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Guidelines for Preventing the Transmission of *Mycobacterium tuberculosis* In Health-care Settings, 2005

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I. INTRODUCTION

A. Overview of the Document

In 1994, the Centers for Disease Control and Prevention (CDC) published the *Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Health-Care Facilities,1994* (*1*). The guidelines were issued in response to 1) a resurgence of tuberculosis (TB) disease that occurred in the United States in the mid-1980s and early 1990s, 2) the documentation of several high-profile health-care–associated (previously termed "nosocomial") outbreaks related to an increase in the prevalence of TB disease and human immunodeficiency virus (HIV) coinfection, 3) lapses in infection-control practices, 4) delays in the diagnosis and treatment of persons with infectious TB disease (*2,3*), and 5) the appearance and transmission of multidrug-resistant (MDR) TB strains (*4,5*).

The 1994 guidelines, which followed statements issued in 1982 and 1990 (*1,6,7*), presented recommendations for TB infection control based on a risk assessment process that classified health-care facilities according to categories of TB risk with a corresponding series of administrative, environmental, and respiratory protection control measures.

The TB infection-control measures recommended by CDC in 1994 were implemented widely in health-care facilities nationwide (*8-15*). The result has been a decrease in the number of TB outbreaks in health-care settings reported to CDC and a reduction in health-care–associated transmission of *Mycobacterium* (*M.) tuberculosis* to patients and health-care workers (HCWs) (*9,16-23*). Concurrent with this success, mobilization of the nation's TB control programs succeeded in reversing the upsurge in reported cases of TB disease, and case rates have declined in the subsequent ten years (*4,5*). Findings indicate that although the 2004 TB rate was the lowest recorded in the United States since national reporting began in 1953, the declines in rates for 2003 (2.3%) and 2004 (3.3%) were the smallest since 1993. In addition, TB rates greater than the U.S. average continue to be reported in certain racial and ethnic populations (*24*). The threat of MDR TB is decreasing, and the transmission of *M. tuberculosis* in health-care settings continues to decrease due to implementation of infection controls and reductions in community rates of TB (*4,5,25*).

Despite the general decline in TB rates in recent years, a marked geographic variation in TB case rates persists, which means that HCWs in different areas face different risks (*10*). In 2003, case rates varied from 0.8 per 100,000 population in Wyoming to 7.7 per 100,000 in New York State, 9.1 per 100,000 in California and 14.0 per 100,000 in the District of Columbia (*26*). In addition, despite the progress, the 2003 rate in the United States of 5.1 per 100,000 population remained higher than the 2000 goal of 3.5, set as part of the national strategic plan for TB elimination (final goal of <1 case per 1,000,000 by 2010) (*4,5,26*).

Given the changes in epidemiology and a request by the Advisory Council for the Elimination of Tuberculosis (ACET) for review and updating of the 1994 TB infection control document, CDC has reassessed the TB infection-control guidelines for health-care settings. The resulting document, *Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Health-Care Settings, 2005*, updates TB control recommendations reflecting shifts in the epidemiology of TB (*27*), advances in our scientific understanding, and changes in health-care practice that have occurred in the United States in the last decade. In the context of diminished risk for health-care–associated transmission of *M. tuberculosis,* this document places emphasis on actions to maintain momentum and expertise needed to avert another TB resurgence and to eliminate the lingering

threat to HCWs, which is mainly from patients or others with unsuspected and undiagnosed infectious TB disease. CDC prepared the current guidelines in consultation with experts in TB, infection control, environmental control, respiratory protection, and occupational health.

The 1994 CDC guidelines were aimed primarily at hospital-based facilities. The 2005 guidelines have been expanded to address a broader concept; health-care–associated settings go beyond the previously defined facilities. The term "health-care setting" includes many types, such as inpatient settings, outpatient settings, TB clinics, settings in correctional facilities where health care is delivered, settings where home-based healthcare and emergency medical services are provided, and laboratories handling clinical specimens that may contain *M. tuberculosis* (Recommendations, Section A.2). The term "setting" has been chosen over the term "facility," used in the previous guidelines, to broaden the potential places for which these guidelines apply.

The definition of health-care "setting" is meant to describe any relationship (physical or organizational) where HCWs encounter patients, and where the potential for exposure to *M. tuberculosis* through air space shared with persons with infectious TB disease or with specimens exists. The concept is complicated because several different setting types may be present in one facility (which more often refers to a physical building or set of buildings) or be dispersed across different geographic locations; or a setting may be part of a contracted service for a large health-care delivery system.

Settings encompass both physical and organizational relationships.

- **Inpatient settings** include emergency departments, hospital rooms, urgent-care settings, intensive care units, surgical suites, laboratories, bronchoscopy suites, sputum induction or inhalation therapy rooms, and autopsy suites.

- **Outpatient settings** include TB treatment facilities, medical settings in correctional facilities (e.g., prisons, jails, and detention centers), dental-care settings, medical offices, ambulatory-care settings, and dialysis units.

- **Nontraditional facility-based settings** include emergency medical services (EMS), home-based health-care and outreach settings, long-term care settings (e.g., hospices, skilled nursing facilities), and homeless shelters. Some of the newly included settings are low-risk, and therefore, specific recommendations are detailed (Recommendations, Section A.2).

In this document, "health-care workers" (HCWs) refers to all paid and unpaid persons working in health-care settings who have the potential for exposure to *M. tuberculosis* through air space shared with persons with infectious TB disease (Recommendations, Section A).

Original and primary references, citing evidence-based science as much as possible, are used throughout this document to support explanatory material and recommendations. Review articles (which include original and primary references) are used in some places for the sake of editorial style and brevity.

This document replaces all previous CDC guidelines for TB infection control in health-care settings (*1,6,7*). Notable changes that differentiate it from the earlier guidelines include

- The risk assessment process which includes the assessment of more aspects of infection control.
- The document uses the term "tuberculin skin test" (TST) instead of "PPD" (or purified protein derivative).
- The whole-blood interferon gamma assay, QuantiFERON®-TB Gold test, is a Federal Drug Administration (FDA)-approved in vitro cytokine-based assay for cell-mediated immune reactivity to *M. tuberculosis* and may be used in place of the TST in TB screening programs for HCWs.
- The frequency of TB screening for HCWs has been decreased for many settings, and the criteria for determination of screening frequency have been changed.
- The scope of settings to which the guidelines apply has been broadened to include laboratories and additional outpatient and nontraditional facility-based settings.
- This document more clearly defines the HCWs who need to have serial tests for *M. tuberculosis* infection performed. In many settings, this change will decrease the number of HCWs who need serial TB screening.
- In general, these recommendations apply to an entire health-care setting rather than to areas within a setting.
- The document uses the recently introduced terms "airborne infection isolation" (AII) and "airborne infection isolation room" (AII room).
- Recommendations for annual respirator training, initial respirator fit testing, and periodic respirator fit testing have been added.
- The document summarizes the available evidence of respirator fit.
- Information on ultraviolet germicidal irradiation (UVGI) and room-air recirculation units has been expanded.
- Additional information regarding MDR TB and HIV infection has been included.

Implementation of all recommendations in this document must safeguard the confidentiality and civil rights of all HCWs and patients who have infection with *M. tuberculosis* and TB disease in accordance with relevant local, state, and federal laws.

A.1 HCWs Who Should Be Included in a TB Screening Program

Part-time, temporary, contract, as well as full-time HCWs should be included in TB screening programs[*]. The list of workers (or job classifications) includes, but is not limited to[†]

- administrators or managers,
- anesthesiologists,
- bronchoscopy staff,
- chaplains,
- clerical staff,
- computer programmers,
- construction staff,
- correctional officers,
- craft or repair staff,
- dental staff,
- dietician or dietary staff,
- emergency department (ED) staff,
- engineers,
- food service staff,

- health aides,
- health and safety staff,
- housekeeping or custodial staff,
- homeless shelter staff,
- infection-control staff,
- intensive-care unit (ICU) staff,
- janitorial staff,
- laboratory staff,
- maintenance staff,
- morgue staff,
- nurses,
- outreach staff,
- pathologist,
- pathology laboratory staff,
- patient transport staff, including emergency medical services
- pediatric staff,
- pharmacists,
- phlebotomists,
- physical and occupational therapists,
- physicians (assistant, attending, fellow, resident or intern),
- psychiatrists,
- psychologists,
- public health educators or teachers,
- public safety staff,
- radiology staff,
- respiratory therapists,
- scientists,
- social workers,
- students (e.g., medical, nursing, technicians),
- technicians (e.g., health, laboratory, radiology, animal),
- veterinarians, and
- volunteers.

[*] In some settings, there may be a choice not to perform baseline TB screening (at the beginning of the HCW's employment) or serial TB screening for HCWs who will *never* be in contact with, or have shared air space with patients who have TB disease (e.g., telephone operators who work in a separate building from patients), or who will never be in contact with clinical specimens that may contain *M. tuberculosis.*

[†] Not all workers or individuals within the listed classifications may need to be included in the TB screening program. Infection control personnel should determine who within these groups and departments needs to be included in the TB screening program based on the risk assessment for the setting.

A.2 Settings Where HCWs May Require a TB Screening Program

The list of settings where suspected and confirmed TB patients visit, includes but is not limited to

Inpatient settings

- autopsy suites,
- bronchoscopy suites,
- cardiac catheter laboratory,

- emergency departments (EDs),
- geriatric inpatient wards,
- gynecologic wards,
- HIV and Acquired immunodeficiency syndrome (AIDS) wards,
- hospices,
- hospitals,
- intensive-care units (ICUs),
- laboratory procedure areas,
- labor or delivery rooms,
- long-term care facilities
- nurseries,
- obstetric wards,
- oncology hostels,
- oncology wards,
- patient rooms,
- pediatric wards,
- physical medicine or rehabilitation wards,
- psychology or substance abuse wards,
- pulmonary wards,
- sputum induction rooms or inhalation therapy rooms,
- surgical (orthopedic, transplant) suites,
- TB wards, and
- urgent-care units.

Outpatient settings (primary care as well as specialty services)

- administrative offices,
- ambulatory-care settings
- correctional facility medical settings,
- dental-care settings,
- drug treatment centers,
- dialysis units,
- employee health offices,
- examination rooms,
- health department
- infusion centers,
- intake areas,
- interview rooms,
- laboratories (e.g., mycobacterial, clinical),
- medical offices (primary care as well as specialty services),
- operating or recovery rooms,
- pathology or autopsy rooms,
- patient procedure or therapy areas,
- radiology areas,
- TB treatment facilities, and
- waiting areas.

Nontraditional facility-based settings

- emergency medical services (EMS),
- home-based health-care settings,
- outreach settings,
- long-term care facilities (e.g., hospices, skilled nursing facilities), and
- homeless shelters.

Other settings where suspected and confirmed TB patients visit, such as

- cafeterias,
- general stores,
- kitchens,
- laundry areas,
- maintenance shops, and
- pharmacies.

B. Pathogenesis, Epidemiology, and Transmission of *M. tuberculosis*

M. tuberculosis is carried in airborne particles, called droplet nuclei, which can be generated when persons who have pulmonary or laryngeal TB disease cough, sneeze, shout, or sing (*28,29*). The particles are an estimated 1–5 µm in size; normal air currents can keep them airborne for prolonged periods and spread them throughout a room or building (*30*). *M. tuberculosis* is generally transmitted only through the air, not by surface contact. Once in the alveoli, local infection may be established, followed by dissemination to draining lymphatics and hematogenous spread throughout the body (*31*). Infection occurs when a susceptible 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 tuberculous pleural effusions may also have concurrent unsuspected pulmonary or laryngeal TB disease.

Usually within 2–12 weeks after initial infection with *M. tuberculosis*, the immune response limits further multiplication of the tubercle bacilli and immunologic test results for *M. tuberculosis* infection become positive. However, some bacilli remain in the body and are viable for many years. This condition is referred to as latent TB infection (LTBI). Persons with LTBI are usually asymptomatic (they have no symptoms of TB disease*)* and are not infectious.

In the United States, LTBI has been traditionally diagnosed on the basis of a positive PPD-based TST result, after TB disease has been excluded. In-vitro cytokine-based immunoassays for the detection of *M tuberculosis* infection have been the focus of intense research and development. The whole-blood interferon gamma assay QuantiFERON-TB test (Cellestis Limited, Carnegie, Victoria, Australia) and the subsequently developed version, QuantiFERON-TB Gold test (Cellestis Limited, Carnegie, Victoria, Australia), are two examples. The QuantiFERON-TB Gold test measures cell-mediated immune responses to peptides representing two *M. tuberculosis* proteins that are not present in any BCG vaccine strain and are absent from most nontuberculous mycobacteria. This assay was approved by the FDA in 2005 and is an available option for detecting *M. tuberculosis* infection. CDC recommendations for the United States on QuantiFERON-TB, have been published (*32*). CDC recommendations for QuantiFERON-TB Gold test are under development. **This document uses the term "QFT" to refer to the QuantiFERON test currently available in the United States.**

Other cytokine-based immunoassays are under development and may be demonstrated to be useful in the diagnosis of *M. tuberculosis* infection. Future FDA licensed products in combination with CDC-issued recommendations may provide additional diagnostic alternatives. Please see the latest QFT-specific CDC recommendations for guidance on diagnostic use of these and related technologies.

A proportion of persons who become infected with *M. tuberculosis* and are not treated for LTBI will develop TB disease during their lifetimes as a result of their infection. The risk for progression of LTBI to TB disease is greatest during the first several years after infection (*33-35*).

The prevalence of TB disease is not distributed evenly throughout all segments of the United States population. Some subgroups and persons have a higher risk for developing TB disease either because they are more likely than others to have been recently exposed to and infected with *M. tuberculosis* or because they have clinical conditions that are associated with an increased risk for progression of LTBI to TB disease (*36*). In some cases, both these factors may be present.

Groups of persons who are at higher risk for exposure to and infection with *M. tuberculosis* and groups of persons who are at higher risk for progression to TB disease once infected are listed below (*36,37*).

B.1 Persons at Higher Risk for Exposure to and Infection With *M. tuberculosis*

Close contacts are persons who share the same air space in a household or other enclosed environment for a prolonged period of time (days or weeks, not minutes or hours) with a person with pulmonary TB disease. A suspect TB patient is a person in whom a diagnosis of TB disease is being considered, whether or not anti-tuberculosis therapy has been started. Persons should generally not remain in this category for >3 months (*28,36*). Close contacts have also been referred to as "high-priority contacts" since they have the highest risk for infection with *M. tuberculosis.* Other persons at higher risk for exposure to and infection with *M. tuberculosis* include

- foreign-born persons, including children, especially those who have arrived to the United States within five years from geographic areas with a high incidence of TB disease (e.g., Asia, Africa, Latin America, Eastern Europe, Russia),
- foreign birth and frequent foreign travel in and to countries with a high prevalence of TB disease
- residents and employees of high-risk congregate settings (e.g., correctional facilities, homeless shelters, long-term care facilities, such as hospices, skilled nursing facilities, and mental institutions),
- HCWs who serve high-risk clients,
- HCWs with unprotected exposure to a patient with TB disease prior to the identification and correct AII of the patient,
- some medically underserved, low-income populations as defined locally,
- high-risk populations, defined locally as having an increased incidence of TB disease (e.g., Asians and Pacific Islanders, African Americans, Hispanics, Native Americans, migrant farm workers),
- infants, children, and adolescents exposed to adults in high-risk categories,
- persons who inject illicit drugs,
- crack cocaine users (*38-43*), and
- persons who use tobacco or alcohol (*44,45*).

B.2 Persons at Higher Risk for Progression From LTBI to TB Disease Include

- persons infected with HIV,
- persons infected with *M. tuberculosis* within the past two years,
- infants and children <4 years of age,
- persons with any of the following clinical conditions or other immunocompromising conditions
  - silicosis,
  - diabetes mellitus,
  - chronic renal failure,
  - some hematologic disorders (leukemias and lymphomas),
  - other specific malignancies (e.g., carcinoma of the head, neck, or lung),
  - body weight more than 10% below ideal body weight,
  - prolonged corticosteroid use,
  - other immunosuppressive treatments (including agents that inhibit inflammatory cytokines such as tumor necrosis factor-alpha antagonists),
  - organ transplant,
  - end-stage renal disease (ESRD), and
  - intestinal bypass or gastrectomy,
- persons with a history of untreated or inadequately treated TB disease, including those with chest radiograph findings consistent with prior TB disease,
- persons who inject illicit drugs, and
- persons who use tobacco or alcohol (*44,45*).

HIV infection is the highest risk factor for progression from LTBI to TB disease (*22,36,37,46*). Therefore, voluntary HIV counseling, testing, and referral should be routinely offered to all persons at risk for LTBI (*1,47,48*). Health-care settings should be particularly aware of the need for preventing transmission of *M. tuberculosis* in settings where persons infected with HIV might be encountered or might work (*49*). And persons who inject illicit drugs or use alcohol, tobacco or crack cocaine may also be at increased risk for infection and disease, but given the many other potential risk factors that commonly occur among such persons, use of these substances has been difficult to identify as separate risk factors.

All HCWs should be informed of the risk of developing TB disease once infected with *M. tuberculosis* (*1*). However, the rate of TB disease among persons who are HIV-infected and untreated for LTBI in the United States is substantially higher, ranging from 1.7–7.9 TB cases per 100 person-years (*50*). Persons infected with HIV who are already severely immunocompromised and who become newly infected with *M. tuberculosis* have a greater risk for developing TB disease compared to newly infected persons without HIV infection (*36,50-54*).

The percentage of patients with TB disease who are HIV-infected is declining in the United States because of improved infection-control practices and better diagnosis and treatment of both HIV infection and TB. With increased voluntary counseling and testing (VCT) and the increasing use of treatment for LTBI, TB disease will probably continue to decrease among HIV-infected persons in the United States (*55*).

Because the risk for disease is particularly high among HIV-infected persons with *M. tuberculosis* infection, HIV-infected contacts of persons with infectious pulmonary or

laryngeal TB disease must be evaluated for *M. tuberculosis* infection including the exclusion of TB disease as soon as possible after learning of exposure (*36,46,50*).

Vaccination with Bacille Calmette-Guérin (BCG) probably does not affect the risk for infection after exposure, but it may decrease the risk for progressing from infection with *M. tuberculosis* to TB disease, notably preventing the development of miliary and meningeal disease in infants and young children (*56,57*).

Although it is well established that HIV infection increases the likelihood of progressing from LTBI to TB disease (*36,46*), it is unknown whether HIV infection increases the risk for becoming infected if exposed to *M. tuberculosis*.

B.3 Characteristics of a Patient With TB Disease That Enhance Infectiousness Include

- presence of cough,
- cavitation on chest radiograph,
- positive acid-fast bacilli (AFB) sputum smear result,
- respiratory tract disease with involvement of the larynx (very infectious),
- respiratory tract disease with involvement of the lung or pleura (exclusively pleural involvement is less infectious),
- failure to cover the mouth and nose when coughing,
- lack of, incorrect, or short duration of anti-tuberculosis treatment, and
- undergoing cough-inducing or aerosol-generating procedures (e.g., bronchoscopy, sputum induction, administration of aerosolized medications)(*58*)
- among adults, younger age and male (*59,60*).

B.4 Environmental Factors That Enhance the Probability of Transmission of *M. tuberculosis* Include

- exposure 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, and
- improper specimen handling procedures.

Characteristics of persons exposed to *M. tuberculosis* that might affect the risk for infection are not as well defined. In general, persons who have been infected with *M. tuberculosis* in the past may be less susceptible to subsequent infection. However, reinfection can occur among previously infected persons (*61,62*). In low incidence countries such as the United States, this is most clear in persons who are severely immunocompromised (*63-67*).

The probability that a person who is exposed to *M. tuberculosis* will become infected depends mainly on the concentration of infectious droplet nuclei in the air and the duration of exposure to a person with infectious TB disease. The closer proximity and the longer duration of exposure, the higher the risk is of being infected with *M. tuberculosis.*

C. Risk for Health-care–Associated Transmission of *M. tuberculosis*

Transmission of *M. tuberculosis* is a recognized risk in health-care settings (*54,68-86*). The magnitude of the risk varies by setting, occupational group, prevalence of TB in the community, patient population, and effectiveness of TB infection-control measures. The risk may be higher in settings in which patients with TB disease might be encountered before diagnosis and before the initiation of anti-tuberculosis treatment and AII precautions (e.g., emergency departments, clinic waiting areas) or where procedures that induce coughing are performed. Health-care–associated transmission of *M. tuberculosis* has been linked to close contact with persons with TB disease during aerosol-generating or aerosol-producing procedures including bronchoscopy (*58,70,87-89*), endotracheal intubation, suctioning (*73*), other respiratory procedures (*8,9,90-93*), open abscess irrigation (*76,90*), autopsy (*78,79,84*), sputum induction and aerosol treatments that induce coughing (*94-97*).

Of reported TB outbreaks in health-care settings, many involved transmission of MDR TB strains to both patients and HCWs (*53,54,77,94,98-101*). Most of the patients and some of the HCWs were HIV-infected and progression to TB disease was rapid. Factors contributing to these outbreaks included delayed diagnosis of TB disease, delayed recognition of drug resistance, and delayed initiation of treatment – all of which resulted in prolonged infectiousness, delayed initiation of and inadequate AII, lapses in AII practices and precautions for cough-inducing and aerosol-generating procedures, and lack of adequate respiratory protection. Several studies suggest that the decline in health-care–associated transmission observed in specific institutions is temporally associated with the rigorous implementation of infection-control measures (*11,12,18-20,102-104*). Because multiple interventions were implemented simultaneously, however, the effectiveness of each could not be determined.

The release of the 1994 CDC infection-control guidelines was followed by increased implementation of recommended infection-control measures, as documented in several national surveys (*13,15,105,106*). In one survey of more than 1,000 hospitals, a TST program was present in nearly all sites, and 70% reported having an AII room (*13*). Other surveys have documented improvement in the proportion of AII rooms meeting CDC criteria and proportion of HCWs using CDC-recommended respiratory protection and receiving serial TSTs (*15,105*). A survey of high-burden New York City hospitals showed a decrease in time that patients with TB disease spent in the emergency department before transfer to a hospital room, an increase in the proportion of patients initially placed in AII, an increase in the proportion of patients started on recommended anti-tuberculosis treatment and reported to the state or local health department, and an increase in the use of recommended respiratory protection and environmental controls (*106*). Reports of increased implementation of recommended TB infection controls, combined with decreased reports of outbreaks of TB disease in health-care settings, suggest that the recommended controls are effective in reducing or preventing health-care–associated transmission of *M. tuberculosis.*

Less information is available about the implementation of CDC-recommended TB infection-control measures in settings other than hospitals. One study identified several major factors that contribute to the costs of a TST program in health departments and hospitals: personnel costs, HCWs' time off from work for TST administration and reading, and training and education of HCWs (*107*). Outbreaks have occurred in outpatient settings (i.e., private physicians offices, pediatric settings) where the guidelines were not followed (*108-110*). CDC-recommended TB infection-control measures are implemented in correctional facilities, and some variations may relate to resources, expertise, and oversight (*111-113*).

D. Fundamentals of TB Infection Control

One of the most important risks for health-care–associated transmission of *M. tuberculosis* in health-care settings arises from patients with unrecognized TB disease who are not promptly placed in AII (*53,54,100,111*), or who are moved from AII too soon, such as patients with unrecognized MDR TB (*101*). In the United States, the problem of MDR TB has been greatly reduced by the use of standardized anti-tuberculosis 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 a HCW or other specially trained person 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.

Effective TB infection control in health-care settings depends on early identification, prompt AII, and treatment of persons with TB disease. All health-care settings need a TB infection-control program designed to detect TB disease early and to isolate and promptly refer or treat persons who have TB disease. Such a program is based on a three-level hierarchy of controls: administrative, environmental and respiratory protection (*60,93,114*).

D.1 Administrative Controls

The first level of TB controls, and the most important, is the use of administrative measures to reduce the risk for exposure to persons who may have TB disease. These controls include

- 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, AII, 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 about 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,*
- applying epidemiologic-based prevention principles including the use of setting-related infection-control data,
- appropriate signage advising respiratory hygiene and cough etiquette, and
- coordinating efforts with the state or local health department.

D.2 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. These include

- controlling the source of infection by use of local exhaust ventilation (hoods, tents, or booths),
- diluting and removing contaminated air by use of general ventilation,
- controlling the airflow to prevent contamination of air in areas adjacent to the source (AII rooms), and
- cleaning the air by use of high-efficiency particulate air (HEPA) filtration or ultraviolet germicidal irradiation (UVGI).

D.3 Respiratory Protection Controls

The first two control levels minimize the number of areas where exposure to *M. tuberculosis* may occur and thus, minimize the number of persons exposed. They also reduce, but do not eliminate, the risk in the few areas where exposure can still occur (e.g., AII rooms, locations where cough-inducing or aerosol-generating procedures are performed, and homes of patients with infectious TB disease). Because persons entering these areas may be exposed to *M. tuberculosis*, the third level of the hierarchy is the use of respiratory protective equipment in situations that pose a relatively 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 (Supplement 5). Measures include

- Implementing a respiratory protection program
- Training HCWs on respiratory protection
- Training patients on respiratory hygiene and cough etiquette procedures

The following recommendations (Section II) specify measures to reduce the risk for transmission of *M. tuberculosis* based on this hierarchy. Additional details are provided in Supplements 1–5.

E. Relevance to Bioterrorism Preparedness and Other Infections Spread Through an Airborne Route

Multidrug-resistant *M. tuberculosis* is classified as a category C agent of biologic terrorism (*115*). Implementation of the TB infection-control guidelines in this document is important for the control and prevention of transmission of *M. tuberculosis* in health-care settings. In addition, a new relevance to bioterrorism preparedness exists. Since September 2001, personnel in many health-care institutions are implementing bioterrorism preparedness plans. After episodes of Severe Acute Respiratory Syndrome (SARS) were reported in November 2002, institutions worldwide began addressing revisions of infection-control measures to prevent the transmission of the Corona Virus (CoV) that causes SARS (*116*). Many of the activities and recommendations for the prevention and control of TB may be useful for preventing transmission of agents of bioterrorism and diseases such as smallpox and SARS. Since agents of smallpox and SARS, for example, are transmitted by air, implementation of a comprehensive infection-control program, including environmental control measures (e.g., AII rooms) and a respiratory protection program, potentially will enhance health-care settings' preparedness for many agents that are transmitted by the airborne route (for the latest information see www.bt.cdc.gov and www.idsociety.org/bt/toc.htm) (*116*).

II. RECOMMENDATIONS FOR PREVENTING TRANSMISSION OF *M. TUBERCULOSIS* IN HEALTH-CARE SETTINGS

A. TB Infection-Control Program

Every health-care setting should have a TB infection-control program in place that is part of an overall infection-control program. Based on the risk assessment for the setting, proper administrative, environmental, and respiratory protection policies and measures to prevent health-care–associated transmission of* M. tuberculosis *should be adopted. These policies will form the basis for a setting-specific TB infection-control program (Table 1). Administrative controls are the most important part of the TB infection-control program.

The specific details of the TB infection-control program will differ depending on whether patients with suspected or confirmed TB disease might be encountered in the setting , or whether patients with suspected or confirmed TB disease will be triaged or transferred to another health-care setting. Administrators making this distinction should obtain medical and epidemiologic consultation from state and local health departments.

A.1 Settings Where Patients With Suspected or Confirmed Infectious TB Disease Are Expected to Be Encountered

The TB infection-control program should consist of administrative controls, environmental controls, and a respiratory protection program. Every setting in which services are provided to persons who have suspected or confirmed infectious TB disease, including nontraditional facility-based settings and laboratories that process specimens for mycobacteriologic studies should have a TB infection-control plan. These settings should

A.1.1 Assign responsibility for the TB infection-control program. Assign supervisory responsibility to a designated person or group with expertise in LTBI and TB disease, infection control, occupational health, environmental controls, and respiratory protection. Give the supervisor or supervisory body the support and authority to conduct a TB risk assessment, implement and enforce TB infection-control policies, and ensure recommended training and education of HCWs.

A.1.2 *If supervisory responsibility is assigned to a committee,* designate one person with a backup as the TB resource person to whom questions and problems should be addressed.

A.1.3 Train the persons responsible for implementing and enforcing the TB infection-control program.

A.1.4 Develop a written TB infection-control plan, and update annually.

A.1.5 Ensure the prompt recognition of patients with suspected or confirmed TB disease.

A.1.6 Conduct a problem assessment if a case of suspected or confirmed TB disease is not promptly recognized or if administrative, environmental or respiratory controls fail.

A.1.7 Perform a contact investigation in collaboration with the state or local health department if health-care–associated transmission of *M. tuberculosis* is suspected (*117*). Implement and monitor corrective action.

A.1.8 Collaborate with the state or local health department to develop administrative controls, consisting of the risk assessment, the written TB infection-control plan, management of patients with suspected or confirmed TB disease, training and

education of HCWs, screening and evaluation of HCWs, problem evaluation, and coordination.
Implement and maintain environmental controls, including AII room(s) (Recommendations, Section J and Supplement 4).

A.1.9 Implement a respiratory protection program.

A.1.10 Perform ongoing training and education of HCWs *(Table 2, Suggested components of an initial TB training and education program for HCWs).*

A.1.11 If a setting accepts patients who have suspected or confirmed TB disease transferred from another setting, the accepting setting should have a plan for such transfers.

A.2 Settings Where Patients With Suspected or Confirmed Infectious TB Disease Are Not Expected to Be Encountered

Settings that do not plan to keep patients with suspected or confirmed infectious TB disease should still have a TB infection-control program in place consisting of administrative, environmental and respiratory protection controls. These settings should

A.2.1 Assign responsibility for the TB infection-control program.

A.2.2 Develop a written TB infection-control plan that outlines a protocol for the prompt recognition, triage, and transfer of persons who have suspected or confirmed TB disease to another health-care setting. Ensure patient and family teaching is provided if prompt and unanticipated transfer is necessary.

A.2.3 Separate persons with suspected or confirmed infectious TB disease from other persons in the setting until the time of transfer.

A.2.4 Conduct an assessment for the need of conducting a Problem evaluation (Section H) if a case of suspected or confirmed TB disease is not promptly recognized, isolated and transferred.

A.2.5 Perform an investigation in collaboration with the state or local health department if health-care–associated transmission of *M. tuberculosis* is suspected.

A.2.6 Perform ongoing training and education of HCWs.

A.2.7 Evaluate the TB infection-control plan at least annually, if possible, to ensure that the setting remains one in which persons who have suspected or confirmed TB disease are not encountered, and that they are promptly transferred to another health-care setting.

A.2.8 Implement environmental controls, as indicated in the infection control plan, for areas where patients with suspected or confirmed TB disease will stay pending transfer to another health-care setting.

A.2.9 Provide respiratory protection, as indicated in the infection control plan, for HCWs who will be attending to patients with suspected or confirmed TB disease pending transfer to another health-care setting, and provide a surgical or procedure mask to persons who have suspected or confirmed infectious TB disease.

B. TB Risk Assessment

Every type of health-care setting should conduct initial and ongoing evaluations of the risk for transmission of *M. tuberculosis* regardless of whether or not patients with suspected or confirmed TB disease are expected to be encountered in the setting. The TB risk assessment determines the types of administrative, environmental, and respiratory protection controls needed for a setting, and serves as a tool for the ongoing evaluation of the quality of TB infection control and the need

for improved infection-control measures. (Parts of the risk assessment are similar to a program review that is conducted by the local TB control program.) Collaboration with the state or local TB control program may be useful in some settings for epidemiological surveillance data necessary to conduct a TB Risk Assessment. A TB risk assessment for health-care settings should be conducted and documented at least annually.

The TB risk assessment determines the risk for health-care–associated transmission of *M. tuberculosis* in the setting by examining a number of factors, including 1) community rate of TB disease, 2) number of patients with TB disease encountered in the setting, regardless of whether they stay in the setting or are transferred to another health-care setting, 3) timeliness of the recognition, isolation, and evaluation of patients with suspected or confirmed TB disease, 4) evidence for transmission of *M. tuberculosis* in the setting, and 5) the types and conditions of the environmental controls present in the setting.

The TB Risk Assessment Worksheet (Table 3) may be used as a guide for conducting a risk assessment for a health-care setting. This worksheet often does not specify values for acceptable performance indicators due to the lack of scientific data. However, a program can use such a tool as part of quality control and assurance, in consultation with infection control experts, to develop an ongoing performance-based evaluation system.

B.1 Settings Where Patients With Suspected Or Confirmed Infectious TB Disease Are Expected to Be Encountered

The findings from the risk assessment will form the basis for decisions about the level of administrative, environmental, and respiratory protective measures needed to ensure a safe environment for HCWs, patients, and others. As an ongoing evaluation tool, the risk assessment can identify the need for improved TB infection controls and can serve as a way to monitor administrative, environmental, and respiratory protective measures to ensure their proper operation. To conduct the initial and ongoing risk assessment, follow these steps

B.1.1 Consult the state or local TB control program to obtain epidemiological surveillance data necessary to conduct a TB risk assessment for the healthcare setting.

B.1.2 Review the number of patients with suspected or confirmed TB disease who have been treated in the setting over at least the last five years.

B.1.3 Determine if persons with unrecognized TB disease have been admitted to or were encountered in the setting in the last year.

B.1.4 Determine which HCWs need to be included in a TB screening program and the frequency of screening (based on risk classification) (Recommendations, Section B.3, Table 4).

B.1.5 Ensure the prompt recognition and evaluation of suspected episodes of health-care–associated transmission *of M. tuberculosis.*

B.1.6 Identify areas in the setting with an increased risk for health-care–associated transmission *of M. tuberculosis* and target them for improved TB infection controls.

B.1.7 Determine the number of AII rooms needed for the setting. The risk classification for the setting should help determine this, depending on the number of TB patients seen. At least one AII room is needed for settings where TB patients stay while they are being treated, plus one additional AII room for every 200 patient-days of cases of suspected or confirmed TB disease. Additional AII rooms may

be considered if options are limited for transferring patients with suspected or confirmed TB disease to other settings with AII rooms.

B.1.8 Determine the types of environmental controls other than AII rooms needed.

B.1.9 Determine which HCWs need to be included in the respiratory protection program.

B.1.10 Conduct periodic reassessments (annually, if possible) to ensure a) proper implementation of the TB infection-control plan, b) prompt detection and evaluation of suspected TB cases, c) prompt isolation of suspected infectious TB cases, d) recommended medical management of patients with suspected or confirmed TB disease (29), e) functional environmental controls, f) implementation of the respiratory protection program, and g) ongoing HCW training and education about TB.

B1.11 Recognize and correct lapses in infection control.

B.2 Settings Where Patients With Suspected Or Confirmed Infectious TB Disease Are Not Expected To Be Encountered

In settings where patients with suspected or confirmed TB disease are not expected to be encountered (where patients may stay before transfer), the initial and ongoing risk assessment should consist of the following steps

B.2.1 In collaboration with the state or local health department, review the community profile of TB disease.

B.2.2 Review the number of patients with suspected or confirmed TB disease who were encountered in the setting over the last five years.

B.2.3 Determine if persons with unrecognized TB disease have been admitted to or were encountered in the setting over the last five years.

B.2.4 Determine which HCWs, if any, need to be included in the TB screening program, and the frequency of screening (based on risk classification) (Recommendations, Section B.3, Table 4).

B.2.5 Determine the types of environmental controls that are currently in place, and determine which, if any, are needed in the setting. This determination may apply only to areas where patients stay before transfer.

B.2.6 Based on the risk assessment for the setting, identify areas in the setting with increased risk for health-care–associated transmission of *M. tuberculosis* and target those areas for improved TB infection controls.

B.2.7 Document procedures that ensure the prompt recognition and evaluation of suspected episodes of health-care–associated transmission of *M. tuberculosis.*

B.2.8 Conduct periodic reassessments (annually, if possible), to ensure a) proper implementation of TB infection-control plan, b) prompt detection and evaluation of suspected TB cases, c) prompt isolation of suspected infectious TB cases before transfer, d) prompt transfer of suspected infectious TB cases, e) proper functioning of environmental controls, as applicable, and f) ongoing TB training and education for HCWs.

B.2.9 Reassess the setting's risk level at least annually.

B.2.10 Recognize and correct lapses in infection control.

B.3 Use of Risk Classification to Determine Need for TB Screening and Frequency of Screening HCWs

The need for a TB screening program for HCWs should be determined for all health-care settings as part of the TB risk assessment. Risk classification should be used to determine

the need for a TB screening program and the frequency of screening (Table 4). In general, a risk classification should be determined for the entire setting. In some settings (e.g., large health-care organizations that encompass several sites or types of services), specific areas defined by geography, functional units, patient population, job type, or location within the setting may be classified separately. Examples illustrating the assignment of risk classifications are provided in Table 5.

TB screening programs provide information that is important in managing individual HCWs and information that facilitates detection of *M. tuberculosis* transmission. The TB screening program consists of baseline and serial testing for *M. tuberculosis* infection, baseline and serial screening for signs or symptoms of TB disease, and TB training and education for HCWs.

Baseline testing for *M. tuberculosis* infection is recommended for all newly hired HCWs who might have contact with persons who have suspected or confirmed TB disease, regardless of the risk classification of the setting. In some settings, there may be a choice not to perform serial TB screening for HCWs who will never be in contact with, or have shared air space with patients who have TB disease (e.g., telephone operators who work in a separate building from patients), or who will never be in contact with clinical specimens that may contain *M. tuberculosis.*

Baseline testing can be conducted with a recommended test to detect *M. tuberculosis* infection (*32*) (Supplement 2). If the TST is used, two-step testing is recommended for newly hired HCWs whose initial TST result is negative (*36,118*). The second-step of a two-step TST should be administered 1–3 weeks after the first TST result was read. A second TST is needed at baseline because injection of PPD for the initial TST may "boost" responses to subsequent tests. In general, in the absence of a known exposure, a large reaction to the second-step of a two-step TST is probably due to boosting as opposed to recent infection with *M. tuberculosis*. The second step of a two-step test can be administered after the recommended 1-3 weeks in situations with constraining operational issues and under the assumption the risk for exposure during the intervening period is low. A second TST is not needed if an HCW has documentation that a TST has been applied at any time during the previous 12 months and the result was negative. (Supplement 2).

TST placement and interpretation should be performed by staff specifically trained in performing the test and who participate in ongoing education about TB trends and practices. It should be noted that the interpretation of TST results may differ when used administratively for infection control as opposed to when used as part of medical evaluation for patient care. For example, a 6 millimeter (mm) TST result may be considered negative for administrative purposes but may be considered positive when deciding to treat an HIV-infected HCW for LTBI. This example highlights the importance of recording actual TST results in mm of induration.

At initial hire, HCWs with documentation of a positive TST result, or documentation of previous treatment for LTBI or TB disease, do not need any further testing for *M. tuberculosis* infection. Instead of participating in serial skin testing, the HCW should receive a medical evaluation and a symptom screen. A symptom screen is a procedure performed during a clinical evaluation in which the HCW is asked if they have

experienced any symptoms of TB disease and are examined for any signs of TB disease. Symptoms of TB disease include coughing for ≥3 weeks, loss of appetite, unexplained weight loss, night sweats, bloody sputum or hemoptysis, hoarseness, fever, fatigue, or chest pain.

