

Chapter 7

Tuberculosis Infection Control

Table of Contents

Chapter Objectives.....	189
Introduction.....	191
Infectiousness.....	192
TB Infection Control Measures.....	196
TB Infection Control Program.....	199
TB Infection Control in Nontraditional Facility-based Settings.....	218
TB Infection Control in the Home.....	222
Chapter Summary.....	224
References.....	226

Chapter Objectives

After working through this chapter, you should be able to

- Describe the factors that determine the infectiousness of a tuberculosis (TB) patient;
- Explain the main goals of a TB infection control program;
- Discuss the three levels of an effective TB infection control program;
- Explain the purpose and the characteristics of a TB airborne infection isolation room; and
- Describe the circumstances when respirators and surgical masks should be used.

Introduction

M. tuberculosis can be transmitted in virtually any setting. Clinicians should be aware that transmission has been documented in health-care settings where health-care workers (HCWs) and patients come in contact with persons with infectious TB who

- Have unsuspected TB disease,
- Have **not** received adequate or appropriate treatment, or
- Have **not** been separated from others.

Health-care settings in this context include clinics and hospitals, as well as nontraditional facility-based settings such as emergency medical services, correctional facilities, home-based health-care and outreach settings, long-term care facilities, and homeless shelters. People who work or receive care in health-care settings (as referenced above) are at higher risk for becoming infected with *M. tuberculosis*; therefore, it is necessary to have a TB infection control plan as part of a general infection control program designed to ensure the following:

- Prompt detection of TB;
- Airborne precautions; and
- Treatment of persons who have been suspected or confirmed to have TB disease (see Chapter 2, Transmission and Pathogenesis of Tuberculosis).

People who work or receive care in health-care settings are at higher risk for becoming infected with *M. tuberculosis*; therefore, it is necessary to have a TB infection control plan.

Study Question

7.1 In which of the following health-care settings can TB be transmitted?

(circle the one best answer)

- F.** Where TB patients have **not** received adequate and appropriate treatment.
- G.** Where TB patients have **not** been separated from others.
- H.** Where persons who have unsuspected TB disease come into contact with others.
- I.** A, B, and C are all correct.
- J.** Only A and B are correct.

Infectiousness

The infectiousness of a TB patient is directly related to the number of droplet nuclei carrying *M. tuberculosis* (tubercle bacilli) that are expelled into the air. Depending on the environment, these tiny particles can remain suspended in the air for several hours. *M. tuberculosis* is transmitted through the air, **not** by surface contact. Infection occurs when a person inhales droplet nuclei containing *M. tuberculosis*, and the droplet nuclei traverse the mouth or nasal passages, upper respiratory tract, and bronchi to reach the alveoli of the lungs. Persons with extrapulmonary TB disease may have concurrent unsuspected pulmonary or laryngeal TB disease. Except for laryngeal TB disease, extrapulmonary TB disease is rarely infectious; however, transmission from extrapulmonary sites has been reported to occur during aerosol-producing procedures such as autopsies and tissue irrigation. The characteristics of a patient with TB disease that are associated with infectiousness include, but are not limited to, those listed in Table 7.1.

The infectiousness of a TB patient is directly related to the number of droplet nuclei carrying *M. tuberculosis* (tubercle bacilli) that are expelled into the air.

Infection occurs when a person inhales droplet nuclei containing *M. tuberculosis*, and the droplet nuclei traverse the mouth or nasal passages, upper respiratory tract, and bronchi to reach the alveoli of the lungs.

Table 7.1
Infectiousness of People Known to
Have or Suspected of Having TB Disease*

Factors Associated with Noninfectiousness	Factors Associated with Infectiousness
No cough	Presence of a cough
No cavity in the lung	Cavity in the lung
No acid-fast bacilli on sputum smear	Acid-fast bacilli on sputum smear
Extrapulmonary (non-pulmonary) TB disease	TB disease of the lungs, airway, or larynx
Receiving adequate treatment for 2 weeks or longer	Not receiving adequate treatment
Not undergoing cough-inducing procedures	Undergoing cough-inducing procedures (e.g., bronchoscopy, sputum induction, and administration of aerosolized medications)
Negative sputum cultures	Positive sputum cultures

* Infectiousness depends on a variety of factors. Clinicians should consider all of these factors when determining whether a TB patient should be considered infectious.

In general, young children with pulmonary TB disease are **less** likely than adults to be infectious, because children are sometimes unable to produce sputum when they cough, or may have paucibacillary TB. However, it is still possible for children to transmit *M. tuberculosis* to others if they have infectious characteristics, such as a positive AFB smear or cavity on a chest radiograph.

In general, young children with pulmonary TB disease are less likely than adults to be infectious, because children are sometimes unable to produce sputum when they cough, or may have paucibacillary TB.

For most patients, infectiousness appears to decline rapidly after adequate and appropriate treatment is started; however, the rate of decline varies from patient to patient. Some patients with unrecognized or inadequately treated drug-resistant TB disease may remain infectious for weeks or even months. Patients with drug-resistant TB disease may **not** respond to the initial drug regimen, acquire further drug resistance, and remain infectious until they receive adequate treatment.

Infectiousness appears to decline rapidly after adequate and appropriate treatment is started; however, the rate of decline varies from patient to patient.

Persons with extrapulmonary TB disease are usually noninfectious unless they also have pulmonary disease, TB disease located in the oral cavity or the larynx, or extrapulmonary disease that includes an open abscess or lesion in which the concentration of organisms is high. Pulmonary TB should be ruled out when there is a diagnosis of extrapulmonary TB disease. Table 7.2 indicates the criteria for patients to be considered noninfectious.

Table 7.2
Criteria for Patients to Be Considered Noninfectious

Criteria
<p>Patients can be considered noninfectious when they meet all of the following three criteria:</p> <ol style="list-style-type: none"> 1. They have three consecutive negative AFB sputum smears collected in 8- to 24-hour intervals (at least one being an early morning specimen); 2. Their symptoms have improved clinically (for example, they are coughing less and they no longer have a fever); and 3. They are compliant with an adequate treatment regimen for 2 weeks or longer.

It is important to consider the environmental factors that enhance the probability that *M. tuberculosis* will be transmitted (Table 7.3).

Table 7.3
Environmental Factors that Enhance the Probability that
***M. tuberculosis* Will Be Transmitted**

Factor	Description
Concentration of infectious bacilli	The more bacilli in the air, the more probable that <i>M. tuberculosis</i> will be transmitted
Space	Exposure in small, enclosed spaces
Ventilation	Inadequate local or general ventilation that results in insufficient dilution or removal of infectious droplet nuclei
Air circulation	Recirculation of air containing infectious droplet nuclei
Specimen handling	Improper specimen handling procedures that generate infectious droplet nuclei
Air pressure	Positive air pressure in infectious patient's room that causes <i>M. tuberculosis</i> organisms to flow to other areas

Study Questions

Indicate if the following statements about infectiousness are true or false.

(Choose the one best answer and write the letter for the correct answer on the line next to the question number.)

