

ENVIRONMENTAL HEALTH SCIENCES EXERCISE 1:
RISK ASSESSMENT: A CASE STUDY OF AN INVESTIGATION OF A
TUBERCULOSIS (TB) OUTBREAK IN A HEALTH CARE SETTING
INSTRUCTOR'S GUIDE VERSION 1.0

**EHS EXERCISE 1: Risk Assessment: A Case Study of an Investigation of a Tuberculosis (TB)
Outbreak in a Health Care Setting**

Estimated Time to Complete in an Online Course or In-person Course Discussion: 30-60 minutes

LEARNING OBJECTIVES

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

- Understand and identify TB risk groups (demographic and occupational)
- Interpret data from a contact investigation
- Identify environmental and occupational risks for TB transmission

ASPH ENVIRONMENTAL HEALTH SCIENCES COMPETENCIES ADDRESSED IN THIS MODULE

- B.2 Describe genetic, physiologic and psychosocial factors that affect susceptibility to adverse health outcomes following exposure to environmental hazards.
- B.4 Specify the current environmental risk assessment frame work
- B.5 Specify approaches for assessing, preventing, and controlling environmental hazards that pose risks to human health and safety
- B.8 Develop a testable model of environmental insult

NOTE: Please note this exercise illustrates for students one way of how to develop a testable model of environmental insult. Also, this case study refers to one specific microenvironment/occupational setting.

Please evaluate this material by clicking here:

<http://www.zoomerang.com/Survey/?p=WEB229TLK456AW>

This material was developed by the staff at the Global Tuberculosis Institute (GTBI), one of four Regional Training and Medical Consultation Centers funded by the Centers for Disease Control and Prevention, in collaboration with faculty and staff at the UMDNJ-School of Public Health. It is published for learning purposes only.

Case study author(s) name and position:

George Khalil, MPH (work done while MPH Candidate)

Marian R. Passannante, PhD, Associate Professor

Samuel D. Annor, MSPH, MT (ASCP) SPH graduate student

Derek G. Shendell, D.Env, MPH, Assistant Professor and Core Course Director

For further information, please contact:

New Jersey Medical School GTBI

225 Warren Street

P.O. Box 1709

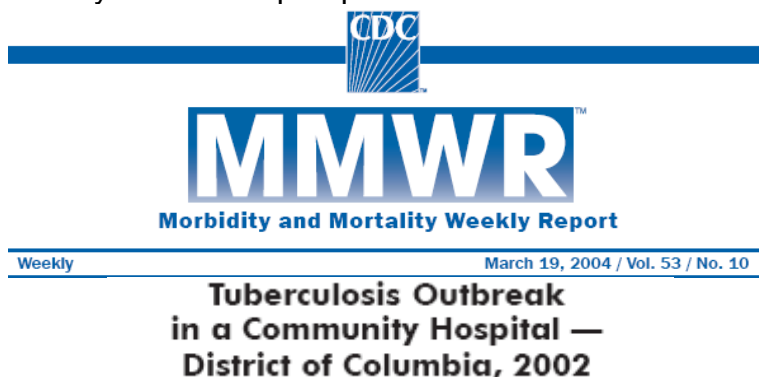
Newark, NJ 07101-1709 or by phone at 973-972-0979

Suggested citation: New Jersey Medical School Global Tuberculosis Institute. /Incorporating Tuberculosis into Public Health Core Curriculum./ 2009: ENVIRONMENTAL HEALTH SCIENCES EXERCISE 1: Risk Assessment: A Case Study Of An Investigation Of A Tuberculosis (TB) Outbreak In A Health Care Setting INSTRUCTOR'S GUIDE VERSION 1.0.

ENVIRONMENTAL HEALTH SCIENCES EXERCISE 1:
RISK ASSESSMENT: A CASE STUDY OF AN INVESTIGATION OF A
TUBERCULOSIS (TB) OUTBREAK IN A HEALTH CARE SETTING
INSTRUCTOR'S GUIDE VERSION 1.0

Quantitative risk assessment (QRA) is the process of identifying and evaluating hazards (agents) and the risk of adverse events that could occur if exposure occurs in defined scenarios. QRA is used in many fields, including engineering, medicine and public health. In environmental and occupational health settings, risk assessors focus on health impacts that might result from being exposed to a particular agent or mixture of agents while working in, living in, or visiting a particular microenvironment indoors (various) and/or outdoors.

This exercise is based on a study published in *Morbidity and Mortality Weekly Report*.¹ The findings from this study have been paraphrased below.