Persons with tuberculous pleural effusions may also have concurrent unsuspected pulmonary or laryngeal TB disease. If extrapulmonary or pleural TB disease is suspected or confirmed, there should be a thorough evaluation to exclude a co-existing infectious pulmonary site of disease(*119*).

Serial testing for *M. tuberculosis* infection, serial screening for signs or symptoms of TB disease, and education are typically accomplished together as part of an ongoing TB screening program for HCWs. The recommended frequency of screening after baseline testing will differ by setting, depending on the risk classification categories (i.e., low-risk, medium-risk, or potential ongoing transmission) (Table 4).

See Supplement 3 for guidance on QFT use in screening.

TB Screening Risk Classifications

Low risk

- All HCWs should receive baseline TB screening upon hire using baseline two-step TSTs to test for infection with *M. tuberculosis*.
- HCWs with a baseline positive or newly positive TST result should receive one chest radiograph to exclude a diagnosis of TB disease. After this baseline chest radiograph is performed and the result is documented, repeat radiographs are not needed unless signs or symptoms of TB disease develop, or a clinician recommends a repeat chest radiograph (*36,120*). Instead of participating in serial skin testing, the HCW should receive an annual symptom screen (which can be done as part of other HCW screening and education efforts). Offer treatment for LTBI to those who are eligible.
- After baseline testing for infection with *M. tuberculosis*, HCWs with negative results in settings classified as low risk do not need further TB screening unless an exposure to *M. tuberculosis* occurs.

Medium risk

- All HCWs should receive baseline TB screening upon hire using baseline two-step TSTs to test for infection with *M. tuberculosis*.
- HCWs with a baseline positive or newly positive TST result should receive one chest radiograph to exclude a diagnosis of TB disease. After this baseline chest radiograph is performed and the result is documented, repeat radiographs are not needed unless signs or symptoms of TB disease develop, or a clinician recommends a repeat chest radiograph (*36,120*). Instead of participating in serial skin testing, HCWs with positive TST results should receive a symptom screen and a medical evaluation. Offer treatment for LTBI to those who are eligible.
- After baseline testing for infection with *M. tuberculosis*, HCWs in settings classified as medium risk should receive TB screening annually (i.e., symptom screen for all HCWs and testing for infection with *M. tuberculosis* for HCWs with baseline negative test results).

Potential ongoing transmission

- Testing for infection with *M. tuberculosis* may need to be performed every 8–10 weeks until lapses in infection control have been corrected and no further evidence of ongoing transmission is apparent.
- The classification of potential ongoing transmission should be used as a temporary classification only. It warrants immediate investigation, and corrective steps; after it has been determined that ongoing transmission has ceased, the setting should be reclassified as medium risk. It is recommended to maintain the classification of medium risk for at least one year.

In general, if uncertain about whether to classify a setting as low risk or medium risk, classify the setting as medium risk. Follow these steps and refer to the TB screening classifications above to determine the risk classification for the setting, and refer to Table 4 for frequency of testing:

B.3.1 Estimate the number of patients with TB disease who were seen or treated in the setting during the preceding year. Derive TB patient counts utilizing laboratory surveillance data on *M. tuberculosis* cultures or specimen results positive for AFB, infection-control records, and (in hospitals), databases containing information on discharge diagnoses. Each patient should be counted only once and children, if patients, should be counted. Parents who have TB but who are not patients, need not be counted.

B.3.2 For inpatient settings with ≥200 beds

B.3.2a Classify settings with a TB patient count of <6 for the past year as low risk.

B.3.2b Classify those with a TB patient count of ≥6 for the past year as medium risk.

B.3.3 For inpatient settings with <200 beds

B.3.3a Classify those with a TB patient count of <3 for the past year as low risk.

B.3.3b Classify those with a TB patient count of ≥3 for the past year as medium risk.

B.3.4 For outpatient, outreach, and home-based health-care settings

B.3.4a Classify those with a TB patient count of <3 for the past year as low risk.

B.3.4b Classify those with a TB patient count of ≥3 for the past year as medium risk.

B.3.5 For TB clinics, TB outreach programs, and other settings in which HCWs are responsible for the care of patients with TB disease. Classify these settings as medium risk.

B.3.6 For correctional facilities where inmates with TB disease are cared for or are housed. Classify these settings as medium risk.

B.3.7 For any of the above settings with evidence suggestive of person-to-person (e.g., patient-to-patient, patient-to-HCW, HCW-to-patient, or HCW-to-HCW) transmission of *M. tuberculosis* during the preceding year, classify these settings as potential ongoing transmission.

B.3.7a Evidence suggestive of person-to-person transmission of *M. tuberculosis* includes a) clusters of TST conversions, b) an HCW with confirmed TB disease, c) increased rates of TST conversions, d) unrecognized TB disease in patients or HCWs, or e) recognition of an identical strain of *M. tuberculosis* in patients or HCWs with TB disease identified by deoxyribonucleic acid (DNA) fingerprinting.

For the risk assessment, a TST conversion is a ≥10 mm increase in the size of the TST induration over a two-year period in any person (HCW or patient) with a documented negative two-step baseline TST result. For persons lacking two-step baseline TST results, a ≥10 mm increase in the size of the TST induration, compared to a single-step baseline result within the past two years, may also be considered a TST conversion, but the possibility of boosting cannot be excluded.

Conversions in test results for *M. tuberculosis* infection are usually interpreted as presumptive evidence of new *M. tuberculosis* infection, and recent infection is associated with an increased risk for progression to TB disease.

B.3.7b Classify these settings as potential ongoing transmission (regardless of other factors) until corrective measures have been taken and transmission has been demonstrated to have stopped.

B.3.7c The classification of potential ongoing transmission should be used as a temporary classification only. It warrants immediate investigation, and corrective steps. After it has been determined that ongoing transmission has ceased, the setting should be reclassified as medium risk. It is recommended to maintain the classification of medium risk for at least one year.

B.3.7d If it is possible to identify an area or group of HCWs in the setting in which the health-care–associated transmission is occurring, then the potential ongoing transmission classification can be limited to that group or area for efficiency and to decrease unwarranted testing in large settings. Otherwise, apply the classification of potential ongoing transmission to the entire setting.

B.3.8 If the risk classification for the setting is medium risk (indicating the need for a serial screening program to test HCWs for *M. tuberculosis* infection), the program should include all HCWs who have duties that involve face-to-face contact with patients with suspected or confirmed TB disease (including transport staff)

B.3.8a *Enter patient rooms or treatment rooms whether or not a* patient is present

B.3.8b *Participate in aerosol-generating or aerosol-producing procedures (e.g., bronchoscopy,* sputum induction, administration of aerosolized medications)(*58*).

B.3.8c *Participate in suspected or confirmed TB specimen processing.*

B.3.8.d *Install, maintain, or replace environmental controls in* areas where people with TB disease are encountered.

B.3.9 Based on the risk assessment, consider any features of the health-care setting that may increase concern about transmission of *M. tuberculosis* and indicate a need for a higher risk classification. These features include a) relatively high prevalence of immunosuppression among patients or HCWs (e.g., persons infected with HIV, organ transplant recipients), b) relatively high or increasing incidence of TB disease in the community served by the health-care setting, c) relatively high or increasing incidence of TB disease diagnosed in the health-care

setting, d) presence of patients with TB disease caused by drug-resistant strains of *M. tuberculosis.*

B.3.10 Based on the risk classification for the setting, determine the need for and frequency of TB screening (Table 4).

B.3.11 Settings that are classified as low-risk lose the ability to detect conversions in test results for *M. tuberculosis* infection through serial screening. In these settings, maintain attention to other administrative controls to detect or prevent transmission of *M. tuberculosis*. Proper use of environmental controls and respiratory protection should also be maintained.

B.3.12 Reassess the risk classification for the setting at appropriate intervals, and at least annually.

Screening HCWs Who Transfer to Other Health-care Settings
All HCWs should receive baseline TB screening, even in settings considered to be low-risk. The low-risk category of the risk assessment allows greater flexibility for serial TB screening. Infection-control plans should address HCWs who transfer from one health-care setting to another, and consider that the transferring HCWs may be at an equivalent or higher risk of exposure in different settings. Infection-control plans may need to be customized to balance the assessed risks and the efficacy of the plan based on consideration of various logistical factors. Guidance is provided based on different scenarios.

For HCWs Transferring From Low-risk to Low-risk Settings
Once a baseline result for infection with *M. tuberculosis* is established, serial testing for *M. tuberculosis* infection is not necessary.

For HCWs Transferring From Low-risk to Medium-risk Settings
Once a baseline result for infection with *M. tuberculosis* is established, annual TB screening (including a symptom screen, and TST for those with negative previous test results) should be performed.

For HCWs Transferring From Low- or Medium-risk Settings to Settings with a Temporary Classification of Potential Ongoing Transmission
Once a baseline result for infection with *M. tuberculosis* is established, a decision should be made on an individual basis regarding follow-up screening. If transmission seems to be continuing, consider including the HCW in the screenings every three months until it has been determined that ongoing transmission has ceased. When the setting is reclassified back to medium-risk, resume to annual TB screening (including a symptom screen, and TST for those with negative test results).

The following recommendations apply to all HCWs:

- For HCWs with documentation of a recent (≤12 months) negative TST result, that test result may be considered the baseline for the new setting, and a second-step TST is not needed.
- For HCWs with documentation of an old (>12 months) negative TST result or if no documentation is available for any test results for *M. tuberculosis* infection, two-step baseline TSTs should be performed.
- For HCWs with documentation of a positive TST result or of previous treatment for LTBI or TB disease, a symptom screen should be performed. If the symptom screen is positive, perform a chest radiograph. For immunocompromised HCWs, a chest radiograph may be recommended even in the absence of symptoms.
- HCWs should carry documentation of TST results, or documentation of treatment of LTBI or TB disease, to the new setting.
- HCWs with untreated LTBI may be offered treatment upon hire, if eligible.

Table 3 here
Table 4 here
Table 5 here

B.4 Calculation and Use of *M. tuberculosis* Infection Conversion Rates

The *M. tuberculosis* infection conversion rate is the percentage of HCWs who have converted their test for *M. tuberculosis* infection within a specified time period. Timely detection of *M. tuberculosis* infection in HCWs not only facilitates treatment for LTBI, but also can indicate the need for a source case investigation and a revision of the risk assessment for the setting. Conversion in test results for *M. tuberculosis*, regardless of the testing methodology used, are usually interpreted as presumptive evidence of new *M. tuberculosis* infection and recent infections are associated with an increased risk for progression to TB disease.

For administrative purposes, a TST conversion is ≥10 millimeter (mm) increase in the size of the TST induration over a two-year period in an HCW with a documented negative (<10 mm) two-step baseline TST result, or in a person who is not a HCW with a negative (<10 mm) TST result within two years.

In settings conducting serial testing for *M tuberculosis* infection, follow these steps to estimate the risk for test conversion in HCWs:

B.4.1 Calculate an *M. tuberculosis* infection test conversion rate by dividing the number of conversions amon*g* HCWs in the setting in a specified period of time (numerator) by the number of HCWs who were tested in the setting over the same period of time (denominator) multiplied by 100. See example below.

B.4.2 Identify areas or groups in the setting with a potentially high risk for *M. tuberculosis* infection test conversions by comparing conversion rates in HCWs with potential exposure to patients with TB disease to conversion rates in HCWs for whom health-care–associated exposure to *M. tuberculosis* is unlikely.

B.4.3 Use *M. tuberculosis* infection test conversion data to identify lapses in infection control.

B.4.4 *M. tuberculosis* infection test conversion rates above the baseline level should trigger an epidemiologic investigation to evaluate the likelihood of health-care–associated transmission (Recommendations, Section H). If *M. tuberculosis* infection test conversions are determined to be the result of well-documented community exposure or probable false-positive test results, the setting's risk classification does not need to be adjusted.

B.4.5 For settings that no longer perform serial testing for *M. tuberculosis* infection among HCWs, reassessment of the setting's risk is important to ensure that the infection-control program is effective. The setting should have ongoing communication with the state or local health department regarding incidence and epidemiology of TB in the population served, and ensure that timely contact investigations are performed for HCWs or patients with unprotected exposure to a person with TB disease.

Example calculation of conversion rates.

Medical Center A is classified as medium risk on risk assessment and uses TST for annual screening. At the end of 2004, there were 10,051 persons designated as HCWs. Of these, 9,246 had a negative baseline for *M. tuberculosis* infection under administrative criteria and who were tested in 2004. Of those tested, 10 HCWs has an increase in TST result by ≥10 mm. The overall setting conversion rate for 2004 is 0.11%. If 5 of the 10 HCWs who converted were among the 100 HCWs employed in the medical intensive care units (MICU) of Hospital X (in Medical Center A), then the MICU setting-specific conversion rate for 2004 is 5%.

Evaluation of HCWs for LTBI should include information from a serial testing program, but this information must be interpreted as only one part of a full assessment. TST or QFT conversion criteria for administrative (surveillance) purposes are not applicable for medical evaluation of HCWs for the diagnosis of LTBI.

See Supplement 3 for use of QFT in risk classification.

B.5 Evaluation of TB Infection-Control Procedures and Identification of Problems

Annual evaluations of the TB infection-control plan are needed to ensure the proper implementation of the plan and to recognize and correct lapses in infection control.

B.5.1 *Review the medical records of a sample of patients with suspected and confirmed TB d*isease who were treated or examined at the setting to identify possible problems in TB infection control. As applicable, base the review on factors such as

- Time interval from
  - Suspicion of TB disease and patient triage to proper AII or referral center (for settings that do not provide care for patients with suspected or confirmed TB disease)
  - Admission until TB disease was suspected
  - Admission until medical evaluation for TB disease was performed
  - Admission until specimens for AFB smears and polymerase chain reaction (PCR)-based nucleic acid amplification (NAA) tests for *M. tuberculosis* were ordered
  - Admission until specimens for mycobacterial culture were ordered
  - Ordering of AFB smears, NAA tests, and mycobacterial culture until collection of specimens
  - Collection of specimens until performance and reporting of AFB smear results
  - Collection of specimens until performance and reporting of culture results
  - Collection of specimens until species identification reported
  - Collection of specimens until drug-susceptibility test results reported
  - Admission until initiation of AII
  - Admission until initiation of anti-tuberculosis treatment
- Duration of AII
- Measurement of meeting criteria for discontinuing AII (note: some patients may be correctly discharged from an AII room to home)
- Patient history of prior admission
- Adequacy of anti-tuberculosis treatment regimens
- Adequacy of procedures for collection of follow-up sputum specimens

- Adequacy of discharge planning
- Number of visits to outpatient setting from the start of symptoms until TB disease was suspected (for outpatient settings)

B.5.2 Note previous hospital admissions and outpatient visits of patients with TB disease before the onset of TB symptoms. Suspect patient-to-patient *transmission* if a) TB disease occurred in a patient who was previously hospitalized and exposed in the hospital to another patient with TB disease who was not placed in an AII room, b) two or more TB patients had overlapping visits to an outpatient setting, or c) isolates from two or more TB patients had identical drug-resistance or DNA fingerprint patterns.

B.5.3 Determine if all HCWs who should participate in TB screening are included in the program and in any investigation of possible health-care–associated transmission of *M. tuberculosis*.

B.5.4 Observe work practices related to AII to determine if employers are enforcing all practices, if HCWs are adhering to infection-control policies and if patient adherence to AII is being enforced.

B.5.5 Use data from the case reviews and observations in the annual risk assessment to determine the need to modify a) administrative controls, protocols, and practices for identifying and isolating patients with suspected or confirmed infectious TB disease, b) laboratory procedures, c) protocols for patient management, or d) TB training and education programs for HCWs.

B.6 Environmental Assessment

B.6.1 Review data from the most recent environmental evaluation to determine if recommended environmental controls are in place (Table 6).

B.6.2 Review environmental control maintenance procedures and logs to determine if maintenance is conducted properly and regularly.

B.6.3 Compare environmental control design specifications with guidelines from the American Institute of Architects (AIA) and other ventilation guidelines (Supplement 4, Table 7) and the installed system performance.

B.6.4 Use environmental data to assist building managers and engineers in evaluating the performance of the installed system(s).

B.6.5 Assess the number and types of aerosol-generating or aerosol-producing procedures (e.g., specimen processing and manipulation, bronchoscopy, sputum induction, administration of aerosolized medications) performed in the setting.

B.6.6 Determine if the number of AII rooms present is suitable for the setting based on AIA Guidelines and the setting risk assessment. JCAHO has adapted the AIA guidelines when accrediting facilities (*121*).

Table 6 here

C. TB Infection-Control Plan

C.1 *Based on the risk assessment for* the setting, decide on proper administrative, environmental, and respiratory protection policies and measures to prevent health-care–associated transmission of *M. tuberculosis*. These decisions will form the basis for a setting-specific TB infection-control plan (Table 1).

C.2 *Update an existing TB infection-control plan, o*r write a new plan if none exists.

C.3 *Conduct a TB risk assessment at least annually*, and more frequently in settings where health-care–associated transmission of *M. tuberculosis* is suspected or confirmed. Based on the results, conduct a problem evaluation and take recommended action. If necessary, also revise the risk classification as indicated.

C.4 *After each risk assessment, review all TB infection-control policies* to ensure that they are effective and meet current needs. Revise the written TB infection-control plan as indicated.

DRAFT

Table 1 here (landscaped pages)

D. Managing Patients Who Have Suspected or Confirmed TB Disease – General Recommendations

The primary TB risk to HCWs is the undiagnosed or unsuspected patient with infectious TB disease. A high index of suspicion for TB disease and rapid implementation of precautions are essential to preventing and interrupting transmission. The TB infection-control plan should include specific policies and work practices to ensure the prompt identification, triage, and referral or management of patients with suspected or confirmed TB disease, and measures should be taken to minimize the risk for transmission of M. tuberculosis to other patients and HCWs. Specific precautions will vary depending on the setting.

D.1 Prompt triage

All health-care settings should implement and enforce protocols to promptly identify, isolate, and either refer or manage persons who have suspected or confirmed infectious TB disease.

D.1.1 When taking patients' medical histories, routinely ask all patients about a) a history of TB exposure, infection, or disease, b) signs or symptoms of TB disease, and c) medical conditions that increase the risk for TB disease (Supplement 2). The medical evaluation should include an interview conducted in the patient's primary language, with the assistance of a qualified medical interpreter if necessary. HCWs who are the first point of contact should be trained to ask questions that will facilitate detection of persons who have suspected or confirmed infectious TB disease. For assistance with language interpretation, contact the state and local health department. Interpretation resources are available (*122*) (www.atanet.org; www.languageline.com; www.ncihc.org).

D.1.2 Consider a diagnosis of respiratory TB disease for any patient with signs or symptoms of infection in the lung, pleura, or airways including larynx, including coughing for ≥3 weeks, loss of appetite, unexplained weight loss, night sweats, bloody sputum or hemoptysis, hoarseness, fever, fatigue, or chest pain. The index of suspicion for TB disease will vary by geographic area and will depend on the population served by the setting. The index of suspicion should be very high for geographic areas and groups of patients characterized by high TB incidence (*26*).

D.1.3 In settings other than TB clinics, promptly refer for medical evaluation any patients with symptoms suggestive of undiagnosed or inadequately treated TB disease to a setting that treats patients with TB disease. Do not keep these patients in the setting any longer than required to arrange a referral or transfer to an AII room. While in the setting, the patient should wear a surgical or procedure mask and should be instructed to observe strict respiratory hygiene and cough etiquette procedures (see Respiratory Hygiene in Glossary) (*123-125*).

D.1.4 Keep any patient with suspected or confirmed pulmonary or laryngeal TB disease (or in rare cases a cutaneous TB abscess) in AII until the patient has been determined to be noninfectious and has demonstrated a clinical response to a standard multidrug anti-tuberculosis treatment regimen (Supplement 1). Since people with extrapulmonary TB disease frequently have coexisting respiratory TB disease, patients suspected to have extra-pulmonary TB should be kept in AII until they are

confirmed to be noninfectious by medical and diagnostic evaluation which may include examination of sputum for AFB.

D.1.5 Persons with tuberculous pleural effusions may also have concurrent unsuspected pulmonary or laryngeal TB disease. These patients should be considered infectious until pulmonary TB disease is excluded(*119*).

D.1.6 HIV-infected patients and other immunocompromised persons with infectious TB disease should be physically separated from other people to protect both themselves and others. To avoid exposing HIV-infected or otherwise severely immunocompromised persons to *M. tuberculosis,* designate certain times of the day for their appointments, or treat them in separate areas of the setting.

D.2 TB AII precautions

Initiate TB AII precautions for any patient who a) has signs or symptoms of TB disease, or b) has documented TB disease and has not completed anti-tuberculosis treatment. For patients placed in AII due to suspected infectious TB disease of the lungs, airway, or larynx, AII can be discontinued when infectious TB disease is considered unlikely* and *either 1) another diagnosis is made that explains the clinical syndrome* or *2) the patient has three consecutive, negative AFB sputum smear results (*126-130*). Each of the three sputum specimens should be collected 8–24 hours apart (*131*), and at least one should be an early morning specimen (because respiratory secretions pool overnight). Generally, this will allow patients with negative sputum smear results to be released from AII in two days.

The setting's risk assessment will determine how many AII rooms each setting needs, depending on the number of TB patients seen. At least one AII room is needed for settings where TB patients stay while they are being treated, plus one additional AII room for every 200 patient-days of cases of suspected or confirmed TB disease. Additional rooms may be considered if options are limited for transferring patients with suspected or confirmed TB disease to other settings with AII rooms. For example, for a hospital with 120 beds, a minimum of one AII room is needed, possibly more, depending on how many TB cases are seen in one year.

D.2.1 Settings where patients with suspected or confirmed TB disease will be encountered

Settings that plan to evaluate and manage patients with TB disease should have at least one AII room or enclosure that meets AII requirements (Supplement 4). These settings should

D.2.1a Develop written policies that specify a) indications for AII, b) persons authorized to initiate and discontinue AII, c) AII practices, d) AII room monitoring procedures, e) procedures for managing patients who do not adhere to AII practices, and f) criteria for discontinuing AII.

D.2.1b Maintain a high index of suspicion for TB disease. If a patient has suspected or confirmed TB disease, promptly initiate AII procedures.

D.2.1c Keep inpatients with suspected or confirmed TB disease in AII until they are determined to be noninfectious and have demonstrated a clinical response to a standard multidrug anti-tuberculosis treatment regimen or until an alternative diagnosis is made. If the alternative diagnosis cannot be clearly established, even with three negative sputum smear results, empiric treatment of TB disease should strongly be considered (Supplement 1).

D.2.1d Keep outpatients with suspected or confirmed TB disease in AII until they are transferred or until their visit is complete.

D.2.2 Settings where patients with suspected or confirmed TB disease will not be encountered

Settings in which patients with suspected or confirmed TB disease are rarely seen do not need an AII room or a respiratory protection program for the prevention of TB transmission. Instead, these settings should

D.2.2a *Develop a written protocol for referring patients with* suspected or confirmed TB disease to a collaborating setting where the patient can be evaluated and managed properly. The collaborating setting should provide documentation of intent to collaborate. Review the triage and referral protocol routinely, and revise it as needed.

D.2.2b *Place any patient with suspected or confirmed TB* disease in an AII room if available, or in a room that meets the requirements for AII, or in a separate room with the door closed, apart from other patients and not in an open waiting area. Allow adequate time to elapse to ensure removal of *M. tuberculosis*-contaminated room air before allowing entry by staff or another patient (Supplement 4, Table 8).

D.2.2c *Give any person with suspected or confirmed TB disease* a surgical or procedure mask to wear that covers the mouth and nose. Instruct the patient to keep the mask on and to change the mask if it becomes wet. If patients cannot tolerate a mask, they should observe strict respiratory hygiene and cough etiquette procedures.

D.2.2d *Promptly recognize and transfer patients with suspected* or confirmed TB disease to a setting that treats patients with TB disease, according to the written protocol.

D.3 AII room practices

AII rooms should be single-patient rooms in which environmental factors and entry of visitors and HCWs are controlled to minimize the transmission of *M. tuberculosis*. All persons including visitors and those who are not HCWs who enter an AII room should wear at least N95 disposable respirators (Supplement 5). Visitors should be instructed by HCWs on the use of the respirator prior to entering an AII room. AII rooms have specific requirements for controlled ventilation, negative pressure, and air filtration (*121*) (Supplement 4). Each inpatient AII room should have a private bathroom. Settings with AII rooms should adhere to the following practices:

D.3.1 Keep doors to AII rooms closed except when patients, HCWs or others must enter or exit the room.

D.3.2 Maintain enough AII rooms to isolate all patients who have suspected or confirmed TB disease. Estimate the number of AII rooms needed based on the results of the risk assessment for the setting.

D.3.3 While the room is being used for TB AII, monitor and record negative pressure in the room on a daily basis. Record results in a local retrievable document.

D.3.4 Consider grouping AII rooms in one part of the health-care setting to limit costs, reduce the possibility of transmitting *M. tuberculosis* to other patients, facilitate the care of TB patients, and facilitate the installation and maintenance of optimal environmental controls (particularly ventilation). Depending on the architecture and the environmental control systems of a particular setting, AII rooms may be grouped either horizontally (i.e., a wing of a facility), or vertically (i.e., the last few rooms of several floors of a facility).

D.3.5 Perform diagnostic and treatment procedures such as sputum collection and inhalation therapy in an AII room.

D.3.6 Ensure patient adherence to AII procedures. In their primary language, with the assistance of a qualified medical interpreter if necessary, educate patients who are placed in an AII room about *M. tuberculosis* transmission and the reasons for their AII. For assistance with language interpretation, contact the state and local health department. Interpretation resources are available (*122*) (www.atanet.org; www.languageline.com; www.ncihc.org). Facilitate patient adherence by use of incentives (e.g., provide telephones, televisions, or radios in AII rooms; grant special dietary requests) and other measures. Address problems that could interfere with adherence (e.g., management of withdrawal from addictive substances, including tobacco).

D.3.7 Patients with suspected or confirmed infectious TB disease who must be transported to another area of the setting or to another setting for a medically essential procedure should bypass the waiting area. While they are being transported to the next setting, patients with suspected or confirmed infectious TB disease should wear surgical or procedure masks that cover the mouth and nose during transport. Schedule procedures on patients with TB disease when a minimum number of HCWs and other patients are present and as the last procedure of the day to maximize the time available for removal of airborne contamination (Supplement 4, Table 8). HCWs and transport staff generally do not need respiratory protection when transporting a patient from one setting to another within a setting.

D.4 Diagnostic procedures

Diagnostic procedures should be performed in settings with appropriate infection-control capabilities where the following recommendations apply for diagnosing TB disease and evaluating patients for potential infectiousness.

D.4.1 Clinical diagnosis

D.4.1a Obtain a complete medical history, including exposure to persons with TB disease and prior history of infection with *M. tuberculosis*, TB disease or treatment of LTBI or TB disease.

D.4.1b Perform a physical examination, testing for infection *with M. tuberculosis*, chest radiograph, microscopic examination, culture and, when indicated, NAA testing of sputum (*36,50,132,133*). Other specimens may need to be collected including those obtained via sputum induction with aerosol inhalation, gastric aspiration, or bronchoscopy (*97,128,134-139*). Gastric aspiration may be necessary for those patients, particularly children, who cannot produce sputum even with aerosol inhalation (*134,135,140,141*).

D.4.1c Place all patients with suspected or confirmed infectious TB disease in AII until they are determined to be noninfectious (Supplement 1). Adult and adolescent patients who may be infectious include persons who are coughing, have cavitation on chest radiograph, have positive AFB sputum smear results, have respiratory tract disease with involvement of the lung, pleura or airways including larynx, who fail to cover the mouth and nose when coughing, who are not on anti-tuberculosis treatment or are on incorrect anti-tuberculosis treatment, or who are undergoing cough-inducing or aerosol-generating procedures (e.g., sputum induction, bronchoscopy, airway suction) *(28,142)*.

D.4.1d Evaluate persons diagnosed with extrapulmonary TB disease for the presence of concurrent pulmonary TB disease.

D.4.1e Most children with TB disease are not infectious and require only standard precautions. The major concern in infection control relates to adult household members and visitors who may be the source case (*143*). Pediatric patients, including adolescents, who may be infectious include those who have extensive pulmonary or laryngeal involvement, prolonged cough, positive sputum AFB smears results, cavitary TB on chest radiograph, or those for whom cough-inducing or aerosol-generating procedures are performed (*143,144*).

D.4.1f Evaluate pediatric patients for infectiousness using the same criteria as for adults (i.e., on the basis of pulmonary or laryngeal involvement) (D.4.1c).

D.4.1g Report patients with suspected or confirmed TB disease immediately to the local public health authorities so that standard procedures for identifying and evaluating TB contacts can be initiated. Coordinate efforts with the state or local health department to arrange treatment and long-term follow-up and evaluation of contacts.

D.4.2 Laboratory diagnosis

D.4.2a For highest quality laboratory results, ensure that laboratories performing mycobacteriologic tests are skilled in both the laboratory and the administrative aspects of specimen processing.

D.4.2b Ensure that laboratories use or have prompt access to the most rapid methods available: a) fluorescent microscopy for AFB smears; b) rapid NAA testing for direct detection of *M. tuberculosis* in patient specimens (*132*); c) solid and rapid broth culture methods for isolation of mycobacteria; d) nucleic acid probes or high-pressure liquid chromatography (HPLC) for species identification; and e) rapid broth culture methods for drug-susceptibility testing. Ensure that laboratories incorporate other more rapid or sensitive tests as they become available, practical, and affordable (Supplement 2) (*145,146*).

D.4.2c *In accordance with state and local laws and regulations*, laboratories should report (by telephone, fax, or e-mail) positive AFB smear results from any specimens within 24 hours of collection and positive culture results within 24 hours of the notation of the positive culture result (*146,147*). Some settings perform AFB smears on-site for rapid results and then send specimens or cultures to a referral laboratory for identification and drug-susceptibility testing. This referral practice can speed the receipt of smear results but delay culture identification and drug-susceptibility results. Settings that cannot provide the full range of mycobacteriologic testing services should contract with their referral laboratories to ensure rapid results while maintaining proficiency for on-site testing. In addition, referral laboratories should be instructed to store isolates in case further testing is necessary.

D.4.2d *Report all drug-susceptibility results on M. tuberculosis* isolates to the state or local health department as soon as these results are available.

D.4.2e *Laboratories that rarely receive specimens for* mycobacteriologic analysis should refer specimens to a laboratory that performs these tests routinely. The reference laboratory should provide rapid testing and reporting. Out-of-state reference laboratories should provide all results to the state or local health department from which the specimen originated.

D.4.3 Special considerations for persons who are at high risk for TB disease or in whom TB disease may be difficult to diagnose

D.4.3a *The probability of TB disease is greater among patients* who a) have a positive TST result, b) previously had TB disease or were exposed to *M. tuberculosis* or c) belong to a group at high risk for TB disease. TB disease is strongly suggested if the diagnostic evaluation reveals AFB in sputum or from any other specimen, a chest radiograph suggestive of TB disease, or signs or symptoms of TB disease.

D.4.3b TB disease can occur simultaneously in immunocompromised persons who have pulmonary infections caused by other organisms (e.g., *Pneumocystis jaroveci* [formerly *P. carinii*], *M. avium complex*) and should be considered in the diagnostic

evaluation of all such patients with signs or symptoms of TB disease (*50*).

D.4.3c TB disease can be difficult to diagnose in persons who have HIV infection (*46*) (or other conditions associated with severe suppression of cell-mediated immunity) due to extrapulmonary disease or nonclassical clinical or even normal radiographic presentation or the simultaneous occurrence of other pulmonary infections (e.g., *P. jaroveci*, *M. avium complex*) (*2*). The difficulty in diagnosing TB disease in persons infected with HIV can be compounded by a false-negative TST result for *M. tuberculosis* infection due to impaired host immunity (*32,50,148*), the possibly lower sensitivity and specificity of sputum smear results for detecting AFB (*50,149*), and the overgrowth of cultures with *M. avium complex* in specimens from patients infected with both *M. tuberculosis* and *M. avium complex*.

For immunocompromised patients who have respiratory signs or symptoms that are attributed initially to infections or conditions other than TB disease, conduct an evaluation for coexisting TB disease. Repeat the evaluation if the patient does not respond to recommended treatment for the presumed cause(s) of the pulmonary abnormalities (Supplement 2). In some settings where immunocompromised patients and patients with TB disease are seen, it may be prudent to implement AII for all high-risk persons (e.g., persons infected with HIV, symptomatic foreign-born persons who have immigrated within the last five years from TB-endemic countries, and persons with pulmonary infiltrates on chest radiograph, or signs or symptoms of TB disease).

D.5 Initiation of treatment

D.5.1 For patients who have confirmed TB disease or who are considered highly probable to have TB disease, start anti-tuberculosis treatment promptly in accordance with current guidelines (Supplement 2) (*29*). TB treatment decisions should be coordinated with the state or local health department.

D.5.2 All inpatient medication should be given by DOT and reported to the state or local health department. DOT is an adherence-enhancing strategy in which a trained HCW or other specially trained person watches a patient swallow each dose of medication and records the dates of the observations. 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 treatment of TB disease and for LTBI whenever feasible. All patients on intermittent (i.e., once- or twice-weekly) treatment for TB disease or LTBI should receive DOT. Rates of relapse and development of drug-resistance are decreased when DOT is used (*150-152*). Collaborate with the state or local health department on decisions about inpatient DOT and arrangements for outpatient DOT (*29*).

D.5.3 Because of the severity of TB disease among immunocompromised patients, DOT is strongly recommended for patients infected with HIV. DOT is used to provide effective therapy, to prevent acquired drug resistance during treatment, and to allow TB disease to be cured with a relatively short course of treatment (6–9 months) (*46*).

E. Managing Patients Who Have Suspected or Confirmed TB Disease – Additional Considerations for Special Circumstances and Settings

The recommendations for preventing transmission of *M. tuberculosis* (Recommendations, Sections A–L) are applicable to all health-care settings, including those that are described in this section. These settings should each have independent risk assessments if they are stand-alone settings, or each should have a detailed section written as part of the risk assessment for the overall setting. Additional TB-infection controls that are applicable to special circumstances and types of health-care delivery settings are described here and summarized in Table 1.

E.1 Minimum requirements

The specific precautions for the settings included in this section vary depending on the setting. Special settings may include inpatient settings such as patient rooms, emergency departments and urgent care settings, intensive care units (ICUs), surgical suites, laboratories, bronchoscopy suites, sputum induction and inhalation therapy rooms, autopsy suites and embalming rooms; outpatient settings such as TB treatment facilities, dental-care settings, medical offices and ambulatory-care settings, and dialysis units; and nontraditional facility-based settings such as emergency medical services (EMS), medical settings in correctional facilities, home-based health-care and outreach settings and long-term care facilities (LTCFs) (Recommendations, Table 1). At a minimum, these settings should do the following:

E.1.1 Perform an annual risk assessment for the setting.

E.1.2 Develop and regularly evaluate and revise a written TB infection-control plan.

E.1.3 Establish and implement protocols for identifying and managing patients with suspected or confirmed TB disease.

E.1.4 Ensure that HCWs receive recommended TB training, education, and screening for *M. tuberculosis* infection as part of the infection-control plan (Recommendations, Section F).

E.1.5 Establish protocols for problem evaluation.

E.1.6 Collaborate with the state or local health department when necessary.

E.1.7 When possible, postpone nonurgent procedures, which may put HCWs at risk, on patients with suspected or confirmed infectious TB disease until the patient is determined to not have TB disease or to be noninfectious.

Inpatient settings

E.2 Emergency departments

In general, the symptoms of TB disease are symptoms for which patients might seek treatment in emergency departments. Since TB symptoms are common and nonspecific, it is possible that infectious TB disease could be encountered in these settings. The use of emergency department-based TB screening has not

been shown to be consistently effective (*153*). Due to the potential for *M. tuberculosis* transmission in these settings, the general recommendations (Recommendations, Section II.D) should be followed.

E.2.1 Minimize the amount of time patients with suspected or confirmed infectious TB disease spend in emergency departments and urgent-care settings.

E.2.2 Ensure that patients with suspected or confirmed infectious TB disease are promptly identified, evaluated, and placed away from other patients. Ideally, such patients should be placed in an AII room. When an AII room is not available, use a room with good general ventilation and use air cleaning technologies such as a portable HEPA filtration system, if available, or transfer the patient to a setting or area with recommended infection-control capacity.

E.2.3 Emergency departments with a high volume of patients with suspected or confirmed TB disease should have at least one AII room. (See Recommendations, Section B, TB Risk Assessment to determine high volume.)

E.2.4 Air-cleaning technologies, such as HEPA filtration and UVGI, may be used to increase equivalent air changes per hour (ACH) in waiting areas (Supplement 4).

E.2.5 HCWs entering an AII room or any room with a patient with infectious TB disease should wear at least an N95 disposable respirator.

E.2.6 After a patient with suspected or confirmed TB disease exits a room, allow adequate time to elapse to ensure removal of *M. tuberculosis*-contaminated room air before allowing entry by staff or another patient (Supplement 4, Table 8).

E.2.7 Before a patient leaves an AII room, perform an assessment of the patient's need to be out of isolation, the risk for transmission and the patient's ability to observe strict respiratory hygiene and cough etiquette procedures.

E.2.8 Instruct patients who are outside an AII room to wear a surgical or procedure mask. Patients who cannot tolerate masks due to medical conditions should observe strict respiratory hygiene and cough etiquette procedures.

E.3 Intensive-care units (ICUs)

Patients with infectious TB disease may become sick enough to require admission to an ICU.

E.3.1 Place ICU patients with suspected or confirmed infectious TB disease in an AII room, if possible.

E.3.2 ICUs with a high volume of patients with suspected or confirmed TB disease should have at least one AII room. (See Recommendations, Section B, TB Risk Assessment to determine high volume.)

E.3.3 Air-cleaning technologies, such as HEPA filtration and UVGI, may be used to increase equivalent air changes per hour (ACH) in waiting areas (Supplement 4).

E.3.4 HCWs entering an AII room or any room with a patient with infectious TB disease should wear at least an N95 disposable respirator.

E.3.5 To help reduce the risk of contaminating a ventilator or discharging *M. tuberculosis* into the ambient air when mechanically ventilating (i.e., with a ventilator or manual resuscitator) a patient with suspected or confirmed TB disease, place a bacterial filter on the patient's endotracheal tube (or at the expiratory side of the breathing circuit of a ventilator) (*154-158*). In selecting a bacterial filter, give preference to models shown by the manufacturer to filter particles 0.3 µm in size in both the unloaded and loaded states with a filter efficiency of ≥95% (i.e., filter penetration of <5%), at the maximum design flow rates of the ventilator for the service life of the filter, as specified by the manufacturer.