Patients		True or False
_____ 7.2	Children are more likely than adults to be infectious.	A. True
_____ 7.3	For most patients, infectiousness appears to decline rapidly after adequate treatment is started.	B. False
_____ 7.4	Some patients with unrecognized or inadequately treated drug-resistant TB disease may remain infectious for weeks or even months.	
_____ 7.5	Patients with drug-resistant TB disease may not respond to the initial drug regimen, acquire further drug resistance, and may remain infectious until they receive adequate treatment.	

7.6 Patients can be considered noninfectious when they meet which of the following criteria?

(choose the one best answer)

- A.** They are compliant with an adequate regimen for 2 weeks or longer.
- B.** Their symptoms have improved clinically.
- C.** They have three consecutive negative sputum smears collected in 8- to 24-hour intervals (at least one being an early morning specimen).
- D.** A, B, and C are all correct.
- E.** Only A and B are correct.

7.7 Which of the following environmental factors can enhance the probability that *M. tuberculosis* will be transmitted?

(choose the one best answer)

- A.** Concentration of infectious bacilli in the air
- B.** Exposure in small, enclosed spaces
- C.** Inadequate local or general ventilation that results in insufficient dilution or removal of infectious droplet nuclei
- D.** A, B, and C are all correct.
- E.** Only A and B are correct.

TB Infection Control Measures

TB infection control measures should be based on a careful assessment of risk for transmission of TB in the facility or setting. The goals of effective TB infection control programs are to

- Detect TB disease early and promptly;
- Isolate those who have or are suspected of having TB disease (airborne precautions); and
- Treat people who have or who are suspected of having TB disease.

TB infection control measures should be based on a careful assessment of risk for transmission of TB in the facility or setting.

Detection of TB Disease

The primary risk to health-care workers (HCWs) and the general population is the undiagnosed or unsuspected patient with TB disease. Within health-care settings, protocols should be implemented and enforced to promptly identify, isolate, separate, and either transfer or manage persons who have suspected or confirmed TB disease. Personnel who admit patients to facilities should be trained to detect signs and symptoms of TB disease. People suspected of having TB disease should be given a diagnostic evaluation as soon as possible (see Chapter 4, Diagnosis of Tuberculosis Disease). Clinicians and other HCWs should suspect TB disease in people who have any of the symptoms listed in Table 7.4 and isolate them until TB is excluded.

Table 7.4
Symptoms of TB Disease

Symptoms
<p>People who have any of the following symptoms should be evaluated for TB disease:</p> <ul style="list-style-type: none">• Persistent cough (3 weeks or longer);• Chest pain;• Bloody sputum;• Weight loss or loss of appetite;• Fever;• Chills;• Night sweats;• Malaise; or• Fatigue

The primary risk to health-care workers (HCWs) and the general population is the undiagnosed or unsuspected patient with TB disease.

Airborne Precautions

TB airborne precautions should be initiated for any patient who has signs or symptoms of TB disease (suspected TB), or who has documented infectious TB disease and remains infectious in spite of treatment.

TB airborne precautions should be initiated for any patient who has signs or symptoms of TB disease (suspected TB), or who has documented infectious TB disease and remains infectious in spite of treatment.

Persons who have or are suspected of having infectious TB disease should be placed in an area away from other patients, preferably in an airborne infection isolation (AII) room. An AII room is a single-occupancy patient-care room in which environmental factors are controlled to minimize transmission of infectious agents. If a facility does **not** have an AII room, patients should be placed in a room that has been designated for isolation of persons with suspected or known infectious TB disease and, if possible, referred to a facility with an AII room.

A patient who has drug-susceptible TB of the lung, airway, or larynx, who is on standard multidrug antituberculosis treatment, and who has had a substantial clinical and bacteriologic response to therapy (e.g., reduction in cough, resolution of fever, and progressively decreasing quantity of AFB on smear result) is probably no longer infectious. However, because culture and drug-susceptibility results are not usually known when the decision to discontinue airborne precautions is made, all patients with suspected TB disease should remain under airborne precautions until they have had three consecutive negative AFB sputum smear results, each collected in 8- to 24-hour intervals, with at least one being an early morning specimen; have received standard multidrug antituberculosis treatment (minimum of 2 weeks); and have demonstrated clinical improvement.

Airborne precautions in a health-care or congregate setting may be discontinued when a patient has been on adequate therapy for 2 weeks or longer, symptoms improve, and there have been three consecutive, negative AFB sputum smear results.

Treatment

Patients who have confirmed TB disease, or who are considered highly probable to have TB disease, should promptly start appropriate treatment (see Chapter 6, Treatment of Tuberculosis Disease).

Study Questions

7.8 Which of the following is NOT a goal of an effective TB infection control program?

(choose the one best answer)

- A. Detect TB disease early and promptly.
- B. Isolate from others those people who have or are suspected of having TB disease.
- C. Ensure everyone wears a personal respirator.
- D. Treat people who have or are suspected of having TB disease.

7.9 The primary risk to health-care workers and the general population is the undiagnosed or unsuspected patient with TB disease.

(choose the one best answer)

- A. True
- B. False

7.10 TB airborne precautions should be initiated for which of the following patients?

(choose the one best answer)

- A. Any patient who has signs or symptoms of TB disease
- B. Any patient who has documented infectious TB disease and remains infectious in spite of treatment
- C. Any patient who has TB meningitis
- D. A, B, and C are all correct.
- E. Only A and B are correct.

TB Infection Control Program

A TB infection control program should be based on the following three levels of hierarchy (Table 7.8):

1. **Administrative controls**, which reduce risk of exposure;
2. **Environmental controls**, which prevent spread and reduce concentration of droplet nuclei; and
3. **Respiratory-protection controls**, which further reduce risk of exposure in special areas and circumstances.

1. Administrative Controls

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

- Assigning someone the responsibility and authority for TB infection control in the health-care setting;
- Conducting a TB infection control risk assessment of the setting;
- Developing and instituting a written TB infection control plan to ensure prompt detection, separation from others (into an AII room if possible), and treatment of persons who have suspected or confirmed TB disease;
- Ensuring the availability of recommended laboratory processing, testing, and reporting of results;
- Implementing effective work practices for managing patients who may have TB disease;
- Ensuring proper cleaning, sterilization, or disinfection of equipment that might be contaminated (e.g., endoscopes);
- Educating, training, and counseling HCWs, patients, and visitors about TB infection and disease;
- Testing and evaluating workers who are at risk for exposure to TB disease;
- Applying epidemiology-based prevention principles, including the use of setting-related TB infection control data;
- Using posters and signs to remind patients and staff of proper cough etiquette (covering mouth when coughing) and respiratory hygiene; and
- Coordinating efforts between local health department and high-risk health-care and congregate settings.

The first and most important level of a TB infection control program is the use of administrative measures to reduce the risk for exposure to persons who might have TB disease.

Health-Care Worker Education and Training

Health-care worker (HCW) education and training on TB infection and disease is an essential part of a TB infection control program and can increase adherence to TB infection control measures. Education and training should emphasize the increased risks posed by an undiagnosed person with TB disease in a health-care setting and the specific measures to reduce this risk. Health-care settings should document that all HCWs, including physicians, have received training relevant to their work setting. Resources for TB education and training can be found on the following websites:

- CDC DTBE website (www.cdc.gov/tb);
- Find TB Resources website (www.findtbresources.org); and
- Regional Training and Medical Consultation Centers' TB Training and Education Products website (<https://sntc.medicine.ufl.edu/rtmccproducts.aspx>.)