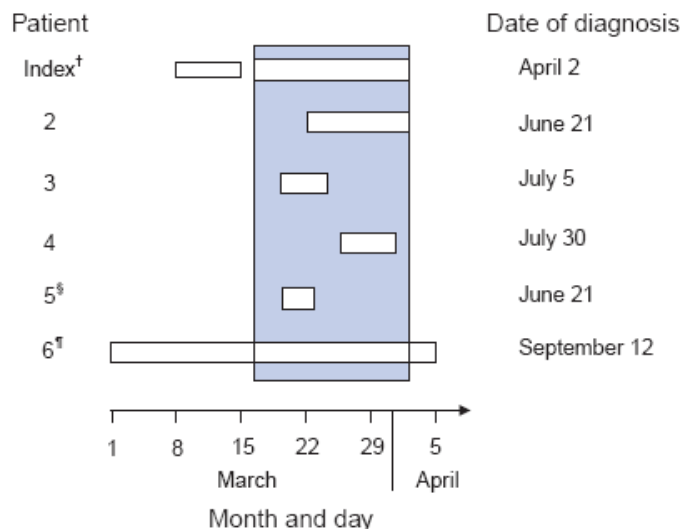


During July 2002, 5 patients at a community hospital in Washington, DC, were diagnosed with active TB disease. An employee at this hospital was also diagnosed with active TB in September 2002. The DC Department of Health contacted the Centers for Disease Control and Prevention (CDC) and requested assistance 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.

ENVIRONMENTAL HEALTH SCIENCES EXERCISE 1:
 RISK ASSESSMENT: A CASE STUDY OF AN INVESTIGATION OF A
 TUBERCULOSIS (TB) OUTBREAK IN A HEALTH CARE SETTING
INSTRUCTOR'S GUIDE VERSION 1.0

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.

ENVIRONMENTAL HEALTH SCIENCES EXERCISE 1:
RISK ASSESSMENT: A CASE STUDY OF AN INVESTIGATION OF A
TUBERCULOSIS (TB) OUTBREAK IN A HEALTH CARE SETTING
INSTRUCTOR'S GUIDE VERSION 1.0

Background Information for Instructors only^a

Investigating persons who have had close contact with tuberculosis (TB) cases is an essential element of public health programs to control and eliminate TB (1,2). These contact investigations are done primarily to discover persons who may require treatment for latent TB infection and also to find and treat additional persons with TB. While not usually highly contagious, TB is generally transmitted to persons who have shared indoor air space frequently or for a long period of time with a person who is infectious (3). Factors that may influence transmission include prolonged hours of contact during the infectious period, close proximity to the person with TB, and lack of ventilation and ultraviolet light in a shared environment. Generally, close contacts who live with a person identified with active TB or who habitually spend time indoors in close proximity to this person are investigated first. If no evidence of TB transmission is found in these close contacts, the investigation ceases. If transmission has occurred, the investigation may be extended. The 'stone-in-the-pond' principle, a technique in which concentric circles of contact persons around the case are sequentially investigated, is practiced in many countries (4).

...If one or more additional persons with TB are identified among the contacts of a person with TB, the person is labeled as the index case for the purpose of the investigation; those subsequently identified are classified as source cases, secondary cases, or unlinked cases. An active TB case found in a contact investigation may be classified as the source of infection to the index case, a secondary case infected by the index case, or a case who neither infected nor was infected by the index case (with a strain of TB unrelated to the strain of the index case). Information about the start and duration of symptoms for the index and the contact cases, and the start and duration of contact between them, facilitates categorization. Categorizing a contact with active TB as a source case, a secondary case, or an unlinked case, based on epidemiologic evidence, helps to direct further investigation. If the source case is known to have drug-resistant TB, establishing epidemiologic links may also aid in choosing an appropriate drug regimen for the contact before cultures and sensitivity test results are available (5).

...DNA fingerprinting has been used to support contact investigations of large clusters of cases in institutional settings and to suggest possible connections among cases without obvious epidemiologic links. This technique is also used, though rarely, to evaluate epidemiologic links found in contact investigations.