E.4 Surgical suites

Surgical suites require special infection-control considerations for preventing transmission of *M. tuberculosis.* Normally, the direction of airflow should be from the operating room to the hallway (positive pressure) to minimize contamination of the surgical field. Some hospitals already have procedure rooms with reversible airflow or pressure while others have positive-pressure rooms with a negative pressure anteroom. Surgical staff, particularly those close to the surgical field, should use respiratory protection (e.g., a valveless N95 disposable respirator), to protect themselves and the patient undergoing surgery.

E.4.1 When possible, postpone nonurgent surgical procedures on patients with suspected or confirmed TB disease until the patient is determined to be noninfectious or determined to not have TB disease.

E.4.2 When surgery cannot be postponed, procedures should be performed in a surgical suite with recommended ventilation controls. Schedule procedures on patients with suspected or confirmed TB disease when a minimum number of HCWs and other patients are present in the surgical suite, and at the end of the day to maximize the time available for removal of airborne contamination (Supplement 4, Table 8).

E.4.3 If a surgical suite or an operating room has an anteroom, the anteroom should be either a) positive pressure relative to both the corridor and the suite or operating room (with filtered supply air), or b) negative pressure relative to both the corridor and the suite or operating room.

E.4.4 If an operating room has no anteroom, keep the doors to the operating room closed, and minimize traffic into and out of the room and in the corridor. Consider using additional air-cleaning technologies, such as HEPA filtration or UVGI, to increase the equivalent ACH. Air-cleaning systems may be placed in the room or in surrounding areas to minimize contamination of the surroundings (Supplement 4, Section IV).

E.4.5 Design the ventilation in the operating room to ensure a sterile environment in the surgical field while preventing contaminated air from flowing to other areas in the health-care setting.

E.4.6 Take steps to reduce the risk for contaminating ventilator or anesthesia equipment or discharging tubercle bacilli into the ambient air when operating on a patient with suspected or confirmed TB disease (*159*). Place a bacterial filter on the patient's endotracheal tube (or at the expiratory side of the breathing circuit of a ventilator or anesthesia machine, if used) (*154-158*). In selecting a bacterial filter, give

preference to models shown by the manufacturer to filter particles 0.3 µm in size in both the unloaded and loaded states with a filter efficiency of ≥95% (i.e., filter penetration of <5%), at the maximum design flow rates of the ventilator for the service life of the filter, as specified by the manufacturer.

E.4.7 When surgical procedures (or other procedures that require a sterile field) are performed on patients with suspected or confirmed infectious TB, respiratory protection should be worn by HCWs to protect the sterile field from the respiratory secretions of HCWs as well as protect HCWs from the infectious droplet nuclei generated from the patient. When selecting respiratory protection, do not use valved or positive-pressure respirators because they do not protect the sterile field. Use a respirator with a valveless filtering facepiece, such as an N95 disposable respirator.

E.4.8 Postoperative recovery of a patient with suspected or confirmed TB disease should be in an AII room. If an AII or comparable room is not available for surgery or post-operative recovery, air-cleaning technologies such as HEPA filtration and UVGI may be used to increase the number of equivalent ACH (Supplement 4); however, the infection control committee should be involved in the selection and placement of these supplemental controls.

E.5 Laboratories

Staff who work in laboratories that handle clinical specimens encounter risks not typically present in other areas of a health-care setting (*160-162*). Laboratories that handle TB specimens include a) pass-through facilities that forward specimens to reference laboratories for analysis; b) diagnostic laboratories that process specimens and perform acid-fast staining and primary culture for *M. tuberculosis*; and c) facilities that perform extensive identification, subtyping, and susceptibility studies.

Procedures involving the manipulation of specimens or cultures containing *M. tuberculosis* introduce additional significant risks that must be addressed in an effective TB infection-control program. Risks for transmission of *M. tuberculosis* in laboratories include aerosol formation during any isolate manipulation, and percutaneous inoculation from accidental exposures. Biosafety recommendations for laboratories performing diagnostic testing for TB have been published (*81,82,145,163,164*).

E.5.1 In laboratories affiliated with a health-care setting (e.g., a hospital), and in free-standing laboratories, the laboratory director, in collaboration with the infection-control staff for the setting, and in consultation with the state TB laboratory, should develop a risk-based infection-control plan for the laboratory that minimizes the risk for exposure to *M. tuberculosis*. Consider factors such as a) incidence of TB disease (including drug-resistant TB) in the community and in patients served by settings that submit specimens to the laboratory, b) design of the laboratory, c) level of TB diagnostic service offered, d) number of specimens processed, and e) whether or not aerosol-generating or aerosol-producing procedures are performed and the

frequency at which they are performed. Referral laboratories should store isolates in case further testing is necessary.

E.5.2 Biosafety Level (BSL)-2 practices and procedures, containment equipment, and facilities are required for nonaerosol-producing manipulations of clinical specimens (e.g., preparing smears for acid-fast staining) (*145*). Handle all specimens suspected of containing *M. tuberculosis* (including specimens processed for other microorganisms) in a Class I or II biological safety cabinet (BSC) (*165,166*). Conduct all aerosol-generating activities (e.g., preparing smears for acid-fast staining, inoculating culture media, setting up biochemical and antimicrobic susceptibility tests, opening centrifuge cups, performing sonication) in a Class I or II BSC (*165*).

E.5.3 For laboratories that are considered at least medium risk (Table 4), conduct testing for *M. tuberculosis* infection at least annually among laboratorians who perform TB diagnostics or manipulate specimens from which *M. tuberculosis* is commonly isolated (e.g., sputum, lower respiratory secretions or tissues). More frequent testing is recommended in the event of a documented *M. tuberculosis* infection test conversion among laboratory staff or a laboratory accident that poses a risk for exposure to *M. tuberculosis* (e.g., malfunction of a centrifuge leading to aerosolization of a sample).

E.5.4 Based on the risk assessment for the laboratory, employees should use personal protective equipment (including respiratory protection) recommended by local regulations for each activity.

- **E.5.4a** For activities that have a low risk for generating aerosols, standard personal protective equipment consists of protective laboratory coats, gowns, or smocks designed specifically for use in the laboratory. Leave protective garments in the laboratory before leaving for nonlaboratory areas.
- **E.5.4b** Wear disposable gloves for all laboratory procedures. Dispose of the gloves when work is completed, when the gloves are overtly contaminated, or when the integrity of the glove is compromised. State or local regulations should determine procedures for the disposal of gloves.
- **E.5.4c** Use face protection (e.g., goggles, full-facepiece respirator, face shield, or other splatter guard) when manipulating specimens outside a BSC.
- **E.5.4d** Use respiratory protection for the performance of procedures that can result in aerosolization outside a BSC. The minimum level of respiratory protection is an N95 filtering facepiece respirator. Provide laboratory workers who use respiratory protection with the same training on respirator use and care and the same fit testing as other HCWs.

E.5.5 After documented laboratory accidents, conduct an investigation of exposed laboratory workers.

E.5.6 Laboratories in which specimens for mycobacteriologic studies (e.g., AFB smears and cultures) are processed should follow the AIA and CDC/NIH guidelines (*121,166*) (Supplement 4).

E.5.7 BSL-3 practices, containment equipment, and facilities are required for the propagation and manipulation of cultures of *M. tuberculosis* or *M. bovis* and for animal studies using primates that are experimentally or naturally infected with *M. tuberculosis* or *M. bovis*. Animal studies utilizing guinea pigs or mice can be conducted at Animal BSL-2 (*166*).

E.5.8 Health-care settings classified as low risk may consider a classification of *medium risk* for the laboratory based on the above outlined factors.

E.6 Bronchoscopy suites

Because bronchoscopy is a cough-inducing procedure that may be performed on patients with suspected or confirmed TB disease, bronchoscopy suites require special attention (*58,88,167,168*). Bronchoscopy can result in the transmission of *M. tuberculosis* either through the airborne route (*58,70,88,93,169*) or a contaminated bronchoscope (*87,89,170-177*). Closed and effectively filtered ventilatory circuitry and minimizing opening of such circuitry in intubated and mechanically-ventilated patients may minimize exposure (Recommendations, Section E.3.5) (*156*).

E.6.1 Avoid bronchoscopy on patients with suspected or confirmed TB disease, or postpone until the patient is determined to be noninfectious, by confirmation of three negative AFB sputum smear results (*126-129*).

E.6.2 When collection of spontaneous sputum specimen is not adequate or possible, sputum induction has been shown to be equivalent to bronchoscopy for obtaining specimens for culture (*127*). Sputum induction can be costly; one study suggests that sputum induction be reserved for those without a productive cough whose signs or symptoms strongly indicate a diagnosis of TB disease (*129*).

E.6.3 Perform a physical examination; test for *M. tuberculosis* infection, obtain a chest radiograph, microscopic examination, culture and NAA testing of sputum or other relevant specimens including gastric aspirates (*132*) as indicated (*50,133,136,141*).

E.6.4 Whenever possible, perform bronchoscopy in a room that meets the ventilation requirements for an AII room (Supplement 4). Air-cleaning technologies such as HEPA filtration and UVGI may be used to increase equivalent ACH.

E.6.5 If sputum specimens must be obtained and the patient cannot produce sputum, consider sputum induction before bronchoscopy (*128*).

E.6.6 In a patient who is intubated and mechanically-ventilated, minimize the opening of circuitry.

E.6.7 Use respiratory protection while present during a bronchoscopy procedure on a patient with suspected or confirmed infectious TB disease. Due to the increased risk for *M. tuberculosis* transmission during the performance of bronchoscopy procedures on patients with TB disease, consider using a higher level of respiratory protection than an N95 disposable respirator such as an elastomeric full-facepiece respirator or a powered air-purifying respirator (PAPR) (Supplement 5).

E.6.8 After bronchoscopy is performed on a patient with suspected or confirmed infectious TB disease, allow adequate time to elapse to

ensure removal of *M. tuberculosis*-contaminated room air before performing another procedure in the same room (Supplement 4, Table 8).

E.6.9 During the period following bronchoscopy when the patient is still coughing, collect at least one sputum for AFB to increase the yield of the procedure.

E.6.10 Keep patients with suspected or confirmed TB disease who are undergoing bronchoscopy in an AII room until coughing subsides.

E.7 Sputum induction and inhalation therapy rooms

Sputum induction and inhalation therapy induces coughing, which increases the potential for transmission of *M. tuberculosis* (*94,95,97*). Therefore, appropriate precautions should be taken when working with patients with suspected or confirmed TB disease.

E.7.1 Sputum induction procedures for persons with suspected or confirmed TB disease should be pursued after it is determined that self-produced sputum collection is inadequate and that the AFB smear result on other specimens collected is negative.

E.7.2 HCWs who order or perform sputum induction or inhalation therapy in an environment without proper controls, for the purpose of diagnosing conditions other than TB disease should assess the patient's risk for TB disease.

E.7.3 In any setting, cough-inducing or aerosol-generating procedures in patients with diagnosed TB should be conducted only after an assessment of infectiousness has been considered for each patient. The criteria for infectiousness used to remove a patient from isolation may not be stringent enough in determining infectiousness of a patient who is to undergo a cough-inducing procedure.

E.7.4 Sputum induction should be performed using local exhaust ventilation (e.g., booths with special ventilation) or alternatively in a room that meets or exceed the requirements of an AII room (Supplement 4)(97).

E.7.5 At least an N95 disposable respirator should be worn by HCWs performing sputum inductions or inhalation therapy on a patient with suspected or confirmed infectious TB disease. Based on the risk assessment, consideration should be given to using a higher level of respiratory protection such as an elastomeric full-facepiece respirator or a PAPR (Supplement 5)(*97*).

E.7.6 After sputum induction or inhalation therapy is performed on a patient with suspected or confirmed infectious TB disease, allow adequate time to elapse to ensure removal of *M. tuberculosis*-contaminated room air before performing another procedure in the same room (Supplement 4, Table 8).

E.7.7 Keep patients with suspected or confirmed TB disease who are undergoing sputum induction or inhalation therapy in an AII room until coughing subsides.

E.8 Autopsy suites

Autopsies performed on bodies with suspected or confirmed TB disease can pose a high risk for transmission of *M. tuberculosis*, particularly during the performance of aerosol-generating procedures (e.g., median sternotomy). Persons who handle bodies may be at risk for transmission of *M. tuberculosis (84,85,178-184)*. Because some procedures performed as part of an autopsy may generate infectious aerosols, special AII measures are required.

E.8.1 Autopsies should not be performed on bodies with suspected or confirmed TB disease without adequate protection for those performing the autopsy procedures.

E.8.2 Settings where autopsies are performed should meet or exceed the requirements of an AII room if possible (Supplement 4, and the drawing in the ACGIH Industrial Ventilation Manual VS-99-07) (*185*). Air should be exhausted to the outside of the building. Air-cleaning technologies, such as HEPA filtration or UVGI may be used to increase the number of equivalent ACH (Supplement 4).

E.8.3 As an added administrative measure, when performing autopsies on bodies with suspected or confirmed TB disease, coordination between attending physician(s) and pathologists for proper infection control and specimen collection should be ensured.

E.8.4 The use of local exhaust ventilation should be considered to reduce exposures to infectious aerosols (e.g., when using a saw, including Striker saw).

E.8.5 For HCWs performing an autopsy on a body with suspected or confirmed TB disease, at least N95 disposable respirators should be worn (Supplement 5). Based on the risk assessment, consider using a higher level of respiratory protection than an N95 disposable respirator such as an elastomeric full-facepiece respirator or a PAPR (Supplement 5).

E.8.6 After an autopsy is performed on a body with suspected or confirmed TB disease, allow adequate time to elapse to ensure removal of *M. tuberculosis*-contaminated room air before performing another procedure in the same room (Supplement 4, Table 8). If time delay is not feasible, the autopsy staff should continue to wear respirators while in the room.

E.9 Embalming rooms

Embalming procedures on bodies with suspected or confirmed TB disease can pose a high risk for transmission of *M. tuberculosis*, particularly during the performance of aerosol-generating procedures. Persons who handle corpses may be at risk for transmission of *M. tuberculosis (84,85,178-183)*. Because some procedures performed as part of embalming may generate infectious aerosols, special AII measures are required.

E.9.1 Embalming should not be performed on bodies with suspected or confirmed TB disease without adequate protection for those performing the procedures.

E.9.2 Settings where embalming is performed should meet or exceed the requirements of an AII room if possible (Supplement 4, and the drawing in the ACGIH Industrial Ventilation Manual VS-99-07) (*185*). Air should be exhausted to the outside of the building. Air-cleaning technologies, such as HEPA filtration or UVGI may be used to increase the number of equivalent ACH (Supplement 4).

E.9.3 The use of local exhaust ventilation should be considered to reduce exposures to infectious aerosols (e.g., when using a saw, including Striker saw) and vapors from embalming fluids.

E.9.4 For HCWs embalming a body with suspected or confirmed TB disease, at least N95 disposable respirators should be worn (Supplement 5). Based on the risk assessment, consider using a higher level of respiratory protection than an N95 disposable respirator such as an elastomeric full-facepiece respirator or a PAPR (Supplement 5).

E.9.5 After embalming is performed on a body with suspected or confirmed TB disease, allow adequate time to elapse to ensure removal of *M. tuberculosis*-contaminated room air before performing another procedure in the same room (Supplement 4, Table 8). If time delay is not feasible, the embalming staff should continue to wear respirators while in the room.

Outpatient settings

Outpatient settings may include TB treatment facilities, dental-care settings, medical offices, ambulatory-care settings and dialysis units. Environmental controls should be implemented based on the types of activities that are performed in the setting. Patients requiring transport should be transported as discussed below under Emergency Medical Services (Recommendations, Section E.14.1).

E.10 TB treatment facilities

TB treatment facilities may include TB clinics, infectious disease clinics, or pulmonary clinics. TB clinics and other settings where patients with TB disease and LTBI are seen on a regular basis require special attention.

E.10.1 The same principles of triage used in emergency departments and ambulatory-care settings (Recommendations, E.12) should be applied to TB treatment facilities. These include prompt identification, evaluation, and AII of patients with suspected or confirmed infectious TB disease.

E.10.2 Screen all TB clinic staff for *M. tuberculosis* infection, including outreach workers (Table 4).

E.10.3 Patients with suspected or confirmed infectious TB disease should be physically separated from all patients, but especially from those with HIV infection and other immunocompromising conditions that increase the likelihood of development of TB disease if infected.

E.10.4 Immunosuppressed patients with suspected or confirmed infectious TB disease need to be physically separated from others to protect both the patient and others. Schedule appointments to avoid exposing HIV-infected or otherwise severely immunocompromised persons to *M. tuberculosis*. Designate certain times of the day for appointments for patients with infectious TB disease, or treat them in areas where immunocompromised persons are not treated.

E.10.5 Persons with suspected or confirmed infectious TB disease should be promptly placed in an AII room to minimize exposure in the waiting room and other areas of the clinic, and they should be instructed to observe strict respiratory hygiene and cough etiquette procedures.

E.10.6 Clinics that provide care for patients with suspected or confirmed infectious TB disease should have at least one AII room. Base the need for additional AII rooms on the risk assessment for the setting.

E.10.7 All cough-inducing and aerosol-generating procedures should be performed using environmental controls (e.g., in a booth or an AII room) (Supplement 4). Keep patients in the booth or AII room until coughing subsides. Do not allow another patient or HCW to enter the booth or AII room until sufficient time has elapsed for adequate removal of *M. tuberculosis*-contaminated air (Supplement 4, Table 8).

E.10.8 Implement a respiratory protection program for all HCWs working in the TB clinic who enter AII rooms, visit areas where persons with suspected or confirmed TB disease are located, or who transport patients with suspected or confirmed TB disease in vehicles. When the risk assessment indicates the need to wear respirators, at least an N95 disposable respirator should be worn.

E.10.9 When patients with suspected or confirmed infectious TB disease are in the TB clinic and not in an AII room, they should wear a surgical or procedure mask.

E.11 Dental-care settings

The generation of droplet nuclei containing *M. tuberculosis* due to dental procedures has not been demonstrated (*186*). Nevertheless, oral manipulations during dental procedures could stimulate coughing and dispersal of infectious particles. Patients and dental HCWs share the same air space for varying periods of time which contributes to the potential for transmission of *M. tuberculosis* in dental settings (*187*). For example, during mostly routine dental procedures in a dental setting, MDR TB may have been transmitted between two dental workers (*188*). The following recommendations should be followed (*189,190*).

E.11.1 Develop infection-control policies for each dental health-care setting based on the community TB risk assessment (Recommendations, Section B), and periodically review the risk assessment (annually, if possible). The policies should include appropriate screening for LTBI and TB disease for dental HCWs, education on the risk for transmission for the

dental HCWs, and provisions for detection and management of patients who have suspected or confirmed TB disease.

E.11.2 Dental HCWs should routinely document whether the patient has a history of TB exposure or signs or symptoms of TB disease when taking a patient's initial medical history and at periodic updates.

E.11.3 If urgent dental care must be provided for a patient who has suspected or confirmed infectious TB disease, provide the dental care in a setting that meets the requirements for an AII room (Supplement 4). Use respiratory protection (at least N95 disposable respirator) while performing procedures on such patients.

E.11.4 In dental health-care settings that routinely provide care to populations at high risk for TB disease, it may be beneficial to use engineering controls (e.g., portable HEPA units) similar to those used in waiting rooms or clinic areas of health-care settings with a comparable community-risk profile.

E.11.5 During clinical assessment and evaluation, a patient with suspected or confirmed TB disease should be instructed to observe strict respiratory hygiene and cough etiquette procedures (*125*) and wear a surgical or procedure mask whenever possible. Postpone nonurgent dental treatment, and promptly refer these persons to an appropriate medical setting for evaluation of possible infectiousness. Keep these patients in the dental health-care setting no longer than required to arrange a referral.

E.12 Medical offices and ambulatory care settings

In general, the symptoms of TB disease are symptoms for which patients might seek treatment in a medical office. Thus, it is possible that infectious TB disease could be encountered in some medical offices and ambulatory care settings.

E.12.1 Due to the potential for *M. tuberculosis* transmission in medical offices and ambulatory care settings, follow the general recommendations for management of patients with suspected or confirmed TB disease as well as the specific recommendations for emergency departments (Recommendations, Section E.2)

E.12.2 Use the risk assessment to determine the need for or selection of environmental controls and the frequency of testing HCWs for *M. tuberculosis* infection.

E.13 Dialysis units

Some patients with TB disease need chronic dialysis for treatment of end-stage renal disease (ESRD) (*191-193*). The incidence of TB disease and infection in patients with ESRD may be higher than in the general population (*193-195*) and may be compounded by the overlapping risks of ESRD and TB disease among patients with diabetes mellitus (*36*). Also, some dialysis patients or patients who are otherwise immunocompromised (e.g., patients with organ transplants) may be on immunosuppressive medications (*169,169,195*).

E.13.1 Patients with ESRD who need chronic dialysis should have at least one test for *M. tuberculosis* infection to determine the need for

treatment of LTBI. Annual re-screening is indicated if ongoing exposure of ESRD patients to *M. tuberculosis* is likely.

E.13.2 Perform hemodialysis procedures on hospitalized patients with suspected or confirmed TB disease in an AII room. Dialysis staff should use recommended respiratory protection, at least an N95 disposable respirator. Patients with suspected or confirmed TB disease who need chronic hemodialysis may need referral to a hospital or other setting with the ability to perform dialysis procedures in an AII room until the patient is no longer infectious or another diagnosis is made. Certain anti-tuberculosis medications are dosed differently for hemodialysis patients (*29*).

Nontraditional facility-based settings

Nontraditional facility- based settings include emergency medical services (EMS), medical settings in correctional facilities, home-based health-care and outreach settings, and long-term care settings (e.g., hospices, skilled nursing facilities), and homeless shelters. Environmental controls should be implemented based on the types of activities that are performed in the setting. Patients requiring transport should be transported as discussed in Section E.14.1.

TB is more common in the homeless than in the general population (*196-199*). Since persons who visit homeless shelters often share exposure and risk characteristics of TB patients who are treated in outpatient clinics, homeless shelters with clinics should observe the same TB infection-control measures as outpatient clinics. ACET has developed recommendations to assist health-care providers, health departments, shelter operators and workers, social service agencies, and homeless persons prevent and control TB in this population (*196*).

E.14 Emergency Medical Services (EMS)

Although the overall risk is low (*200*), documented transmission of *M. tuberculosis* has occurred in EMS occupational settings (*201*), and approaches to reduce this risk have been described (*200,202*).

E.14.1 Patients with suspected or confirmed TB disease should be transported in an ambulance whenever possible. The ambulance ventilation system should be operated in the non-recirculating mode and the maximum amount of outdoor air be provided to facilitate dilution. If the vehicle has a rear exhaust fan, use this fan during transport. If the vehicle is equipped with a supplemental recirculating ventilation unit that passes air through HEPA filters before returning it to the vehicle, use this unit to increase the number of ACH (190). Airflow should be from the cab (front of vehicle) over the patient and out the rear exhaust fan. If an ambulance is not used, the ventilation system for the vehicle should bring in as much outdoor air as possible, and the system should be set to non-recirculating. If possible, physically isolate the cab from the rest of the vehicle and place the patient in the rear seat (*201*).

E.14.2 Include EMS personnel in a comprehensive screening program to test for *M. tuberculosis* infection and provide baseline screening and

follow-up testing as indicated by the setting's risk classification. Some personnel transport patients to a variety of settings with different levels of risk; base the risk classification on the type of risk encountered most frequently.

E.14.3 Include EMS personnel in the follow-up contact investigations of patients with infectious TB disease. The Ryan White Comprehensive AIDS Resource Emergency Act of 1990 (Public law 101–381) mandates notification of EMS personnel after they have been exposed to a patient with suspected or confirmed infectious TB disease (Title 42 U.S.Code 1994).

E.14.4 When transporting a patient with suspected or confirmed infectious TB disease in a vehicle, the patient should wear a surgical or procedure mask, if possible.

E.15 Medical settings in correctional facilities

TB is a substantial health concern in correctional facilities; employees and inmates are at high risk (*112,203-212*). TB outbreaks in correctional facilities can lead to transmission in surrounding communities (*208,213,214*). ACET recommends that all correctional facilities have a written TB infection-control plan (*203*), and several studies indicate that screening correctional employees and inmates is an important TB control measure (*211,215,216*).

The higher risk for *M. tuberculosis* transmission in health-care settings in correctional facilities (including jails and prisons) is due to the disproportionate number of inmates with risk factors for TB infection and TB disease (*210,217*). Compared with the general population, inmates have higher TB prevalence, associated with a higher prevalence of HIV infection (*204*), increased illicit substance use, lower socioeconomic status (*208*), and their presence in settings that are higher risk for transmission of *M. tuberculosis*.

E.15.1 Follow the recommendations for inpatient and outpatient settings.

E.15.2 Develop a TB infection-control plan that is setting-specific, even if the institution is part of a multi-facility system (*203,218*).

E.15.3 Medical settings in correctional facilities should be classified as at least medium risk; therefore, all correctional facility health-care personnel and other staff including correctional officers who may come into contact with a person with TB disease should be screened for TB at least annually (*208,210,215*).

E.15.4 Collaborate with the state or local health department on decisions about TB contact investigations and discharge planning (*112,219*).

E.15.5 Collaborate with the state or local health department to provide TB training and education to inmates and employees (*203*). Corrections staff should be educated about signs and symptoms of TB disease and encouraged to facilitate prompt evaluation of inmates with suspected infectious TB disease (*213*).

E.15.6 Ensure the availability of at least one AII room. Any inmate with suspected or confirmed infectious TB disease should be placed in an AII room immediately or transferred to a setting with an AII room.

Base the number of additional AII rooms needed on the risk assessment for the setting.

E.15.7 Collect sputum samples in sputum induction booths or AII rooms, not in inmates' cells. Sputum collection may also be performed safely outside, away from other people, windows and ventilation intakes.

E.15.8 Inmates with suspected or confirmed TB disease should be transported using the recommendations provided in E.14.1.

E.15 .9 Inmates with suspected or confirmed infectious TB disease who must be transported outside an AII room for medically essential procedures should wear a surgical or procedure mask during transport, if possible. If risk assessment indicates the need for respiratory protection, drivers or HCWs and other staff who are transporting patients with suspected or confirmed infectious TB disease in an enclosed vehicle should wear at least an N95 disposable respirator. The risk assessment should consider the potential for shared air. Medical or security staff who transport infectious TB patients in a vehicle or who must enter AII rooms should wear respiratory protection (at least N95 disposable respirators).

E.15.10 Implement a respiratory protection program, including training, education, and fit-testing in the correctional facility's TB infection-control program.

E.15.11 Correctional facilities should maintain a tracking system for inmate TB screening and treatment and establish a mechanism for sharing this information with state and local health departments and other correctional facilities (*203,208*).

E.15.11 Ensure the confidentiality of inmates during screening for signs or symptoms of TB disease and risk factors.

E.16 Home-based health-care and outreach settings

Transmission of *M. tuberculosis* has been documented in staff who work in home-based health-care and outreach settings (*220,221*).

E.16.1 The setting's infection-control plan should include training that reminds HCWs who provide medical services in the homes of patients or other outreach settings of the importance of early evaluation of signs or symptoms of TB disease for early detection and treatment of TB disease. Training should also include the role of the HCW in educating patients about the importance of reporting signs or symptoms of TB disease, and the importance of reporting any adverse effects to treatment for LTBI or TB disease.

E.16.2 HCWs who provide medical services in the homes of patients with suspected or confirmed TB disease can help prevent transmission of *M. tuberculosis* by a) educating patients and other household members about the importance of taking medications as prescribed, b) facilitating medical evaluation of signs or symptoms of TB disease, and c) administering DOT, including DOT for treatment of LTBI whenever feasible.

E.16.3 HCWs who provide medical services in the homes of patients should not perform cough-inducing or aerosol-generating procedures on patients with suspected or confirmed infectious TB disease because recommended infection controls are not likely to be in place. Sputum collection should be performed outdoors, away from other people, windows and ventilation intakes.

E.16.4 Patients with suspected or confirmed TB disease should be transported using the recommendations provided in E.14.1.

E.16.5 HCWs who provide medical services in the homes of patients with suspected or confirmed infectious TB disease should instruct TB patients to observe strict respiratory hygiene and cough etiquette procedures. Until such patients are no longer infectious (Supplement 1), HCWs should wear respiratory protection (at least N95 disposable respirators) when entering TB patients' homes or when transporting patients with suspected or confirmed TB disease (Supplement 5).

E.17 Long-term care facilities (e.g. hospices, skilled nursing facilities)

Infection with *M. tuberculosis* poses a health risk to patients, HCWs, visitors and volunteers in these settings (*222,223*). Transmission of *M. tuberculosis* has occurred in long-term care facilities (*224-227*), and pulmonary TB disease has been documented in HIV-infected patients and other immunocompromised persons residing in hospices (*225,228,229*). New employees and residents to these settings should receive a symptom screen and possibly a test for *M. tuberculosis* infection to rule out TB disease.

E.17.1 Long-term care facilities must have adequate administrative and environmental controls including AII capabilities and a respiratory protection program if they accept patients with suspected or confirmed infectious TB disease.

E.17.2 The setting should have a written protocol for the early identification of patients with signs or symptoms of TB disease and procedures for referring these patients to a setting where they can be evaluated and managed.

E.17.3 Patients with suspected or confirmed infectious TB disease should not stay in long-term care facilities unless adequate administrative and environmental controls and a respiratory protection program are in place.

E.17.4 Persons with TB disease who are determined to be noninfectious may remain in the long-term care facility and do not need to be in AII.

F. Training and Education of HCWs

HCW training and education about infection with *M. tuberculosis* and TB disease is an essential part of administrative controls in a TB screening program. Training physicians and nurse managers is especially important given the leadership role they often play in infection control. HCW training and education can increase adherence to TB infection-control measures. Training and education 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. HCWs receive many different types of training, and therefore it may be preferable to combine training for TB infection control with other related trainings.

F.1 Initial TB training and education

F.1.1 The setting should document that all HCWs, including physicians**,** have received initial TB training relevant to their work setting and additional occupation-specific education. The level and detail of baseline training will vary according to the responsibilities of the HCW and the risk classification of the setting.

F.1.2 Educational materials on TB training are available from a variety of sources at no cost in hard copy, on videotape (*230*), on compact discs and on-line. The state or local health department should have access to additional materials and resources, and may be able to help develop a setting-specific TB education program. Suggested components of a baseline TB training program for HCWs are provided in Table 2. CDC's TB website provides access to training and education materials (at www.cdc.gov/tb, under Education/Training Materials). Additional training and education materials may be found on the TB Education and Training Resources Website (www.findtbresources.org). Supplement 8 lists additional TB-related websites and resources.

F.1.3 Physicians, trainees, students, and other HCWs who work in a health-care setting but do not receive payment from that setting should receive baseline training in TB infection-control policies and practices, the TB screening program, and reporting procedures for a *M. tuberculosis* infection test conversion or diagnosis of TB disease.

F.1.4 Initial TB training should be provided prior to the HCW starting duties**.**

F.2 Follow-up TB training and education

F.2.1 All settings should conduct an annual evaluation of the need for follow-up training and education for HCWs based on the number of untrained and new HCWs, changes in the organization and services of the setting, and availability of new TB infection-control information.

F.2.2 If a potential or known exposure to *M. tuberculosis* occurs in the setting, prevention and control measures should include retraining of HCWs in the infection-control procedures established to prevent the recurrence of exposure.

F.2.3 If a potential or known exposure results in a newly recognized positive TST result, test conversion, or diagnosis of TB disease, education might include information on a) transmission of *M. tuberculosis*, b) noninfectiousness of HCWs with LTBI, and c) potential infectiousness of HCWs with TB disease.

F.2.4 The Occupational Safety and Health Administration (OSHA) requires annual respiratory protection training for HCWs who use respiratory devices (Supplement 5).

F.2.5 HCWs in settings with a classification of potential ongoing transmission should receive additional training and education on a) signs and symptoms of TB disease, b) *M. tuberculosis* transmission, c) infection-control policies, d) importance of TB screening for HCWs, and e) responsibilities of employers and employees regarding *M. tuberculosis* infection test conversion and diagnosis of TB disease.

F.2.6 HCWs with TB disease should be allowed to return to work when 1) they have had three negative AFB sputum smear results (*126-129*) collected 8–24 hours apart with at least one being an early morning specimen (because respiratory secretions pool overnight), 2) they have responded to anti-tuberculosis treatment that is likely to be effective based on susceptibility results, *and* 3) they are determined to be noninfectious by a physician knowledgeable and experienced in managing TB disease (Supplements 1 and 2). Consideration should also be given to the type of setting and the potential risk to patients (e.g., general medical office versus HIV clinic) (Supplements 1 and 2).

Table 2 here

G. HCW screening programs for TB support surveillance and clinical care

TB screening programs provide information that is important in caring for individual HCWs and information that facilitates detection of *M. tuberculosis* transmission. The screening program consists of four main components, 1) baseline testing for *M. tuberculosis* infection, 2) serial testing for *M. tuberculosis* infection, 3) serial screening for signs or symptoms of TB disease, and 4) TB training and education.

Surveillance data from HCWs can protect both HCWs and patients. Screening can prevent future transmission by identifying lapses in infection control and expediting treatment for persons with LTBI or TB disease. Tests to screen for *M. tuberculosis* infection should be administered, interpreted, and recorded according to the procedures detailed in Supplement 2. Protection of privacy and maintenance of confidentiality of HCW test results should be ensured. Methods to screen for infection with *M. tuberculosis* are available.

G.1 Baseline testing for *M. tuberculosis* infection

Baseline testing for *M. tuberculosis* infection is recommended for all newly hired HCWs who might have contact with persons who have suspected or confirmed infectious TB disease, regardless of the risk classification of the setting. In some settings, there may be a choice to not perform baseline TB screening or serial TB screening for HCWs who will *never* be in contact with, or have shared air space with patients who have TB disease (e.g., telephone operators who work in a separate building from patients), or who will never be in contact with clinical specimens that may contain *M. tuberculosis.* Baseline test results provide a basis for comparison in the event of a potential or known exposure to *M. tuberculosis* and facilitate the detection and treatment of LTBI or TB disease in an HCW before employment begins and reduces the risk to patients and other HCWs.

G.1.1 If TST is used and if the baseline first-step TST result is positive, TB disease should be excluded, and if excluded, then the HCW should be evaluated for treatment of LTBI. Two-step testing is recommended for HCWs whose initial TST result is negative (e.g., < 10 mm for most HCWs) (*36,118*). If the first-step TST result is negative, the second-step TST should be administered 1–3 weeks after the first TST result was read. A second TST is needed at baseline because injection of PPD for the initial TST may “boost” responses to subsequent tests. If the second TST result is also negative, the person is classified as negative.

A positive result to the second-step of a two-step TST is likely due to boosting as opposed to recent infection with *M. tuberculosis*. These responses may result from remote infections with *M. tuberculosis*, infection with a nontuberculous mycobacterium (NTM), also known as mycobacteria other than TB (MOTT), or previous BCG vaccination. Two-step testing will minimize the possibility that boosting will lead to an unwarranted suspicion of transmission of *M. tuberculosis* with subsequent testing. A second TST is not needed if the HCW has a

documented TST result from any time during the previous 12 months (Recommendations, Section G.2).

G.1.1.1 Perform and document the baseline two-step TST results before the employee begins work (preferably) or within ten days of beginning work.

G.1.1.2 If the second test of a two-step TST result is not read within 48–72 hours, administer a third test as soon as possible (even if many months have passed) and ensure that the result is read within 48–72 hours (*36*). Some studies indicate that positive TST reactions may still be measurable from four up to seven days after testing (*231,232*). However, if a patient fails to return in 72 hours and has a negative test result, the TST should be repeated (*37*).

G.1.2 TST reactivity due to the administration of BCG at birth or in early childhood wanes over the course of 10–15 years. Thus, many HCWs with previous BCG vaccination will have a negative test result for *M. tuberculosis* infection (*81,233-238*). Because HCWs with a history of BCG are often from high TB-prevalence countries, positive test results for *M. tuberculosis* infection in HCWs with previous BCG vaccination should be interpreted as representing infection with *M. tuberculosis* (*81,233-239*). Although BCG reduces the occurrence of severe forms of TB disease in children and overall may reduce the risk for progression from LTBI to TB disease (*240,241*), BCG does not prevent *M. tuberculosis* infection(*242*), Test results for *M. tuberculosis* infection for HCWs *with* a history of BCG should be interpreted using the same diagnostic cut points used for HCWs *without* a history of BCG vaccination.

G.2 Baseline testing for *M. tuberculosis* infection after TST within the past 12 months

G.2.1 A second TST is not needed if the HCW has a documented TST result from any time during the previous 12 months. If a newly employed HCW has had a documented negative TST result within the past 12 months, a single TST may be administered in the new setting (Table 9). This additional TST represents the second stage of two-step testing. The second test decreases the possibility that boosting on later testing will lead to incorrect suspicion of transmission of *M. tuberculosis* in the setting.

G.2.2 A recent TST (<1 year) is not a contraindication to a subsequent TST unless the test was associated with severe ulceration or anaphylactic shock, which are very rare adverse events (*28,243-245*). Multiple TSTs are safe and do not increase the risk for a false-positive result or a TST conversion in persons without infection with mycobacteria (*36*).

G.3 Baseline documentation of a history of TB disease, a previously positive test result for *M. tuberculosis* infection, or completion of treatment for LTBI or TB disease

G.3.1 It is not necessary to perform additional tests for *M. tuberculosis* infection on HCWs with a *documented* history of TB disease, *documented* previously positive test result for *M. tuberculosis* infection, or *documented* completion of treatment for LTBI or TB disease. Documentation of a previously positive test result for *M. tuberculosis* infection may substitute for a baseline test if the documentation includes a recorded TST result in mm.

G.3.2 All other HCWs should undergo baseline testing for *M. tuberculosis* infection to ensure that the test result on record in the setting has been performed and measured using the procedures detailed in Supplement 2.

G.3.3 A recent TST (<1 year) is not a contraindication to the administration of an additional test unless the TST was associated with severe ulceration or anaphylactic shock, which are very rare adverse events (*28,243,244*). However, the recent test may complicate interpretation of subsequent test results due to the possibility of boosting.

G.4 Serial follow-up of TB screening and testing for *M. tuberculosis* infection

G.4.1 The need for serial follow-up screening for groups of HCWs with negative test results for *M. tuberculosis* infection is an institutional decision that is based on the setting's risk classification. This decision and changes over time based on updated risk assessments should be official and documented.

G.4.2 If a serial follow-up screening program is required, the risk assessment for the setting (Recommendations, Section B) will determine which HCWs should be included in the program and the frequency of screening. Two-step TST testing should not be performed for follow-up testing.