All health-care settings should conduct an annual evaluation for follow-up education and training based on the

- Number of untrained or new HCWs;
- Changes in the organization and services of the health-care setting; and
- Availability of new TB infection control information.

Facility Risk Assessment

Health-care and congregate settings should conduct an annual evaluation of the risk for transmission of *M. tuberculosis*. The risk assessment determines the type of administrative, environmental, and respiratory-protection controls needed by examining the

- Number of patients with TB disease in the setting;
- Promptness of detection, isolation, and evaluation of patients with suspected or confirmed TB disease;
- Evidence of transmission of *M. tuberculosis* in the setting; and
- Community rate of TB disease.

Health-care and congregate settings should conduct an annual evaluation of the risk for transmission of *M. tuberculosis*.

Risk Classification

The purpose of the risk classification is to determine the need for a TB testing program for HCWs and the frequency of testing. The risk classification, or risk level, will vary; however, all settings should perform risk classification as part of risk assessment to determine the need for and frequency of a HCW testing program, regardless of the likelihood of encountering persons with TB disease. Baseline TB testing should be conducted for HCWs upon hiring (see Chapter 3, Testing for Tuberculosis Infection and Disease). The three TB risk classifications are indicated in Table 7.5.

Table 7.5
TB Risk Classifications

Risk Classification	Need for Testing	Frequency of Testing
Low risk	Should be used for settings in which persons with TB disease are not expected to be encountered.	Exposure to <i>M. tuberculosis</i> in these settings is unlikely, and further testing is not needed unless exposure has occurred.
Medium risk	Should be used for facilities in which the risk assessment has determined that HCWs will possibly be exposed to persons with TB disease.	Repeat testing should be done annually.
Potential ongoing transmission	Should be temporarily assigned to any setting where there is evidence of person-to-person transmission of <i>M. tuberculosis</i> in the past year.	Testing should be repeated every 8 to 10 weeks until there is no evidence of ongoing transmission.

2. Environmental Controls

The second level of hierarchy is the use of environmental controls to prevent the spread and reduce the concentration of droplet nuclei and includes:

- Primary environmental controls; and
- Secondary environmental controls (Table 7.6).

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

**Table 7.6
Environmental Controls**

Primary Environmental Control	Secondary Environmental Control
<p>Controls the source of infection by diluting and removing contaminated air and by using general ventilation</p> <ul style="list-style-type: none"> • Uses natural ventilation (e.g., open doors, windows) • Uses mechanical ventilation equipment to circulate and move air in a building • Uses local exhaust ventilation (e.g., hoods, tents, or booths) 	<p>Controls airflow in areas adjacent to the source and cleans air</p> <ul style="list-style-type: none"> • Controls the airflow to prevent contamination of air in areas adjacent to the source (AII rooms) • Cleans the air by using high efficiency particulate air (HEPA) filtration or ultraviolet germicidal irradiation (UVGI)

Primary Environmental Controls

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.

Ventilation is the movement and the replacement of air in a building with air from the outside or with clean, recirculated air. When fresh air enters a room, it dilutes the concentration of particles in room air, such as droplet nuclei. There are two types of ventilation:

- Natural ventilation
- Mechanical ventilation

Natural Ventilation

Natural ventilation relies on cross ventilation in a building designed for good air exchange; for example, the use of open doors and windows to bring in air from outside. Natural ventilation can be useful for nontraditional facility-based and congregate settings that do not have a central ventilation system. In these settings, waiting rooms, shelter dormitories, or other rooms in which people congregate should have an operable window, door, or skylight that is kept open as often as possible. Fans can be used to help distribute the air (Figure 7.1). If the direction of airflow is unknown, staff should sit near the fresh air source and clients should sit near the exhaust location (Figure 7.2). This can help protect staff from droplet nuclei expelled by patients with unidentified TB disease. In addition to these environmental measures, cough etiquette and respiratory hygiene should be encouraged to further reduce risk (Figure 7.3).

Figure 7.1
Exhaust Fan Used for Distributing Air



Figure 7.2
Natural Ventilation in TB Exam or Counseling Room

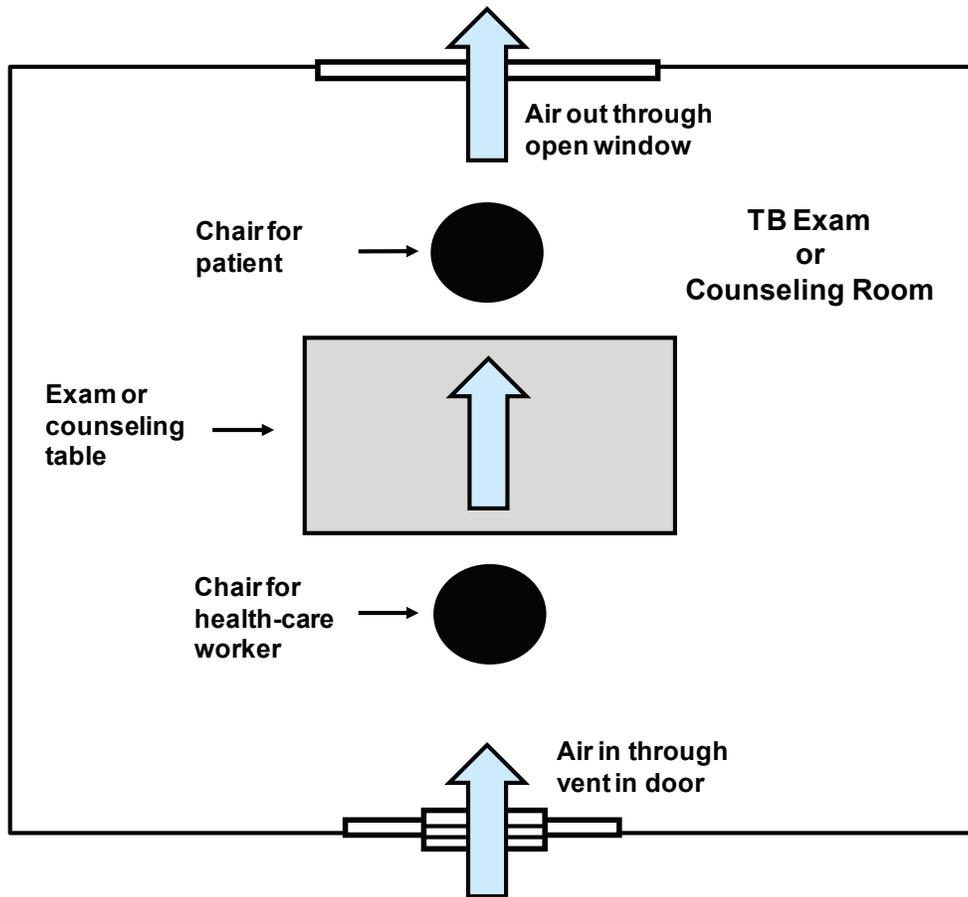


Figure 7.3
Person with Infectious TB in Waiting Room



Mechanical Ventilation

Mechanical ventilation refers to the use of equipment to circulate and move air in a building. Mechanical ventilation should be used by hospitals, TB clinics, and other health-care and congregate settings expecting to see a confirmed or suspected TB patient. Mechanical ventilation consists of

- Local exhaust ventilation; and
- General ventilation.