Works Cited within the instructor's background information presented on this page:

1. Advisory Council for the Elimination of Tuberculosis. Essential components of a tuberculosis prevention and control program. MMWR Morb Mortal Wkly Rep. 1995;44(RR-11):1-18.
2. Advisory Council for the Elimination of TB. Tuberculosis elimination revisited: obstacles, opportunities, and a renewed commitment. MMWR Recomm Rep. 2002;48(RR-9):1-13.
3. Institute of Medicine. Ending neglect: The elimination of tuberculosis in the United States. 1st ed. Washington (DC): National Academy Press; 2000.
4. Veen J. Microepidemics of tuberculosis: the stone-in-the-pond theory. Tuber Lung Dis. 1992;73:73-76.
5. Villarino M, Dooley S, Geiter L, Castro K, Snider D. Management of persons exposed to multidrug-resistant tuberculosis. MMWR Morb Mortal Wkly Rep. 1992;41(RR-11):61-71.

^a Bennett DE, Onorato IM, Ellis BA, Crawford JT, Schable B, Byers R, et al. DNA fingerprinting of Mycobacterium tuberculosis isolates from epidemiologically linked case pairs. Emerg Infect Dis [serial online]. <http://www.cdc.gov/ncidod/EID/vol8no11/02-0420.htm> Retrieved April 24, 2009.

End of background information for Instructors

STUDENT QUESTIONS FOR EXERCISE 1

The table below comes from the MMWR article¹. It provides the TST results for tested staff at the hospital, by assignment, as a measure of the amount of possible exposure to the TB patient. The hospital administration hypothesized staff with direct patient care should have had the most exposure, ward-based staff should have had some exposure, and other staff should have had the least amount of potential 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)

This is a cohort study since it examines a cohort (workers) classified by exposure status and looks at the TST results as the outcome. Please remember exposure status in this case study refers to the location and nature of each subject's work assignment. If we assume no staff had prior positive TSTs, then these are cumulative incidence rates (# cases/population at risk). The incidence rates are a measure of the risk of developing a TB infection after being exposed to the TB patient.

Question 1

Please calculate the ratio of the “direct care” % positive to the “other” group % positive. Next, please calculate the ratio of the “ward-based” % positive to the “other” group % positive. These measurements are called relative risks (RRs). How would you interpret these RRs?

Question 2

If the “direct care” employees had the same amount of risk of being TST positive (i.e., infected with TB) as the “other” workers, what would the RR be?

Question 3

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

Answer Key for Questions 1-3

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*		RR†	(95% CI‡)
			No.	(%)		
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.

Answer Key for Question 1

RR= $32/7=4.5$. This means the “direct care” employees are 4.5 times more likely to have a positive TST result compared with those described as “other” employees.”

Similarly, the RR of $23/7.2$ (decimal not in table but stated in text of article)= 3.2 This means the “ward-based” employees are over three times more likely to have a positive TST result compared with those described as “other” employees.”

Exposure is related to the risk of developing new infection. This could be described as a dose-response relationship.

Answer Key for Question 2

It would be one (1, or 1.0).

Answer Key for Question 3

We do not know if the results represent the whole population since it is neither a full accounting of hospital staff and patients nor a probability sample. For example, those individuals who did not agree to be tested may differ in some ways from those who did, including being potentially more susceptible and vulnerable individuals. Thus, the “Healthy Worker Effect” is one part of the potential selection bias.

ENVIRONMENTAL HEALTH SCIENCES EXERCISE 1:
RISK ASSESSMENT: A CASE STUDY OF AN INVESTIGATION OF A
TUBERCULOSIS (TB) OUTBREAK IN A HEALTH CARE SETTING
INSTRUCTOR'S GUIDE VERSION 1.0

On the next three pages you will find an excerpt from “Guidelines for Preventing the Transmission of *Mycobacterium tuberculosis* in Health-Care Setting, 2005” from Morbidity and Mortality Weekly Report December 30, 2005 / 54(RR17);1-141. Use the information provided in this excerpt to answer the remaining questions in this exercise.

Fundamentals of TB Infection Control²

One of the most critical risks for health-care–associated transmission of *M. tuberculosis* in health-care settings is from patients with unrecognized TB disease who are not promptly handled with appropriate airborne precautions (56,57,93,104) or who are moved from an All room too soon (e.g., patients with unrecognized TB and MDR TB) (94). In the United States, the problem of MDR TB, which was amplified by health-care–associated transmission, has been substantially reduced by the use of standardized antituberculosis treatment regimens in the initial phase of therapy, rapid drug susceptibility testing, directly observed therapy (DOT), and improved infection-control practices (1). DOT is an adherence-enhancing strategy in which an HCW or other specially trained health professional watches a patient swallow each dose of medication and records the dates that the administration was observed. DOT is the standard of care for all patients with TB disease and should be used for all doses during the course of therapy for TB disease and for LTBI, whenever feasible. All health-care settings need a TB infection-control program designed to ensure prompt detection, airborne precautions, and treatment of persons who have suspected or confirmed TB disease (or prompt referral of persons who have suspected TB disease for settings in which persons with TB disease are not expected to be encountered). Such a program is based on a three-level hierarchy of controls, including administrative, environmental, and respiratory protection (86,107,108).