G.4.3 If possible, stagger follow-up screening (rather than testing all HCWs at the same time each year) so that all HCWs who work in the same area or profession are not tested in the same month. Staggered screening of HCWs (e.g., on the anniversary of their employment or on their birthdays) increases opportunities for early recognition of infection-control problems that can lead to conversions in test results for *M. tuberculosis* infection. Aggregate analysis of TB screening data on a periodic regular basis is important for detecting problems.

G.5 HCWs with a newly recognized positive test result for *M. tuberculosis* infection or signs or symptoms of TB disease

G.5.1 Clinical evaluation

G.5.1a Promptly evaluate any HCW with a newly recognized positive test result for *M. tuberculosis* infection, test conversion or signs or symptoms of TB disease. Arrange with employee health, the state or local health department, or a personal physician for evaluation of HCWs with suspected TB disease. Any physicians who evaluate HCWs with suspected TB disease should be familiar with current diagnostic and therapeutic guidelines for LTBI and TB disease (*29,36*).

G.5.1b The definitions for positive test results for *M. tuberculosis* infection and test conversion in HCWs are found in Supplement 2. Symptoms of disease in the lung, pleura, or airways including larynx include coughing

≥3 weeks, loss of appetite, unexplained weight loss, night sweats, bloody sputum or hemoptysis, hoarseness, fever, fatigue, or chest pain. The evaluation should include a clinical examination and symptom screen (a procedure used during a clinical evaluation in which patients are asked if they have experienced any signs or symptoms of TB disease), a chest radiograph, and collection of sputum specimens.

G.5.1c If TB disease is diagnosed, begin anti-tuberculosis therapy immediately according to published guidelines (*29*). The diagnosing clinician (who may or may not be a physician with the institution's infection-control program) should notify the state or local health department in accordance with disease reporting laws, which generally specify a 24-hour time limit.

G.5.1d If TB disease is excluded, offer the HCW treatment for LTBI in accordance with published guidelines (*36,246*) (Supplement 2). If the HCW has already completed treatment for LTBI and is part of a TB screening program, an annual symptom review should be performed instead of testing for LTBI.

G.5.1e Providers evaluating HCWs who are otherwise at low risk for LTBI may choose a 15 mm induration cut point in interpreting a positive baseline TST result; however, HCWs with a previously negative test result who have an increase of ≥10 mm induration on follow-up testing probably have acquired *M. tuberculosis* infection and should be evaluated for TB disease, and when disease is excluded, treated for LTBI unless medically contraindicated (*36,246*).

G.5.2 Chest radiography

G.5.2a HCWs with a baseline positive or newly positive TST result should receive one chest radiograph to exclude a diagnosis of TB disease. After this baseline chest radiograph is performed and the result is documented, repeat radiographs are not needed unless signs or symptoms of TB disease develop, or a clinician recommends a repeat chest radiograph (*36,120*). Instead of participating in serial testing for *M. tuberculosis* infection, HCWs with a positive test result for *M. tuberculosis* infection should receive a symptom screen. The frequency of this symptom screen should be determined by the risk classification for the setting.

G.5.2b Serial follow-up chest radiographs are not recommended for HCWs with documentation of a previously positive test result for *M. tuberculosis* infection, treatment for LTBI, or treatment for TB disease, or for asymptomatic HCWs with negative test results for *M. tuberculosis* infection.

G.5.2c HCWs who have a previously positive test result for *M. tuberculosis* infection and who change jobs should carry documentation of a baseline chest radiograph result (and the positive test result for *M. tuberculosis* infection) to their new employers.

G.5.3 Workplace restrictions

G.5.3a HCWs with a newly recognized positive test result for *M. tuberculosis* infection should be evaluated by a physician as soon as possible. Standing orders for chest radiographs in the case of a newly recognized

positive test result for *M. tuberculosis* infection and standard procedures for prompt communication with the state or local health department can facilitate prompt evaluation. Keep symptomatic HCWs away from the workplace until a diagnosis of TB disease is excluded.

G.5.3b HCWs with TB disease should be allowed to return to work when all three of these criteria are met: 1) they have had three consecutive, sputum samples (*126-129*) collected 8–24 hours apart that are negative with at least one being an early morning specimen (because respiratory secretions pool overnight), *and* 2) they have responded to anti-tuberculosis treatment that is likely to be effective (may be based on susceptibility results), *and* 3) they are determined to be noninfectious by a physician knowledgeable and experienced in managing TB disease (Supplements 1 and 2).

G.5.3c Asymptomatic HCWs do not need to be excluded from the workplace should be completely evaluated within ten days of starting employment.

G.5.3d HCWs with suspected or confirmed infectious pulmonary, laryngeal, endobroncheal or tracheal TB disease or a draining tuberculous skin lesion pose a risk to patients, HCWs and other persons, and should be excluded from the workplace until they are documented to be noninfectious (Supplements 1 and 2).

G.5.3e HCWs with extrapulmonary TB disease usually do not need to be excluded from the workplace as long as there is no involvement of the respiratory track. They may be confirmed as noninfectious and may continue to work if documented evidence is available that indicates that concurrent pulmonary TB disease has been excluded.

G.5.3e Once TB disease is excluded, no risk for transmission of *M. tuberculosis* to other HCWs or patients exists, and the HCW may return to work with no restrictions. HCWs receiving treatment for LTBI may return to work immediately.

G.5.3f HCWs with LTBI who cannot take or do not accept or complete a full course of treatment for LTBI should not be excluded from the workplace. They should be counseled about the risk for developing TB disease and instructed to seek prompt evaluation if signs or symptoms of TB disease develop. If serial follow-up screening is required in the setting (if the setting is classified as medium risk), these HCWs should receive a symptom screen annually and should be offered treatment for LTBI again unless medically contraindicated (*36*). HCWs with signs or symptoms of TB disease should be referred for further medical evaluation.

G.5.3g HCWs who have a documented positive TST result and who leave employment should be counseled again, if possible, about the risk for developing TB disease and instructed to seek prompt evaluation with the local health department or their primary physician if symptoms of TB disease develop. Consider mailing letters to former HCWs who have LTBI. This information should be recorded in the HCWs employee health record when they leave employment.

G.5.4 Identification of source cases and recording of drug-susceptibility patterns

G.5.4a If an HCW has a conversion in a test result for *M. tuberculosis* infection, evaluate the HCW for a history of suspected or known exposure to *M. tuberculosis* to determine the potential source.

G.5.4b When the source case is known, identify the drug-susceptibility pattern of the *M. tuberculosis* isolate from the source. Record the drug-susceptibility pattern in the HCW's medical or employee health record to guide the treatment of LTBI or TB disease, if indicated.

G.6 HCWs with medical conditions associated with increased risk for progression to TB disease

HCWs who are severely immunocompromised require special precautions. HIV infection is the highest risk factor for progression from LTBI to TB disease (*22,36,37,46*). Other immunocompromising conditions, including diabetes mellitus, some cancers, and some drug treatments, also increase the risk for rapid progression from LTBI to TB disease. TB disease can also adversely affect the clinical course of HIV infection and AIDS, and can complicate HIV treatment (*29,36,50*).

G.6.1 Serial TB screening beyond that indicated by the risk classification for the setting is not indicated for persons with most medical conditions that suppress the immune system or otherwise increase the risk for infection with *M. tuberculosis* progressing to TB disease (*55*). However, consideration should be given to repeating the TST for HIV-infected persons whose initial TST result was negative and whose immune function has improved in response to highly active antiretroviral therapy (HAART) (i.e., those whose CD4-T lymphocyte count has increased to >200 cells/ml).

G.6.2 All HCWs should, however, be encouraged during their initial TB training to learn if they have such a medical condition and should be aware that receiving medical treatment can improve cell-mediated immunity. HCWs should be informed about the availability of counseling, testing and referral for HIV (*47,48*).

G.6.3 HCWs should know whether they are immunocompromised, and they should be aware of the risks from exposure to *M. tuberculosis* (*1*). In some cases, reassignment to areas where exposure is minimized or nonexistent may be medically advisable or desirable. Immunocompromised HCWs should have the option of an assignment in an area or activity that has a low risk for exposure to *M. tuberculosis*. This choice is a personal decision for the immunocompromised HCW (*247*) (http://www.eeoc.gov/laws/ada.html). Health-care settings should provide education and follow infection-control recommendations (*77*).

G.6.4 Information provided by HCWs on their immune status and requests for voluntary work assignments should be treated confidentially, according to written procedures on the confidential handling of such information. All HCWs should be made aware of these procedures at the time of employment and during initial TB training and education.

H. Problem Evaluation

Contact investigations may be initiated in response to a) conversions in test results in HCWs for *M. tuberculosis* infection, b) diagnosis of TB disease in an HCW, c) suspected person-to-person transmission of *M. tuberculosis,* d) lapses in TB infection-control practices that expose HCWs and patients to *M. tuberculosis*, or e) possible TB outbreaks identified using automated laboratory systems (*248*).

In these situations, the objectives of a contact investigation may be to a) determine the likelihood that transmission of *M. tuberculosis* has occurred, b) determine the extent of *M. tuberculosis* transmission, c) identify persons who were exposed and, if possible, the source(s) of potential transmission, d) identify factors that could have contributed to transmission, including failure of environmental infection-control measures, failure to follow infection-control procedures, or inadequacy of current measures or procedures, e) implement recommended interventions, f) evaluate the effectiveness of the interventions, and g) ensure that exposure to *M. tuberculosis* has been terminated and that the conditions leading to exposure have been eliminated.

Earlier recognition of a setting in which *M. tuberculosis* transmission has occurred could be facilitated through innovative approaches to TB contact investigations such as network analysis and genetic typing of isolates. Network analysis makes use of information such as shared locations within a setting that may not be collected in traditional TB contact investigations (*41*). This type of information may be useful during contact investigations involving hospitals or correctional settings to identify any shared wards, hospital rooms, or cells. Genotyping of isolates is universally available in the United States and is a useful adjunct in the investigation of *M. tuberculosis* transmission (*40,96,249*). Because the situations prompting an investigation are likely to vary, investigations should be tailored to the individual circumstances. The following recommendations provide general guidance for conducting contact investigations.

H.1 General recommendations for investigating conversions in test results for *M. tuberculosis* infection in HCWs

H.1.1 An *M. tuberculosis* infection test conversion may need to be reported to the health department, depending on state and local regulations.

H.1.2 Problem evaluation during contact investigations should be accomplished through cooperation between infection-control personnel, occupational health, and the state or local TB control program.

H.1.3 If a test conversion in an HCW is detected as a result of serial screening and the source is not apparent, conduct a source case investigation to determine the probable source and the likelihood that transmission occurred in the health-care setting (*117*).

H.1.4 Identify and correct lapses in TB infection control that may have contributed to the transmission of *M. tuberculosis.*

H.1.5 Record and report *M. tuberculosis* infection test conversions and TB disease among HCWs according to OSHA requirements (www.osha.gov/recordkeeping). Consult OSHA standard 29 Code of Federal Regulations (CFR) 1904, Recording and Reporting Occupational Injuries and Illness, to determine recording and reporting requirements (*250*).

H.2 Investigating an *M. tuberculosis* infection test conversion with a probable source outside the health-care setting

If an *M. tuberculosis* infection test conversion in an HCW is detected, and exposure *outside* the health-care setting has been documented by the corresponding state or local health department, terminate the investigation within the health-care setting.

H.3 Investigating an *M. tuberculosis* infection test conversion with a known source in the health-care setting

H.3.1 An investigation of the conversion should be done in collaboration with the state or local health department. If an *M. tuberculosis* infection test conversion in an HCW is detected and the HCW's history does not suggest exposure outside the health-care setting but does identify a probable source in the setting

H.3.1a Identify and evaluate close contacts of the suspected source case, including other patients and visitors.

H.3.1b Determine possible reasons for the exposure.

H.3.1c Implement interventions to correct the lapse(s) in infection control.

H.3.1d Immediately screen HCWs and patients if they were close contacts to the source case.

For exposed HCWs and patients in a setting which has chosen to screen for infection with *M. tuberculosis* using the TST

- Administer a symptom screen
- Administer a TST to those who had previously negative TST results. (A two-step baseline TST should not be performed in contact investigations.)
- If the initial TST result is negative, repeat the TST and symptom screen 8–10 weeks after the end of exposure.
- If the baseline TST result is positive, administer a symptom screen.
- If the symptom screen or the initial or 8–10 week follow-up TST result is positive, the exposed person should be promptly evaluated for TB disease, including a chest radiograph.
- If TB disease is excluded, further medical and diagnostic evaluation for LTBI is needed, which includes a judgment about the extent of exposure.

H.3.1.e If no additional conversions in the test results for *M. tuberculosis* are detected on follow-up testing, terminate the investigation.

H.3.2 If additional conversions in the tests for M. *tuberculosis* are detected on follow-up testing, transmission might still be occurring and additional actions are needed. Implement a classification of potential ongoing transmission for that specific setting or group of HCWs.

H.3.2a Promptly report the initial cluster of test conversions to the state or local health department.

H.3.2b Reassess possible reasons for exposure and transmission.

H.3.2c Evaluate the degree of adherence to the interventions implemented.

H.3.2d Repeat testing for *M. tuberculosis* infection 8–10 weeks after the end of exposure for HCW contacts who previously had negative test results.

H.3.2e Expand the circle of contacts to include others who may have been exposed.

H.3.2f If no additional TST conversions are detected on the second round of follow-up testing, terminate the investigation.

H.3.3 If additional TST conversions are detected on the second round of follow-up testing, maintain a classification of potential ongoing transmission and consult the state or local health department or other persons with expertise in TB infection control for assistance.

H.3.4 The classification of potential ongoing transmission should be used as a temporary classification only. It warrants immediate investigation and corrective

steps; after it has been determined that ongoing transmission has ceased, the setting should be reclassified as medium risk. It is recommended to maintain the classification of medium risk for at least one year.

H.4 Investigating an *M. tuberculosis* infection test conversion in an HCW with an unknown exposure

H.4.1 If an *M. tuberculosis* infection test conversion in an HCW is detected and the HCW's history does not suggest exposure outside the health-care setting and does not identify a probable source of exposure in the setting, further investigation to identify a probable source in the health-care setting is warranted.

H.4.2 If no source case is identified, estimate the interval during which the HCW may have been infected. Generally, this is 8–10 weeks before the most recent negative *M. tuberculosis* infection test result through two weeks before the first positive *M. tuberculosis* infection test result (i.e., a conversion in *M. tuberculosis* infection test result).

H.4.3 Review laboratory and infection-control records to identify all patients (and any HCWs) who have or had suspected or confirmed infectious TB disease and who may have transmitted *M. tuberculosis* to the HCW.

H.4.4 If the investigation identifies a likely source identify and evaluate contacts of the suspected source. Close contacts are the highest priority for screening.

H.4.4a For presumed exposed HCWs and patients in a setting which has chosen to screen for infection with *M. tuberculosis* using the TST

- administer a symptom screen,
- administer a TST to those who had previously negative TST results, (a two-step baseline TST should not be performed in contact investigations)
- if the initial TST result is negative, repeat the TST and symptom screen 8–10 weeks after the end of exposure,
- if the symptom screen, or the baseline TST result, or the 8–10 week follow-up TST result is positive, the presumed exposed person should be promptly evaluated for TB disease, including a chest radiograph, and
- if TB disease is excluded, further medical and diagnostic evaluation for LTBI is needed, which includes a judgment about the extent of exposure.

H.4.4b For presumed exposed HCWs and patients in a setting which has chosen to screen for infection with *M. tuberculosis* using the QFT, see Supplement 3.

H.4.5 If the investigation does not identify a likely source

H.4.5a If serial TB screening is performed in the setting, review the results of screening of other HCWs in the same area of the health-care setting or same occupational group.

H.4.5b If serial TB screening is not performed in the setting or if insufficient numbers of recent results are available, conduct additional TB screening of other HCWs in the same area or occupational group.

H.4.6 If the review and screening yield no additional conversions, then no evidence to indicate health-care–associated transmission exists and the investigation should be terminated. Whether HCW conversions resulted from exposure in the setting or elsewhere or whether true infection with *M. tuberculosis* has even occurred is

uncertain. However, the absence of other data implicating health-care–associated transmission suggests that the conversion could have resulted from a) unrecognized exposure to *M. tuberculosis* outside the health-care setting, b) cross-reactivity with another antigen such as BCG or nontuberculous mycobacteria (NTM; also known as MOTT) or c) errors in applying, reading, or interpreting the test result for *M. tuberculosis* infection.

H.4.7 If the review and screening identify additional TST conversions, health-care–associated transmission is more likely.

H.4.7a Implement a classification of potential ongoing transmission.

H.4.7b Evaluate the patient identification process, TB infection-control policies and practices, and environmental controls to identify lapses that could have led to exposure and transmission.

H.4.7c If no problems are identified, implement a classification of potential ongoing transmission, and consult the state or local health department or other persons with expertise in TB infection control for assistance.

H.4.7d If problems are identified, implement recommended interventions and repeat testing for *M. tuberculosis* infection 8–10 weeks after the end of exposure for HCWs with negative test results.

H.4.7e If no additional test conversions are detected on follow-up testing, terminate the investigation.

H.4.8 If additional conversions in test results for *M. tuberculosis* infection are detected on follow-up testing

H.4.8a Maintain a classification of potential ongoing transmission.

H.4.8b Reassess possible reasons for exposure and transmission.

H.4.8c Evaluate the appropriateness of and degree of adherence to the interventions implemented.

H.4.8d Repeat testing for *M. tuberculosis* infection 8–10 weeks after the end of exposure for HCWs with negative test results.

H.4.8e Consult the state or local health department or other persons with expertise in TB infection control.

H.4.8f If no additional conversions are detected on this second round of follow-up testing, terminate the investigation.

H.4.8g If additional conversions are detected, continue a classification of potential ongoing transmission and consult the state or local health department or other persons with expertise in TB infection control.

H.4.8h The classification of potential ongoing transmission should be used as a temporary classification only. It warrants immediate investigation and corrective steps; after it has been determined that ongoing transmission has ceased, the setting should be reclassified as medium risk. It is recommended to maintain the classification of medium risk for at least one year.

H.5 Investigating a case of TB disease in an HCW

H.5.1 Occupational health services and other physicians in the setting should have procedures for immediately notifying the local administrators or infection-control personnel if an HCW is diagnosed with TB disease so that a problem evaluation can be initiated.

H.5.2 If an HCW is diagnosed with TB disease and does not have a previously documented positive test for *M. tuberculosis* infection, conduct an investigation

to identify the probable sources and circumstances for transmission (Recommendations, Section H.1).

H.5.3 If an HCW is diagnosed with TB disease, regardless of previous test status, an additional investigation must be conducted to ascertain whether *M. tuberculosis* was transmitted from this HCW to others, including other HCWs, patients and visitors.

H.5.3a Determine the potential infectiousness of the HCW and, if potentially infectious, the likely period of infectiousness (Recommendations, H.7.2d).

H.5.3b For HCWs with suspected or confirmed infectious TB disease, conduct an investigation that includes 1) identification of contacts (e.g., other HCWs, patients, visitors), 2) evaluation of contacts for LTBI and TB disease, and 3) notification of the state or local health department for consultation and investigation of community contacts who were exposed outside the health-care setting.

H.5.3c *M. tuberculosis* genotyping may be performed such that the results are promptly available and they are useful adjuncts to epidemiologically based public health investigations of contacts and possible source cases, especially in sorting out the role of laboratory contamination (*65,96,173,249,251-265*).

H.5.4 When confidentiality laws prevent the state or local health department from communicating information regarding a patient's identity, staff at the hospital should work with its legal counsel and the HCW to determine how the hospital may be notified without breaching confidentiality.

H.6 Investigating possible patient-to-patient transmission of *M. tuberculosis*

H.6.1 Routinely record information about TB cases among patients in the setting for risk classification and risk assessment purposes. Documented information by location and date should include results of sputum smear and culture, chest radiograph, drug-susceptibility testing, and adequacy of infection-control measures.

H.6.2 Each and every case of TB that transits through a healthcare setting (not just those diagnosed) should prompt an assessment by the infection-control team, while the patient is still in the setting or, shortly thereafter. The assessment should focus on 1) a determination of infectiousness of the patient, 2) confirmation of compliance with local public health reporting requirements (including the prompt reporting of a person with suspected TB disease as required), and 3) assessment of the adequacy of infection control.

A contact investigation should be initiated in situations where infection control is deemed to be inadequate and the patient is infectious. Patients with positive AFB sputum smear results are more infectious than patients with negative AFB sputum smear results, but it is possible for patients with negative AFB sputum smear results to be infectious (*266*). Patients with negative AFB sputum smear results, but who undergo aerosol-generating or aerosol-producing procedures (including bronchoscopy) without adequate infection control measures, represent a potential risk of exposure. All investigations should be conducted in consultation with the local public health department.

H.6.3 If serial surveillance of these cases reveals one of the following conditions, patient-to-patient transmission may have occurred and a contact investigation should be initiated if

- High proportion of patients with TB disease were admitted to or seen in the setting during the year preceding onset of their TB disease, especially when TB disease is seen in patients who were otherwise unlikely to be exposed to *M. tuberculosis.*
- Increase in the number of TB patients diagnosed with drug-resistant TB compared to the previous year.
- Isolates from multiple patients have identical and characteristic drug-susceptibility or DNA fingerprint patterns.

H.6.4 If surveillance of TB cases in patients suggests the possibility of patient-to-patient transmission of *M. tuberculosis*

H.6.4a Collaborate with the state or local health department to conduct an investigation.

H.6.4b For settings where HCWs are serially tested for *M. tuberculosis* infection, review HCW records for an increase in the number of conversions in test results for *M. tuberculosis* infection.

H.6.4c Review patient surveillance data and medical records for additional cases of TB disease.

H.6.4d Look for possible exposures from patients with newly diagnosed TB disease to other patients with TB disease during previous or current admissions. Determine if the patients were admitted to the same room or area, or if they received the same procedure or went to the same treatment area on the same day.

H.6.5 If the investigation suggests that transmission has occurred

H.6.5a Evaluate possible causes of transmission of *M. tuberculosis* (e.g., delayed diagnosis of TB disease, institutional barriers to implementing timely and correct AII practices, inadequate environmental controls).

H.6.5b Determine if other patients or HCWs may have been exposed. If so, evaluate these persons for LTBI and TB disease (i.e., test for *M. tuberculosis* infection, and administer a symptom screen).

H.6.5c If the state or local health department was not previously contacted, notify the health department so that a community contact investigation can be initiated, if necessary.

H.6.5d Consider the possibility of laboratory errors in diagnosis, or the contamination of bronchoscopes (*89,176*),or other equipment (*143*).

H.7 Contact investigations

H.7.1 The main goal of contact investigations is to identify secondary cases of TB disease and LTBI among contacts so that they can begin therapy as needed (*267-269*). Contact investigations should be accomplished through cooperation between infection-control personnel and the local TB control program.

Initiate a contact investigation if

- a person with TB disease was seen in a health-care setting and TB disease was not diagnosed and reported quickly, resulting in failure to apply recommended TB infection controls,

- environmental controls or other infection-control measures were found to be malfunctioning while a person with TB disease was in the setting, or
- an HCW develops TB disease and exposes other persons in the setting.

H.7.2 As soon as TB disease is diagnosed or a problem is recognized, standard public health practice prioritizes the identification of other patients, HCWs and visitors who may have been exposed to the index case before TB infection-control measures were correctly applied (*49*). Consider that visitors to the patient may also be contacts, or may possibly be the source case.

Depending on the circumstance, the following activities should be done in collaboration with or by the state or local health department (see http//www.cdc.gov/mmwr/preview/mmwrhtml/00038823.htm) (*270*).

H.7.2a Interview the index case and all HCWs who may have been exposed.

H.7.2b Review the index case's medical records.

H.7.2c Determine the exposure site(s), (i.e., where the index case lived, worked, visited, or was hospitalized before being placed in AII).

H.7.2d Determine the infectious period of the index case, that is the time period during which a person with TB disease is considered contagious and most capable of transmitting *M. tuberculosis* to other persons sharing the same air space (i.e., contacts).

For programmatic purposes, for patients with positive AFB sputum smear results, the infectious period can be considered to begin three months before the collection date of the first positive smear result or the symptom onset date (whichever is earlier) and ends when the patient is placed into AII or the date of collection for the first of consistently negative smear results (whichever is earlier).

For patients with negative AFB sputum smear results, the infectious period can be considered to begin one month before the symptom onset date and ends when the patient is placed into AII.

H.7.2e Determine the exposure period for each contact. The exposure period is the time during which a person shared the same air space with a person with TB disease.

H.7.3 Determine if transmission occurred from the index case to persons with whom the index had intense contact. Determine the intensity of the exposure based on proximity, overlap with the infectious period of the index case, duration of exposure, presence or absence of infection-control measures, infectiousness of the index case, and performance of procedures that could increase the risk for transmission during contact (e.g., sputum induction, bronchoscopy, airway suction). Determine the exposed cohort of contacts for TB screening.

The following activities (Recommendations, Sections H.7.4–H.7.7) should be accomplished through cooperation between infection-control personnel and the local TB control program.

H.7.4 The most intensely exposed HCWs and patients should be screened as soon as possible after exposure to *M. tuberculosis* occurred. Identify and evaluate contacts of the suspected source. Close contacts are the highest priority for screening.

For presumed exposed HCWs and patients in a setting which has chosen to screen for infection with *M. tuberculosis* using the TST

- administer a symptom screen,
- administer a TST to those who had previously negative TST results (a two-step baseline TST should not be performed in contact investigations),
- if the initial TST result is negative, repeat the TST and symptom screen 8–10 weeks after the end of exposure,
- if the symptom screen or the initial or 8–10 week follow-up TST result is positive, promptly evaluate the HCW for TB disease, including performing a chest radiograph, and
- if TB disease is excluded, provide further medical and diagnostic evaluation for LTBI, including determining the extent of exposure.

For presumed exposed HCWs and patients in a setting which has chosen to screen for infection with *M. tuberculosis* using the QFT, see Supplement 3.

H.7.5 If the most intensely exposed persons have test conversions or positive test results for *M. tuberculosis* infection in the absence of a previous history of a positive test result or TB disease, evaluate persons with whom the index patient had less contact. If the evaluation of the most intensely exposed contacts yields no evidence of transmission, it is not necessary to expand testing to others.

H.7.6 Exposed persons with documented previously positive test results for *M. tuberculosis* infection do not require either repeat testing for *M. tuberculosis* infection or a chest radiograph (unless they are immunocompromised or otherwise at a high risk for TB disease) but they should be questioned about signs or symptoms of TB disease at the time of screening. If the person has signs or symptoms of TB disease, a) record the symptoms in the HCW's medical chart or employee health record, b) perform a chest radiograph, c) perform a full medical evaluation, and d) obtain sputum samples for smear and culture, if indicated.

H.7.7 Determine why a TB disease diagnosis or AII was delayed or procedures failed, which led to transmission of *M. tuberculosis* in the setting. Record the reasons and corrective actions taken, including changes in policies, procedures, and TB training and education practices.

I. Collaboration with the State or Local Health Department

I.1 Coordinate with the local TB control program for assistance with the planning and implementation of TB control activities in the health-care setting and for names of experts to help with policies, procedures, and program evaluation.

I.2 By law, the state or local health department must be notified when TB disease is suspected or confirmed in a patient or HCW so that follow-up can be arranged and a community contact investigation can be conducted. Notify the state or local health department as early as possible before the patient is discharged to facilitate follow-up, and continuation of therapy by DOT (*29*).

I.3 For inpatient settings, coordinate a discharge plan with the patient (including a patient who is an HCW with TB disease) and the TB control program of the state or local health department.

I.4 In accordance with state and local laws, laboratories should report (by telephone, fax, or e-mail) positive AFB smear results from any specimens within 24 hours of collection and positive culture results within 24 hours of the notation of the positive culture result (*146,147*). Report all drug-susceptibility test results on *M. tuberculosis* isolates to the state or local health department as soon as these results are available.

I.5 Develop procedures to ensure that the state or local health department notifies the health-care setting if a HCW is suspected of having or is diagnosed with TB disease by a physician outside the setting.

I.6 HCW and patient confidentiality should be ensured.

J. Environmental Controls

Environmental controls are the second line of defense in the TB infection-control program, after administrative controls. Environmental controls include technologies for the removal or inactivation of airborne *M. tuberculosis*. These technologies include local exhaust ventilation, general ventilation, HEPA filtration, and ultraviolet germicidal irradiation (UVGI). These controls help to prevent the spread and reduce the concentration of infectious droplet nuclei in the air. A summary of environmental controls and their use in prevention of transmission of *M. tuberculosis* is provided below. Supplement 4 contains detailed information on the application of environmental controls.

J.1 Local exhaust ventilation

Local exhaust ventilation is a source-control technique used for capturing airborne contaminants, such as infectious droplet nuclei or other infectious particles, before they are dispersed into the general environment. Local exhaust ventilation methods utilize external hoods, enclosing booths, and tents.

J.1.1 Use local exhaust ventilation (e.g., enclosed, ventilated booth) for cough-inducing and aerosol-generating procedures.

J.1.2 When local exhaust is not feasible, perform cough-inducing and aerosol-generating procedures in a room that meets the requirements for an AII room.

J.2 General ventilation

General ventilation systems dilute and remove contaminated air and control airflow patterns in a room or setting.

J.2.1 Include an engineer or other professional with expertise in ventilation as part of the health-care setting's staff, or hire a consultant with expertise in ventilation engineering specific to health-care settings.

J.2.2 Design ventilation systems to meet all applicable federal, state, and local requirements.

J.2.3 A single-pass ventilation system is the preferred choice in areas where infectious airborne droplet nuclei may be present (e.g., AII rooms). Use HEPA filtration if recirculation of air is necessary.

J.2.4 AII rooms in existing health-care settings should have an airflow of $\geq$6 air changes per hour (ACH). When feasible, the airflow should be

increased to 12 ACH by a) adjusting or modifying the ventilation system, or b) using air-cleaning methods such as room-air recirculation units containing HEPA filters or UVGI systems that increase the equivalent ACH. New construction or renovation of health-care settings should be designed so that AII rooms achieve an airflow of ≥12 ACH. Table 7 provides ventilation rates for other areas in health-care settings.

J.2.5 If using a variable air volume (VAV) ventilation system in an AII room, design the system to maintain the room under negative pressure at all times. The VAV system minimum set point must be adequate to maintain the recommended mechanical and outdoor ACH, and a negative pressure ≥0.01 inch of water gauge relative to adjacent areas.

J.2.6 Determine the required number of AII rooms, other negative-pressure rooms, and local exhaust devices based on the risk assessment for the setting. The location of these rooms and devices will depend, in part, on where recommended ventilation conditions can be achieved. Grouping AII rooms in one area may facilitate the care of patients with TB disease and the installation and maintenance of optimal environmental controls.

J.2.7 Check AII rooms for negative pressure using smoke tubes or other visual checks before occupancy, and daily when occupied by a patient with suspected or confirmed TB disease.

J.2.8 Design, construct, and maintain general ventilation systems so that air flows from clean to less clean (more contaminated) areas.

J.2.9 Design general ventilation systems to provide optimal airflow patterns within rooms and to prevent air stagnation or short-circuiting of air from the supply area to the exhaust area.

J.2.10 Health-care settings serving populations with a high prevalence of TB disease may need to improve the existing general ventilation system or use air-cleaning technologies in general-use areas such as waiting rooms, emergency medical service areas, and radiology suites. Applicable approaches include a) single-pass, nonrecirculating systems that exhaust air to the outside, b) recirculation systems that pass air through HEPA filters before recirculating it to the general ventilation system, and c) room-air recirculation units with HEPA filters and UVGI systems.

J.3 Air-cleaning methods

J.3.1 High-efficiency particulate air (HEPA) filters

J.3.1a HEPA filters can be used to filter infectious droplet nuclei from the air and *must be used* a) when discharging air from local exhaust ventilation booths or enclosures directly into the surrounding room or area, and b) when discharging air from 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).

J.3.1b HEPA filters can be used to remove infectious droplet nuclei from air that is recirculated in a setting or exhausted directly to the outside.

J.3.1c HEPA filters can also be used as an added safety measure in exhaust ducts to remove droplet nuclei from air being discharged to the outside.

J.3.1d Air can be recirculated through HEPA filters in areas in which a) no general ventilation system is present, b) an existing system is incapable of providing sufficient ACH, or c) air cleaning (particulate removal) without affecting the fresh-air supply or negative-pressure system is desired. Such uses can increase the number of equivalent ACH in the room or area.

J.3.1e Recirculation of HEPA-filtered air can be achieved by a) exhausting air from the room into a duct, passing it through a HEPA filter installed in the duct, and returning it to the room or the general ventilation system, b) filtering air through HEPA recirculation systems installed on the wall or ceiling of the room, or c) filtering air through portable room-air recirculation units.

J.3.1f To ensure adequate functioning, install HEPA filters carefully and maintain the filters per manufacturers' instructions. Maintain written records of all HEPA maintenance and monitoring (*116*).

J.3.1g Manufacturers of room-air recirculation units should provide installation instructions and documentation of the filtration efficiency and of the overall efficiency of the unit in removing airborne particles from a space of a given size.

J.3.2 Ultraviolet germicidal irradiation (UVGI)

UVGI is an air-cleaning technology that can be used in a room or corridor to irradiate the air in the upper portion of the room (upper-air irradiation), installed in a duct to irradiate air passing through the duct (duct irradiation), or incorporated into room air-recirculation units.

J.3.2a UVGI can be used in ducts that recirculate air back into the same room or in ducts that exhaust air directly to the outside. However, UVGI should not be used in place of HEPA filters when discharging air from isolation booths or enclosures directly into the surrounding room or area or when discharging air from an AII room into the general ventilation system.

J.3.2b For each system, follow design guidelines to maximize UVGI effectiveness in equivalent ACH. Because air velocity, air mixing, relative humidity, UVGI intensity, and lamp position all affect the efficacy of UVGI systems, consult a UVGI system designer before purchasing and installing a UVGI system. Experts who might be consulted include industrial hygienists, engineers, and health physicists.

J.3.2c To function properly and minimize potential hazards to HCWs and other room occupants, upper-air UVGI systems should be properly installed, maintained, and labeled. A person knowledgeable in the use of UV radiometers and/or actinometers should monitor UV irradiance levels to ensure that exposures in the work area are within safe exposure levels. UV irradiance levels in the upper-air, where the air disinfection is occurring,

should also be monitored to determine that irradiance levels are within the desired effectiveness range.

J.3.2d Change and clean UVGI tubes according to the manufacturer's instructions or when irradiance measurements indicate that output is reduced below effective levels.

J.3.2e In settings that use UVGI systems, education of HCWs should include a) basic principles of UVGI systems (mechanism and limitations), b) potential hazardous effects of UVGI if overexposure occurs, c) potential for photosensitivity associated with certain medical conditions or use of some medications, and d) importance of maintenance procedures and record keeping.

J.3.2f In settings that use UVGI systems, patients and visitors should be informed of the purpose of UVGI systems and be warned about the potential hazards and safety precautions.

J.4 Program issues

J.4.1 Personnel from engineering, maintenance, safety and infection control, and environmental health should collaborate to ensure the optimal selection, installation, operation, and maintenance of environmental controls.

J.4.2 Develop a written maintenance plan that outlines the responsibility and authority for maintenance of the environmental controls and addresses HCW training needs. Standard operating procedures should include the notification of infection-control personnel before performing maintenance on ventilation systems servicing TB patient-care areas.

J.4.3 Schedule routine preventive maintenance for all components of the ventilation systems (e.g., fans, filters, ducts, supply diffusers, exhaust grills) and air-cleaning devices.

J.4.4 Conduct quality control (QC) checks to verify that environmental controls are operating as designed and that records are current.

J.4.5 Make provisions for emergency electrical power so that the performance of essential environmental controls is not interrupted during a power failure.

K. Respiratory protection

The first two levels of the infection-control hierarchy, administrative and environmental controls, minimize the number of areas where exposure to *M. tuberculosis* may occur. They also reduce, but do not eliminate, the risk in the few areas where exposures can still occur (e.g., AII rooms and rooms where cough-inducing or aerosol-generating procedures are performed). Because persons entering these areas may be exposed to airborne *M. tuberculosis*, the third level of the hierarchy is the use of respiratory protective equipment in situations that pose a high risk for exposure (Supplement 5).

On October 17, 1997, OSHA published a proposed standard for occupational exposure to *M. tuberculosis* (*271*). On December 31, 2003, OSHA announced the termination of rulemaking for a TB standard (*272*). Prior OSHA policy permitted the use of any Part 84 particulate filter respirator for protection against TB disease (*273*). Respirator usage for TB had been regulated by OSHA under CFR Title 29, Part 1910.139 (29CFR1910.139) (*274*) and compliance policy directive (CPL) 2.106 (*Enforcement Procedures and*

Scheduling for Occupational Exposure to Tuberculosis). Respirator usage for TB is now regulated under the general industry standard for respiratory protection (29CFR1910.134, http://www.osha.gov/SLTC/respiratoryprotection/index.html) (*275*). General information on respiratory protection for aerosols, including *M. tuberculosis*, has been published (*276-278*).

K.1 Indications for use

K.1.1 Respiratory protection should be used by

- All persons, including HCWs and visitors, entering rooms in which patients with suspected or confirmed infectious TB disease are being isolated.
- Persons present during cough-inducing or aerosol-generating procedures performed on patients with suspected or confirmed infectious TB disease.
- Persons in other settings where administrative and environmental controls are not likely to protect them from inhaling infectious airborne droplet nuclei. This may also include persons who transport patients with suspected or confirmed infectious TB disease in vehicles (e.g., EMS vehicles or ideally, ambulances) and persons who provide urgent surgical or dental care to patients with suspected or confirmed infectious TB disease (Supplement 1).

K.1.2 Laboratorians conducting aerosol-producing procedures may require respiratory protection. A decision concerning use of respiratory protection in laboratories should be made on an individual basis depending on the type of ventilation in use for the laboratory procedure and the likelihood of aerosolization of viable mycobacteria which may result from the laboratory procedure.

K.2 Respiratory protection program

OSHA requires health-care settings where HCWs use respiratory protection to develop, implement, and maintain a respiratory protection program. All HCWs who use respiratory protection should be included in the program (Supplement 5).

K.2.1 Training of HCWs

K.2.1a Provide HCWs with annual training on

- Nature, extent, and hazards of TB disease in the health-care setting; this training may be done in conjunction with other related training on infectious disease associated with airborne transmission such as SARS-Corona Virus (CoV) and measles
- The risk assessment process and its relationship to the respirator program
- Signs and symbols used to show that respirators are required in an area
- Reasons for using respirators
- Environmental controls used to prevent the spread and reduce the concentration of infectious droplet nuclei

- Reasons for selecting a particular respirator for a given hazard (Recommendations, Section K.2.2)
- Operation, capabilities, and limitations of respirators
- Cautions about facial hair and respirator use
- OSHA regulations regarding respirators including assessment of employees' knowledge

K.2.1b Provide opportunities for trainees to handle and wear a respirator until proficient (Recommendations, Section K.2.3).

K.2.1c Provide trainees with copies or summaries of lecture materials for use as references.