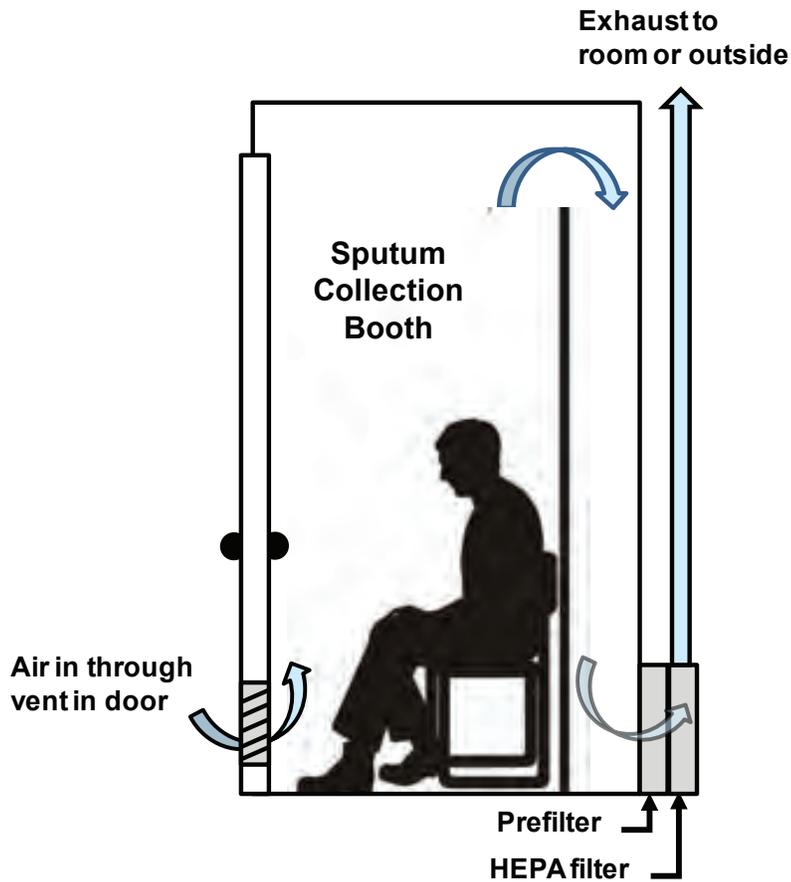
Local exhaust ventilation stops airborne contaminants before they spread into the general environment. Local exhaust ventilation includes the use of

- External hoods;
- Booths; and
- Tents.

Local exhaust ventilation should be used for cough-inducing and aerosol-generating procedures (Figure 7.4). If local exhaust ventilation **cannot** be used, cough-inducing and aerosol-generating procedures should be performed in an AII room. If an AII room is **not** available, the procedures should be performed outdoors and away from

- People;
- Windows; and
- Air intakes.

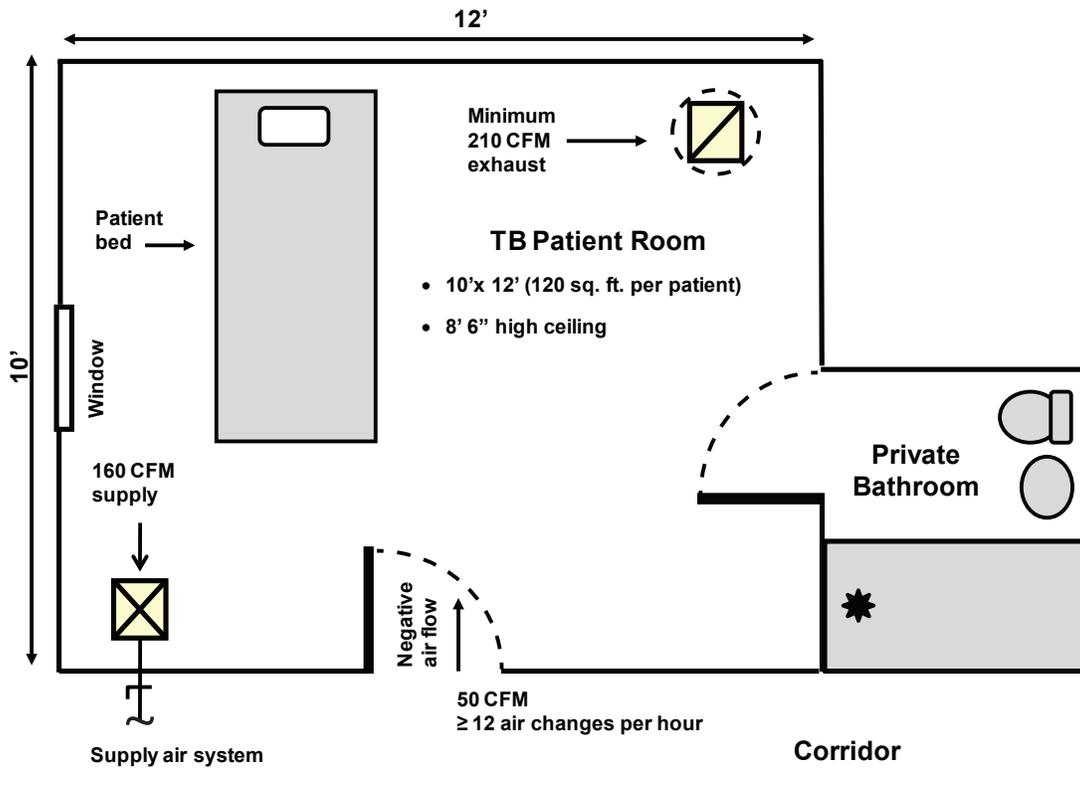
Figure 7.4
Local Exhaust in Sputum Collection Booth



General ventilation systems maintain air quality in health-care settings by the

- Dilution of contaminated air;
- Removal of contaminated air; and
- Control of airflow patterns in the patient's procedure room or setting (e.g., negative pressure in AII rooms) (Figure 7.5).

Figure 7.5
Airborne Infection Isolation (AII) Room



TB AII rooms are designed to prevent the spread of droplet nuclei expelled by a patient with TB disease. In TB clinics, hospitals, and other inpatient settings, patients known to have TB disease or suspected of having TB disease should be placed in a TB AII room immediately. Health-care facilities that provide care for patients with suspected or confirmed TB disease should have at least one AII room. Medical facilities in correctional settings should also have at least one AII room. The need for additional AII rooms should be based on the TB risk assessment for the setting.

In TB clinics, hospitals, and other inpatient settings, patients known to have TB disease or suspected of having TB disease should be placed in a TB AII room immediately.

