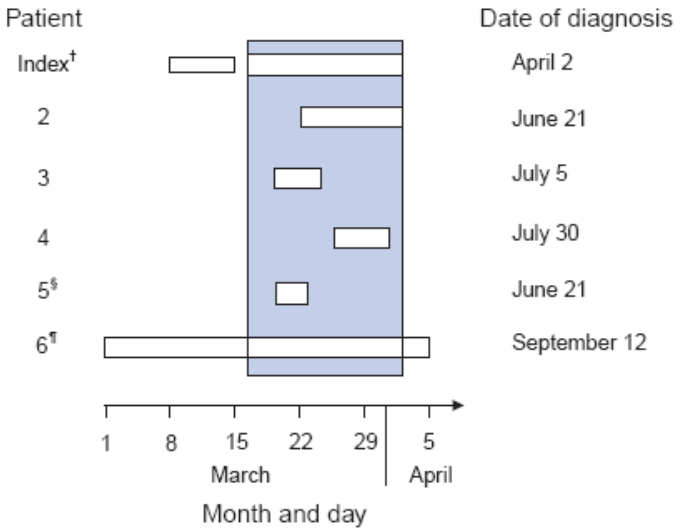
The next part of the exercise is based on a study published in *Morbidity and Mortality Weekly Report.*[6] The findings from this study have been paraphrased below.



During July 2002, 5 patients at a community hospital in Washington, DC, were diagnosed with active TB disease. An employee at this hospital was also diagnosed with active TB in September 2002. The DC Department of Health contacted the Centers for Disease Control and Prevention (CDC) and requested assistance with an investigation of this unusual occurrence (outbreak) of TB. A team was formed to investigate the occurrence of these cases. The team included individuals from the CDC staff, the local health department, and the infection control department at the hospital. The team reviewed the hospital and health department records of these 6 active TB cases.

One case was a patient who spent 3 weeks on 2 general medical wards at the hospital before being placed in respiratory isolation with a diagnosis of TB on April 2, 2002. DNA fingerprinting was conducted on specimens from all 6 active TB cases and all 6 had matching genotypes. Based on the review of hospital and health department records, this patient was identified as the source (or index case) of the outbreak. The figure presented below shows the amount of time during which the index case and the other (secondary cases) were in contact, along with the dates of diagnosis of TB disease.

FIGURE. Days of overlap* on hospital A ward, by date of tuberculosis diagnosis — District of Columbia, 2002



* All five secondary patients spent time on the medical ward with the index patient during his last admission to hospital A. The area within the box indicates the period of overlap. All secondary patients had tuberculosis (TB) diagnosed within 6 months of the exposure.
† The index patient was treated at hospital B during March 4–6. He was placed in respiratory isolation in hospital A on April 2.
§ Patient 5 had TB diagnosed posthumously when a sputum culture grew *Mycobacterium tuberculosis*. His specimen was collected on May 9, and he died on May 20 from acute respiratory failure secondary to a stroke. His specimen was confirmed on June 21.
¶ Patient 6 worked as a phlebotomist for hospital A and was assigned to the patient ward.

Hospital staff members who may have come into contact with this patient were identified by examining the patient's medical records and comparing that information with the dates and assignments that were found in the hospital's employment records. A total of 784 members of the hospital staff were categorized into 3 exposure groups: 1) direct-care providers, who had direct contact with the patient; 2) workers on the same ward as the patient, but who were not involved in the patient's medical care; or 3) other workers who spent time on the ward but were not assigned there while the patient was present..

Overall 495 (or 63%) of these 784 staff members were evaluated using a TST. The Table below provides the TST results for all tested staff at their hospital by assignment, as a measure of the amount of possible exposure to the patient. Those with direct patient care should have had the most exposure; staff members who were ward-based should have some exposure, and other staff should have had the least amount of exposure.

TABLE. Tuberculin skin test (TST) results among staff at hospital A, by type of work assignment — District of Columbia, April–September 2002

Assignment	No. workers	No. evaluated	TST-positive* No.	(%)
Direct care	106	65	21	(32)
Ward-based	49	26	6	(23)
Other	629	404	29	(7)
Total	784	495	56	(11)

Question 9
What type of epidemiologic study design is this investigation? Please explain.

Question 10
Assuming that no staff members who were tested had a prior positive TST result, what type of measures are the TST positive percentages?

Question 11
Using the incidence rate in the other group as the referent group, calculate and interpret the RR for direct care and ward-based workers.

Question 12
How is it possible to determine if these RRs are more than would be expected by chance?