K.2.1d Provide instructions to refer all respirator problems immediately to the respiratory program administrator.

K.2.2 Selection of respirators

Respiratory protective devices used in health-care settings for protection against *M. tuberculosis* should meet the following criteria (*279,280*).

K.2.2a Any of the non-powered particulate filter respirators certified by CDC/NIOSH (N-, R-, or P-95, 99, or 100), including disposable respirators, or PAPRs with high-efficiency filters. CDC/NIOSH has certified N95 respirators that also meet Federal Drug Administration (FDA) requirements for surgical masks, and can be used for protection against bloodborne pathogens (*281*).

K.2.2b Ability to adequately fit respirator wearers (e.g., a fit factor of $\geq$100 for disposable and half-mask respirators) who are included in a respiratory protection program.

K.2.2c Ability to fit the different facial sizes and characteristics of HCWs. This can usually be met by making respirators available in different sizes and models.

K.2.2d The fit of filtering facepiece respirators varies due to different facial types and respirator characteristics (*10,282-291*). Selection of respirators may be informed through consultation with respirator fit-testing experts, CDC, occupational health and infection control professional organizations, peer-reviewed research, and respirator manufacturers, and from advanced respirator training courses.

K.2.3 Fit testing

A fit test is used to determine which respirator fits the user adequately and to ensure that the user knows when the respirator fits properly. After a risk assessment is conducted to validate the need for respiratory protection, perform fit testing during the initial respiratory protection program training and periodically thereafter and in accordance with Federal, state, and local regulations. See OSHA website for current regulations (http://www.osha.gov/SLTC/respiratoryprotection/index.html).

Fit testing provides a means to determine which respirator model and size fits the wearer best and to confirm that the wearer can don the respirator properly to achieve a good fit. Periodic fit testing for respirators used in TB environments can serve as an effective training

tool in conjunction with the content included in employee training and retraining. The frequency of periodic fit testing should be supplemented by the occurrence of a) risk of transmission of *M. tuberculosis*, b) facial features of the wearer, c) medical condition that would affect respiratory function, d) physical characteristics of respirator (despite the same model number), or e) model or size of the assigned respirator (*283*).

K.3 Respirator options: general recommendations

K.3.1 In situations requiring respiratory protection, the minimum respiratory protection device is a filtering facepiece (nonpowered, air-purifying, half-facepiece) respirator, such as an N95 disposable respirator. This CDC/NIOSH-certified respirator meets the minimum filtration performance for respiratory protection in areas where patients with suspected or confirmed TB disease may be encountered.

K.3.2 For situations in which the risk for exposure to *M. tuberculosis* is especially high due to cough-inducing and aerosol-generating procedures, more protective respirators may be needed (Recommendations, Section K.4).

K.4 Respirator options: special circumstances

K.4.1 Visitors to AII rooms and other areas with patients who have suspected or confirmed infectious TB disease should wear respirators. Visitors may wear N95 disposable respirators and should be instructed by HCWs on the use of the respirator prior to entering an AII room. (See Fit check in Glossary.)

K.4.2 Particulate respirators vary widely by model, and fit testing is usually not easily available to visitors., The fit of filtering facepiece respirators varies due to different facial types and respirator characteristics (*10,282-291*). Selection of respirators may be informed through consultation with respirator fit-testing experts, CDC, occupational health and infection control professional organizations, peer-reviewed research, and respirator manufacturers, and from advanced respirator training courses. This voluntary use of respirators by visitors might provide some level of protection.

K.4.3 The risk assessment for the setting may identify a limited number of circumstances (e.g., bronchoscopy or autopsy on persons with suspected or confirmed TB disease, selected laboratory procedures) for which a level of respiratory protection that exceeds the minimum level provided by an N95 disposable respirator should be considered. In such circumstances, provide HCWs with a level of respiratory protection that both exceeds the minimum criteria and is compatible with patient-care delivery. Such protection may include more protective respirators such as full-facepiece respirators or PAPRs (Supplement 5). Detailed information on these and other respirators has been published (*276,277,280,292*).

K.4.4 In some settings HCWs may be at risk for both inhalation exposure to *M. tuberculosis* and mucous membrane exposure to bloodborne pathogens. In these situations, the HCW may wear a nonfluid resistant respirator with a full-face shield or the combination product surgical

mask/N95 disposable respirator to achieve both respiratory protection and fluid protection.

K.4.5 When surgical procedures (or other procedures requiring a sterile field) are performed on persons with suspected or confirmed infectious TB disease, respiratory protection worn by HCWs must also protect the surgical field. The patient should be protected from the HCW's respiratory secretions, and the HCW from infectious droplet nuclei that may be expelled by the patient or generated by the procedure. Respirators with exhalation valves and PAPRs do not protect the sterile field.

K.4.6 Settings where patients with suspected or confirmed infectious TB disease will not be encountered do not need a respiratory protection program for exposure to *M. tuberculosis*. However, these settings should have written protocols for the early identification of persons with signs or symptoms of TB disease and procedures for referring these patients to a setting where they can be evaluated and managed. Filtering facepiece respirators should also be available for emergency use by HCWs who may be exposed to persons with suspected or confirmed TB disease before transfer. In addition, respirators and the associated respiratory protection program may be needed to protect HCWs from other infectious diseases or exposures to harmful vapors and gases. Their availability or projected need for other exposures should be considered in the selection of respirators for protection against TB to minimize replication of effort.

K.4.7 Surgical masks are designed to prevent respiratory secretions of the wearer from entering the air. To reduce the expulsion of droplet nuclei into the air, persons with suspected or confirmed TB disease should be instructed to observe respiratory hygiene and cough etiquette procedures (*125*) and should wear surgical masks when not in AII rooms. These patients do not need to wear particulate respirators.

K.4.8 Patients with suspected or confirmed TB disease should never wear any kind of respiratory protection that has an exhalation valve. This type of respirator does not prevent droplet nuclei from being expelled into the air.

L. Cough-Inducing and Aerosol-Generating Procedures

L.1 General recommendations

Procedures that involve instrumentation of the lower respiratory tract or induction of sputum can increase the likelihood that droplet nuclei will be expelled into the air. These cough-inducing procedures include endotracheal intubation, suctioning, diagnostic sputum induction, aerosol treatments (e.g., pentamidine therapy, nebulized treatments), bronchoscopy, and laryngoscopy, Gastric aspiration and nasogastric tube placement can also induce cough in some patients. Other procedures that can generate aerosols include irrigating tuberculous abscesses, homogenizing or lyophilizing tissue, performing autopsies on cadavers with untreated TB disease, and other processing of tissue that may contain tubercle bacilli and TB laboratory procedures.

L.1.1 If possible, postpone cough-inducing or aerosol-generating procedures on patients with suspected or confirmed infectious TB disease unless the procedure and can be performed with recommended precautions.

L.1.2 When a cough-inducing or aerosol-generating procedure must be performed on a patient with suspected or confirmed infectious TB disease, use a local exhaust ventilation device (e.g., booth or special enclosure). If this is not feasible, perform the procedure in a room that meets the ventilation requirements for an AII room.

L.1.3 After completion of cough-inducing procedures, keep patients in the AII room or enclosure until coughing subsides. Give the patients tissues, and instruct them to cover the mouth and nose with tissues when coughing. Dispose of tissues in accordance with the infection control plan.

L.1.4 Before the booth, enclosure, or room is used for another patient, allow enough time for the removal of at least 99% of airborne contaminants. This interval will vary based on the efficiency of the ventilation or filtration system (Supplement 4, Table 8).

L.1.5 For postoperative recovery, do not place the patient in a recovery room with other patients. Rather, place the patient in a room that meets the ventilation requirements for an AII room. If the room does not meet the ventilation requirements for an AII room, air-cleaning technologies (e.g., HEPA filtration, UVGI) can be used to increase the number of equivalent ACH (Supplement 4).

L.1.6 Perform all manipulations of suspected or confirmed *M. tuberculosis* specimens that may generate aerosols in a biological safety cabinet.

L.1.7 When in rooms or enclosures in which cough-inducing or aerosol-generating procedures are being performed, respiratory protection should be worn.

L.2 Special considerations for bronchoscopy

L.2.1 Bronchoscopy can result in the transmission of *M. tuberculosis* either through the airborne route (*70,88,93,169*) or a contaminated bronchoscope (*87,89,170-176*).

L.2.2 Whenever possible, perform bronchoscopy in a room that meets the ventilation requirements for an AII room (Supplement 4). Air-cleaning technologies can be used to increase equivalent ACH.

L.2.3 If a bronchoscopy must be performed in a positive-pressure room (e.g., operating room), exclude TB disease before performing the procedure. Examine three spontaneous or induced sputum specimens for AFB (if possible) to exclude a diagnosis of TB disease before bronchoscopy is considered as a diagnostic procedure (*127,293*).

L.2.4 In a patient who is intubated and mechanically-ventilated, minimize the opening of circuitry.

L.2.5 For HCWs present during bronchoscopic procedures on patients with suspected or confirmed TB disease, a respirator with a level of protection of at least an N95 disposable respirator should be worn. Protection greater than an N95 disposable respirator such as a full-facepiece elastomeric respirator or PAPR should be considered.

L.3 Special considerations for administration of aerosolized pentamidine and other medications

Patients receiving aerosolized pentamidine (or other aerosolized medications) who are immunocompromised and have a confirmed or suspected pulmonary infection (i.e., PCP or pneumonia caused by *Pneumocystis jaroveci*, previously called *Pneumocystis carinii* pneumonia) are also at risk for TB disease. Patients receiving other aerosolized medications may have an immunocompromising condition that puts them at greater risk for TB disease.

L.3.1 Screen patients for TB disease before initiating prophylaxis with aerosolized pentamidine. Include a medical history, test for infection with *M. tuberculosis*, and chest radiograph.

L.3.2 Before each subsequent treatment with aerosolized pentamidine, screen patients for signs or symptoms of TB disease. If signs or symptoms are present, evaluate the patient for TB disease.

L.3.3 Give patients with suspected or confirmed TB disease oral prophylaxis for *P. jaroveci* (formerly *P. carinii*), if clinically practical.

L.3.4 Patients receiving other aerosolized medication may have immunocompromising conditions; therefore, if warranted, they should be similarly screened, evaluated, and treatment with oral medications should be considered.

SUPPLEMENT 1: ESTIMATING THE INFECTIOUSNESS OF A TB PATIENT

I. General Principles

Transmission of *M. tuberculosis* is most likely to result from exposure to persons who have a) unsuspected pulmonary TB disease and are not receiving anti-tuberculosis treatment, b) diagnosed TB disease and are receiving inadequate therapy, or c) diagnosed TB disease and are early in the course of effective therapy. Administration of effective anti-tuberculosis treatment has been associated with decreased infectiousness among persons who have TB disease (*294*). Effective treatment reduces coughing, the amount of sputum produced, the number of organisms in the sputum, and the viability of the organisms in the sputum. However, the duration of therapy required to decrease or eliminate infectiousness varies (*295*). Some TB patients are never infectious, whereas those with unrecognized or inadequately treated drug-resistant TB disease may remain infectious for weeks or months (*2,3,94,101,169,296-299*). In one study, 17% of transmission occurred from persons with negative AFB smear results (*266*). Rapid laboratory methods, including PCR-based techniques, can decrease diagnostic delay and reduce the duration of infectiousness (*300*).

The infectiousness of patients with TB correlates with the number of organisms they expel into the air (*301*). The number of organisms expelled are related to several factors: a) presence of cough lasting ≥3 weeks, b) cavitation on chest radiograph, c) positive AFB sputum smear result, d) respiratory tract disease with involvement of the lung or airways including larynx, e) failure to cover the mouth and nose when coughing, f) lack of, incorrect, or short duration of anti-tuberculosis treatment (*302*), or g) undergoing cough-inducing or aerosol-generating procedures (e.g., sputum induction, bronchoscopy, airway suction). Closed and effectively filtered ventilatory circuitry and minimizing opening of such circuitry in intubated and mechanically-ventilated patients may minimize exposure (Recommendations, Section E.3.2).

Persons with extrapulmonary TB disease are generally not infectious unless they have concomitant pulmonary disease, nonpulmonary 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, especially if drainage from the abscess or lesion is extensive or if aerosolization of drainage fluid is performed (*76,79,84,90,303*). Persons with tuberculous pleural effusions may also have concurrent unsuspected pulmonary or laryngeal TB disease. These patients should be considered infectious until pulmonary TB disease is excluded. Patients with suspected tuberculous pleural effusions or extrapulmonary TB disease should be considered pulmonary TB suspects until concomitant pulmonary disease is excluded(*119*).

Although children with TB disease are generally less likely than adults to be infectious, transmission from young children can occur (*142,144*). Therefore, children and adolescents with TB disease should be evaluated for infectiousness using most of the same criteria as for adults (i.e., presence of cough lasting ≥3 weeks; cavitation on chest radiograph; respiratory tract disease with involvement of lungs, airways, or larynx; lack of, incorrect, or short duration of anti-tuberculosis treatment (*302*), undergoing cough-inducing or aerosol-generating procedures (e.g., sputum induction, bronchoscopy, airway suction). Although gastric lavage is useful in the diagnosis of pediatric TB disease, the grade of the positive AFB smear result does not correlate with infectiousness. Pediatric patients who might be infectious include those who are not on anti-tuberculosis treatment, have just been started on treatment or are on inadequate treatment, *and* who have extensive pulmonary or laryngeal involvement, coughing ≥3 weeks, cavitary TB disease, positive AFB sputum smear results, or who are undergoing cough-inducing or aerosol-

generating procedures. Children who have typical primary TB lesions on chest radiograph and do not have any of these indicators of infectiousness may not need to be placed in AII.

There are no data on the transmission of *M. tuberculosis* and its association with the collection of gastric aspirate specimens. Children who do not have predictors for infectiousness do not need to have gastric aspirates obtained in an AII room or other special enclosure; however, the procedure should not be preformed in an area where a person or persons infected with HIV may be exposed. Because the source case for pediatric TB patients may be a member of the infected child's family, parents and other visitors of all hospitalized pediatric TB patients should be screened for TB disease as soon as possible to ensure that they do not become sources of health-care–associated transmission of *M. tuberculosis* (*304-307*).

In general, patients who have suspected or confirmed TB disease and who are not on anti-tuberculosis treatment should be considered infectious if characteristics include

- Presence of cough
- Cavitation on chest radiograph
- Positive acid-fast bacilli (AFB) sputum smear result
- Respiratory tract disease with involvement of the lung, or airways including larynx
- Failure to cover the mouth and nose when coughing
- Undergoing cough-inducing or aerosol-generating procedures (e.g., sputum induction, bronchoscopy, airway suction)

If a patient with one or more of these characteristics is on standard multi-drug therapy with documented clinical improvement, usually in connection of smear conversion over several weeks, the risk of infectiousness is reduced.

II. Suspected TB disease

For patients placed in AII due to suspected infectious TB disease of the lungs, airway, or larynx, AII can be discontinued when the likelihood of infectious TB disease is considered unlikely **and** either 1) another diagnosis is made that explains the clinical syndrome **or** 2) the patient has three negative AFB sputum smear results (*126-129*). Each of the three consecutive sputum specimens should be collected 8–24 hours apart (*131*), and at least one should be an early morning specimen (because respiratory secretions pool overnight). Generally, this will allow patients with negative sputum smear results to be released from AII in two days.

Hospitalized patients in whom the suspicion of TB disease remains after the collection of three negative AFB sputum smear results should not be released from AII until they are on standard multidrug anti-tuberculosis treatment **and** are clinically improving. Thus, a patient who is suspected of having TB disease of the lung, airway, or larynx, is symptomatic with cough and not responding clinically to anti-tuberculosis treatment, should not be released from AII into a nonAII room and additional sputum specimens should be collected for AFB examination until three negative AFB sputum smear results are obtained (*28,29*). Further diagnostic approaches may need to be considered such as sputum induction and, after sufficient time on treatment, bronchoscopy.

Because patients with TB disease who have negative AFB sputum smear results can still be infectious (*266*), patients with suspected disease who meet the above criteria for release from AII should not be released to an area where other patients with immunocompromising conditions are housed.

III. Confirmed TB disease
A patient who has drug-susceptible TB of the lung, airway, or larynx, who is on standard multidrug anti-tuberculosis treatment and who has had a significant clinical and bacteriologic response to therapy (i.e., 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 AII is made, all patients with suspected TB disease should remain in AII while hospitalized until they

- have had three consecutive negative AFB sputum smear results, each collected 8–24 hours apart, with at least one being an early morning specimen, and
- have received standard multidrug anti-tuberculosis treatment (minimum of two weeks), and
- have demonstrated clinical improvement.

IV. Discharge to home of patients with suspected or confirmed TB disease
If a hospitalized patient who has suspected or confirmed TB disease is deemed medically stable (including patients with positive AFB sputum smear results indicating pulmonary TB disease), the patient may be discharged from the hospital before converting the positive AFB sputum smear results to negative AFB sputum smear results if

- a specific plan exists for follow-up care with the local TB control program,
- the patient has been started on a standard multidrug anti-tuberculosis treatment regimen and DOT has been arranged,
- no children less than 4 years of age or persons with immunocompromising conditions are present in the household,
- all immunocompetent household members have been previously exposed to the patient, and
- the patient is willing to not travel outside of the home except for health care associated visits until the patient has negative sputum smear results.

V. Release setting
Patients with suspected or confirmed infectious TB disease should not be released to health-care settings or homes where the patient can expose others who are at high risk for progressing to TB disease if infected, such as persons infected with HIV or young children. Coordination with the local health department TB program is indicated in such circumstances.

VI. Drug-Resistant TB disease
Because the consequences of transmission of MDR TB are severe, some infection-control practitioners may choose to keep persons with suspected or confirmed MDR TB disease in AII during the entire hospitalization, regardless of sputum smear results.

The role of drug resistance in transmission is complex. Transmission of drug-resistant organisms to persons with and without HIV infection is well documented (*54,308,309*). In some cases, transmission from patients with TB disease caused by drug-resistant organisms may be extensive due to prolonged infectiousness due to delays in diagnosis and delays in initiation of effective therapy (*53,94,98,101,255,310,311*).

Although many TB outbreaks among HIV-infected persons have been reported (*51,52,99*), the risk for transmission does not appear to be increased from patients with TB disease and HIV infection compared to TB patients without HIV infection (*54,312-315*). It is not clear whether persons infected with HIV are more likely to be infected with *M. tuberculosis* if exposed.

However, once infected with *M. tuberculosis*, the risk for progression to TB disease in persons infected with HIV is high (*316*). Progression to TB disease can be rapid, and even as soon as one month after exposure (*51,53,54,101*).

SUPPLEMENT 2: DIAGNOSIS AND TREATMENT OF LATENT TB INFECTION (LTBI) AND TB DISEASE

I. Procedures to diagnose latent tuberculosis infection (LTBI) and TB disease

Latent tuberculosis infection (LTBI) is a condition following exposure to a person with infectious TB disease and subsequent infection with *M. tuberculosis* where the bacilli are alive but inactive in the body. People who have LTBI but who do not have TB disease are asymptomatic (have no symptoms), do not feel sick, and cannot spread TB to other people.

In the United States, LTBI has been traditionally diagnosed based on a positive TST result, after TB disease has been excluded. (The TST, previously referred to as "PPD" test, consists of a small dose of PPD-tuberculin injected just beneath the surface of the skin by the Mantoux method.) *In vitro* cytokine-based immunoassays for the detection of *M tuberculosis* infection have been the focus of intense research and development. This document uses the term "QFT" to refer to the QuantiFERON-TB test currently available in the United States. Please see Supplement 3 for guidance and recommendation of the use of QFT in the setting of infection control. For guidance on the use of these and related technologies, CDC will periodically publish recommendations on the diagnosis of *M. tuberculosis* infection.

TB disease should be considered for any patient who has signs or symptoms of disease, including coughing for ≥3 weeks, loss of appetite, unexplained weight loss, night sweats, bloody sputum or hemoptysis, hoarseness, fever, fatigue, or chest pain. The index of suspicion for TB disease will vary by individual risk factors, geographic area, and prevalence of TB disease in the population served by the health-care setting. Persons exposed to patients with infectious TB disease may acquire LTBI depending on host immunity and the degree and duration of exposure. Diagnostic tests for TB disease include chest radiography and laboratory tests of sputum (examination for AFB and culture). The treatment of persons with TB disease involves important aspects of TB control by stopping transmission of *M. tuberculosis* and preventing persons with LTBI from developing infectious TB disease (*33*).

In most U.S. populations, targeted testing for LTBI and TB disease is performed to identify persons with LTBI and TB disease who would benefit from treatment. Therefore, all testing activities should be accompanied by a plan for follow-up care of persons with LTBI or TB disease. A decision to test for infection with *M. tuberculosis* should be based on a commitment to treat LTBI (*36*). Health-care agencies or other settings should consult with the state or local health department before starting a program to test HCWs for infection with *M. tuberculosis* to ensure that adequate provisions are in place for the evaluation and treatment of persons whose test results are positive, including the medical supervision of the course of treatment for those who are treated for LTBI or TB disease.

Groups that are not at high risk for LTBI or TB disease should not be tested routinely, because testing in low-risk populations diverts resources from other priority activities. In addition, TB screening of low-risk persons is discouraged because a substantial proportion of persons from low-risk populations who have positive TST results may actually have false-positive TST results and may not represent infection with *M.*

tuberculosis (*36,317*). Testing for infection with *M. tuberculosis* should be performed for well-defined, high-risk groups. These groups can be divided into two categories (Introduction, Sections B.1 and B.2):

- persons at higher risk for exposure to and infection with *M. tuberculosis*, and
- persons at higher risk for progression from LTBI to TB disease.

Flexibility is needed in defining high-priority groups for TB screening. The changing epidemiology of TB indicates that the risk for TB among groups currently considered high priority may decrease over time, and groups currently not identified originally as being at high risk may be considered as high priority.

A. Tuberculin skin test (TST)

The TST is often the first step of a TB diagnostic evaluation that may lead to diagnosing LTBI. Although currently available preparations of PPD used in TSTs are less than 100% sensitive and specific for the detection of LTBI, the TST is currently the most widely used diagnostic test for *M. tuberculosis* infection in the United States. The TST is less sensitive in patients who have TB disease.

As with all medical tests, the TST is subject to variability, and variability in reading TST results has been documented (*81,234,318*). Many of the variations in administering and reading TST results can be avoided by training and attention to details (*319*). Detailed information on the use of TSTs for diagnosing LTBI has been published (*36*), and details of TST administration and TST result reading procedures are described below.

A.1 Adherence to TST and Treatment of LTBI

Operational policies, procedures, and practices at health-care settings can enhance HCW adherence to serial TST and treatment for LTBI. A recent focus group study identified both potential barriers and facilitators to adherence (*320*). HCWs identified structural factors such as inconvenient TST screening schedules and locations, long waiting times, the cost of LTBI medication, and the failure of private physicians to recommend treatment for LTBI as factors that negatively impacted adherence. Facilitators that help HCWs adhere to having TSTs placed included active follow-up by supervisors and occupational health staff, work-site visits for TST screening, and provision of counseling to address informational and emotional needs. Misinformation and stigma about TB also emerged in the discussions, suggesting the need for additional training and education for HCWs. The findings also suggest that the establishment of TST policies and procedures that address these issues may improve HCWs' adherence to serial skin testing and treatment of LTBI (*320*).

A.2 Administering the TST

For each patient, conduct a risk assessment that takes into consideration recent exposure to *M. tuberculosis*, clinical conditions that increase risk for TB disease if infected, and the program's capacity to deliver treatment for LTBI to determine if the TST should be administered. A decision to test for infection with *M. tuberculosis* should be based on a commitment to treat LTBI (*36*).

The recommended method for tuberculin skin testing is the Mantoux method, which is an intradermal administration of a measured amount of tuberculin (*230,319,321-323*). Mantoux TST training materials supporting the guidance in this document are available free of charge from CDC at www.cdc.gov/tb (*230,319,321-323*). Multi-puncture tests (e.g., tine tests) are not as reliable as the Mantoux method of skin testing and should not be used as a diagnostic test in the United States (*28*). Contact the state and local health department for TST resources.

Before administering TSTs or performing any other procedure involving patient contact, HCWs should wash their hands using an appropriate hand-washing technique (*324*). In certain field settings it may be necessary to use additional hand-hygiene techniques. State or local regulations should determine what additional standard precautions should be followed (i.e., whether or not gloves should be worn while placing TSTs and the procedures for the disposal of supplies).

See Table 10, Recommended quality control (QC) procedural observation checklists, for details on administering TSTs and reading TST results. Details of TST administration procedures are also described below.

A.2.1 Locate and clean the injection site. Select an area ≥2 inches away from the elbow (*36,325*). The area should be free of any barriers (e.g., muscle margins, heavy hair, veins, sores, or scars) to placing the TST and reading the TST result.

A.2.2 Prepare the syringe. Check the vial to be sure it contains PPD (*326*) and check the expiration date on the vial. Fill the syringe with 0.1 ml of tuberculin. Use a ¼- to ½-inch 27-gauge needle or finer, disposable tuberculin (preferably a safety-type) syringe.

- **A.2.2a** Pre-filling of syringes is not recommended. Tuberculin is adsorbed in varying amounts by glass and plastics. To minimize reduction in potency by adsorption, tuberculin should be given as soon after the syringe has been filled as possible. Following these procedures will also help avoid contamination; test doses should always be removed from the vial under strictly aseptic conditions, and the remaining solution should remain refrigerated (not frozen) (*36,325*).
- **A.2.2b** Tuberculin should be stored in the dark as much as possible and exposure to strong light should be avoided (*36,325*).
- **A.2.2c** To prevent needlestick injuries, needles should not be recapped, purposely bent or broken, removed from disposable syringes, or otherwise manipulated by hand.

A.2.3 Inject tuberculin just beneath the surface of the skin (intradermally) (*243,244*). Hold the needle bevel up, and insert the needle slowly at a 5–15 degree angle. Inject 5 TU of PPD antigen into the volar surface of the forearm (palm-side up).

A.2.4 Check the skin test. A tense, pale elevation of the skin (a wheal) 6–10 mm in diameter (*327*) should be produced as the TST is administered. Explain to the patient that the wheal is absorbed naturally in approximately ten minutes.

A.2.4a If the TST is administered incorrectly (i.e., too deeply or too shallow), a new TST should be placed immediately. It is preferable to apply the second TST on the other arm or in a different area of the same arm (≥2 inches from the first site) so that the TST result will be easier to read (*36*).

A.2.4b Caution the patient to avoid pressure on the wheal (blot the injection site lightly with a gauze pad if a drop of blood appears). The National Health and Nutrition Examination Survey (NHANES) TST manual states to avoid covering the skin with anything that may interfere with reading the TST result (e.g., adhesive bandages, cream, ointment, lotion, liquids, medication). Also, advise the patient not to scratch the site, which may interfere with reading the TST result (*327*).

A.2.5 Record all the information required for documentation by the setting (e.g., date and time of TST administration, who placed the TST, injection site location, lot number of tuberculin).

A.2.6 Syringe and needle technologies continue to evolve to help prevent needle stick injuries (http://www.cdc.gov/nip/dev/jetinject.htm). Institutional policy should determine which skin test device has been evaluated and approved for use by your setting (*328*).

A.3 Reading the TST result

Reading the TST result consists of first determining the presence or absence of induration (hard, dense, raised formation), and if induration is present, measuring the diameter of induration transverse (perpendicular) to the long axis of the forearm (*36,319*). Erythema, or redness of the skin, should not be considered when reading a TST result.

The TST result should be read by a designated, trained HCW 48–72 hours after the TST is placed (*36,36,327*). If the TST was not read between 48–72 hours, ideally, another TST should be placed as soon as possible and read within 48–72 hours (*36*). Some studies indicate that positive TST reactions may still be measurable from four up to seven days after testing (*231,232*). However, if a patient fails to return within 72 hours and has a negative test result, the TST should be repeated (*37*). Patients and HCWs should not be allowed to read their own TST results. Experience has shown that HCWs do not measure their own TST results reliably (*38*).

See Table 10, Recommended QC procedural observation checklist, for reading TST results; detailed procedures are described below.

A.3.1 Visually inspect the TST site under good light. Determine the presence or absence of induration (hard, dense, raised formation). Do not measure erythema (abnormal redness of the skin) as part of the TST result.

A.3.2 If induration is present, palpate the induration. Use fingertips to find margins of the induration.

A.3.3 Mark the induration by placing small dots on both sides of the induration with a ballpoint pen or fine-tipped eyeliner pencil. For the palpation method, use fingertip as a guide for marking the widest edges of the

induration (not erythema) with dots transverse to the long axis of the forearm. An eyeliner pencil is useful for TST training and for blinded independent duplicate readings (BIDRs) (see BIDR in Glossary) because the dots are easy to remove. Alternative TST result reading methods have been described, including the pen method of induration marking (*321-323,329*).

A.3.4 Measure the induration with a TST ruler or any ruler that measures mm. Place the "0" ruler line inside the edge of the left dot. Read the ruler line inside right dot edge (use lower measurement if between two gradations on mm scale) as shown in Figure 1.

Figure 1 here

A.3.5 Record all TST results in mm, even those classified as negative. Do not record only as "positive" or "negative." Record the absence of induration as "0 mm" (*327*).

A.3.6 In very rare instances, the reaction may be severe (vesiculation, ulceration, or necrosis of the skin). Report severe adverse events to the FDA MedWatch Adverse Events Reporting System (AERS) 1-800-FDA-1088 (telephone); 1-800-FDA-0178 (fax); Report Form 3500 in the Physicians' Desk Reference; www.fda.gov/medwatch.

A.4 Interpreting the TST result and its positive-predictive value

The positive-predictive value of a TST is the probability that a person with a positive TST result is actually infected with *M. tuberculosis.* The positive predictive value is dependent on the prevalence of infection with *M. tuberculosis* in the population being tested and the specificity of the test (*234,330,331*).

A.4.1 In populations with a low prevalence of infection with *M. tuberculosis,* the probability that a positive TST result represents true infection with *M. tuberculosis* can be very low, especially if the cut point is set too low, (i.e., the test is not adequately specific and there is a low prevalence in the population).

A.4.2 In populations with a high prevalence of infection with *M. tuberculosis* and inadequate test specificity, the probability that a positive TST result using the same cut point represents true infection with *M. tuberculosis* is much higher.

A.5 Interpreting the TST result in HCWs

TST result interpretation depends on two factors: 1) measured TST induration in mm, and 2) the person's risk of being infected with *M. tuberculosis* and risk of progression to TB disease if infected.

The three cut points on Table 11 should be used to determine whether the TST result should be classified as positive or negative. A TST result with no induration (0 mm) or a measured induration below the defined cut point for each category is considered to signify absence of infection with *M. tuberculosis.*

In the context of TST screening as part of a TB infection-control program, the interpretation of TST results occurs in two distinct parts: 1) interpretation by standard criteria, without regard to personal risk factors or setting-specific factors, of the TST results for infection control, surveillance, and referral purposes, and 2) interpretation by individualized criteria to determine need for treatment of LTBI.

Determining the need for treatment of LTBI is a subsequent and separate task. For infection-control and surveillance purposes, TST results are interpreted and recorded under strict criteria, without considering setting-based or personal risk factors (Supplement 2, Table 12). Any HCW with a positive TST result from serial TB screening should be referred to a medical provider for an evaluation

and to determine the need for treatment of LTBI based on individual risk (Supplement 2, Table 11).

A.5.1 Interpreting the TST result for infection control and surveillance

On baseline TST testing, a TST result of ≥10 mm is considered positive for most HCWs, and a TST result of ≥5 mm is considered positive for HCWs who are infected with HIV or who have other immunocompromising conditions (Supplement 2, Table 11). All HCWs with positive baseline TST results should be referred for medical and diagnostic evaluation, and further skin testing does not need to be performed.

On serial screening for the purposes of infection-control surveillance, TST results showing an increase of ≥10 mm within two years should be interpreted and recorded as a TST conversion. For the purposes of assessment and monitoring of infection control, TST conversion rates should be regularly determined. Health-care settings with a large number of HCWs to be tested may have systems in place that can accurately determine the TST conversion rate every month (e.g., from among a group of HCWs tested annually), while smaller settings may have imprecise estimates of their TST conversion rate even with annual assessments.

The precision of the setting's TST conversion rate and any analysis assessing change from baseline TST results will depend on the number and frequency of HCWs tested. This should be considered when establishing a regular interval for TB screening for HCWs.

After a known exposure in a health-care setting, close HCW contacts who have TST results of ≥5 mm should be considered to have a positive TST result, and interpreted as a new infection only in HCWs whose prior TST result is 0 mm. However, HCWs with a baseline or follow-up TST result of >0 mm but <10 mm with a health care–associated exposure to *M. tuberculosis*, who then have an increase of ≥10 mm should be considered to have a TST conversion due to a new infection (Supplement 2, Table 12).

In a contact investigation, a follow-up TST should be administered 8–10 weeks after the end of exposure (rather than 1–3 weeks later, as in two-step testing). In this circumstance, a change from a negative TST result to a positive TST result should not be interpreted as a boosted reaction. The change in the TST result indicates a TST conversion and suggests recent exposure, transmission, and infection.

All HCWs who are immunocompromised should be referred for a medical and diagnostic evaluation for any TST result of ≥5 mm on baseline or follow-up screening. Because infection-control staff will usually not know the immune status of the HCWs being tested, HCWs who have TST results of 5–9 mm should be advised that such results can

be an indication for referral for medical evaluation for HCWs who have HIV infection or other causes of severe immunosuppression.

Once a HCW has met criteria for a positive TST result and has documentation to support this, repeat TSTs do not need to be performed because their results would not provide any additional information (*28*). This includes HCWs who have positive TST results but who will not receive treatment for LTBI after medical evaluation. For future TB screening, instead of participating in serial skin testing, the HCW should receive a medical evaluation and a symptom screen annually.

A.5.2 Interpreting the TST result for medical and diagnostic referral and evaluation

HCWs who have a positive TST result and who meet the criteria for referral should have a medical and diagnostic evaluation. During that evaluation, it is possible that for HCWs who are at low risk, such as those from low-incidence settings, a baseline result of ≥15 mm of induration (instead of ≥10 mm) may be the cut point. Table 11 presents the criteria used to determine the need for treatment of LTBI.

Setting-based risk factors, such as the prevalence of TB disease and personal risk factors, such as having an immunocompromising condition or known contact with a TB case, should be assessed when choosing the cut point for a positive TST result in making decisions for the diagnosis and treatment of LTBI. The medical evaluation can occur in different settings, including an occupational health clinic, state or local health department, or private medical clinic.

Table 12 here

For HCWs who are otherwise at low risk for LTBI and are tested at the start of employment, a baseline TST result of ≥15 mm from two-step testing (instead of ≥10 mm) induration may be considered the cut point for a positive TST result for clinical purposes. When 15 mm is used as the cut point, TST results of 10–14 mm may be considered clinically negative (*332*); these HCWs should not have repeat TSTs, and the referring physician may not recommend treatment for LTBI. This may be especially true in areas of the country where the prevalence of infection with nontuberculous *mycobacteria* (NTM) (also known as *Mycobacterium* other than tuberculosis, MOTT) is high (see NTM and MOTT in Glossary).

HCWs who have TST results of 5–9 mm on two-step baseline testing should be advised that such results may be an indication for treatment of LTBI if the HCW is a contact of a person with infectious TB disease, has HIV infection, or has other causes of severe immunosuppression (e.g., organ transplant, receipt of the equivalent of ≥15 mg/day of prednisone for ≥1 month). The risk for TB disease in persons treated with corticosteroids increases with higher dose and longer duration of corticosteroid use.

HCWs with negative two-step baseline TST results who are referred for medical evaluation for an increase of ≥10 mm induration on follow-up TST screening, even who are otherwise at low risk for TB disease, probably acquired *M. tuberculosis* infection since receiving the previous TST and

should be evaluated for TB disease. If disease is excluded, the HCW should be offered treatment for LTBI if they have no contraindication to treatment.

Table 11 here

A.6 Quality Control (QC) Program for techniques of TST administration and reading TST results

Random variation (i.e., differences in procedural techniques) in TST administration and reading TST results can cause poor quality TST results, including false-positive or false-negative TST results. Many of the variations in administering TSTs and reading TST results can be avoided by training and attention to details. HCWs who are responsible for TST procedures should be trained to reduce variation by following standardized operational procedures, and should be observed by an expert TST trainer. All TST procedures (administering, reading and recording the results) should be supervised and controlled to detect and correct variation. Corrective actions may include coaching and demonstration by the TST trainer. Annual re-training is recommended for HCWs responsible for administering TSTs and reading TST results.

One strategy to identify TST procedure variation is to use a quality control tool (Supplement 2, Table 10 and Table 13). The expert TST trainer should observe the procedures and indicate procedural variation on the observation checklists.

A.6.1 QC for administering TSTs by the Mantoux method

Ideally, the TST trainer should participate in QC TST administrations with other TST trainers to maintain TST trainer certification. State regulations specify who is qualified to administer the test by injection. The TST trainer should first ensure antigen stability by maintaining the manufacturer's recommended cold chain (i.e., controlling antigen exposure to heat and light from the time it is out of refrigeration until the time it is placed back into refrigeration or until the vial is empty or expired). The TST trainer should prevent infection during an injection by preventing contamination of solution, needle, syringe, and by preparing the skin.

The TST trainer should prevent antigen administration errors by controlling the five rights of administration: 1) the right antigen, 2) the right dose, 3) the right patient, 4) the right route, 5) the right time for TST administration, reading, and clinical evaluation (*333*). Finally, the TST trainer should observe and coach the HCW trainee in administering multiple intradermal injections by the Mantoux method. The TST trainer should record procedural variation on the observation checklist (Supplement 2, Table 10). TST training and coaching should continue until ≥10 correct skin test placements (i.e., ≥6 mm wheal) are achieved (Supplement 2, Table 10).

For training purposes, normal saline for injection may be used instead of PPD for intradermal injections. Volunteers are usually other HCWs who agree to be tested. Try to recruit volunteers who have known positive

TST results so the trainees can practice reading positive TST results. A previous TST is not a contraindication to a subsequent TST unless the test was associated with severe ulceration or anaphylactic shock, which are very rare adverse events (*28,243,244*).

The following describes a model TST training program for placing TSTs from a study conducted by the National Health and Nutrition Examination Survey (NHANES) (*327*).

A.6.2 Initial training for a TST placer ideally consists of

- Three hours of introductory lecture and demonstration by an expert TST placer or trainer. An expert TST trainer is a qualified HCW who has received training on administering multiple TSTs and reading multiple TST results.
- Nine hours of supervised practical work using procedural checklists observed and coached by the expert TST trainer (Supplement 2, Table 10).
- Administering ≥10 total skin tests on volunteers, using injectable saline, and producing ≥10 wheals that measure 6–10 mm.