Health-care facilities that provide care for patients with suspected or confirmed TB disease and medical facilities in correctional settings should have at least one AII room.

One characteristic of AII rooms is their negative pressure relative to other parts of the facility. Negative pressure causes air to flow from the corridors into the AII room. The air from the AII room **cannot** escape to the other parts of the health-care setting when the door is closed and the ventilation system is operating properly. The doors and windows of AII rooms must be kept closed as much as possible in order to maintain negative pressure, and the pressure must be checked periodically to make sure that it remains negative. Air from the AII room can be exhausted directly to the outdoors, where the droplet nuclei will be diluted in the outdoor air, or passed through a special high efficiency particulate air (HEPA) filter that removes most (99.97%) of the droplet nuclei before it is returned to the general circulation. If a HEPA filter is **not** used, the air should be exhausted directly to the outside away from air-intake vents, persons, and animals, in accordance with applicable federal, state, and local regulations on environmental discharges.

One characteristic of AII rooms is the negative pressure relative to other parts of the facility. Negative pressure allows air to flow from the corridors into the AII room.

Air from the AII room can be exhausted directly to the outdoors, where the droplet nuclei will be diluted in the outdoor air, or passed through a special high efficiency particulate air filter that removes most (99.97%) of the droplet nuclei before it is returned to the general circulation.

In existing health-care settings, AII rooms should have airflow of six or more air changes per hour (ACH). In new or renovated health-care settings, AII rooms should have airflow of at least 12 ACH. When feasible, the airflow in existing health-care setting AII rooms should be increased to 12 ACH by

- Adjusting or modifying the ventilation system; or
- Using air-cleaning methods: room-air recirculation units containing HEPA filters or ultraviolet germicidal irradiation (UVGI) systems that increase the equivalent ACH.

It is important that AII rooms be single-patient rooms with a private bathroom. Entry of visitors and HCWs should be restricted and monitored to minimize the transmission of *M. tuberculosis*. All HCWs who enter an AII room should wear N95 disposable filtering facepiece respirators (see Respiratory-Protection Controls). An N95 respirator should be fitted correctly before using. Visitors should be offered and encouraged to use respiratory protection (i.e., N95 respirator) and instructed by HCWs on how to use it.

Health-care settings with AII rooms should observe the policies and practices indicated in Table 7.7.

Table 7.7
Policies and Practices for Airborne Infectious Isolation
(AII) Rooms in Health-Care Settings

Policies and Practices
<ul style="list-style-type: none"> • Keep doors and windows closed as much as possible; • Maintain an adequate number of AII rooms; • Check negative pressure by monitoring and recording the direction of airflow on a daily basis; • Perform diagnostic and treatment procedures in the AII room; • Ensure patients adhere to AII precautions; • Group AII rooms in one part of the health-care setting; • Schedule patients with suspected and confirmed infectious TB disease for procedures when few HCWs and no other patients are present; • Provide a surgical mask for patients with suspected or confirmed infectious TB disease during transport, in waiting areas, and when others are present; and • Review environmental control maintenance procedures and logs to determine if maintenance is being conducted properly and regularly.

Secondary Environmental Controls

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 HEPA filtration (Figure 7.6) or ultraviolet germicidal irradiation (UVGI) (Figure 7.7). HEPA filters can be used to filter droplet nuclei from the air and must be used when discharging air from:

- Local exhaust ventilation booths or enclosures directly into the surrounding room or area; and
- An AII room (or other negative-pressure room) into the general ventilation system (e.g., in settings in which the ventilation system or building configuration makes venting the exhaust to the outside impossible).

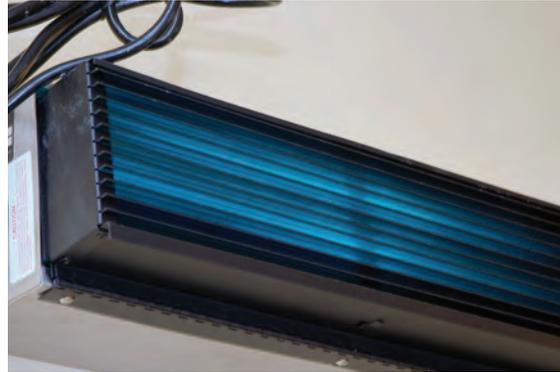
Secondary environmental controls consist of controlling the airflow to prevent contamination of air in areas adjacent to the source (AII rooms) and cleaning the air by using HEPA filtration or UVGI.

UVGI is an air-cleaning technology that consists of the use of special lamps that give off germicidal ultraviolet irradiation (wave length=254 nm). The lamps are used to inactivate the tubercle bacilli contained in the droplet nuclei. Overexposure to UV light can be harmful to the skin and eyes; lamps must be installed in the upper part of rooms or corridors or placed in exhaust ducts. Regular, appropriate maintenance is essential to ensure UVGI lamps are operating correctly.

Figure 7.6
HEPA Filter



Figure 7.7
Ultraviolet Germicidal Irradiation (UVGI)



3. Respiratory-Protection Controls

Respiratory-protection control is the third level of a TB infection control program and consists of the use of personal protective equipment in situations that pose a high risk for exposure to TB disease (Figure 7.8). Use of respiratory protection can further reduce risk for exposure of HCWs to droplet nuclei expelled into the air. The following measures can be taken to reduce risk for exposure:

- Implementing a respiratory-protection program;
- Training HCWs on respiratory protection; and
- Educating patients on respiratory hygiene and the importance of cough etiquette.

Respiratory-protection control is the third level of a TB infection control program and consists of the use of protective equipment in situations that pose a high risk for exposure to TB disease.

Figure 7.8
Health-Care Worker and Infectious TB Patient
Using Respiratory Protection



All health-care settings that use respiratory-protection controls are required by the Occupational Safety and Health Administration (OSHA) to develop, implement, and maintain a respiratory-protection program.

Administrative and environmental controls minimize the number of areas in which exposure to *M. tuberculosis* might occur and therefore minimize the number of persons exposed. These control measures also reduce, but do **not** eliminate, the risk for exposure in limited areas. In these settings, respiratory protection should be used by all persons, including HCWs and visitors. These settings include:

- TB AII rooms;
- Rooms where cough-inducing or aerosol generating procedures are done;
- Ambulances and other vehicles transporting infectious TB disease patients; and
- Homes of infectious TB disease patients (for HCWs; other persons should not visit the homes of infectious persons).

The effectiveness of a respiratory-protection program requires the development of written standard procedures. Standard procedures should include information and guidance for the proper selection, use, and care of respirators. Settings where HCWs use respiratory protection to prevent transmission of *M. tuberculosis* should develop, implement, and maintain a respiratory-protection program. The program should provide HCWs with annual training on TB control, TB infection control, and respiratory protection, including fit-testing.

Settings where HCWs use respiratory protection to prevent transmission of *M. tuberculosis* should develop, implement, and maintain a respiratory-protection program.

The minimum respiratory protection is a filtering face-piece respirator and must be selected from those approved by CDC/National Institute for Occupational Safety and Health (NIOSH) under Title 42 CFR, Part 84. It must meet one of the following specifications:

- Nonpowered air-purifying respirators (N95, N99, N100, R95, R99, R100, P95, P99, and P100), including disposables;
- Powered air-purifying respirators (PAPRs) with high-efficiency filters; or
- Supplied-air respirators.