The authors present the following information[6]:

TABLE. Tuberculin skin test (TST) results among staff at hospital A, by type of work assignment — District of Columbia, April–September 2002

Assignment	No. workers	No. evaluated	TST-positive* No.	(%)	RR†	(95% CI§)
Direct care	106	65	21	(32)	4.5	(2.7–7.4)
Ward-based	49	26	6	(23)	3.2	(1.5–7.0)
Other	629	404	29	(7)		Referent
Total	**784**	**495**	**56**	**(11)**		

* A TST of ≥5 mm during the investigation in a person with a documented negative TST during the preceding 2 years.
† Relative risk.
§ Confidence interval.

Question 13
Are these RRs statistically significant?

Question 14 A-B
A. Can it be determined if there is a significant difference at the .05 significance level between direct care and ward-based employees by looking at the RRs and CIs provided in this table?

B. Interpret the results of the statistical test below.

Table 3. Contingency table

Type of Worker (Direct/Ward-Based Care) by TST Result (Positive/Negative)

Count Total % Col % Row %	Positive	Negative	
Direct care	21 23.08 77.78 32.31	44 48.35 68.75 67.69	65 71.43
Ward-based care	6 6.59 22.22 23.08	20 21.98 31.25 76.92	26 28.57
	27 29.67	64 70.33	91

Test	Chi-square	p value
Pearson	0.758	0.3839

Fisher Exact Test	Prob	Alternative Hypothesis
Left	0.8707	Prob(TB test result=negative) is greater for type=direct than ward
Right	0.2722	Prob(TB test result=negative) is greater for type=ward than direct
2-Tail	0.4537	Prob(TB test result=negative) is different across type

Relative Risk

Description	RR	Lower 95% CI	Upper 95% CI
P(positive|direct)/P(positive|ward)	1.4	0.638528	3.069559

Question 15

What are the implications of the fact that not all employees received a TST in this study?

Question 16

What is the amount of risk attributed to direct patient contact compared with contact on the ward?

The following editorial note appeared at the end of the article:

> This report describes recent nosocomial transmission of *M. tuberculosis* in a community hospital. The index patient spent 3 weeks hospitalized with unrecognized TB, possibly masked by HIV infection. AIDS patients can have atypical presentations of TB disease resulting in diagnostic delays (6). Because TB was not initially a diagnostic consideration, the patient was not placed immediately in respiratory isolation.
>
> Although the incidence of TB continues to decline (7), heightened awareness and vigilance is required by hospital staff to identify and treat persons with suspected TB promptly. Patients with suspected TB should be placed in respiratory isolation until infectious TB is ruled out. When the patient is transported for medical procedures that cannot be performed in the isolation room, the patient should wear a surgical mask. Hospital infection-control programs are encouraged to develop protocols and implement administrative procedures for HIV-infected patients with pulmonary symptoms suggestive of TB. Finally, local TB-control programs can assist hospital infection-control staff in investigating community contacts of persons hospitalized with TB (2).

This note emphasizes the importance of prompt diagnosis of TB along with a strong infection control program in the prevention of nosocomial (or hospital-based) outbreaks of diseases such as TB.

References cited in this editorial note

2. CDC. Guidelines for preventing the transmission of *Mycobacterium tuberculosis* in health-care facilities, 1994. *MMWR.* 1994;43(No. RR-13).

6. Kenyon T, Ridzon R, Luskin-Hawk R, et al. A nosocomial outbreak of multidrug-resistant tuberculosis. *Ann Intern Med*.1997;127:32-36.

7. CDC. Trends in tuberculosis–United States, 1998–2003. *MMWR.* 2004;53:209-214.

Works Cited

1. CDC. *Reported Tuberculosis in the United States, 2007*. Atlanta, GA: US Department of Health and Human Services, CDC, September 2008.

2.New Jersey Medical School National Tuberculosis Center. *Basic Epidemiology for Tuberculosis Program Staff.* 2005:43.

3. Lobato MN, Hopewell PC. Mycobacterium tuberculosis infection after travel to or contact with visitors from countries with a high prevalence of tuberculosis. *Am J Respir Crit Care Med*.1998;158:1871-1875.

4. Stop TB Partnership. http://www.stoptb.org/countries/ Accessed November 16, 2009.

5. Gordis L. *Epidemiology, Second Edition*. New York, NY: W.B. Sanders Co; 2005.

6. Centers for Disease Control and Prevention. Tuberculosis outbreak in a community hospital-District of Columbia, 2002*. MMWR Morb Mortal Wkly Rep*. 2004;53:214-216.