[NOTE: In environmental public health and occupational health/industrial hygiene, four levels of an industrial hygiene hierarchy of control may be noted, i.e., the three listed above preceded by process controls/source substitution. Process controls and source substitution are based on engineering principles. Environmental, or area, controls to reduce worker exposure to emissions can also be based on engineering principles.]

Administrative Controls

The first and most important level of TB controls is the use of administrative measures to reduce the risk for exposure to persons who might have TB disease. Administrative controls consist of the following activities:

- assigning responsibility for TB infection control in the setting;
- conducting a TB risk assessment of the setting;
- developing and instituting a written TB infection-control plan to ensure prompt detection, airborne precautions, and treatment of persons who have suspected or confirmed TB disease;
- ensuring the timely availability of recommended laboratory processing, testing, and reporting of results to the ordering physician and infection-control team;
- implementing effective work practices for the management of patients with suspected or confirmed TB disease;

- ensuring proper cleaning and sterilization or disinfection of potentially contaminated equipment (usually endoscopes);
- training and educating HCWs [Health Care Workers] regarding TB, with specific focus on prevention, transmission, and symptoms;
- screening and evaluating HCWs who are at risk for TB disease or who might be exposed to *M. tuberculosis* (i.e., TB screening program);
- applying epidemiologic-based prevention principles, including the use of setting-related infection-control data;
- using appropriate signage advising respiratory hygiene and cough etiquette; and
- coordinating efforts with the local or state health department.

HCWs with TB disease should be allowed to return to work when they 1) have had three negative AFB sputum smear results (109–112) collected 8–24 hours apart, with at least one being an early morning specimen because respiratory secretions pool overnight; and 2) have responded to antituberculosis treatment that will probably be effective based on susceptibility results. In addition, HCWs with TB disease should be allowed to return to work when a physician knowledgeable and experienced in managing TB disease determines that HCWs are noninfectious (see Treatment Procedures for LTBI and TB Disease). Consideration should also be given to the type of setting and the potential risk to patients (e.g., general medical office versus HIV clinic) (see Supplements, Estimating the Infectiousness of a TB Patient; Diagnostic Procedures for LTBI and TB Disease; and Treatment Procedures for LTBI and TB Disease).

Environmental Controls

The second level of the hierarchy is the use of environmental controls to prevent the spread and reduce the concentration of infectious droplet nuclei in ambient air.

Primary environmental controls consist of controlling the source of infection by using local exhaust ventilation (e.g., hoods, tents, or booths) and diluting and removing contaminated air by using general ventilation

Secondary environmental controls consist of controlling the airflow to prevent contamination of air in areas adjacent to the source (All rooms) and cleaning the air by using high efficiency particulate air (HEPA), filtration, or UVGI.

Respiratory-Protection Controls

The first two control levels minimize the number of areas in which exposure to *M. tuberculosis* might occur and, therefore, minimize the number of persons exposed. These control levels also reduce, but do not eliminate, the risk for exposure in the limited areas in which exposure can still occur. Because persons entering these areas might be exposed to *M. tuberculosis*, the third level of the hierarchy is the use of respiratory protective equipment in situations that pose a high risk for exposure. Use of respiratory protection can further reduce risk for exposure of HCWs to infectious droplet nuclei that have been expelled into the air from a patient with infectious TB disease (see

ENVIRONMENTAL HEALTH SCIENCES EXERCISE 1:
RISK ASSESSMENT: A CASE STUDY OF AN INVESTIGATION OF A
TUBERCULOSIS (TB) OUTBREAK IN A HEALTH CARE SETTING
INSTRUCTOR'S GUIDE VERSION 1.0

Respiratory Protection). The following measures can be taken to reduce the risk for exposure:

- implementing a respiratory-protection program,
- training HCWs on respiratory protection, and
- training patients on respiratory hygiene and cough etiquette procedures.