It is important that respirators fit different face sizes and features properly. It is also important to understand the difference between respirators and surgical masks.

Respirators are designed to protect HCWs and other individuals from inhaling droplet nuclei (Figure 7.9). Surgical masks are designed to reduce the number of droplets being exhaled into the air by persons with infectious TB disease when they breathe, talk, cough, or sneeze (Figure 7.10). Persons suspected or confirmed to have infectious TB disease should be given, and encouraged to use, a surgical mask to minimize the risk of expelling droplet nuclei into the air.

Respirators are designed to protect HCWs and other individuals from inhaling droplet nuclei.

Surgical masks are designed to reduce the number of droplets being exhaled into the air by persons with infectious TB disease when they breathe, talk, cough, or sneeze.

Figure 7.9
Respirator for
Health-Care Workers



Health-care worker wearing
a respirator



Respirators

- Designed to filter out droplet nuclei from being inhaled by the health-care worker and other individuals.
- Should properly fit different face sizes and features.
- Should **NOT** be worn by the patient.

Figure 7.10
Surgical Mask for
Persons with Infectious TB Disease



Infectious TB patient wearing
a surgical mask



Surgical masks

- Designed to stop droplet nuclei from being spread (exhaled) by the patient.
- Should **NOT** be worn by the health-care worker

Table 7.8
TB Infection-Control Program: Level of Controls

Administrative Controls
<ul style="list-style-type: none"> • Assign responsibility for TB infection control • Conduct TB risk assessment • Develop and institute a written TB infection-control plan • Ensure the timely availability of recommended laboratory processing, testing, and reporting of results • Implement effective work practices for the management of patients with suspected or confirmed TB disease • Ensure proper cleaning and sterilization or disinfection of potentially contaminated equipment • Train and educate health-care workers • Test and evaluate health-care workers for TB infection and disease • Apply epidemiology-based prevention principles • Use posters and signs demonstrating and advising respiratory hygiene and cough etiquette • Coordinate efforts with the local or state health department.
Environmental Controls
<ul style="list-style-type: none"> • Reduce concentration of infectious droplet nuclei through the following technologies: <ul style="list-style-type: none"> » Ventilation technologies, including <ul style="list-style-type: none"> – Natural ventilation – Mechanical ventilation » High efficiency particulate air filtration (HEPA) » Ultraviolet germicidal irradiation (UVGI)
Respiratory Protection Controls
<ul style="list-style-type: none"> • Implement a respiratory-protection program • Train health-care workers on respiratory protection • Educate patients on respiratory hygiene and the importance of covering their cough • Test HCWs for mask fit and functionality

Study Questions

Case study– Jose

Jose, the Harris County TB Control Manager, is conducting a risk assessment to determine the type of administrative, environmental, and respiratory-protection controls that are needed in his area.

7.11 What things should Jose examine?

(choose the one best answer)

- A. Number of patients with TB disease in the setting and the community rate of TB disease
- B. Evidence of transmission of *M. tuberculosis* in the setting
- C. Promptness of detection, isolation, and evaluation of patients with suspected or confirmed TB disease.
- D. A, B, and C are all correct.
- E. Only A and B are correct.

Match the setting and testing characteristics for each type of TB risk classification.

(Choose the one best answer and write the letter for the correct answer on the line next to the question number.)

Setting and Testing Characteristics	TB Risk Classification
____ 7.12 Temporarily assigned to any setting with evidence of person-to-person transmission of <i>M. tuberculosis</i> in the past year.	A. Low-risk classification
____ 7.13 Setting where persons with TB disease are not expected to be encountered.	B. Medium-risk classification
____ 7.14 Facilities in which the risk assessment has determined that health-care workers will possibly be exposed to persons with TB disease.	C. Potential ongoing transmission classification
____ 7.15 Repeat testing is not needed unless exposure has occurred.	
____ 7.16 Repeat testing should be done every 8 to 10 weeks until there is no evidence of ongoing transmission.	
____ 7.17 Repeat testing should be done annually.	

Indicate whether the types of environmental controls below are primary or secondary controls. (Choose the one best answer and write the letter for the correct answer on the line next to the question number.)

Environmental Controls	Primary/Secondary Controls
___ 7.18 HEPA filtration	A. Primary control
___ 7.19 Natural, mechanical, and local exhaust ventilation	B. Secondary control
___ 7.20 Ultraviolet germicidal irradiation	
___ 7.21 Controls airflow in areas adjacent to the source and cleans air	
___ 7.22 Controls the source of infection by diluting and removing contaminated air and by using general ventilation	

Indicate if the following statements about TB airborne infection isolation (AII) rooms are true or false. (Choose the one best answer and write the letter for the correct answer on the line next to the question number.)

Statements about TB AII Rooms	True or False
___ 7.23 Designed to prevent the spread of the droplet nuclei to other rooms in the facility.	A. True B. False
___ 7.24 Have positive pressure relative to other parts of the facility.	
___ 7.25 Air from the AII room is exhausted directly to the outdoors, or passes through a special filter that removes all of the droplet nuclei.	
___ 7.26 Entry of visitors and health-care workers should be restricted and monitored to minimize the transmission of <i>M. tuberculosis</i> .	
___ 7.27 Patients staying in AII rooms should wear N95 disposable filtering face-piece respirators.	
___ 7.28 AII rooms can be used for multiple patients.	

7.29 Which of the following respiratory protection measures reduces risk for exposure to TB disease? (choose the one best answer)

- A.** Implementing a respiratory-protection program
- B.** Training health-care workers on respiratory protection
- C.** Educating patients on respiratory hygiene and the importance of cough etiquette
- D.** A, B, and C are all correct.
- E.** Only A and B are correct.

7.30 Which of the following statements about respiratory protection is true? (choose the one best answer)

- A.** Respirators are designed to protect health-care workers and other individuals from inhaling droplet nuclei.
- B.** Surgical masks are designed to reduce the number of droplets being exhaled into the air by persons with infectious TB disease.
- C.** Health-care workers can wear surgical masks for protection against droplet nuclei, and persons with infectious TB disease can wear respirators to prevent the spread of TB.
- D.** A, B, and C are all correct.
- E.** Only A and B are correct.

Match the activities with the type of TB infection control.

(Choose the one best answer and write the letter for the correct answer on the line next to the question number.)

Activities	TB Infection Controls
____ 7.31 Use natural exhaust ventilation and mechanical ventilation to remove contaminated air.	A. Administrative controls
____ 7.32 Use personal protective equipment in situations that pose a high risk for exposure to TB disease.	B. Environmental controls
____ 7.33 Assign someone the responsibility and authority for TB infection control in the health-care setting.	C. Respiratory protection controls
____ 7.34 Ensure the availability of recommended laboratory processing, testing, and reporting of results.	
____ 7.35 Control the airflow to prevent contamination of air in areas adjacent to the source and clean the air by using HEPA filtration or UVGI.	
____ 7.36 Conduct a TB infection control risk assessment of the setting.	