TST training should include supervised TST administration, which is a procedure in which an expert TST trainer supervises a TST trainee during all steps on the procedural observation checklist for TST administration (Supplement 2, Table 10). Wheal size should be checked for all supervised TST administrations, and skin tests should be repeated if wheal size is inadequate (i.e., if <6 mm). TST training and coaching should continue until ≥10 correct skin test placements (i.e., ≥6 mm wheal) are achieved.

A.6.3 QC for reading TST results by the palpation method

The TST trainer should participate in QC readings with other TST trainers to maintain TST trainer certification. When training HCWs to read TST results, it is helpful to provide measurable TST responses, (i.e., try to recruit volunteers who have known positive TST results so the trainees can practice reading positive TST results).

TST readers should correctly read both measurable (>0 mm) and nonmeasurable responses (0 mm) (e.g., ≥20 TST results, ≥10 measurable and ≥10 nonmeasurable, if possible). The TST trainer should observe and coach the HCW in reading multiple TST results by the palpation method and should record procedure variation on the observation checklist (Supplement 2, Table 13).

The TST trainer should conduct BIDRs for comparison with the HCW's reading. BIDRs are performed when two or more consecutive TST readers immediately measure the same TST result by standard procedures without consulting or observing one another's readings and record results independently (may use recommended procedural

observation checklist; Table 13). BIDRs help ensure TST readers continue to read TST results correctly.

The following describes a model TST training program for reading TST results NHANES (*327*). The number of hours, sessions and number of BIDR readings should be decided by the setting's TB risk assessment. The following information is for an model TST training program.

Initial training for a TST reader ideally should consist of

- Six hours of introductory lecture and demonstration by an expert TST reader. Training materials are available from CDC (*230,319*) and CDC-sponsored Regional Model and Training Centers and should also be available at the state or local health department.
- Four sessions (16 hours total) of supervised practical work using procedural checklists (observed and coached by an expert TST reader).
- Performing (≥80) BIDR readings. TST trainers should attempt to organize the sessions so that at least 50% of the TST results read have a result >0 mm according to the expert TST reader.
- On the last day of TST training, performing ≥30 BIDR readings (out of the total 80 readings). TST trainers should attempt to ensure that at least 25% of those tested have a TST result >0 mm according to the expert TST reader.
- Missing no more than two items on the procedural observation checklist (Supplement 4, Table 7) for three random observations by an expert TST reader.
- Performing all procedures on the checklist correctly during the final observation.

To be a qualified TST trainer, two or more trainees should perform all procedures on the checklist (Supplement 2, Table 13) correctly and achieve a satisfactory measurement. Trainees should read TST results by the BIDR method.

TST training and coaching should continue until the HCW is able to perform all procedures correctly and a satisfactory measurement is achieved (i.e., the trainer and the trainee read the TST results within 2 mm of each other). For example, if the trainer reads the TST result as 11 mm (this may be considered the "gold standard" reading), the trainee's reading should be between 9–13 mm to be considered correct. Only a single mm measurement should be recorded (not "11 mm x 11 mm" or "11 mm x 15 mm").

The following Quality control (QC) Procedural Observation Checklist (Supplement 2, Table 13) is recommended by CDC as a tool for use during TST training.

Table 10 here

Table 13 here

A.7 Special considerations in tuberculin skin testing

A.7.1 Anergy

The absence of a reaction to a TST does not exclude a diagnosis of TB disease or infection with *M. tuberculosis*. In immunocompromised persons, delayed-type hypersensitivity (DTH) responses such as tuberculin reactions can decrease or disappear more rapidly; and a few otherwise healthy persons apparently are incapable of reacting to tuberculin even after diagnosed infection with *M. tuberculosis*. This condition, called anergy, can be caused by many factors, such as advanced HIV infection, measles infection, sarcoidosis, poor nutrition, certain medications, vaccinations, TB disease itself, and other factors (*308,334-338*). However, anergy skin in conjunction with skin testing is no longer recommended routinely for screening for *M. tuberculosis* infection (*336*).

Anergy testing is not useful in screening for diagnosing LTBI or asymptomatic TB disease (*339*). Anergy testing is not routinely recommended for anyone infected with HIV or who are otherwise immunocompromised because TST results alone, positive or negative, are not sensitive or specific enough to guide clinical decision making (*336*).

A.7.2 Reconstitution of DTH in HIV-infected persons taking antiretroviral therapy

In one prospective study (*340*), TB patients who initially had negative TST results had positive TST results after initiation of HAART. HCWs must be aware of the potential public health and clinical implications of restored TST reactivity among persons who have not been diagnosed with TB disease but who may have LTBI. Repeat testing for infection with *M. tuberculosis* is recommended in HIV-infected persons previously known to have negative TST results after the initiation of HAART (*55*). Recommendations on the prevention and treatment of TB in HIV-infected persons have been published (*36,50,246*).

A.7.3 Pregnancy

Tens of thousands of pregnant women have received TSTs since the test was developed, and no documented episodes of TST-related fetal harm have been reported (*341*). There is no evidence that the TST has adverse effects on the pregnant mother or fetus (*36*). Pregnant HCWs should be included in serial skin testing as part of an infection-control program or a contact investigation since no contraindication for skin testing exists (*342*). Guidelines issued by the American College of Obstetricians and Gynecologists (ACOG) emphasize that postponement of the diagnosis of infection with *M. tuberculosis* during pregnancy is unacceptable (*343*).

A.7.4 Booster phenomenon and two-step testing

In some persons with LTBI, the DTH responsible for TST reactions wanes over time. Repeated TSTs can elicit a reaction called “boosting” whereupon despite LTBI an initial TST result is negative, but a subsequent TST result is positive. For example, a TST administered years after infection with *M. tuberculosis* can

produce a false-negative result. This TST may stimulate (or "boost") the person's ability to react to tuberculin, resulting in a positive result to a subsequent test (including the second-step of a two-step procedure) (*33,81,317,342,343*). With serial testing, a boosted reaction on a subsequent TST might be misinterpreted as a newly acquired infection relative to the false-negative result from the initial TST. Misinterpretation of a boosted reaction as a new infection with *M. tuberculosis* or TST conversion could prompt unnecessary investigations to find the source case, unnecessary treatment for the person tested, and unnecessary testing of other HCWs. The booster phenomenon can occur in anyone, but it is more likely to occur in older persons, persons with remote infection with *M. tuberculosis* (i.e., infected many years ago), persons infected with NTM (also known as MOTT), and persons with prior BCG vaccination (*36,235,240,344,345*).

All newly employed HCWs to be screened with TSTs should receive baseline two-step TSTs upon hire unless they have documentation of either a positive TST result, or treatment for LTBI or TB disease (*36,118*). If an initial TST result is negative, the second-step of a two-step TST should be administered 1–3 weeks after the first TST result was read. The second step can be administered after the recommended 3 weeks in constraining circumstances if the risk for exposure during the intervening period is low. In HCWs with one documented negative TST result during the 12 months proceeding employment, only one additional TST is needed for baseline testing.

Since any setting may have HCWs at risk of boosting, and that a rate of boosting even as low as 1% can result in unnecessary investigation of transmission, baseline two-step testing should be performed on all newly hired HCWs and others who will receive serial TSTs, such as residents of long term care facilities. This is especially important for settings that are classified as low-risk where testing is indicated only upon exposure and a reliable baseline test is necessary to detect health-care–associated transmission of *M. tuberculosis*. Guidance for baseline TST for HCWs is provided in Table 11. To estimate the frequency of boosting in a particular setting, a four-appointment schedule of TST administration and reading (i.e., appointments for TST administration and reading both tests) is necessary, rather than the three-appointment schedule (i.e., appointments for the administration of both tests, with reading of the second-step TST result only) (*203*).

If the result of the baseline first-step of a two-step TST meets the criteria for medical and diagnostic evaluation (Supplement 2, Table 7), further skin testing is not necessary (even if the medical and diagnostic evaluation do not result in the diagnosis of LTBI). A positive result to the second-step of a two-step TST after a negative first test most probably represents boosting. On the basis of the second-step TST result and the criteria in Table 7, the HCW should be referred for medical and diagnostic evaluation. A boosted reaction should never be considered a TST conversion. If the second test result does not meet the criteria for referral for medical and diagnostic evaluation, the HCW should be classified as uninfected and retested as needed. A reaction on any subsequent TST that

meets the criteria for a positive test in Table 7 most probably represents new infection with *M. tuberculosis* (*36*).

Two-step testing should be used only for baseline screening not in contact investigations. In a contact investigation, for those with a negative TST, a follow-up test should be administered 8–10 weeks after the end of exposure (rather than 1–3 weeks later, as in a two-step TST). In this circumstance, a change from a negative to a positive TST result indicates a TST conversion suggesting recent exposure, transmission, and infection and should not be interpreted as a boosted response.

After a known exposure in a health care–associated setting (close contact to a patient or HCW with infectious TB disease), TST results of ≥5 mm should be considered positive and interpreted as a new infection in HCWs whose prior TST result is 0 mm. Those HCWs with a baseline or follow-up TST result >0 mm but <10 mm and a health-care–associated exposure to *M. tuberculosis* who have an increase in the TST size of ≥10 mm should be interpreted as having a TST conversion due to new infection.

Table 9 here

A.7.5 BCG vaccination

In the United States, vaccination with BCG is not recommended routinely for anyone, including HCWs or children (*233*). Prior BCG vaccination is not a contraindication to having a TST administered, or two-step skin testing. HCWs with prior BCG vaccination should receive baseline and serial skin testing in the same way as those without BCG vaccination (*239*) (Supplement 2, Table 9).

Prior BCG vaccination can lead to boosting in baseline two-step testing in some persons (*81,237,344-346*). It is not possible to distinguish a boosted TST reaction resulting from BCG vaccination (a false-positive TST result) and a TST result due to prior infection with *M. tuberculosis* (true positive TST result) (*36*). Infection-control programs should refer HCWs with positive TST results for medical evaluation as soon as possible (Supplement 2, Table 11).

Prior BCG vaccination increases the probability of a boosted reaction that is likely to be uncovered on initial two-step skin testing. For an HCW with a negative baseline two-step TST result who is a known contact of a patient who has suspected or confirmed infectious TB disease, treatment for LTBI should be considered if the follow-up TST result is ≥5 mm, regardless of BCG vaccination status.

A.7.6 PPD preparations for diagnosing infection with *M. tuberculosis*

Two PPD preparations are currently available in the United States: Tubersol® (Aventis Pasteur) (*243*) and Aplisol® (Parkdale Pharmaceuticals) (*244*). When compared with the United States reference PPD, there was no difference in TST interpretation between the two (*347*); however, when Tubersol® and Aplisol®

were compared to each other, there was a slight difference in reactivity, Aplisol producing slightly larger reactions than Tubersol®, but this difference did not reach statistical significance (*347*). The difference in specificity, 98% versus 99%, is small, however when applied in large institutional settings, which test thousands of workers annually who are at low risk for infection with *M. tuberculosis*, this difference in specificity may affect the rate of positive TST results seen.

TB screening programs should use one antigen consistently and realize that changes in products might make serial changes in tuberculin skin testing results difficult to interpret. In one report, systematic changes in product use resulted in a cluster of pseudo-conversions that were believed erroneously to indicate a health-care–associated outbreak (*348*). Persons responsible for making decisions about the choice of pharmacy products should seek advice from the state or local health department's TB infection-control program before switching PPD preparations and should inform program staff of any changes.

B. Chest radiography

Chest radiography is used to look for abnormalities suggestive of pulmonary TB disease. HCWs who have positive test results for *M. tuberculosis* infection or signs or symptoms of TB disease regardless of results tests for *M. tuberculosis* infection should have a chest radiograph performed to exclude a diagnosis of TB disease. However, a chest radiograph is not a substitute for tests for *M. tuberculosis* infection in a serial TB screening program for HCWs.

Persons who have LTBI or cured TB disease should not have repeat chest radiographs performed routinely (*120*). Repeat radiographs are not needed unless signs or symptoms of TB disease develop, or a clinician recommends a repeat chest radiograph (*36,120*).

Radiographic abnormalities that strongly suggest pulmonary TB disease include upper-lobe infiltration, cavitation, and effusion. Infiltrates can be patchy or nodular and seen in the apical or subapical posterior upper lobes or superior segment of the lower lobes in the lungs. If radiographic or clinical findings are consistent with TB disease, further studies (e.g., medical evaluation, bacteriologic examinations, comparison of current and prior chest radiographs) should be performed (*29*).

A chest radiograph to exclude pulmonary TB disease is indicated for all persons being considered for treatment of LTBI. If chest radiographs do not indicate pulmonary TB *and* if no signs or symptoms of TB disease are present, persons with a positive test result for infection with *M. tuberculosis* may be candidates for treatment of LTBI. In persons with LTBI, the chest radiograph is usually normal, although it may show abnormalities suggestive of prior TB disease or other pulmonary conditions. In patients with signs or symptoms of TB disease, pulmonary infiltrates may only be apparent on computed tomography (CT) scan. Previous, healed TB disease can produce radiographic findings that usually differ from those associated with current TB disease. These findings include nodules, fibrotic scars, calcified granulomas, or basal pleural thickening. Nodules and fibrotic scars might contain slowly multiplying tubercle bacilli and pose a high risk for progression to TB disease. Calcified nodular lesions (calcified granulomas) and apical pleural thickening pose a lower risk for progression to TB disease (*29*).

B.1 Chest radiography and pregnancy

Because TB disease is dangerous to both mother and fetus, pregnant women who have a positive TST result or who are suspected of having TB disease as indicated by symptoms or other concerns, should receive chest radiographs (with shielding consistent with safety guidelines) as soon as feasible, even during the first trimester of pregnancy (*29,36,341*).

B.2 Chest radiography and HIV-infected persons

The radiographic presentation of pulmonary TB in persons infected with HIV might be apical (in the top part of the lungs). However, apical cavitary disease is less common among such patients. More common chest radiograph findings for persons infected with HIV are infiltrates in any lung zone, mediastinal or hilar adenopathy, or, in rare cases, a normal chest radiograph. Typical and cavitary lesions are usually seen in patients with higher CD4 counts, and the more atypical patterns are seen in patients with lower CD4 counts. (*29,46,101,148,349-354*).

C. Evaluation of sputum samples

Sputum examination is a crucial diagnostic procedure for pulmonary TB disease (*28*) and is indicated for

- persons suspected of having pulmonary TB disease due to chest radiograph findings consistent with TB disease, especially those with any symptoms of infection in the lung, pleura, or airways including larynx,
- persons with chest radiographic findings suggestive of prior, healed TB disease,
- HIV-infected persons with any respiratory signs or symptoms regardless of chest radiograph findings, and
- persons suspected of having pulmonary TB disease for whom bronchoscopy is planned.

C.1 Sputum specimen collection

Persons requiring sputum collection for smear and culture should have at least three consecutive sputum specimens obtained, each collected 8–24 hours apart (*131*), with at least one being an early morning specimen (*355*). Specimens should be collected in a sputum induction booth or in an AII room. In resource-limited settings without environmental containment, or when an AII room is not available, sputum collection may be performed safely outdoors, away from other people, windows and ventilation intakes. Patients should be instructed on how to produce an adequate sputum specimen (containing little saliva), and should be supervised and observed by a HCW during the collection of sputum, if possible (*28*). However, if the patient's specimen is judged to be inadequate it should still be sent for bacteriologic testing. The HCW should wear an N95 disposable respirator during sputum collection.

C.2 Sputum induction

For patients who are unable to produce an adequate sputum specimen, expectoration may be induced by inhalation of an aerosol of warm, hypertonic saline. As sputum induction is a cough-inducing procedure, pre-treatment with a bronchodilator should be considered in patients with a history of asthma or other

chronic obstructive airway diseases. Bronchodilator medication should be available during any sputum induction in the event of induced bronchospasm (*126,356,357*).

The patient should be seated in a small, well-ventilated sputum induction booth or in an AII room (Supplement 4). For best results, an ultrasonic nebulizer that generates an aerosol of approximately 5 ml/minute should be used. Three percent hypertonic saline is commercially available, and its safety has been demonstrated. At least 30 ml of 3% saline should be administered; administration of smaller volumes will have a lower yield. Higher concentrations may be used with an adjustment in the dose and closer monitoring for adverse effects.

Patients should be instructed to breathe deeply and cough intermittently. Sputum induction should be continued for up to 15 minutes or until an adequate specimen (containing little saliva) is produced. Induced sputum will often be clear and watery. Any expectorated material produced should be labeled as expectorated sputum, and sent to the laboratory.

C.3 Laboratory examination

Detection of AFB in stained smears by microscopy can provide the first bacteriologic indication of TB disease. Laboratories should report positive smear results within 24 hours of collection and positive culture results within 24 hours of the notation of the positive culture. A positive result for AFB in a sputum smear is predictive of increased infectiousness. Smears allow identification of mycobacteria, but definitive identification, strain typing, and drug-susceptibility testing of *M. tuberculosis* require that a culture be performed (*28*). Negative AFB sputum smear results do not exclude a diagnosis of TB disease if clinical suspicion of disease is high. In the United States, 63% of patients with reported positive sputum culture results have positive AFB sputum smear results (*26*).

A culture of sputum or other clinical specimen that contains *M. tuberculosis* provides a definitive diagnosis of TB disease. In most cases, identification of *M. tuberculosis* and drug-susceptibility results are available within 28 days (or 4–6 weeks) using recommended rapid methods such as liquid culture and DNA probes. A negative culture result is obtained in approximately 14% of patients with confirmed pulmonary TB disease (*4,5*). Testing sputum with techniques such as NAA facilitates the rapid detection and identification of *M. tuberculosis* but should not replace culture and drug-susceptibility testing in patients with suspected TB disease (*28,132,358*). Mixed mycobacterial infection can obscure the identification of *M. tuberculosis* during the laboratory evaluation (e.g., due to cross contamination or dual infections) and can be distinguished by the use of mycobacterial species-specific DNA probes (*359*). Examination of colony morphology on solid culture media can also be useful.

Drug-susceptibility tests should be performed on initial isolates from all patients to assist in the identification of an effective anti-tuberculosis treatment regimen. Drug-susceptibility tests should be repeated if sputum specimens continue to be culture-positive after three months of anti-tuberculosis treatment or if culture

results become positive for *M. tuberculosis* after a period of negative culture results (*28,29*).

D. Bronchoscopy

If possible, bronchoscopy should be avoided in patients with a clinical syndrome consistent with pulmonary or laryngeal TB disease because bronchoscopy substantially increases the risk of transmission either through an airborne route (*70,87,88,169,360*) or a contaminated bronchoscope (*87,89,170-176*), including in persons with negative AFB sputum smear results. Microscopic examination of three consecutive sputum specimens, obtained 8–24 hours apart, with at least one obtained in the early morning, is recommended instead of bronchoscopy, if possible. In a patient who is intubated and mechanically-ventilated, closed circuitry may reduce the risk of exposure.

If the suspicion for pulmonary TB disease is high or if the patient is seriously ill with a disorder, either pulmonary or extrapulmonary, that is thought to be TB disease, multidrug anti-tuberculosis treatment using one of the recommended regimens should be initiated promptly, often before AFB smear results are known (*29*). Microscopic examination of three sputum specimens, each obtained 8–24 hours apart (*131*), with at least one obtained in the early morning, is recommended for patients and HCWs. Obtaining three sputum samples is safer than performing bronchoscopy. With regard to AFB smear and culture results, three sputum samples have an increased yield compared with a single specimen (*127,357*) and induced specimens have better yield that specimens obtained without induction. Sputum induction is well-tolerated (*97,126,137,138,141,357,361,362*), even in children(*139,356*), and sputum specimens (either spontaneous or induced) should be obtained in all cases prior to a bronchoscopy (*126,356,363,364*).

In circumstances where a person who is suspected of having TB disease is not on a standard anti-tuberculosis treatment regimen and the sputum smear results (possibly including induced specimens) are negative, yet a reasonably high suspicion for TB disease remains, further consideration to initiate treatment for TB disease should be given. If the underlying cause of a radiographic abnormality remains unknown, further evaluation with bronchoscopy may be indicated; however, in cases where TB disease remains a diagnostic possibility, initiation of a standard anti-tuberculosis treatment regimen for a period of time prior to bronchoscopy may reduce the risk for transmission. Bronchoscopy may be valuable in establishing the diagnosis; in addition, a positive culture result can be both of clinical and public health importance in order to obtain drug-susceptibility results. Bronchoscopy in patients with suspected or confirmed TB disease should not be undertaken until after consideration of the risks of transmission of *M. tuberculosis* (*28,70,88,169,360*). If bronchoscopy is performed, because it is a cough-inducing procedure, additional sputum samples for AFB smear and culture should be collected after the procedure to increase the diagnostic yield.

II. Treatment for Latent TB Infection (LTBI)

Treatment for LTBI is essential to controlling and eliminating TB disease in the United States as it substantially reduces the risk that infection with *M. tuberculosis* will progress to TB disease (*10,365*). Certain groups of people are at very high risk of developing TB disease once infected, and every effort should be made to begin treatment for LTBI and to ensure those persons complete the entire course of treatment (Supplement 2, Table 11).

Before beginning treatment of LTBI, a diagnosis of TB disease should be excluded by history, medical examination, chest radiography, and when indicated, bacteriologic studies. Also before offering treatment of LTBI, ensure that the patient has not experienced adverse reactions with prior INH treatment (*222*).

A. Candidates for Treatment of LTBI

Persons in the following high-risk groups should be given treatment for LTBI if their TST result is ≥5 mm, regardless of age (*29,36*):

- persons infected with HIV,
- recent contacts of a person with TB disease,
- persons with fibrotic changes on chest radiograph consistent with prior TB disease, and
- organ transplant recipients and other immunosuppressed persons (e.g., persons receiving ≥15 mg/day of prednisone for ≥1 month).

Persons in the following high-risk groups should be considered for treatment of LTBI if their TST result is ≥10 mm:

- persons with TST conversions
- recent immigrants (i.e., within the last five years) from countries with a high-incidence of TB disease,
- persons who inject illicit drugs,
- residents and employees in the following high-risk congregate settings
    - correctional facilities,
    - long-term care facilities (e.g., hospices, skilled nursing facilities),
    - hospitals and other health-care facilities,
    - residential settings for persons with HIV/AIDS or other immunocompromising conditions, and
    - homeless shelters,
- mycobacteriology laboratory personnel
- persons with any of the following clinical conditions or other immunocompromising conditions that place them at high risk for TB disease
    - silicosis,
    - diabetes mellitus,
    - chronic renal failure,
    - some hematologic disorders (e.g., leukemias and lymphomas),
    - other specific malignancies (e.g., carcinoma of the head, neck, or lung),
    - unexplained weight loss of ≥10% of ideal body weight,
    - gastrectomy, and
    - jejunoileal bypass,
- persons living in areas with high incidence of TB disease,

- children <4 years of age, and
- infants, children, and adolescents exposed to adults at high risk for developing TB disease.

Persons with no known risk factors for TB disease may be considered for treatment of LTBI if their TST result is ≥15 mm. However, programs to screen HCWs for infection with *M. tuberculosis* should only be conducted among high-risk groups. All testing activities should be accompanied by a plan for follow-up care for persons with LTBI or if it is found, TB disease. A decision to test for infection with *M. tuberculosis* should be based on a commitment to treat LTBI (*36*).

Persons who may not be good candidates for treatment of LTBI include those with a previous history of liver injury or a history of excessive alcohol consumption. Active hepatitis and end-stage liver disease are relative contraindications to the use of isoniazid for treatment of LTBI (*36,246*). If the decision is made to treat such patients, baseline and follow-up monitoring of serum aminotransaminases should be considered.

For persons who have prior positive TST results, and who completed treatment for LTBI in the past (meaning they took at least six months of INH, four months of rifampin, or two months of rifampin and pyrazinamide [RZ]), it is not necessary for them to be treated again, unless reinfection occurs. Documentation of completed therapy for LTBI (or TB disease) is ideal. Instead of participating in serial skin testing, the HCW should receive a medical evaluation and a symptom screen annually. A symptom screen is a procedure used during a clinical evaluation in which patients are asked if they have experienced any signs or symptoms of TB disease.

Screening HCWs for infection with *M. tuberculosis* is an important administrative measure for the control of TB transmission in health-care settings. TB screening can detect ongoing transmission of *M. tuberculosis* and prevent future transmission by identifying lapses in infection control and identifying persons infected with *M. tuberculosis* and TB disease. Most individual HCWs, however, do not have the risk factors for progression to disease that serve as the basis for the current recommendations for targeted testing and treatment of LTBI. Most HCWs in the United States do not provide care in high TB-prevalence areas. Therefore, HCWs should be tested as determined by risk classification for the health-care setting, and may be categorized as having a positive TST result or TST conversion as part of the TB infection-control program for the purposes of surveillance and referral, but may not necessarily be a candidate for treatment of LTBI.

In the context of TST screening as part of an infection-control program, the interpretation of TST results in HCWs occurs in these steps:

A.1 HCWs should receive baseline TST testing, following the indications for two-step testing (Supplement 2, Table 9).

A.2 HCWs should receive serial TST screening as determined by the health-care setting's risk classification (Recommendations, Table 4 and Section G).

A.3 For infection-control purposes, the results of the TSTs should be recorded and interpreted as part of the TB infection-control program as either a 1) negative TST result, 2) previously documented positive TST result, or 3) TST conversion.

All recordings should also document the size of the induration in mm, not simply "negative" or "positive."

A.4 To determine whether treatment for LTBI should be indicated, HCWs should be referred for medical and diagnostic evaluation according to the TST result criteria in Table 12.

A.5 In conjunction with a medical and diagnostic evaluation, HCWs with positive TST results should be considered for treatment of LTBI according to the criteria in Table 11.

A.6 HCWs cannot be compelled to take treatment for LTBI, but should be encouraged to do so if eligible for treatment.

It is important to note that HCWs' TST results might be considered positive or a TST conversion as part of the TB infection-control program for the purposes of surveillance and referral, but some of these HCWs may not be considered candidates for treatment of LTBI according to the individual medical and diagnostic evaluation. Once an HCW has been classified as having a positive TST result or as a TST converter, further skin testing is not necessary.

B. Treatment regimens for LTBI

For persons suspected of having LTBI, treatment of LTBI should not begin until TB disease has been excluded. Persons highly suspected of having TB disease should receive the standard multidrug anti-tuberculosis treatment regimen for treatment of TB disease until the diagnosis is confirmed or excluded.

Standard regimens for the treatment of LTBI are shown in Table 14. Although regimens are broadly applicable, modifications that should be considered under special circumstances include HIV infection, suspected drug resistance, pregnancy (*46,366*).

Reports of severe liver injury and death associated with the combination of RZ for treatment of LTBI (*367-369*) prompted the American Thoracic Society (ATS) and CDC to revise previous recommendations (*36,50*) to indicate that RZ should generally not be offered for the treatment of LTBI (*246*). If the potential benefits significantly outweigh the demonstrated risk for severe liver injury and death associated with this regimen and the patient has no contraindications, a physician with experience treating LTBI and TB disease should be consulted prior to the use of this regimen (*246*). Clinicians should continue the appropriate use of rifampin and pyrazinamide in standard multidrug anti-tuberculosis treatment regimens for the treatment of TB disease (*29*).

For all regimens for treatment of LTBI, nonadherence to intermittent dosing (i.e., once- or twice-weekly) results in a larger proportion of total doses missed than daily dosing. DOT should be used for all doses during the course of treatment of LTBI whenever feasible; however, *all* patients on intermittent treatment for LTBI (or TB disease) should receive DOT. Collaborate with the state or local health department on decisions about DOT arrangements (*29*).

Table 14 here

B.1 Contacts of patients with drug-susceptible TB disease

Persons with a previously negative TST result who are contacts of patients with drug-susceptible TB disease and who subsequently have a positive TST result (≥5 mm) should be evaluated for treatment of LTBI, regardless of age. Most persons who are infected with *M. tuberculosis* will have a positive TST result within 6 weeks of exposure (*81,234,370-372*). Therefore, contacts of patients with drug-susceptible TB disease with negative TST results should be retested 8–10 weeks after the end of exposure to a patient with suspected or confirmed TB disease. Persons infected with *M. tuberculosis* should be advised that it is possible that they can be reinfected with *M. tuberculosis* if re-exposed (*63-67*). Persons infected with HIV, persons receiving immunosuppressive therapy, regardless of TST result, and persons with a prior positive TST result who are close contacts of a person with suspected or confirmed TB disease, should be considered for treatment of LTBI.

The interpretation of TST results is more complicated in a contact investigation among HCWs who have negative baseline TST results from two-step testing, but where there was induration >0 mm on the baseline TST or subsequent serial testing. Differences in the TST results between the contact investigation and previous baseline and serial TST could be due to a) inter-test variability in reaction size (TST readers measuring the TST results differently), b) intervening exposure to NTM (also known as MOTT), BCG or *M. tuberculosis*, and c) reversion.[1] In practice, only inter-test variability and exposure to or infection with NTM or *M. tuberculosis* are likely.

Treatment of LTBI should not be started until a diagnosis of TB disease has been excluded. If uncertain about the presence of TB disease due to an ambiguous chest radiograph, a standard multidrug anti-tuberculosis treatment regimen may be started and adjusted as necessary based on the results of sputum cultures and the patient's clinical response (*29*). If cultures are obtained without initiating therapy, treatment for LTBI should not be initiated until all culture results are reported as negative.

B.2 Contacts of patients with drug-resistant TB disease

Treatment for LTBI caused by drug-resistant or MDR TB disease is complex and should be done in consultation with the state or local health department's infection-control program and experts in the medical management of drug-resistant TB. Sometimes this will require waiting for results of susceptibility testing. Treatment should be guided by susceptibility test results from the isolate to which the patient was exposed and is presumed infected (*29,373,374*).

III. Pretreatment evaluation and monitoring of treatment

The pretreatment evaluation of persons who are targeted for treatment of LTBI provides an opportunity for health-care providers to a) establish rapport with patients, b) discuss details of the patient's risk for progression from LTBI to TB disease, c) explain the benefits of treatment and the importance of adhering to the drug regimen,

[1] Reversion is defined as a subsequent TST result which is appreciably smaller than a previous test; reversion has been observed to be more likely when the intervening time between TSTs increases.

d) review possible adverse effects of the regimen, including interactions with other medications, and e) establish an optimal follow-up plan.

Monitoring for adverse effects of anti-tuberculosis medications must be individualized. Persons on treatment for LTBI should be specifically instructed to look for symptoms associated with the most common reactions to the medications they are taking (*36*). Laboratory testing should be performed to evaluate possible adverse effects (*29*,*36*). Routine laboratory monitoring during treatment of LTBI is indicated for patients with abnormal baseline test results and for persons with a risk for hepatic disease.

Baseline laboratory testing is indicated for persons infected with HIV, pregnant women, women in the immediate postpartum period (usually within three months of delivery), persons with a history of liver disease, persons who use alcohol regularly, and those who have or who are at risk for chronic liver disease.

All patients being treated for LTBI should have clinical monitoring at least monthly, including a brief clinical assessment in the person's primary language for signs of hepatitis (nausea, vomiting, abdominal pain, jaundice, and yellow or brown urine). Patients on treatment for LTBI should be told about the adverse effects of the drug(s) and the need for prompt cessation of treatment and clinical evaluation if adverse effects occur.

Due to the risk for serious hepatic toxicity and death, the use of the combination of RZ for the treatment for LTBI should not generally be offered. If it is used, a physician with experience treating LTBI and TB disease should be consulted prior to the use of this regimen, and more extensive biochemical and clinical monitoring is recommended (*246*).

III. Treatment for TB Disease

Suspected or confirmed TB cases must be reported to the state or local health department in accordance with laws and regulations. Case management for TB disease should be coordinated with officials of the state or local health department. Regimens for treatment of TB disease must contain multiple drugs to which the organisms are susceptible. For persons with TB disease, treatment with a single drug can lead to the development of bacterial resistance to that drug. Likewise, adding a single drug to a failing anti-tuberculosis treatment regimen can lead to resistance to the added drug (*29*).

For most patients, the preferred regimen for treating TB disease consists of an initiation two-month phase of four drugs (isoniazid, rifampin, pyrazinamide, and ethambutol), followed by a continuation phase of isoniazid and rifampin of at least four months, for a minimum total treatment of six months. Completion of therapy is based on the number of doses taken within a maximal period of time, and not simply six months (*29*). Persons with cavitary pulmonary TB disease and positive culture results of sputum specimens at the completion of two months of therapy should receive a longer seven-month continuation phase due to the significantly higher rate of relapse (*29*).

TB treatment regimens may need to be altered for persons infected with HIV who are on ART (*46*). Whenever possible, the care of persons with both TB disease and HIV infection should be provided by or in consultation with experts in the management of both TB and HIV-related disease (*29*). To prevent the emergence of rifampin-resistant

organisms, persons with TB disease, HIV infection, and with CD4 cell counts <100 cells/mm^3 should not be treated with highly intermittent (i.e., once- or twice-weekly) regimens. These patients should receive daily treatment during the intensive phase by DOT (if feasible) and daily or three times weekly by DOT during the continuation phase (*375*). Detailed information on TB treatment for persons infected with HIV has been posted and updated (www.dhfs.state.wi.us/AIDS-HIV/Resources/Overviews/AIDS_HIV.htm, www.hiv-druginteractions.org and http://www.cdc.gov/nchstp/tb/TB_HIV_Drugs/TOC.htm) and published (*29,50*).

Drug-susceptibility testing should be performed on all initial isolates from patients with TB disease. When results from drug-susceptibility tests become available, the anti-tuberculosis treatment regimen should be reassessed and the drugs used in combination should be adjusted accordingly (*373,374,376-378*). If drug resistance is present, clinicians who are not experts in the management of patients with drug-resistant TB disease should seek expert consultation (*29*), and collaborate with the state or local health department for treatment decisions.

The major determinant of the outcome of treatment is patient adherence to the drug regimen. Thus, careful attention should be paid to measures designed to enable and foster adherence (*29,320,379*). DOT is an adherence-enhancing strategy in which a trained HCW or other specially trained person watches a patient swallow each dose of medication and records the dates that the DOT 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. Plans for DOT should be coordinated with the state or local health department (*29*).

IV. Reporting of Serious Adverse Events

HCWs should report very serious adverse events associated with the administration of tuberculin antigen or treatment of LTBI or TB disease to the FDA MedWatch AERS 1-800-FDA-1088 (telephone); 1-800-FDA-0178 (fax); Report Form 3500 in the Physicians' Desk Reference; www.fda.gov/medwatch. Specific instructions for the types of adverse events that should be reported are included in MedWatch report forms.

SUPPLEMENT 3: THE USE OF QFT FOR DOING SURVEILLANCE AND DIAGNOSING *M. TUBERCULOSIS* INFECTIONS IN HEALTH-CARE SETTINGS

In the United States, LTBI has been traditionally diagnosed on the basis of a positive PPD-based TST result, after TB disease has been excluded. In-vitro cytokine-based immunoassays for the detection of *M tuberculosis* infection have been the focus of intense research and development. The whole-blood interferon gamma assay QuantiFERON-TB test (Cellestis Limited, Carnegie, Victoria, Australia) and the subsequently developed version, QuantiFERON-TB Gold test (Cellestis Limited, Carnegie, Victoria, Australia), are two examples. The QuantiFERON-TB Gold test measures cell-mediated immune responses to peptides representing two *M. tuberculosis* proteins that are not present in any BCG vaccine strain and are absent from most nontuberculous mycobacteria. This assay was approved by the FDA in 2005 and is an available option for detecting *M. tuberculosis* infection. CDC recommendations for the United States on QuantiFERON-TB, have been published (*32*). CDC recommendations for QuantiFERON-TB Gold test are under development. **This document uses the term "QFT" to refer to the QuantiFERON test currently available in the United States.**

QuantiFERON-TB Gold test is an in-vitro test is based on measuring interferon-gamma (IFN-γ) released in heparinized whole blood when incubated overnight with mitogen (serving as a positive control), Nil (i.e., all reagents except antigens, which sets a baseline), and peptide mixes simulating ESAT-6 and CFP-10, two proteins that are relatively specific for *M. tuberculosis*. Specific antigens of these two proteins are found in *M. tuberculosis*-complex organisms (i.e., *M. tuberculosis, M. bovis, M. africanum, M. microti, M. canetti*) but not in most other mycobacteria or in vaccine-variant *M. bovis*, bacille Calmette-Guérin (BCG). Lymphocytes from most individuals who have been infected by *M. tuberculosis* complex show their sensitivity to ESAT-6 or CFP-10 by releasing IFN-γ, while infection by most other mycobacteria, including BCG, does not appear to cause this sensitivity.

The blood tests using IFN-γ methods require one less patient visit, assess responsiveness to *M. tuberculosis* antigens, and do not boost anamnestic immune responses. Interpretation of the QFT result is less subjective than interpretation of a skin test result, and the QFT result may be affected less by prior BCG vaccination and sensitization to environmental mycobacteria (e.g., *M. avium* complex) than the PPD-based TST. QFT may be more efficient and cost effective than TSTs (*32*). Screening programs that use QFT may eliminate the need for two-step testing because this test does not boost sensitization.

Other cytokine-based immunoassays are under development and may be demonstrated to be useful in the diagnosis of *M. tuberculosis* infection. Future FDA-approved products, in combination with CDC-issued recommendations, could provide additional diagnostic alternatives. **For guidance on the use of these and related technologies, CDC will periodically publish recommendations on the diagnosis of *M. tuberculosis* infection.** QFT may be used in both testing and infection-control surveillance programs for HCWs.

A. Baseline testing with QFT

For the purposes of establishing a baseline, a single negative QFT result is sufficient evidence that the HCW is probably not infected with *M. tuberculosis* (Table 15). However, see cautions (below) about making medical care decisions for persons at increased of progressing to TB disease from *M. tuberculosis* infection (Table 16).

A.1 If using the QFT for baseline testing of HCWs, including those in low-risk settings, one negative QFT result is sufficient to demonstrate that the HCW is not infected with *M. tuberculosis* (Table 17).

A.2 Obtain and document the baseline QFT result, preferably prior to the HCW starting duties. HCWs with positive baseline results should be referred for a medical and diagnostic evaluation to exclude TB disease and then consider treatment for LTBI, in accordance with current CDC guidelines.

A.3 Persons with a positive QFT result do not need to be tested further for surveillance.

A.4 For HCWs who have indeterminate test results, providers should consult the responsible laboratorian for advice on interpreting the result and making further decisions (*380*).

B. Serial testing with QFT for infection-control surveillance

B.1 When using QFT for serial testing, a conversion for administrative purposes is a change from a negative to a positive result (Table 17).

B.2 For HCWs who have indeterminate test results, providers should consult the responsible laboratorian for advice on interpreting the result and making further decisions (*380*).

B.3 Persons with indeterminate results should not be counted for administrative calculations of conversion rates.

C. Exposure of HCWs and patients to *M. tuberculosis* in a setting which has chosen to screen for infection using the QFT

Known and presumed exposure

C.1 Administer a symptom screen.

C.2 Obtain the QFT result.