[**NOTE:** It is also important to note personal protective gear/equipment (PPE), based on new (2009-09) state (e.g., New Jersey) and then federal laws, must be provided and paid for by the employer via the supervisor or manager. A proper respiratory PPE program includes identifying the equipment to be used as well as proper fit and testing prior to actual use. The equipment typically includes replaceable cartridges to filter targeted biological and chemical agents of exposure (hazards).]

Works Cited (numbered as originally appeared in this referenced MMWR article):

56. Edlin BR, Tokars JI, Grieco MH, et al. An outbreak of multidrug-resistant tuberculosis among hospitalized patients with the acquired immunodeficiency syndrome. *N Engl J Med* 1992;326:1514–21.
57. Kenyon TA, Ridzon R, Luskin-Hawk R, et al. A nosocomial outbreak of multidrug-resistant tuberculosis. *Ann Intern Med* 1997;127:32–6.
86. Williams J, Schneider N, Gilligan ME. Implementing a tuberculosis control program. *Am J Infect Control* 1995;23:152–5.
93. Dooley SW, Jarvis WR, Martone WJ, Snider DE Jr. Multidrug-resistant tuberculosis. *Ann Intern Med* 1992;117:257–9.
94. Pearson ML, Jereb JA, Frieden TR, et al. Nosocomial transmission of multidrug-resistant *Mycobacterium tuberculosis*. A risk to patients and health care workers. *Ann Intern Med* 1992;117:191–6.
104. CDC. Drug-susceptible tuberculosis outbreak in a state correctional facility housing HIV-infected inmates—South Carolina, 1999–2000. *MMWR* 2000;49:1041–4.
107. Fennelly KP, Nardell EA. The relative efficacy of respirators and room ventilation in preventing occupational tuberculosis. *Infect Control Hosp Epidemiol* 1998;19:754–9.
108. Joint Commission on Accreditation of Healthcare Organizations. 2005 Critical access hospitals: surveillance, prevention, and control of infection. Oak Brook, IL: Joint Commission Resources; 2005.
109. Al Zahrani K, Al Jahdali H, Poirier L, Rene P, Menzies D. Yield of smear, culture and amplification tests from repeated sputum induction for the diagnosis of pulmonary tuberculosis. *Int J Tuberc Lung Dis* 2001;5:855–60.
110. Conde MB, Soares SL, Mello FC, et al. Comparison of sputum induction with fiberoptic bronchoscopy in the diagnosis of tuberculosis: experience at an acquired immune deficiency syndrome reference center in Rio de Janeiro, Brazil. *Am J Respir Crit Care Med* 2000;162:2238–40.
111. Bell D, Leckie V, McKendrick M. The role of induced sputum in the diagnosis of pulmonary tuberculosis. *J Infect* 2003;47:317–21.
112. Merrick ST, Sepkowitz KA, Walsh J, Damson L, McKinley P, Jacobs JL. Comparison of induced versus expectorated sputum for diagnosis of pulmonary tuberculosis by acid-fast smear. *Am J Infect Control* 1997;25:463–6.

Question 4

What environmental factors might increase the transmission risk of *M. tuberculosis*?

Question 5

There are multiple levels of environmental/industrial hygiene controls that are important in addressing an outbreak of an infectious disease like TB in an occupational setting. From the most important to first attempt to so-called "last resort options," these levels of controls are: process (source substitution, etc), engineering, administrative including behavioral and social or environmental, and personal protective equipment/gear. Please provide one example for each type of control.

Question 6

Building off of question 5, what is the difference between environmental controls and engineering controls?

Question 7

Referring back to principles of quantitative risk assessment, should economic considerations be addressed before instituting any appropriate industrial hygiene hierarchy controls? Please state why.

Answer Key for Question 4

The probability of the risk for transmission of *M. tuberculosis* is increased as a result of various environmental factors, including:

- Exposure to TB in small, enclosed spaces
- Inadequate local or general ventilation that results in insufficient dilution or removal of infectious droplet nuclei
- Recirculation of air containing infectious droplet nuclei
- Inadequate cleaning and disinfection of medical equipment
- Improper procedures for handling specimens

(Reference 2, page 6).

Answer Key for Question 5

Answers will vary, but will be found in excerpt.

For example, engineering controls include enhanced ventilation systems including filtration and the use of pressure differentials to isolate rooms of patients with TB, etc. For example, administrative controls include requiring surgical paper masks covering nose and mouth and/or gloves to be worn by staff at all times when entering rooms of patients with TB; frequent hand washing or use of waterless hand sanitizer; etc. For example, personal protective equipment/gear includes specialized respirators approved by federal agencies (NIOSH of U.S. CDC).

