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 framework
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.

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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.*

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.
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.
STUDENT QUESTIONS FOR EXERCISE 1

The table below comes from the MMWR article\textsuperscript{1}. 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.

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?
Fundamentals of TB Infection Control

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 AII 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 (AII 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...
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):


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.
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 Facts[^3] [http://www.cdc.gov/tb/topic/basics/risk.htm](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.
Works Cited in Exercise