C.3 A QFT conversion probably indicates recent *M. tuberculosis* infection, and therefore, TB disease must be excluded. Experience with QFT in contact investigations is limited. Special care is needed in the management of vulnerable populations, such as young children and immunocompromised persons, including those who are HIV-infected (Table 16).

C.4 If the symptom screen or the QFT result is positive, the exposed person should be evaluated for TB disease promptly, which includes a chest radiograph. If TB disease is excluded, further medical and diagnostic evaluation for LTBI is needed, which includes a judgment about the extent of exposure.

D. Performing QFT

The test should be performed as described in the product insert provided with the QFT kit. This insert also is available from the manufacturer's website (www.cellestis.com).

E. Interpretation of test results and referral for medical and diagnostic evaluation

HCWs who meet the criteria for referral should have a medical and diagnostic evaluation (see Supplements 1 and 2). Table 11 presents the factors affecting treatment decisions during medical and diagnostic evaluation by risk for infection with *M. tuberculosis*. Further, because QFT and other indirect tests for *M. tuberculosis* infection are diagnostic aids, the test results must be interpreted in the context of epidemiological, historical, physical, and diagnostic findings. A greater likelihood of infection, as estimated from historical or epidemiological details (e.g., exposure to tuberculosis) or due to the presence of an illness suggestive of tuberculosis, increases the predictive value of a positive result. Setting-based risk factors, such as the prevalence of TB disease in the setting should be considered when making decisions for the diagnosis and treatment of LTBI.

Medical conditions that impair or alter immune function (Table 16) decrease the predictive value of a negative result, and additional diagnostic methods (e.g., bacteriology, radiography, histology) are required as evidence before excluding *M. tuberculosis* infection when the QFT result is negative. Medical evaluations can occur in different settings, including an occupational health clinic, state or local health department, hospital, or private medical clinic.

Indeterminate QFT results are reported for either of two test conditions:

1. The IFN-γ responses to all antigens (ESAT-6, CFP-10, and mitogen) are below a cut-off threshold. The weak response to mitogen could be caused by non-standard storage or transportation of the blood sample, by laboratory errors, or by lymphocytic insensitivity caused by immune dysfunction.

2. The IFN-γ response to the Nil (solution without antigen) exceeds a specified threshold, and the responses to both ESAT-6 and CFP-10 do not exceed the response to Nil by at least 50%. This could be caused by non-standard storage or transportation, laboratory errors, or circulating IFN-γ, which can be increased in ill HCWs or patients.

For HCWs who have indeterminate test results, providers should consult the responsible laboratorian for advice on interpreting the result and making further decisions (*380*).

F. Interpreting the QFT result for infection control and surveillance

QFT conversion rates should be determined regularly. The precision of the QFT conversion rate will depend, in part, on the number of HCWs tested and this should be considered when establishing a regular interval for evaluation and monitoring of HCWs with QFTs. Health-care settings with a large number of HCWs may have testing schedules that can accurately determine the QFT conversion rate each month, that is, from annual results of a HCW cohort tested within the given month, if testing is staggered throughout the year. QFT conversion rates are more difficult to calculate in settings with fewer test results.

G. Quality control (QC) program for the QFT

There are several aspects to obtaining quality QFT results: specimen collection, transport, and handling, and conducting the test in the laboratory. The QFT needs to meet strict performance parameters for a valid test result to be achieved. QC is an on-going laboratory matter; The infection-control team should assist the laboratory in assuring that all requisite conditions are present. The laboratory performing the QFT will be required to validate its performance of the test prior to processing clinical samples. State and federal laboratory requirements regulate laboratory testing procedures.

H. Special considerations

H.1 An indeterminate result does not mean that the test has failed; it indicates the specimen has inadequate responsiveness for the test to be performed. This may reflect the condition of the HCW or patient, who for example might be immunosuppressed. Alternatively, the specimen may have been handled incorrectly. For HCWs who have indeterminate test results, providers should consult the responsible laboratorian for advice on interpreting the result and making further decisions (*380*). Skin testing for cutaneous anergy is not useful in screening for asymptomatic LTBI or for diagnosing tuberculosis disease (*339*).

H.2 QFT use with HIV-infected persons taking antiretroviral therapy (ART)

To date, the effect of HIV infection and the effect of antiretroviral therapy (ART) on the performance of the QFT have not been fully evaluated.

H.3 Persons aged <17 years or pregnant

The use of the QFT has not been evaluated among pregnant women and persons aged <5 years, and is not recommended for such populations (*32*).

H.4 Booster phenomenon and QFT

The QFT does not involve the injection of any substance into the individuals being tested and is not affected by the booster phenomenon. The QFT may be repeated as often as required without any possibility of boosting.

H.5 BCG vaccination

In the United States, vaccination with BCG is not recommended routinely (*233*). However, BCG is widely used outside the United States, and foreign-born persons are commonly employed in the United States as HCWs. Prior BCG vaccination is not a

contraindication to having a QFT performed. BCG does not appear to influence QFT test results with the version of the test approved in 2005 (i.e., QuantiFERON-TB Gold). HCWs who have received BCG vaccination should receive a baseline QFT in the same way as those without BCG vaccination, and the test result should be interpreted without reference to BCG.

DRAFT

Table 15 here
Table 16 here
Table 17 here

SUPPLEMENT 4: ENVIRONMENTAL CONTROLS

I. Overview

Environmental controls include the following technologies to remove or inactivate *M. tuberculosis*: local exhaust ventilation, general ventilation, high-efficiency particulate air (HEPA) filtration, and ultraviolet germicidal irradiation (UVGI). These controls help to prevent the spread and reduce the concentration of airborne infectious droplet nuclei. Environmental controls are the second line of defense in the TB infection-control program, and they work in harmony with administrative controls.

The reduction of occupational exposures to *M. tuberculosis* can be facilitated through the effective use of environmental controls at the source of exposure (e.g., coughing patient or laboratory specimen), or in the general workplace environment. Source control is amenable to situations where the source has been identified and the generation of the contaminant is localized. Source-control techniques can prevent or reduce the spread of infectious droplet nuclei into the air by collecting infectious particles as they are released. These techniques are especially important during procedures that are likely to generate infectious aerosols (e.g., bronchoscopy, sputum induction, endotracheal intubation, suctioning, irrigating tuberculous abscesses, aerosol treatments, autopsies on cadavers with untreated TB disease, and some laboratory specimen manipulations) and when patients with infectious TB disease are coughing or sneezing.

Unsuspected and undiagnosed cases of infectious TB disease are currently believed to represent a significantly large proportion of the current risk to health-care workers (HCWs) (*10,92*). In such situations, source control is not a feasible option. Instead, general ventilation and air cleaning must be relied upon for control. General ventilation can be used to dilute the air and remove air contaminants as well as to control airflow patterns in rooms or in a health-care setting. Air-cleaning technologies include HEPA filtration to reduce the concentration of *M. tuberculosis* droplet nuclei and UVGI to kill or inactivate the microorganisms so they no longer pose a risk for infection.

Ventilation systems for health-care settings should be designed, and modified when necessary, by ventilation engineers in collaboration with infection-control practitioners and occupational health staff. Recommendations for designing and operating ventilation systems have been published (*121,185,381*). The many types and conditions for use of ventilation systems in health-care settings and the individual needs of these settings preclude the provision of extensive guidance in this document.

The information provided below is conceptual in nature and intended to educate HCWs about environmental controls and how these controls may be used in the TB infection-control program. This information should not be used in place of consultation with experts who can advise on ventilation system design, selection, installation, and maintenance. Because environmental controls will fail if they are not properly operated and maintained, routine training and education of staff are key components to a successful TB infection-control program. This section does not specifically address mechanical ventilators (Recommendations, Section E.3.5).

II. Local exhaust ventilation

Local exhaust ventilation captures airborne contaminants at or near their source and removes the contaminants without exposing persons in the area to infectious agents. It is considered the most efficient way to remove airborne contaminants because it captures them before they can disperse. Local exhaust devices typically use hoods. Two types of hoods are 1) enclosing devices, in which the hood either partially or fully encloses the infectious source, and 2) exterior devices, in which the infectious source is near but outside the hood. Fully enclosed hoods, booths, or tents are always preferable to exterior devices due to their superior ability to prevent contaminants from escaping into the HCW's breathing space. Descriptions of both enclosing and exterior devices have been published (*185*).

A. Enclosing devices

Enclosing devices for local exhaust ventilation include 1) booths for sputum induction or administration of aerosolized medications (Supplement 4, Figure 2), 2) tents or hoods for enclosing and isolating a patient, and 3) biological safety cabinets (BSCs) (*165*). These devices are available in various configurations. The simplest device is a tent placed over the patient; the tent has an exhaust connection to the room-discharge exhaust system. The most complex device is an enclosure with a sophisticated self-contained airflow and recirculation system (Supplement 4, Figure 2).

Figure 2 here

Tents and booths should have sufficient airflow to remove at least 99% of airborne particles during the interval between the departure of one patient and the arrival of the next (Supplement 4, Table 8). The time required to remove a given percentage of airborne particles from an enclosed space depends on 1) the number of ACH, which is a function of the volume (number of cubic feet of air) in the room or booth and the rate at which air is exiting the room or booth at the intake source; 2) the location of the ventilation inlet and outlet; and 3) the configuration of the room or booth. The surfaces of tents and booths should be periodically cleaned in accordance with manufacturers' recommendations and the guidance provided in Supplement 6.

Table 8 here

B. Exterior Devices

Exterior devices for local exhaust ventilation are usually hoods that are very near to, but not enclosing, an infectious patient. The airflow produced by these devices should be sufficient to prevent cross-currents of air near the patient's face from allowing droplet nuclei to escape. Whenever possible, the patient should face directly into the opening of the hood to direct any coughing or sneezing into the hood. The device should maintain an air velocity of 200 feet per minute (fpm) at the patient's breathing zone to ensure the capture of droplet nuclei. Smoke tubes should be used to verify that the control velocity at the typical location of the patient's breathing zone is adequate to provide capture for the condition of highest expected cross-drafts, and then the patient's breathing zone should be maintained at this location for the duration of the treatment.

C. Discharge of exhaust from booths, tents, and hoods

Air from booths, tents, and hoods is either discharged into the room in which the device is located or to the outside. If the exhaust air is discharged into the room, a HEPA filter

should be incorporated at the discharge duct or vent of the device. The exhaust fan should be located on the discharge side of the HEPA filter to ensure that the air pressure in the filter housing and booth is negative with respect to adjacent areas. Uncontaminated air from the room will flow into the booth through all openings, thus preventing infectious droplet nuclei in the booth from escaping into the room. Section IV. A.3 of this Supplement contains additional information on the installation, maintenance, and monitoring of HEPA filters.

Most commercially available booths, tents, and hoods are fitted with HEPA filters; additional HEPA filtration is not needed with these devices. If a device does not incorporate a HEPA filter, the air from the device should be exhausted directly to the outside and away from air-intake vents, persons, and animals, in accordance with applicable federal, state, and local regulations on environmental discharges.

III. General Ventilation

General ventilation is used to 1) dilute and remove contaminated air, 2) control the direction of airflow in a health-care setting, and 3) control airflow patterns in rooms.

A. Dilution and removal of contaminated air

General ventilation maintains air quality by both air dilution and removal of airborne contaminants. Uncontaminated supply air mixes with contaminated room air (dilution), and air is subsequently removed from the room by the exhaust system (removal). These processes reduce the concentration of droplet nuclei in the room air.

A.1 Ventilation systems for air dilution and removal

Two types of general ventilation systems are used to dilute and remove contaminated air: single-pass air systems and recirculating air systems.

In a *single-pass air system*, the supply air is either outside air that has been heated or cooled, or air that is uncontaminated from a central system that supplies several areas. After air passes through the room or area, 100% of the air is exhausted to the outside. A single-pass system is the preferred choice for an AII room because it prevents contaminated air from being recirculated to other areas of the health-care setting.

In a *recirculating air system*, a small portion of the exhaust air is discharged directly to the outside and replaced with fresh outside air, which mixes with the portion of exhaust air that was not discharged. If not treated, the resulting air mixture can contain a large proportion of contaminated air when it is recirculated to areas serviced by the system. This air mixture can be recirculated into the general ventilation, and infectious particles can be carried from contaminated areas to uncontaminated areas. Alternatively, the air mixture could be recirculated in a specific room or area so that other areas are not affected. The use of air-cleaning technologies for removing or inactivating infectious particles in recirculated air systems is discussed in Section IV of this Supplement.

A.2 Delivery of general ventilation

General ventilation is delivered by either constant air volume (CAV) systems or variable air volume (VAV) systems. In general, CAV systems are best for AII rooms and other negative-pressure rooms because the negative-pressure

differential is easier to maintain. VAV systems are acceptable if provisions are made to maintain the minimum mechanical and outside ACH and a negative pressure ≥0.01 inch of water gauge relative to adjacent areas at all times.

A.3 Ventilation rates

Recommended ventilation rates (air change rates) for health-care settings are usually expressed in numbers of ACH, which is the ratio of the volume of air entering the room per hour to the room volume. It equals the exhaust airflow (Q cfm) divided by the room volume (V cubic feet) multiplied by 60.

$$ACH = (Q \div V) \times 60$$

Table 7 provides ventilation recommendations for selected areas in new or renovated health-care settings. These recommendations have been adapted from those published by the American Institute of Architects (*121*). The feasibility of achieving a specific ventilation rate depends on the construction and operational requirements of the ventilation system and might differ for retrofitted and newly constructed facilities. The expense and effort of achieving a high ventilation rate may be reasonable for new construction but less so when retrofitting an existing setting.

In existing settings, air-cleaning technologies such as fixed or portable room-air recirculation units (also called portable air cleaners) or UVGI may be used to increase the equivalent ACH. This "equivalent ventilation" concept has been used to compare microbial inactivation by UVGI with particle removal by mechanical ventilation (*382,383*) and to compare particle removal by HEPA filtration of recirculated air with particle removal by mechanical ventilation. The equivalent ventilation approach does not, however, negate the requirement to provide sufficient fresh outside air for occupant comfort (Supplement 4, Table 7).

To dilute the concentration of normal room-air contaminants and minimize odors, a portion of the supply air should come from the outdoors (Supplement 4, Table 7). Health-care settings should consult ASHRAE Standard 62.1, *Ventilation for Acceptable Indoor Air Quality*, for outside air recommendations in areas not listed in Table 7 (*384*).

Table 7 here

B. Control of Airflow Direction in a Health-Care Setting

Airflow direction is controlled in health-care settings to contain contaminated air and prevent its spread to uncontaminated areas.

B.1 Directional Airflow

The general ventilation system should be designed and balanced so that air flows from less contaminated (more clean) to more contaminated (less clean) areas (*121,381*). For example, air should flow from corridors (cleaner areas) into AII rooms (less clean areas) to prevent the spread of contaminants. In some rooms in which surgical and invasive procedures are performed and in protective environment (PE) rooms, the direction of airflow should be from the room to the hallway. Environmental control recommendations for situations involving the care and treatment of patients with TB disease in operating rooms and PE rooms

are provided in Section III, Part F of this supplement. Cough-inducing or aerosol-generating procedures should not be performed on patients with suspected or confirmed TB disease in rooms where air flows from the room to the hallway.

B.2 Negative pressure for achieving directional airflow

The direction of airflow is controlled by creating a lower (negative) pressure in the area into which the flow of air is desired. Negative pressure is the relative air-pressure difference between two areas in a health-care setting. For air to flow from one area to another, the air pressure in the two areas must be different. Air will flow from a higher pressure area to a lower pressure area. A room that is under negative pressure has a lower pressure than adjacent areas, which keeps air flowing from the adjacent rooms or areas into the room. Negative pressure is achieved by exhausting air at a higher volumetric rate than the rate that the air is being supplied.

C. Control of airflow patterns in rooms

General ventilation systems should be designed to provide controlled patterns of airflow in rooms and to prevent air stagnation or short-circuiting of air from the supply to the exhaust, (i.e., passage of air directly from the air supply to the exhaust). To provide controlled airflow patterns, the air supply and exhaust should be located so that clean air flows first to parts of the room where HCWs are likely to work and then across the infectious source and into the exhaust. In this way, HCWs are not positioned between the infectious source and the exhaust. This configuration is not always possible but should be used whenever feasible.

One way to achieve a controlled airflow pattern is to supply air at the side of the room opposite the patient and exhaust it from the side where the patient is located (Supplement 4, Figure 3A). Another method, which is most effective when the supply air is cooler than the room air, is to supply air near the ceiling and exhaust it near the floor (Supplement 4, Figure 3B). Care must be taken to ensure that furniture or moveable equipment does not block the low exhausts. Airflow patterns are affected by air temperature differentials, location of the supply diffusers and exhaust grilles, location of furniture, movement of HCWs and patients, and the configuration of the space.

Figures 3A and 3B here

If the room ventilation is not designed for a “plug-flow” type of airflow pattern (described in Figures 3A and 3B), then adequate mixing must be maintained to minimize air stagnation. Most rooms with properly installed supply diffusers and exhaust grilles will have adequate mixing. A qualitative measure of mixing is the visualization of air movement with smoke tubes at several locations in the room. Smoke movement in all areas of the room indicates good mixing. More sophisticated studies can be conducted using a tracer gas to quantify air-mixing and air-exchange rates.

If areas of air stagnation are present, air mixing can be improved by adding a circulating fan or repositioning the supply and exhaust vents. Room-air recirculation units positioned in the room or installed above the ceiling can also improve air mixing. If supply or exhaust vents, circulating fans or room-air recirculation units are placed incorrectly, HCWs may not be adequately protected.

D. Achieving negative pressure in rooms

Negative pressure is needed to control the direction of airflow between selected rooms in a health-care setting and their adjacent spaces to prevent contaminated air from escaping from the room into other areas (*121*) (Figure 4). Control of a room's differential airflow and total leakage area is critical to achieving and maintaining negative pressure. Differential airflow, differential pressure, and leakage area are inter-related. This relationship is shown in Figure 4 and is expressed in the empirical equation below (*385*).

$$A_E = 0.01138 * (\Delta Q^{1.170}/\Delta P^{0.602})$$

In the equation, A_E is the leakage area in square inches, ΔQ is the differential airflow rate in cfm, and ΔP is the differential pressure drop in inches of water gauge. This empirical equation was used to develop Figure 4, which shows that changing one parameter will influence one or both of the other parameters.

Figure 4 here

For example, the control of differential pressure can frequently be improved by increasing the air tightness or seal of a room, maintaining the HVAC system, and ensuring continuous monitoring. In a room that is already very tight (e.g., with 10 square inches of leakage), however, a small change in differential pressure will have a large affect on differential airflow. Similarly, a room with a larger leakage area (e.g., 300 square inches of leakage) requires a higher differential airflow rate to achieve a pressure differential of 0.01 inch of water gauge. As shown in Figure 4, reducing the leakage in a room with 300 square inches of leakage can help achieve a pressure differential of 0.01 inch of water gauge. If the leakage area is reduced to approximately 40 square inches, a pressure differential of 0.01 inch of water gauge can be achieved by exhausting approximately 100 cubic feet per minute (cfm) more air from the room than is supplied to the room.

Room leakage can occur through cracks or spaces near doors, windows, ceiling, and utility connections. Measures should be taken to minimize these leaks. Changes in the performance of the HVAC system will affect the pressure differential in a room and can potentially cause a negative-pressure room to become positive-pressure. Each of these parameters therefore requires close monitoring to ensure that minor changes in the performance of the HVAC system do not adversely affect the entire system (*386,387*).

D.1 Pressure differential

To achieve negative pressure in a room that has a normally functioning ventilation system, first measure and balance the supply and exhaust airflows to achieve an exhaust flow greater than the supply flow. Next, measure the pressure differential across the closed door. Although the minimum pressure difference needed for airflow into a room is quite small (about 0.001 inch of water gauge), a pressure differential of $\geq$0.01 inch of water gauge (2.5 Pascals [Pa]) is now recommended. This higher pressure differential is easier to measure and offers a margin of safety for maintaining negative pressure as the pressure in surrounding areas changes due to the opening and closing of doors, operation of elevators, stack effect (rising of warm air, similar to a chimney), ventilation system fluctuations, and other factors. The higher pressurization value is consistent with the most recent AIA recommendations for isolation applications in health-care

settings (*121*) and is the generally accepted level of negative pressurization for microbiology and biomedical laboratories (*388*).

Opening of doors and windows can drastically affect the negative pressure in an AII room. Infection control requires AII room windows and doors to remain closed, except when doors must be opened for people to enter or leave the room. It may also be necessary to keep certain doors in the corridor outside the AII rooms closed to maintain the negative-pressure differential between an AII room and the corridor. Pressurization cannot be maintained in rooms or spaces that are not enclosed.

If ≥0.01 inch of water gauge is not achieved and cannot be achieved by increasing the flow differential (within the limits of the ventilation system), the room should be inspected for leakage. Figure 4 can be used to estimate the total room leakage area based on the previously measured pressure and air flow differentials. If the room leakage is too large, for example 300 square inches, it may be difficult to maintain a negative-pressure differential as high as 0.01 inch of water gauge. A lower value is acceptable if air-pressure monitoring shows that negative pressure is always maintained (or airflow indicators consistently show airflow in the desired direction). If negative pressure cannot be maintained, the leakage area may need to be reduced by sealing cracks around windows or replacing porous suspended ceiling panels with gasketed or sealed solid panels.

Since negative pressure in an AII room can be affected by even minor changes in the operation of the ventilation system, negative pressure can be difficult to maintain with a VAV ventilation system. To maintain negative pressure, a VAV supply system should be coupled with a compensating exhaust system that increases when the supply flow rate increases. Alternatively, the exhaust can be set at a fixed rate that ensures negative pressure throughout the VAV supply cycle. The VAV minimum flow rate must also be adequate to maintain the recommended minimum mechanical and outdoor ACH (Supplement 4, Table 7).

D.2 Alternate methods for achieving negative pressure

Although not a substitute for negative pressure in an AII room, an anteroom can reduce the escape of droplet nuclei during the opening and closing of the door to an AII room and can buffer an AII room from pressure fluctuations in the corridor. To function properly, an anteroom must have more air exhausted from the room than supplied in order to remove *M. tuberculosis* that can enter from the AII room. An anteroom can also have its own supply diffuser, if needed, to balance the pressure with the corridor. If an anteroom is unventilated or not properly ventilated, it will function only as a lesser contaminated vestibule between the AII room and the corridor and may not prevent the escape of droplet nuclei into the corridor. To adjust airflow and pressure differentials, health-care settings should consult a ventilation engineer who is knowledgeable about all applicable regulations, including building fire codes.

If the desired negative pressure cannot be achieved because a room lacks a separate ventilation system or the room's system cannot provide the proper airflow, steps should be taken to provide a way to discharge air from an AII

room. One way to achieve negative pressure in a room is to add a supplemental exhaust unit. If an AII room has a window or an outside wall, a small exhaust fan can be used. An engineer should be consulted to evaluate the potential for negative effects on surrounding areas (e.g., disruption of exhaust airflow in adjoining bathrooms) and to ensure the provision of the recommended amounts of outdoor air. The exhaust must not be discharged where it can immediately re-enter the building or pose a hazard to persons outside.

Fixed room-air recirculation systems, (i.e. systems that recirculate the air in an entire AII room), can be designed to achieve negative pressure by discharging a portion of the air to the outside. Some portable room-air recirculation units are also designed to discharge air to the outside to achieve negative pressure. These air cleaners must be designed specifically for this purpose.

D.3 Monitoring negative pressure

Negative pressure must be monitored to ensure that air is always flowing from the corridor (or surrounding area) into the AII room. Negative pressure can be monitored either continuously or periodically. Monitoring methods include chemical aerosols (e.g., smoke tube), differential pressure-sensing devices (e.g., manometer), and physical indicators (e.g., flutter strips).

A chemical aerosol resembling smoke can be used to observe airflow between a room and the surrounding area, or within a room. Devices called smoke tubes generate the chemical aerosol resembling smoke, which follows the local air currents wherever it is released. To check the negative pressure in a room, hold a smoke tube approximately 2 inches in front of the base of the AII room's closed door or in front of the air transfer grille, if the door has such a feature. Hold the smoke tube parallel to the door. A small amount of smoke should be generated slowly to ensure that the velocity of smoke emanating from the tube does not overpower the air velocity (Supplement 4, Figure 5). If the room is under negative pressure, the smoke will travel into the room (from higher to lower pressure). If the room is not under negative pressure, the smoke will be blown outward or stay in front of the door. Any room air cleaners in the room should be operating. Persons using smoke tubes should avoid inhaling the smoke because direct inhalation of high concentrations of the smoke can be irritating (*389*).

Figure 5

Manometers are used to monitor negative pressure. They provide either noncontinuous (periodic) pressure measurements or continuous pressure monitoring. A continuous monitoring indicator can simply be a visible or audible warning signal indicating that air pressure is positive. Both periodic and continuous pressure detectors generate a digital or analog signal that can be recorded for later verification or used to adjust the room's ventilation control system automatically.

Physical indicators such as flutter strips are sometimes used to provide a continuous visual sign that a room is under negative pressure. These simple and

inexpensive devices are placed directly in the door and can be useful in identifying a pressure differential problem.

Pressure-measuring devices should sense the pressure just inside the airflow path into the AII room (e.g., at the base of the door). Unusual airflow patterns can cause pressure variations. For example, the air can be under negative pressure at the middle of a door and under positive pressure at the base of the same door. Figure 6 shows the ideal location of a pressure-measuring device. If the pressure-sensing ports of the device cannot be located directly across the airflow path, it will be necessary to validate that the negative pressure at the sensing point is and remains the same as the negative pressure across the flow path.

Pressure-sensing devices should incorporate an audible warning with a time delay to indicate an open door. When a door is open, the negative pressure cannot be maintained, but this should not generate an alarm unless the door is left open. Therefore, the time delay should allow adequate time for persons to enter or leave an AII room without activating the alarm.

Figure 6 here

The pressure differentials used to achieve low negative pressure (<0.005 inch) require the use of very sensitive mechanical devices, electronic devices, or pressure gauges to ensure accurate measurements. Pressure measuring and monitoring devices can give false readings if the calibration has drifted. For example, a sensor may indicate that the room pressure is slightly negative with respect to the corridor, but, due to air current momentum effects or "drift" of the electrical signal, air may actually be flowing out of the AII room through the opening at the base of the door. In one study, of 38 AII rooms with electrical or mechanical devices to continuously monitor air pressurization, half had airflow at the door in the opposite direction of that indicated by the continuous monitors (*390*). The investigators attributed this problem to instrument limitations and device malfunction. A negative pressure differential of ≥0.01 inch of water gauge (compared with the previously recommended 0.001 inch of water gauge) may help to minimize this problem.

Periodic checks are required to maintain the desired negative pressure and the optimal operation of monitoring devices:

- AII rooms should be checked for negative pressure before occupancy.
- When occupied by a patient, an AII room should be checked daily with smoke tubes or other visual checks for negative pressure.
- If pressure-sensing devices are used in AII rooms occupied by patients with suspected or confirmed TB disease, negative pressure should be checked daily by use of smoke tubes or other visual checks.
- If these AII rooms are not being used for patients who have suspected or confirmed TB disease but potentially could be used for such patients, the negative pressure should be checked monthly.
- Laboratories should be checked daily for negative pressure.

E. AII rooms and other negative-pressure rooms

AII rooms are used to 1) separate patients who are likely to have infectious TB from other persons, 2) provide an environment in which environmental factors are controlled to reduce the concentration of droplet nuclei, and 3) prevent the escape of droplet nuclei from such rooms into adjacent areas using directional airflow. Other negative-pressure rooms include bronchoscopy suites, sputum induction rooms, selected examination and treatment rooms, autopsy suites, and clinical laboratories.

E.1 Preventing the escape of droplet nuclei

AII rooms used for TB isolation should be single-patient rooms with negative pressure relative to the corridor or other areas connected to the room. Opening of doors and windows can drastically affect the negative pressure in an AII room. Infection control requires AII room windows and doors to remain closed, except when doors must be opened for people to enter or leave the room. It may also be necessary to keep certain doors in the corridor outside the AII rooms closed to maintain the negative-pressure differential between an AII room and the corridor. The use of self-closing doors is recommended. The room's openings (e.g., windows, electrical and plumbing entries) should be sealed as much as possible, with the exception of a small gap (1/8–1/2 inch) at the base of the door to provide a controlled airflow path. Proper use of negative pressure will prevent contaminated air from escaping the room (*391,392*).

E.2 Reducing the concentration of droplet nuclei

AII rooms in existing health-care settings should have an airflow of ≥6 mechanical ACH. Whenever feasible, this airflow rate should be increased to ≥12 mechanical ACH by adjusting or modifying the ventilation system or should be increase to ≥12 equivalent ACH by supplementing with air-cleaning technologies such as fixed or portable room-air recirculation systems or UVGI systems. New construction or renovation of existing health-care settings should be designed so that AII rooms achieve a total air change rate of ≥12 mechanical ACH. These recommendations are consistent with guidelines by ASHRAE and AIA that recommend ≥12 mechanical ACH for AII rooms (*121,381*). Table 7 provides ventilation recommendations for other negative-pressure rooms in new or renovated health-care settings.

To dilute the concentration of normal room air contaminants and minimize odors, a portion of the supply air should come from the outdoors. A minimum of 2 ACH of outdoor air should be provided to AII rooms and other negative-pressure rooms (*121,381*).

E.3 Exhaust from AII rooms and other negative-pressure rooms

Air from AII rooms and other negative-pressure rooms for patients with suspected or confirmed TB disease should be exhausted directly to the outside and away from air-intake vents, persons, and animals, in accordance with applicable federal, state, and local regulations on environmental discharges. Exhaust ducts should be located away from areas such as sidewalks or windows that can be opened. Ventilation system exhaust discharges and inlets should be designed to prevent the re-entry of exhausted air. Wind blowing over a building creates a highly turbulent recirculation zone that can cause exhausted air to re-enter the building. Exhaust flow should be discharged above this zone. Design

guidelines for proper placement of exhaust ducts have been published (*393*). If recirculation of air from such rooms into the general ventilation system is unavoidable, the air should be passed through a HEPA filter before recirculation.

E.4 Alternatives to negative-pressure rooms

AII can also be achieved by the use of negative-pressure enclosures (e.g., tents or booths). These can provide patient isolation in emergency departments and medical testing and treatment areas and can supplement AII in designated negative-pressure rooms.

F. Other selected settings

Operating rooms, autopsy suites, sputum induction rooms, and aerosolized treatment rooms pose potential hazards from infectious aerosols generated during procedures on patients with TB disease (*79,97,394-396*). Table 1 summarizes recommended administrative, environmental and respiratory protection controls for these and other selected settings, and Section II.E of the main document describes additional or specialized TB infection controls that are applicable to special circumstances and types of health-care delivery settings. Table 7 provides ventilation recommendations for these settings in new or renovated health-care facilities. Existing facilities may need to augment the current ventilation system or use the air-cleaning methods described below to increase the number of equivalent ACH.

Patients with TB disease who also require a protective environment (PE) room (e.g., severely immunocompromised patients) are a special case. These patients require protection from common airborne infectious microorganisms and must be placed in a room that has HEPA-filtered supply air and is under positive pressure relative to its surroundings (*121*). If an anteroom is not present, the use of other air-cleaning methods should be considered to increase the equivalent ACH. The air-cleaning systems can be placed in the room and in surrounding areas to minimize contamination of the surroundings. Similar controls can be utilized in operating rooms that are used for patients with TB disease since these rooms must be maintained under positive pressure relative to their surroundings to maintain a sterile field.

IV. Air-Cleaning Methods

A. High-efficiency particulate air (HEPA) filtration

HEPA filtration can be used to supplement other recommended ventilation measures by providing a minimum removal efficiency of 99.97% of particles $\geq$0.3 µm in diameter. This air-cleaning method is considered an adjunct to other ventilation measures. Used alone, it neither provides outside air for occupant comfort nor satisfies other recommended ventilation measures, such as using source control whenever possible and minimizing the spread of contaminants in a setting through control of airflow patterns and pressure differentials.

HEPA filters have been shown to reduce the concentration of *Aspergillus* spores (which range in size from 1.5 µm to 6 µm) to below measurable levels (*397-399*). Because droplet nuclei generated by TB patients are believed to range from 1–5 µm in diameter (*302*) (comprable in size to *Aspergillus* spores) (*400*), HEPA filters will remove *M. tuberculosis*-containing infectious droplet nuclei from contaminated air. HEPA filters can be used to clean air before it is 1) exhausted to the outside, 2) recirculated to other areas

of a health-care setting, or 3) recirculated in an AII room. Because electrostatic filters can degrade over time with exposure to humid environments and ambient aerosols (*401*), their use in systems that recirculate air back into the general ventilation system from AII rooms and treatment rooms should be avoided. If used, the filter manufacturer should be consulted regarding the performance of the filter to ensure that it maintains its desired filtration efficiency over time and with loading.

A.1 Use of HEPA filtration when exhausting air to the outside

HEPA filters can be used as an added safety measure to clean air from AII rooms and local exhaust devices (e.g., booths, tents, hoods) before exhausting it to the outside. This added measure is not necessary, however, if the exhaust air cannot re-enter the ventilation system supply and does not pose a risk to persons and animals where it is exhausted.

In many instances, exhaust air is not discharged directly to the outside. Rather, the air is directed through heat-recovery devices (e.g., heat wheels, or radiator-like devices). Heat wheels are often used to reduce the costs of operating ventilation systems (*402*). As the wheel rotates, energy is transferred into or removed from the supply inlet air stream. If a heat wheel is used with a system, a HEPA filter should also be used. The HEPA filter should be placed upstream from the heat wheel due to the potential for leakage across the seals separating the inlet and exhaust chambers and the theoretical possibility that droplet nuclei could be impacted on the wheel by the exhaust air and subsequently stripped off into the supply air.

A.2 Recirculation of HEPA-filtered air

Air from AII rooms and other negative-pressure rooms should be exhausted directly to the outside. In some instances, however, recirculation of air into the general ventilation system from such rooms is unavoidable (e.g., in settings in which the ventilation system or building configuration makes venting the exhaust to the outside impossible). In such cases, HEPA filters should be installed in the exhaust duct exiting the room to remove infectious organisms from the air before it is returned to the general ventilation system.

Individual room-air recirculation can be used in areas where no general ventilation system exists, where an existing system is incapable of providing sufficient ACH, or where air cleaning (particulate removal) is desired without affecting the fresh air supply or negative-pressure system. Recirculation of HEPA-filtered air in a room can be achieved by 1) exhausting air from the room into a duct, passing it through a HEPA filter installed in the duct, and returning it to the room (Supplement 4, Figure 7); 2) filtering air through HEPA recirculation systems installed on the wall or ceiling of the room (Supplement 4, Figure 8); or 3) filtering air through portable HEPA recirculation systems. In this document, the first two approaches are referred to as fixed room-air recirculation systems because the recirculation systems are not easily movable.

Figures 7 and 8 here

A.2.1 Fixed room-air recirculation systems

The preferred method of recirculating HEPA-filtered air is by use of a built-in system in which air is exhausted from the room into a duct, filtered through a HEPA filter, and returned to the room (Supplement 4, Figure 7). This technique can add equivalent ACH in areas in which the recommended minimum ACH is difficult to meet with general ventilation. This "equivalent ventilation" concept compares particle removal by HEPA filtration of the recirculated air with particle clearance from exhaust ventilation. Because the air does not have to be conditioned, this permits higher airflow rates than the general ventilation system can usually achieve. An alternative is to install HEPA filtration units on the wall or ceiling (Supplement 4, Figure 8).

Fixed recirculation systems are preferred to portable (free-standing) units because they can be installed with a greater degree of reliability. In addition, many fixed systems have a higher airflow capacity than portable systems, and the potential for short circuiting of air is reduced as the distance between the air intake and exhaust is increased.

A.2.2 Portable room-air recirculation systems

Portable room-air recirculation units with HEPA filters (also called portable air cleaners) may be considered when 1) a room has no general ventilation system, 2) the system cannot provide adequate ACH, or 3) increased effectiveness in airflow is needed. Effectiveness depends on the ability to circulate as much of the air in the room as possible through the HEPA filter. Effectiveness can vary depending on the room's configuration, the furniture and persons in the room, the placement of the HEPA filtration unit relative to the supply diffusers and exhaust grilles, and the degree of mixing of air within the room.

Portable room-air recirculation units have been shown to be effective in removing bioaerosols and aerosolized particles from room air (*403-408*). Findings show that many commercially-available units are useful in reducing the concentration of airborne particles and are therefore helpful in reducing airborne disease transmission. The performance of 14 units was evaluated for volumetric airflow, airborne particle reduction, noise level, and other parameters (*404*). Volumetric airflow rates ranged from 110 cfm to 1,152 cfm, and equivalent ACH ranged from an average of 8–22 in a standard-size, extremely well-mixed, single-patient room. Recommendations were provided to make subsequent models safer, more effective, quieter, and easier to use and service. Purchasers should be aware that several of the manufacturers' specifications indicated flow rates of "free-wheeling" fans and not the fan under the load of a filter.

Portable HEPA filtration units should be designed to 1) achieve $\geq$12 equivalent ACH, 2) ensure adequate air mixing in all areas of the rooms and 3) be compatible with the ventilation system. An estimate of the unit's ability to circulate the air in a room can be made by visualizing airflow patterns as described previously for estimating room air mixing (Supplement 4, Section III.C). If the air movement is adequate in all areas of the room, the unit should be effective.

If portable devices are used, units with relatively high volumetric airflow rates that provide maximum flow through the HEPA filter are preferred. Placement should be selected to optimize the recirculation of AII room air through the HEPA filter. Careful consideration must be given to obstacles (e.g., furnishings, medical equipment, walls) that could disrupt airflow and to system specifications (e.g., physical dimensions, airflow capacity, locations of air inlet and exhaust, noise) to maximize performance of the units, minimize short-circuiting of air, and reduce the likelihood that the units will be switched off by room occupants.

A.3 Installing, maintaining, and monitoring HEPA filters

The performance of HEPA filters depends on proper installation, testing, and meticulous maintenance (*409*), especially if the system recirculates air to other parts of the health-care setting. Improper design, installation, or maintenance could allow infectious particles to circumvent filtration and escape into the general ventilation system (*381*). These failures also could impede proper ventilation performance.

HEPA filters should be installed to prevent leakage between filter segments and between the filter bed and its frame. A regularly scheduled maintenance program is required to monitor filters for possible leakage and filter loading. A quantitative filter performance test such as the dioctyl phthalate (DOP) penetration test (*410,411*) should be performed at the initial installation and every time the filter is changed. Records should be maintained for all filter changes and testing. A leakage test using a particle counter or photometer should be performed every 6–12 months for filters in general-use areas and in areas with systems likely to be contaminated with *M. tuberculosis* (e.g., AII rooms).

A manometer or other pressure-sensing device should be installed in the filter system to provide an accurate and objective means of determining the need for filter replacement. Pressure drop characteristics of the filter are supplied by the manufacturer. Installation of the filter should allow for maintenance that will not contaminate the delivery system or the area served. For general infection control purposes, special care should be taken to avoid jarring or dropping the filter element during or after removal.