Answer Key to Question 6

Engineering controls are more specific to an individual process or apparatus affecting many workers. Also, engineering controls are relatively higher in priority on the industrial hygiene hierarchy than environmental controls. An example of environmental controls is a HEPA filter added to an existing HVAC system to enhance particle filtration for a specific area/indoor space. Examples of engineering controls are local exhaust ventilation (e.g., booths, hoods, and tents) and general ventilation (including directional airflow and negative pressure to isolate specific areas).

Answer Key to Question 7

Yes. The risks must be weighed against the costs and benefits of these control measures. Cost considerations should include the costs of failure to implement controls, both to equipment and to human/worker health (acute and/or chronic exposure effects) as well as the actual capital and maintenance costs of control measures. Furthermore, the benefits are both to human health (physical, mental) but also to equipment longevity.

Question 8

In considering TB risk assessment in a case such as the one described in referenced MMWR article, persons with any high risk factor(s) for the disease are considered by the U.S. CDC as candidates for tuberculin skin test screening. Please list three (3) risk factors for TB. These risk factors may include socio-demographics, factors related to exposure as well as susceptibility/vulnerability factors. You may refer to the CDC website Basic TB Facts³ <http://www.cdc.gov/tb/topic/basics/risk.htm> to answer this question as well.

Question 9

Environmental controls, consists of primary and secondary environmental controls. Please explain the difference(s) between these two levels.

Question 10

Environmental strategies for protecting building occupants against TB transmission, especially in healthcare settings, include building mechanical ventilation systems and negative pressure isolation rooms. This is related to epidemiologic concept of quarantine.

Please explain what a negative pressure room is. Also, please list an advantage and a disadvantage of negative pressure rooms.

Answer Key for Question 8

A person who is immunocompromised due to age (younger—infants, toddlers, primary-school aged children—or older adults/elderly), mal-/under-nutrition, co-infection with HIV, etc and/or also diagnosed with a cancer, kidney disease, diabetes Type I-II, etc (i.e., examples of co-morbidity).

[As examples, overall, about 5- 10% of infected persons who do not receive treatment for latent TB infection will develop TB disease at some time in their lives, and for persons whose immune systems are weak, especially those with HIV infection, the risk of developing TB disease is much higher than for persons with normal immune systems.³]

Persons at high risk for developing TB disease include:

- Persons who have immigrated from areas of world with high rates of TB;
- People in groups with historically high rates of TB transmission, such as homeless persons, injection drug users, and persons with HIV infection; and/or,
- Persons who work indoors or reside with people who are at high risk for TB in facilities or institutions such as hospitals, homeless shelters, correctional facilities, nursing homes, and residential homes for those with HIV.

Answer Key for Question 9

Primary environmental controls consist of controlling the source of infection, *i.e., the biological exposure agent. Examples include using local exhaust ventilation (e.g., hoods, tents, or booths) and diluting and removing contaminated air by using general ventilation.

Secondary environmental controls consist of controlling the airflow to prevent contamination of air in areas adjacent to the source. Examples include cleaning the air by using high efficiency particulate air (HEPA) filtration

Answer Key for Question 10

A negative pressure room is sealed and maintained using mechanical means at a relatively constant lower pressure than adjacent areas. The purpose is to prevent contaminated air from the room being isolated, such as a TB patient's room, from flowing into adjacent patient rooms or work areas like a nurse's station.

Advantage: Negative pressure rooms protect health workers and other patients.

Disadvantage: Negative pressure rooms are expensive and time consuming to build and maintain given the technology and trained/skilled staff required to establish one.

References Cited for Exercise 1 and Questions 1-10

1. U.S. Centers for Disease Control and Prevention. **Tuberculosis Outbreak in a Community Hospital —District of Columbia, 2002**. MMWR 2004;53:214-221. Retrieved from: <http://www.cdc.gov/mmwr/PDF/wk/mm5310.pdf>. Last accessed June 16, 2009.
2. U.S. Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of *Mycobacterium tuberculosis* in Health-Care Settings, 2005. MMWR 2005;54(No. RR-17):6-7. Retrieved from: <http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5417a1.htm>. Last accessed June 16, 2009.
3. U.S. Centers for Disease Control and Prevention. Basic TB Facts. Retrieved from: <http://www.cdc.gov/tb/topic/basics/risk.htm>. Last accessed June 16, 2009.

END OF INSTRUCTOR'S VERSION FOR EXERCISE 1