TB Infection Control in Nontraditional Facility-Based Settings

All nontraditional facility-based settings where patients with TB disease receive care should establish and follow a TB infection control program. These settings include but are **not** limited to

- Correctional facilities;
- Homeless shelters;
- Long-term care facilities;
- Home-based health-care and outreach settings; and
- Emergency medical services (EMS) (Table 7.9).

All nontraditional facility-based settings where patients with TB disease receive care should establish and follow a TB infection control program.

Correctional Facilities

TB disease can be a substantial health concern in correctional facilities. TB outbreaks in correctional facilities can lead to transmission in surrounding communities. Health-care settings in correctional facilities should be classified as at least **medium risk** based on the possibility of exposure to persons with TB disease. Correctional facilities overall are classified as minimal risk or non-minimal risk based on the TB risks of the population housed in the facility. A respiratory-protection program should be implemented with at least one AII room available where inmates with suspected or confirmed TB disease can be isolated immediately. Those inmates who must be transported should wear a surgical mask during transport. Correctional facilities should maintain a tracking system for inmate TB testing and treatment, and establish a mechanism for sharing this information with state and local health departments and other correctional facilities.

Homeless Shelters

TB disease is more common in the homeless population than in the general population. Several factors in the shelter environment can influence the likelihood of *M. tuberculosis* transmission, including crowding and the state of the ventilation system. The absolute number and population density of persons sharing the same breathing space is important. If all other factors are constant, the size of the shelter population is directly proportional to the likelihood that someone with infectious TB will be present and that someone else will become infected. Conversely, the smaller the population and less crowded the shelter, the lower the risk. Homeless shelters should implement a tracking system for clients and establish a mechanism for sharing this information with state and local health departments when appropriate.

Long-Term Care Facilities

TB disease poses a health risk in long-term care facilities (LTCFs) such as hospice and skilled-nursing facilities. Transmission of *M. tuberculosis* has occurred in LTCFs and pulmonary TB disease has been documented in HIV-infected patients and other immunocompromised patients residing in hospices. LTCFs must have adequate administrative and environmental controls if they accept patients with suspected or confirmed infectious TB disease. These include airborne precaution capabilities and a respiratory-protection program. People most at risk in LTCFs include

- Patients;
- HCWs;
- Visitors; and
- Volunteers

Home-Based Health-Care and Outreach Settings

Transmission of *M. tuberculosis* has been documented in home-based health-care and outreach settings. HCWs in these settings should be able to

- Evaluate signs and symptoms of TB disease for early detection and treatment;
- Educate patients on the importance of reporting symptoms and signs of TB disease; and
- Wear an N95 personal respirator when entering homes of persons with suspected or confirmed infectious TB disease or when transporting such persons in an enclosed vehicle.

Emergency Medical Services (EMS)

Although the overall risk is low, there has been documented transmission of *M. tuberculosis* in EMS occupational settings. EMS personnel should be included in

- Comprehensive training, education, and testing programs for TB infection; and
- Follow-up testing as indicated by the risk classification of the setting.

Drivers, HCWs, and other staff transporting patients with suspected or confirmed TB should wear an N95 respirator, and the patients should wear a surgical mask. In addition, ambulances should allow for the maximum amount of outdoor air to be circulated in the vehicle.

Table 7.9
TB Infection Control for Nontraditional Settings

Setting	Transmission of <i>M. tuberculosis</i>	Screening/testing	Recommendations
Correctional facilities	<ul style="list-style-type: none"> • Substantial health concern • TB outbreaks in these settings can lead to transmission in surrounding communities • Health-care settings in these facilities are at least medium risk 	<ul style="list-style-type: none"> • All correctional staff should be screened and tested for TB annually 	<ul style="list-style-type: none"> • Implement a respiratory-protection program with at least one AII room or have a transfer policy • Inmates with suspected or confirmed TB disease should be isolated immediately and wear a surgical mask when being transported outside of an AII room • Facilities should maintain a tracking system for sharing information with state and local health departments and other correctional facilities
Homeless shelters	<ul style="list-style-type: none"> • Occurs in these settings • More common in homeless shelters than in general population • Frequent visitors are at risk of exposure 	<ul style="list-style-type: none"> • Symptom screening 	<ul style="list-style-type: none"> • Evaluate the resident for signs and symptoms of TB disease for early detection and treatment • Educate staff on importance of reporting signs and symptoms of TB disease

Setting	Transmission of <i>M. tuberculosis</i>	Screening/testing	Recommendations
Long-term care facilities	<ul style="list-style-type: none"> Occurs in these settings Poses a health risk to patients, health-care workers, visitors, and volunteers 	<ul style="list-style-type: none"> New employees and residents should receive symptom screening and possibly testing upon entry 	<ul style="list-style-type: none"> Must have adequate administrative and environmental controls that include <ul style="list-style-type: none"> » Airborne precaution capabilities » Respiratory-protection program Patients with suspected or confirmed infectious TB disease should not stay in LTCFs unless adequate administrative and environmental controls are in place
Home-based health-care and outreach settings	<ul style="list-style-type: none"> Occurs in these settings 	<ul style="list-style-type: none"> Symptom screening Employees should receive annual screening and/or testing 	<ul style="list-style-type: none"> Evaluate the resident for signs and symptoms of TB disease for early detection and treatment Educate patients and staff on importance of reporting signs and symptoms of TB disease Wear an N95 respirator when entering homes of persons suspected of having infectious TB disease
Emergency medical services	<ul style="list-style-type: none"> Low health concern 	<ul style="list-style-type: none"> Include a comprehensive employee screening program to test for TB infection Conduct follow-up testing as indicated by the risk classification of the setting 	<ul style="list-style-type: none"> Drivers, health-care workers, and other staff should wear an N95 respirator in a high-risk situation Persons with suspected TB who are transported in an ambulance should wear a surgical mask Ambulances should allow for maximum amount of outdoor air to circulate in the vehicle

Study Question

7.37 Which of the following statements about TB infection control in nontraditional settings is true?

(choose the one best answer)

- A.** All nontraditional settings where patients with TB disease receive care should establish and follow a TB infection control program.
- B.** Nontraditional settings include correctional facilities, homeless shelters, long-term care facilities, home-based health-care, and emergency medical services.
- C.** Emergency medical services has a documented overall high level of transmission of *M. tuberculosis*.
- D.** A, B, and C are all correct.
- E.** Only A and B are correct.

TB Infection Control in the Home

Patients who are suspected to have, or have, confirmed TB disease are frequently sent home after starting treatment, even though they may still be infectious. Patients with TB disease can be sent home even if they do **not** have three negative sputum smears, if the following criteria are met:

- A follow-up plan has been made with the local TB program;
- The patient is on standard TB treatment, and directly observed therapy (DOT) has been arranged;
- No infants or children less than 5 years of age or persons with immunocompromising conditions are present in the household; and
- The patient is willing to remain isolated in the home except for health-care associated visits until the patient has negative sputum smear results.

Patients who have suspected or confirmed TB disease are more likely to have already transmitted TB infection to members of their household before their TB disease was diagnosed and treatment was started. However, TB patients and members of their household should take steps to prevent the further spread of TB infection after they return home (Table 7.10). Patients with TB disease should

- Be instructed to cover their mouth and nose when coughing or sneezing;
- Sleep alone and **not** in a room with other household members; and
- **Refrain** from having visitors in the home until they are noninfectious.

HCWs who visit TB patients in their homes should take the following precautions to protect themselves from exposure to *M. tuberculosis* (Table 7.10):

- Instruct patients to cover their mouth and nose with a tissue when coughing or sneezing;
- Wear a respirator when visiting the home of a patient with infectious TB disease or when transporting a patient with infectious TB disease in a vehicle; and
- Collect specimens in a well ventilated area, away from other household members

In addition, HCWs whose responsibilities include visiting infectious patients should participate in an annual TB testing program.

Table 7.10
TB Infection Control in the Home

Steps that Patients Can Take to Prevent the Further Transmission of TB in the Home	Precautions for Health-Care Workers to Take to Protect Themselves from Exposure to <i>M. tuberculosis</i>
<ul style="list-style-type: none"> • Cover their mouth and nose when coughing or sneezing • Sleep alone and not in a room with other household members • Refrain from having visitors in the home until they are noninfectious. 	<ul style="list-style-type: none"> • Instruct patients to cover their mouth and nose with a tissue when coughing or sneezing • Wear a respirator when visiting the home of a patient with infectious TB disease or when transporting a patient with infectious TB disease in a vehicle • Collect specimens in a well-ventilated area, away from other household members

Study Questions

7.38 Elton was just diagnosed with TB and is considered infectious. Lilian, his nurse, is instructing him about steps he can take to prevent the spread of TB infection to others when he returns home today. Which of the following steps should Lilian mention? (choose the one best answer)

- A. Cover his mouth and nose when coughing or sneezing.
- B. Do **not** have visitors until he is noninfectious.
- C. It is ok to sleep in the same room with his wife.
- D. A, B, and C are all correct.
- E. Only A and B are correct.

Lilian will be conducting DOT at Elton’s home starting tomorrow. Which of the following precautions should Lilian take to protect herself from exposure to TB?

(Choose the one best answer and write the letter for the correct answer on the line next to the question number.)

Precautions for Health-Care Workers Visiting the Home of a TB Patient Who May Be Infectious	Yes or No
_____ 7.39 Spray the room where they will meet with a disinfectant before Elton enters it.	A. Yes (take this precaution)
_____ 7.40 Wear a respirator when visiting Elton’s home.	B. No (this is not an effective precaution)
_____ 7.41 Wear a surgical mask when visiting Elton’s home.	
_____ 7.42 Collect specimens in a well-ventilated area, away from other household members.	
_____ 7.43 Refrain from touching any surfaces in the home.	

Chapter Summary

M. tuberculosis can be transmitted in virtually any setting. Clinicians should be aware that transmission has been documented in health-care settings where HCWs and patients come in contact with persons with infectious TB who

- Have unsuspected TB disease,
- Have **not** received adequate treatment, or
- Have **not** been isolated from others.

The infectiousness of a TB patient is directly related to the number of droplet nuclei carrying *M. tuberculosis* (tubercle bacilli) that are expelled into the air. Depending on the environment, these tiny particles can remain suspended in the air for several hours. *M. tuberculosis* is transmitted only through the air, **not** by surface contact. Infection occurs when a person inhales droplet nuclei containing *M. tuberculosis*, and the droplet nuclei traverse the mouth or nasal passages, upper respiratory tract, and bronchi to reach the alveoli of the lungs. Persons with extrapulmonary TB disease may have concurrent unsuspected pulmonary or laryngeal TB disease. Except for laryngeal TB disease, extrapulmonary TB disease is rarely infectious; however, transmission from extrapulmonary sites has been reported to occur during aerosol-producing procedures such as autopsies and tissue irrigation.

For most patients, infectiousness appears to decline rapidly after adequate and appropriate treatment is started; however, the rate of decline varies from patient to patient. Some patients with unrecognized or inadequately treated drug-resistant TB disease may remain infectious for weeks or even months. Patients with drug-resistant TB disease may **not** respond to the initial drug regimen and may remain infectious until they receive adequate treatment.

TB infection control measures should be based on a careful assessment of risk for transmission of TB in the facility or setting. The goals of effective TB infection control programs are to

- Detect TB disease early and promptly;
- Isolate those who have or are suspected of having TB disease (airborne precautions); and
- Treat people who have or are suspected of having TB disease.

The primary risk to HCWs and the general population is the undiagnosed or unsuspected patient with TB disease. Within health-care settings, protocols should be implemented and enforced to promptly identify, isolate, and either transfer or manage persons who have suspected or confirmed TB disease. Personnel who admit patients to facilities should be trained to detect signs and symptoms of TB disease.

A TB infection control program should be based on the following three levels of hierarchy:

- 1. Administrative controls**, which reduce risk of exposure;
- 2. Environmental controls**, which prevent spread and reduce concentration of droplet nuclei; and
- 3. Respiratory-protection controls**, which further reduce risk of exposure in special areas and circumstances.

The first and most important level of a TB infection control program is the use of administrative measures to reduce the risk for exposure to persons who might have TB disease.

The second level of hierarchy is the use of environmental controls to prevent the spread and reduce the concentration of infectious droplet nuclei and includes primary and secondary controls.

Respiratory-protection control is the third level of a TB infection control program and consists of the use of protective equipment in situations that pose a high risk for exposure to TB disease. Use of respiratory protection can further reduce HCW risk of exposure to droplet nuclei expelled into the air.

All nontraditional facility-based settings where patients with TB disease receive care should establish and follow a TB infection control program. These settings include but are **not** limited to

- Correctional facilities;
- Homeless shelters;
- Long-term care facilities;
- Home-based health-care and outreach settings; and
- Emergency medical services;

Patients who are suspected to have, or have, confirmed TB disease are frequently sent home after starting treatment, even though they may still be infectious. Patients with TB disease can be sent home even if they do **not** have three negative sputum smears, if the following criteria are met:

- A follow-up plan has been made with the local TB program;
- The patient is on standard TB treatment, and DOT has been arranged;
- No infants or children less than 5 years of age or persons with immunocompromising conditions are present in the household unless they have been evaluated and started on treatment; and
- The patient is willing to remain isolated in the home except for health-care associated visits until the patient has negative sputum smear results.

References

CDC. Guidelines for preventing the transmission of *Mycobacterium tuberculosis* in health-care settings, 2005. *MMWR* 2005; 54 (No. RR-17).

www.cdc.gov/mmwr/preview/mmwrhtml/rr5417a1.htm?s_cid=rr5417a1_e

CDC. Prevention and control of tuberculosis in correctional and detention facilities: Recommendations from CDC. *MMWR* 2006; 55 (No. RR-09): 1–44.

www.cdc.gov/mmwr/preview/mmwrhtml/rr5509a1.htm

Curry International Tuberculosis Center (US). Tuberculosis Infection Control: A Practical Manual for Preventing TB; 2007. www.currytbcenter.ucsf.edu/products/a-z_list.cfm