The scheduled maintenance program should include procedures for installation, removal, and disposal of filter elements. HEPA filter maintenance should be performed only by adequately trained personnel and only while the ventilation system or room-air recirculation unit is not being operated.

Laboratory studies indicate that re-aerosolization of viable mycobacteria from filter material (HEPA filters and N95 disposable respirator filter media) is unlikely under normal conditions (*412-414*). Although these studies indicate that it is unlikely that *M. tuberculosis* would become an airborne hazard once removed by a HEPA filter (or other high-efficiency filter material), the risks associated with handling loaded HEPA filters in ventilation systems under field-use conditions have not been evaluated. For this reason, persons performing

maintenance and replacing filters on any ventilation system that is likely to be contaminated with *M. tuberculosis* should wear a respirator (Supplement 5) in addition to eye protection and gloves. When feasible, HEPA filters may be disinfected in 10% bleach solution or other appropriate mycobacteriacide before removal(*415*). In addition, filter housing and ducts leading to the housing should be labeled clearly with the words "TB-Contaminated Air" or other similar warning. Disposal of filters and other potentially contaminated materials should be in accordance with applicable state or local regulations.

One or more lower-efficiency disposable pre-filters installed upstream can extend the life of a HEPA filter by at least 25%. If the disposable filter is followed by a 90% extended surface filter, the life of the HEPA filter can be extended by almost 900% (*185*). Pre-filters should be handled and disposed of in the same manner as the HEPA filter.

B. Ultraviolet germicidal irradiation (UVGI)

Ultraviolet (UV) radiation is a form of electromagnetic radiation with wavelengths between the blue region of the visible spectrum and the x-ray region. For convenience of classification, the International Commission on Illumination has divided the wavelengths between 100 nanometers (nm) and 400 nm into three wavelength bands: UV-A (long wavelengths, range 315–400 nm), UV-B (midrange wavelengths, range 280–315 nm), and UV-C (short wavelengths, range 100–280 nm). These spectral band designations are used to define approximate spectral regions and may vary among sources (*416*). UV-C radiation can be produced by a number of artificial sources (e.g., arc lamps, metal halide lamps). Most commercially available UV lamps used for germicidal purposes are low-pressure mercury vapor lamps that emit radiant energy in the UV-C range, predominantly at a wavelength of 253.7 nm (*417*).

Research has demonstrated that UVGI is effective in killing or inactivating *M. tuberculosis* under experimental conditions (*294,383,418-422*) and in reducing transmission of other infectious agents in hospitals (*423*), military housing (*424*), and classrooms (*425-427*). Due to the results of numerous studies (*382,428-431*) and the experiences of clinicians and mycobacteriologists during the past several decades, UVGI has been recommended as a supplement or adjunct to other TB infection-control and ventilation measures in settings where the need to kill or inactivate *M. tuberculosis* is important (*6,7,203,432,433*). UVGI alone does not provide outside air or circulate interior air, both of which are essential in achieving acceptable air quality in occupied spaces.

B.1 Applications of UVGI

UVGI is considered a method of air cleaning because it can kill or inactivate microorganisms so that they are no longer able to replicate and form colonies. UVGI is not a substitute for HEPA filtration prior to exhausting the air from AII rooms back into the general circulation. UVGI lamps can be placed in ducts, in fixed or portable room air-recirculation units, or in upper-air irradiation systems. The use of this air-cleaning technique has increased in recent years, particularly in large open areas where unsuspected or undiagnosed patients with TB disease might be present (e.g., emergency department waiting rooms, shelters,

correctional facilities) and the costs of conditioning large volumes of outdoor air are prohibitive.

For each UVGI system, guidelines should be followed to maximize effectiveness. Effectiveness can be expressed in terms of an equivalent air change rate (*426,434-436*), comparing the ability of UVGI to inactivate organisms with removal via general ventilation. Initially, it is important to understand and characterize the application for which UVGI will be used. Because the effectiveness of UVGI systems will vary, the use of UVGI must be carefully evaluated and the level of efficacy clearly defined and monitored.

The number of persons who are properly trained in the design and installation of UVGI systems is limited. It is strongly recommended that health-care facility managers consult a UVGI system designer to address safety and efficacy considerations before such a system is procured and installed. Experts who might be consulted include industrial hygienists, engineers, and health physicists.

B1.1 Duct irradiation

Duct irradiation is designed to kill or inactivate *M. tuberculosis* without exposing persons to UVGI. In duct irradiation systems, UVGI lamps are placed inside ducts to disinfect the exhaust air from AII rooms or other areas where *M. tuberculosis* may be present before it is recirculated to the same room (desirable) or to other areas served by the system (less desirable). When UVGI duct systems are properly designed, installed, and maintained, high levels of UVGI can be produced in the duct that can potentially cause high UVGI exposures during maintenance operations.

Duct-irradiation systems depend on the circulation of as much of the room air as possible through the duct. Velocity profiles and mixing are important factors in determining the UVGI dose received by airborne particles. Design velocity for a typical UVGI unit is approximately 400 fpm (*437*). The particle residence time must be sufficient for inactivation of the microorganisms. When used in ducts, UVGI lamps should be placed at right angles to the direction of airflow at the center of the longest run.

Duct irradiation may be used in

- Ventilation systems serving AII rooms to recirculate air from the room, through a duct containing UV lamps, and back into the same room. UVGI duct systems should not be used either in place of HEPA filters if air from AII rooms must be recirculated to other areas of a setting or as a substitute for HEPA filtration of air from booths, tents, or hoods used for cough-inducing or aerosol-generating procedures.
- Return air ducts serving patient rooms, waiting rooms, emergency departments, and general-use areas where patients with undiagnosed TB disease could potentially contaminate the recirculated air

- Recirculating ventilation systems serving rooms or areas where ceiling heights are too low for the safe and effective use of upper-air UVGI.

B.1.2 Upper-air irradiation

In upper-air irradiation, UVGI lamp fixtures are suspended from the ceiling and installed on walls. The base of the lamps are shielded to direct the radiation upward and outward to create an intense zone of UVGI in the upper air while minimizing the levels of UVGI in the lower part of the room where the occupants are located. The system depends on air mixing to move the air from the lower part of the room to the upper part where microbial-contaminated air can be irradiated.

An important consideration is the placement of UVGI fixtures to achieve sufficient irradiance of the upper-air space. The ceiling should be high enough (≥8 feet) for a large volume of upper air to be irradiated without overexposing occupants in the lower part of the room to UVGI. System designers must consider the mechanical ventilation system, room geometry, and emission characteristics of the entire fixture.

Upper-air UVGI may be used in

- AII rooms and rooms where aerosol-generating or aerosol-producing procedures (e.g., bronchoscopy, sputum induction, administration of aerosolized medications) are performed.
- Patient rooms, waiting rooms, emergency departments, corridors, central areas, and other large areas where patients with undiagnosed TB disease could potentially contaminate the air.
- Operating rooms and adjacent corridors where procedures are performed on patients with TB disease.
- Medical settings in correctional facilities.

B.1.3 UVGI-containing portable room air cleaners

In portable room air-recirculation units containing UVGI, a fan moves a volume of room air across UVGI lamps to disinfect the air before it is recirculated back to the room. Some portable units contain both a HEPA filter (or other high-efficiency filter) as well as UVGI lamps.

In addition to the guidelines described above for the use of portable room air recirculation systems containing HEPA filtration, consideration must be given to the volume of room air that passes through the unit, the UVGI levels, particle residence time, and particulate filter efficiency (if present). One study in which a bioaerosol chamber was used showed that portable room air cleaners with UVGI lamps as the primary air-cleaning mechanism are effective (> 99%) in inactivating or killing airborne vegetative bacteria (*438*). Additional studies need to be performed in rooms with portable air cleaners that rely only on UVGI for air cleaning.

Portable room air cleaners with UVGI may be used in

- AII rooms as an adjunct method of air cleaning.

- Waiting rooms, emergency departments, corridors, central areas, or other large areas where patients with undiagnosed TB disease could potentially contaminate the air.
-

B.2 Effectiveness of UVGI

Air mixing, air velocity, relative humidity, UVGI intensity, and lamp configuration affect the efficacy of UVGI systems. For upper-air systems, airborne microorganisms in the lower, occupied areas of the room must move to the upper part of the room to be killed or inactivated by upper-air UVGI. Air mixing can occur through convection caused by temperature differences, fans, location of supply and exhaust ducts, or movement of people.

B.2.1 Air mixing

UVGI has been shown to be effective in killing bacteria in the upper-air applications under conditions in which air mixing was accomplished mainly by convection. In one early study, aerosolization of *M. bovis* BCG (a surrogate for *M. tuberculosis*) in a room without mechanical ventilation that relied primarily on convection and infiltration resulted in 10–25 equivalent ACH, depending on the number of UVGI fixtures used (*382*). Other early studies examined the effect of air mixing on UVGI efficacy (*439,440*). These studies indicated that the efficacy of UVGI was greatly increased if cold supply air relative to the lower portion of the room entered through diffusers in the ceiling. The authors concluded that large temperature gradients between the upper and lower portions of the room favored (cold air in the upper portion of the room) or inhibited (hot air in the upper portion of the room) vertical mixing of air between the two zones. When large-bladed ceiling fans were used to promote mixing in the experimental room, the ability of UVGI to inactivate *Serratia marcescens,* an organism known to be highly sensitive to UVGI, was doubled (*441,442*).

Recent studies conducted with louvered UVGI fixtures have reported similar effects. One study documented an increase in UVGI effectiveness of 16% at two ACH and 33% at six ACH when a mixing fan was used (*443*). Another study conducted in a simulated health-care room found that 1) at zero ACH, a high degree of efficacy of upper-air UVGI was achieved in the absence or presence of mixing fans when no temperature gradient was created, and 2) at six ACH, bringing in warm air at the ceiling resulted in a temperature gradient with cooler room air near the floor and a UVGI efficacy of only 9%. Turning on box fans under these winter conditions increased UVGI efficacy nearly ten-fold (to 89%) (*421,444*).

To reduce variability in upper-air UVGI efficacy due to temperature gradients in the room, a fan should be routinely used to continually mix the air, unless the room has been shown to be well mixed under various conditions of operation. Use of a fan would also reduce or remove the suggested winter versus summer variable ACH requirements for optimal upper-air UVGI efficacy (*445*).

B.2.2 Relative humidity

In studies conducted in bioaerosol chambers, the ability of UVGI to kill or inactivate microorganisms declined sharply when the relative humidity exceeded 60% (*446-449*). In room studies, declines in the ability of upper-air UVGI to kill or inactivate microorganisms at high relative humidity (65%, 75% and 100%) (*382*) (*421*) have also been reported. The exact mechanism responsible for the reduced effectiveness of UVGI at these higher levels of relative humidity is unknown but does not appear to be related to changes in UV irradiance levels. Relative humidity changes from 55–90% resulted in no corresponding changes in measured UVGI levels (*436*). In another study, an increase in relative humidity from 25–67% did not reduce UVGI levels (*421*). Bacteria have been shown to absorb significant amounts of water from the air as the relative humidity increases. It has been suggested that at high humidity, the UV irradiance levels required to inactivate the bacteria may approach the higher levels needed for liquid suspensions of bacteria (*447*). The ability of bacteria to repair UVGI damage to their DNA via photoreactivation has also been reported to increase as relative humidity increases (*421,447*).

For optimal efficacy of upper-air UVGI, relative humidity should be maintained at ≤60%, a level that is consistent with current recommendations for providing acceptable indoor air quality and minimizing environmental microbial contamination in indoor environments(*384,450*).

B.2.3 Ventilation rates

The relationship between ventilation and UVGI has also been evaluated. Some predicted inactivation rates have been calculated and published for varying flow rates, UV intensity, and distances from the lamp based on radiative heat transfer theory (*437*). In room studies with extremely well-mixed air, ventilation rates (zero ACH, three ACH and six ACH) were combined with various irradiation levels of upper-air UVGI. All experiments were conducted at 50% relative humidity and 70°F. In general, using *M. parafortuitum* as a surrogate for *M. tuberculosis*, ventilation rates had no adverse effect on the efficiency of upper-air UVGI. The combined effect of both environmental controls was mostly additive in this artificial environment, with perhaps a small loss of upper-air UVGI efficiency at six ACH (*421*). Thus, it is possible to use ventilation rates of up to six ACH in an extremely well-mixed room and achieve ≥12 ACH (mechanical ACH + equivalent ACH) by combining these rates with the appropriate level of upper-air irradiation (*421*). It has been suggested that higher ventilation rates (>6 ACH) may, however, decrease the time the air is irradiated and thus decrease the killing of bacteria (*428,451*).

Ventilation rates up to six mechanical ACH do not appear to adversely affect the performance of upper-air UVGI in an extremely well-mixed room. Further studies are needed to examine the combined effects of mechanical ventilation and UVGI at higher room-air exchange rates.

B.2.4 UVGI intensity

UVGI intensity field plays a primary role in the performance of upper-air UVGI systems. The UVGI dose received by microorganisms is a function of UVGI times duration of exposure. Intensity is influenced by the lamp wattage, distance from the lamp, surface area, and presence of reflective surfaces. The number of lamps, location, and UVGI level needed in a room depends on the room's geometry, area, and volume, and the location of supply air diffusers (*421,435*). UVGI fixtures should be spaced to reduce overlap while maintaining an even irradiance zone in the upper air.

The emission profile of a fixture is an important determinant of UVGI effectiveness. Information on total UVGI output for a given fixture (lamp plus housing and louvers) should be requested from the manufacturer and used for comparison when selecting UVGI systems. Information on only the UVGI output of the lamp is inadequate; the lamp output will be greater than the output for the fixture due to losses from reflectors and nonreflecting surfaces and the presence of louvers and other obstructions (*435,436*). In addition, information provided by the manufacturer reflects ideal laboratory conditions; damage to fixtures or improper installation will affect UV output. Because old or dust-covered UVGI lamps are less effective, routine maintenance and cleaning of UVGI lamps and fixtures is important. UVGI system designers should consider room geometry, fixture output, room ventilation, and the desired level of equivalent ACH in determining the types, numbers, and placement of UVGI fixtures in a room to achieve target irradiance levels in the upper air.

B.3 Health and safety issues

Short-term overexposure to UV radiation can cause erythema (abnormal redness of the skin), photokeratitis (inflammation of the cornea), and conjunctivitis (inflammation of the conjunctiva) (*452*). Symptoms of photokeratitis and conjunctivitis include a feeling of sand in the eyes, tearing, and sensitivity to light. Photokeratitis and conjunctivitis are reversible conditions, but they may be debilitating while they runs their course. Because the health effects of UVGI are generally not evident until after exposure has ended (typically 6–12 hours later), HCWs may not recognize them as occupational injuries.

In 1992, UV-C (100–280 nm) radiation was classified by the International Agency for Research on Cancer as "probably carcinogenic to humans (Group 2A)" (*453*). This classification was based on studies suggesting that UV-C radiation can induce skin cancers in animals, DNA damage, chromosomal aberrations, and sister chromatid exchange and transformation in human cells in vitro; and DNA damage in mammalian skin cells in vivo. In the animal studies, a contribution of UV-C to the tumor effects could not be excluded, but the effects were greater than expected for UV-B alone (*453*). Some studies have demonstrated that UV radiation can activate HIV gene promoters (i.e., genes in HIV that prompt replication of the virus) in laboratory samples of human cells (*454-459*). The potential for UV-C to cause cancer and promote HIV in humans is unknown, but skin penetration may be an important factor. It has been

reported that only 20% of incident 250 nm UV penetrates the stratum corneum, compared to approximately 30–60% of 300 nm UV (UV-B) (*460*).

In upper-air UVGI systems, fixtures must be designed and installed to ensure that UVGI exposures to occupants are below current safe exposure levels. Health-hazard evaluations have identified potential problems at some settings using UVGI systems. These include overexposure of HCWs to UVGI and inadequate maintenance, training, labeling, and use of personal protective equipment (PPE) (*396,461,462*). An improperly maintained (unshielded) germicidal lamp was believed to be the cause of dermatosis or photokeratitis in five HCWs in an emergency department (*463*) and three HCWs who were inadvertently exposed to an unshielded UVGI lamp in a room that had been converted from a sputum induction room to an office (*464*). These case reports highlight the importance of posting warning signs to identify the presence of UVGI and suggest shielding to minimize UVGI exposures to occupants in the lower room. In most applications, properly designed, installed, and maintained UVGI fixtures provide protection from most, if not all, of the direct UVGI in the lower room. However, radiation reflected from glass, polished metal, and high-gloss ceramic paints can be harmful to persons in the room, particularly if more than one UVGI fixture is in use. Surfaces in irradiated rooms that can reflect UVGI into occupied areas of the room should be covered with nonUV-reflecting material.

Although more study is needed, lightweight clothing made of tightly woven fabric and UV-absorbing sunscreens with solar-protection factors (SPFs) of 15 or higher may help protect photosensitive persons. Plastic eyewear containing a UV inhibitor that prevents the transmission of $\geq$95% of UV radiation in the 210–405 nm range is commercially available. HCWs should be advised that any eye or skin irritation that develops after UVGI exposure should be evaluated by an occupational health professional.

B.4 Exposure criteria

In 1972, CDC/NIOSH published a recommended exposure limit (REL) for occupational exposure to UV radiation (*452*). The REL is intended to protect HCWs from the acute effects of UV exposure. Photosensitive persons and those exposed concomitantly to photoactive chemicals may not be protected by the recommended standard.

The CDC/NIOSH REL for UV radiation is wavelength dependent because different wavelengths have different adverse effects on the skin and eyes (*452*). At 254 nm, the predominant wavelength for germicidal UV lamps, the CDC/NIOSH REL is 0.006 joules per square centimeter (J/cm^2) for a daily eight-hour work shift. The American Conference of Governmental Industrial Hygienists (ACGIH®) has a Threshold Limit Value® for UV radiation that is identical to the REL for this spectral region (*465*). Many HCWs move around considerably in the course of their work and are not exposed to constantly changing UV irradiance levels for eight hours. Permissible exposure times (PET) for HCWs with unprotected eyes and skin can be calculated for various irradiance levels as follows:

$$\text{PET (seconds)} = \frac{0.006\ \text{J/cm}^2\ \text{(the CDC/NIOSH REL at 254 nm)}}{\text{Measured irradiance level (at 254 nm) in W/cm}^2}$$

Exposures exceeding the CDC/NIOSH REL require the use of PPE to protect the skin and eyes.

B.5 Labeling, maintenance, and monitoring

B.5.1 Labeling and posting

Health-care settings should post warning signs on UV lamps and wherever high-intensity (i.e., UVGI exposure greater than the REL) UVGI irradiation is present to alert maintenance staff, HCWs, and the general public of the hazard. The warning signs should be written in the languages of the affected persons. Some examples are shown below:

Wall sign for upper-air UVGI

CAUTION
ULTRAVIOLET ENERGY
SWITCH OFF LAMPS BEFORE
ENTERING UPPER ROOM

General warning posted near UVGI lamps

CAUTION
ULTRAVIOLET ENERGY
PROTECT EYES and SKIN

Warning posted on the door of air handlers where UVGI is present in ductwork

CAUTION
ULTRAVIOLET ENERGY IN DUCT
DO NOT SWITCH OFF SAFETY BUTTON
OR ACTIVATE LAMPS WITH DOOR OPEN

B.5.2 Maintenance

Because the UVGI output of the lamps declines with age, a schedule for replacing the lamps should be developed in accordance with manufacturers' recommendations. The schedule can be determined from a time-use log, a system based on cumulative time, or routinely (e.g., at least annually). UVGI lamps should be checked monthly for dust build-up, which lessens radiation output. A dirty UVGI lamp should be allowed to cool and then should be cleaned in accordance with the manufacturer's recommendations so that no residue remains.

UVGI lamps should be replaced if they stop glowing, if they flicker, or if the measured irradiance (Supplement 4, Section B.5.3) drops below the performance criteria or minimum design criterion set forth by the design engineers. Maintenance personnel must switch off all UVGI lamps before entering the upper part of the room or before accessing ducts for any purpose. Only a few seconds of direct exposure to the intense UVGI in the upper-air space or in ducts can cause dermatosis or photokeratitis.

Protective clothing and equipment (e.g., gloves, goggles, face shield, sunscreen) should be worn if exposure greater than the recommended levels is possible or UVGI radiation levels are unknown.

Banks of UVGI lamps can be installed in ventilation system ducts. Safety devices and lock-out or tag-out protocols should be used on access doors to eliminate exposures of maintenance personnel. For duct irradiation systems, the access door for servicing the lamps should have an inspection window through which the lamps are checked periodically for dust build-up and to ensure they are functioning properly. The access door should have a warning sign written in appropriate languages to alert maintenance personnel to the health hazard of looking directly at bare UV lamps. The lock for this door should have an automatic electric switch or other device that turns off the lamps when the door is opened.

Types of fixtures used in upper-air irradiation include wall-mounted, corner-mounted, and ceiling-mounted fixtures that have louvers or baffles to block downward radiation and ceiling-mounted fixtures that have baffles to block radiation below the horizontal plane of the fixtures. If possible, light switches that can be locked should be used to prevent injury to persons who might unintentionally turn the lamps on during maintenance procedures. Because lamps must be discarded after use, consideration should be given to selecting germicidal lamps that are manufactured with relatively low amounts (i.e., $\leq$5 mg) of mercury. UVGI products should be UL (Underwriters Laboratories) or ETL (Electrical Testing Laboratories) listed for their specific application and installed in accordance with the National Electric Code.

B.5.3 Monitoring

UVGI intensity should be measured by an industrial hygienist or other person knowledgeable in the use of UV radiometers with a detector designed to be most sensitive at 254 nm. Equipment used to measure UVGI should be maintained and calibrated on a regular schedule, as recommended by the manufacturer.

UVGI should be measured in the lower room to ensure that exposures to occupants are below levels that could result in acute skin and eye effects. The monitoring should consider typical duties and locations of the HCWs and should be done at eye level. At a minimum, UVGI levels should be measured at the time of initial installation and whenever fixtures are moved or other changes are made to the system that could affect UVGI. This could include changes to the room that may result in higher exposures to occupants (e.g., addition of UV-reflecting materials, or painting of walls and ceiling). UVGI monitoring information, lamp maintenance, meter calibration, and lamp and fixture change-outs should be recorded.

UVGI measurements should also be made in the upper air to define the area that is being irradiated and determine if target irradiance levels are met (*466*). Measurements can be made using UVGI radiometers or other

techniques such as spherical actinometry, which measures the UVGI in an omnidirectional manner to estimate the energy to which microorganisms would be exposed (*467*). Because high levels of UVGI can be measured in the upper air, persons making the measurements should use adequate skin and eye protection. UVGI radiation levels close to the fixture source can have permissible exposure times on the order of seconds or minutes for HCWs with unprotected eyes and skin. Thus, overexposures can occur with very brief UVGI exposures in the upper air (or in ventilation system ducts where banks of unshielded UV lamps are placed) in HCWs who are not adequately protected.

B.6 Upper-Air UVGI Systems and Portable Room-Air Recirculation Units

A recent study examined the relationship between three portable room-air recirculation units with different capture or inactivation mechanisms and an upper-air UVGI system in a simulated health-care room (*407*). The study determined that the equivalent ACH produced by the recirculation units and that produced by the upper-air UVGI system were approximately additive. For example, one test using aerosolized *M. parafortuitum* provided an equivalent ACH for UVGI of 17 and an equivalent ACH for the recirculation unit of 11; the total experimentally measured equivalent ACH for the two systems was 27. Thus, the use of portable room-air recirculation units in conjunction with upper-air UVGI systems may increase the overall removal of *M. tuberculosis* droplet nuclei from room air.

V. Environmental Controls: Program Issues

To be most effective, environmental controls must be installed, operated, and maintained correctly. Ongoing maintenance is a critical part of infection control that should be addressed in the written TB infection-control plan. The plan should outline the responsibility and authority for maintenance and address staff training needs. At one hospital, improperly functioning ventilation controls were believed to be an important factor in the transmission of MDR TB disease to three patients and a correctional officer, three of whom died (*468*). In three other multi-hospital studies evaluating the performance of AII rooms, failure to routinely monitor air-pressure differentials, or a failure of the continuous monitoring devices installed in the AII rooms, resulted in a significant percentage of the rooms being under positive pressure (*54,390,469,470*).

Routine preventive maintenance should be scheduled and should include all components of the ventilation systems (e.g., fans, filters, ducts, supply diffusers, exhaust grilles) and any air-cleaning devices in use. Performance monitoring should be conducted to verify that environmental controls are operating as designed. Performance monitoring may include 1) directional airflow assessments using smoke tubes and use of pressure monitoring devices that are sensitive to pressures as low as approximately 0.005 inch of water gauge and 2) measurement of supply and exhaust airflows to compare with recommended air change rates for the respective areas of the setting. Records should be kept to document all preventive maintenance and repairs.

Standard procedures should be established to ensure that maintenance staff notifies infection-control personnel before performing maintenance on ventilation systems servicing patient-care areas. Likewise, infection-control staff should request assistance

from maintenance personnel in checking the operational status of AII rooms and local exhaust devices (e.g., booths, hoods, tents) before use. A protocol that is well-written and followed will help to prevent unnecessary exposures of HCWs and patients to infectious aerosols. Proper labeling of ventilation system components (e.g., ducts, fans, filters) will help identify air-flow paths. Clearly labeling which fan services a given area will help prevent accidental shutdowns (*471*).

In addition, provisions should be made for emergency power to avoid interruptions in the performance of essential environmental controls during a power failure.

SUPPLEMENT 5: RESPIRATORY PROTECTION

I. Considerations for Selection of Respirators

The overall effectiveness of respiratory protection is affected by 1) the level of respiratory protection selected (e.g., the assigned protection factor), 2) the fit characteristics of the respirator model, 3) the care in donning the respirator, and 4) the adequacy of the fit-testing program. Although data on the effectiveness of respiratory protection from many hazardous airborne materials have been collected, the precise level of effectiveness in protecting HCWs from *M. tuberculosis* transmission in health-care settings has not been determined.

Information on the transmission parameters of *M. tuberculosis* is also incomplete. Neither the smallest infectious dose of *M. tuberculosis* nor the highest level of exposure to *M. tuberculosis* at which transmission will not occur has been defined conclusively (*166,472,473*). Furthermore, the size distribution of droplet nuclei and the number of particles containing viable *M. tuberculosis* organisms that are expelled by patients with infectious TB disease have not been adequately defined, and accurate methods of measuring the concentration of infectious droplet nuclei in a room have not been developed. Nevertheless, in certain settings (e.g., AII rooms, ambulances during the transport of infectious TB patients), administrative and environmental controls alone may not adequately protect HCWs from infectious airborne droplet nuclei.

On October 17, 1997, OSHA published a proposed standard for occupational exposure to *M. tuberculosis* (*271*). On December 31, 2003, OSHA announced the termination of rulemaking for a TB standard (*272*). Prior OSHA policy permitted the use of any Part 84 particulate filter respirator for protection against infection with *M. tuberculosis* (*273*). Respirator usage for TB had been regulated by OSHA under CFR Title 29, Part 1910.139 (29CFR1910.139) (*274*) and compliance policy directive (CPL) 2.106 (*Enforcement Procedures and Scheduling for Occupational Exposure to Tuberculosis*). Respirator usage for TB is now regulated under the general industry standard for respiratory protection (29CFR1910.134) (*275*). General information on respiratory protection for aerosols, including *M. tuberculosis*, has been published (*276-278*).

A. Performance criteria for respirators

Performance criteria for respirators are derived from data on 1) effectiveness of respiratory protection against noninfectious hazardous materials in workplaces other than health-care settings and an interpretation of how these data may be applied to respiratory protection against *M. tuberculosis,* 2) efficiency of respirator filters in filtering biological aerosols, 3) face-seal leakage, and 4) characteristics of respirators used in conjunction with administrative and environmental controls in outbreak settings to stop transmission of *M. tuberculosis* to HCWs and patients.

- Particulate filter respirators certified by CDC/NIOSH, either non-powered respirators with N-, R-, or P-95, 99, or 100 filters (including disposable respirators), or PAPRs with high-efficiency filters may be used for protection against airborne TB.

The most important attribute of a respirator is the ability to fit the different facial sizes and characteristics of HCWs. Studies have shown that fitting characteristics vary widely

among respirator models. The fit of filtering facepiece respirators varies due to different facial types and respirator characteristics (*10,282-291*). Selection of respirators may be informed through consultation with respirator fit-testing experts, CDC, occupational health and infection control professional organizations, peer-reviewed research, and respirator manufacturers, and from advanced respirator training courses. Data have shown that fit characteristics cannot be determined solely by physical appearance of the respirator (*284*).

B. Types of respiratory protection for TB

Respirators encompass a range of devices that vary in complexity from flexible masks covering only the nose and mouth, to units that cover the user's head (e.g., loose-fitting or hooded PAPRs), and those that have independent air supplies (e.g., airline respirators). Respirators must be selected from those approved by CDC/NIOSH under the provisions of 42 CFR, Part 84 (*474*).

B.1 Nonpowered air-purifying respirators

Nine classes of nonpowered, air-purifying, particulate-filter respirators are certified under 42 CFR 84. These include N-, R-, and P-series respirators of 95%, 99%, and 100% (99.7%) efficiency (Supplement 5, Table 18). The N, R and P classifications are based on the capacity of the filter to withstand exposure to oil. All of these respirators meet or exceed CDC's filtration efficiency performance criteria during the service life of the filter (*1,276,277*).

Nonpowered air-purifying respirators work by drawing ambient air through the filter during inhalation. Inhalation causes negative pressure to develop in the tight-fitting facepiece and allows air to enter while the particles are captured on the filter. Air leaves the facepiece during exhalation because positive pressure develops in the facepiece and forces air out of the mask through the filter (disposable) or through an exhalation valve (replaceable and some disposable).

The classes of certified nonpowered air-purifying respirators include both filtering facepiece (disposable) respirators and elastomeric (rubber-like) respirators with filter cartridges. The certification test for filtering facepieces and filter cartridges consists only of a filter performance test. It does not address respirator fit. Although all N-, R-, and P-series respirators are recommended for protection against *M. tuberculosis* infection in health-care settings and other workplaces that are generally free of oil aerosols that could degrade filter efficiency, well-fitting N-series respirators are usually less expensive than R- and P-series respirators (*276,277*). All respirators should be replaced as needed based on hygiene considerations, increased breathing resistance, time-use limitations specified in the NIOSH approval, and respirator damage, and in accordance with manufacturer specifications.

B.2 Powered air-purifying respirators (PAPRs)

A PAPR uses a blower that draws air through the filters into the facepiece. PAPRs can be equipped with a tight-fitting or loose-fitting facepiece, a helmet, or a hood. PAPR filters are classified as "high-efficiency" and are different from those described in Table 18. A hooded PAPR high-efficiency filters meet the N100, R100, and P100 criteria at the beginning of their service life. No loading tests using 0.3 μm particles are conducted as part of certification. PAPRs may be

useful for persons with facial hair or other conditions that prevent an adequate face to facepiece seal (*475*).

B.3 Atmosphere-supplying respirators

Positive-pressure airline (supplied-air) respirators are provided with air from a stationary source (compressor) or an air tank.

Table 18 here

C. Effectiveness of respiratory protection devices

Data on the effectiveness of respiratory protection against hazardous airborne materials are based on experience in the industrial setting; data on protection against transmission of *M. tuberculosis* in health-care settings are not available. The parameters used to determine the effectiveness of a respiratory protective device are face-seal efficacy and filter efficiency.

C.1 Face-seal leakage

Face-seal leakage is the weak link that limits a respirator's protective ability. Excessive face-seal leakage compromises the ability of particulate respirators to protect HCWs from airborne materials (*476*). A proper seal between the respirator's sealing surface and the face of the person wearing the respirator is essential for the effective and reliable performance of any tight-fitting, negative-pressure respirator.

For tight-fitting, negative-pressure respirators (e.g., N95 disposable respirators), the amount of face-seal leakage is determined by 1) the fit characteristics of the respirator, 2) the care in donning the respirator, and 3) the adequacy of the fit-testing program. Studies suggest that a well-fitting respirator plus a fit test produces better results than a well-fitting respirator without a fit test or a poor-fitting respirator with a fit test. Increased face-seal leakage can result from additional factors, including incorrect facepiece size, failure to follow the manufacturer's instructions at each use, beard growth, perspiration or facial oils that can cause facepiece slippage, improper maintenance, physiological changes of the HCW, and respirator damage.

Face-seal leakage is inherent in tight-fitting negative-pressure respirators. Every time a person wearing a nonpowered particulate respirator inhales, negative pressure (relative to the workplace air) is created inside the facepiece. Due to this negative pressure, air containing contaminants can leak into the respirator through openings at the face-seal interface and avoid the higher-resistance filter material. A half-facepiece respirator, including an N95 disposable respirator should have <10% leakage. Full facepiece, nonpowered respirators have the same leakage (<2%) as PAPRs with tight-fitting full-facepieces.

The more complex PAPRs and positive-pressure airline respirators reduce or eliminate this negative facepiece pressure and thus reduce leakage into the respirator and enhance protection. A PAPR is equipped with a blower that forcibly draws ambient air through high-efficiency filters and then delivers the filtered air to the facepiece. This air is blown into the facepiece at flow rates that generally exceed the expected inhalation flow rates. The pressure inside the

facepiece reduces face-seal leakage to low levels, particularly during the relatively low inhalation rates expected in health-care settings. PAPRs with a tight-fitting facepiece have <2% face-seal leakage under routine conditions (*280*). PAPRs with loose-fitting facepieces, hoods, or helmets have <4% inward leakage under routine conditions (*280*). Thus, a PAPR may offer lower levels of face-seal leakage than nonpowered, half-mask respirators.

C.2 Filter penetration

Aerosol penetration through respirator filters depends on at least five independent variables: 1) filtration characteristics for each type of filter, 2) size distribution of the droplets in the aerosol, 3) linear velocity through the filtering material, 4) filter loading (i.e., amount of contaminant deposited on the filter), and 5) electrostatic charges on the filter and on the droplets in the aerosol (*286*).

When N95 disposable respirators are used, filter penetration may approach 5% (50% of the allowable leakage of 10% for an N95 disposable respirator). When high-efficiency filters are used in PAPRs or for half-facepiece respirators, filter efficiency is high (effectively 100%) and filter penetration is less of a consideration. Therefore, for high-efficiency or 100-series filter respirators, most inward leakage of droplet nuclei occurs at the respirator's faceseal or exhalation valve.

II. Implementing a Respiratory Protection Program

If respirators are used in a health-care setting, OSHA requires the development, implementation, administration, and periodic reevaluation of a respiratory protection program (*275,279,280*). The most important elements of a respiratory protection program include a) assignment of responsibility, b) training, and c) fit testing (*1*). All HCWs who use respirators for protection against infection with *M. tuberculosis* should be included in the respiratory protection program. Visitors to patients with TB disease should be given respirators to wear while in AII rooms and should be given information on TB transmission and general instructions on respirator use. The health-care setting should develop a policy on use of respirators by visitors.

The number of HCWs included in the respiratory protection program will vary depending on 1) the number of persons who have suspected or confirmed TB disease seen in a setting, 2) the number of rooms or areas in which patients with suspected or confirmed infectious TB disease stay or are encountered, and 3) the number of HCWs needed to staff these rooms or areas. In settings where respiratory protection programs are required, enough HCWs should be included to provide adequate care for patients with suspected or confirmed TB disease. However, administrative measures should be used to limit the number of HCWs exposed to *M. tuberculosis* (Introduction, Section D.1).

Information on the development and management of a respiratory protection program is available in technical training courses that cover the basics of respiratory protection. Such courses are offered by OSHA, American Industrial Hygiene Association, universities, manufacturers, and private contractors. To be effective and reliable, respiratory protection programs must include at least the following elements (*278-280*).

A. Assignment of responsibility

One person (the program administrator) must be in charge of the respiratory protection program and be given the authority and responsibility to manage all aspects of the program. The administrator must have sufficient knowledge (obtained by training or experience) to develop and implement a respiratory protection program. Preferably, the administrator should have a background in industrial hygiene, safety, health care, or engineering. The administrator should report to the highest official possible (e.g., manager of the safety department, supervisor of nurses, HCWs' health manager, infection-control manager) and should be allocated sufficient time to administer the respiratory protection program in addition to other assigned duties.

B. Standard operating procedures

The effectiveness of a respiratory protection program requires the development of written standard procedures. These procedures should include information and guidance for the proper selection, use, and care of respirators (*278*).

C. Screening

HCWs should not be assigned a task requiring use of respirators unless they are physically able to perform job duties while wearing the respirator. HCWs who might need to use a respirator should be screened by a physician or other licensed healthcare professional for pertinent medical conditions at the time they are hired and then re-screened periodically (*278*). The screening process should begin with a screening questionnaire for pertinent medical conditions, the results of which should be used to identify HCWs who need further evaluation (Supplement 5, Tables 19 and 20). Unless prescribed by the screening physician, serial physical examination or testing with chest radiographs or spirometry is neither necessary nor required (*289*).

D. Training

D.1 Provide HCWs with annual training on

- Nature, extent, and hazards of TB disease in the health-care setting; this training may be done in conjunction with other related training on infectious disease associated with airborne transmission (e.g., SARS-Corona Virus [CoV] and measles), and with serial TB screening.
- The risk assessment process and its relationship to the respirator program
- Signs and symbols used to show that respirators are required in an area
- Reasons for using respirators
- Environmental controls used to prevent the spread and reduce the concentration of infectious droplet nuclei
- Reasons for selecting a particular respirator for a given hazard (Recommendations, Section K.2.2 and K.4.3)
- Operation, capabilities, and limitations of respirators
- Respirator care (Section G, below)
- Cautions about facial hair and respirator use
- Applicable Federal, state, and local regulations regarding respirators including assessment of employees' knowledge

D.2 Provide opportunities for trainees to handle and wear a respirator until proficient (Recommendations, Section K.2.3).
D.3 Provide trainees with educational material for use as references.
D.4 Provide instructions to refer all respirator problems immediately to the respirator program administrator.

E. Selection

Filtering facepiece respirators used for protection against *M. tuberculosis* must be selected from those approved by CDC/NIOSH under the provisions of 42 CFR 84 (www.cdc.gov/niosh/celintro.html). A listing of CDC/NIOSH-approved disposable particulate respirators (filtering facepieces) may be found at http://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/. If a health-care setting uses respirators for protection against other regulated hazards (e.g., formaldehyde, ethylene oxide), then these potential exposures should be specifically addressed in the program. Combination product surgical mask/N95 disposable respirators (respirator portion certified by CDC/NIOSH and surgical mask portion listed by FDA) are available that provide both respiratory protection and bloodborne pathogen protection. Selection of respirators may be informed through consultation with respirator fit-testing experts, CDC, occupational health and infection control professional organizations, peer-reviewed research, and respirator manufacturers, and from advanced respirator training courses (*10,282-291*).

F. Fit testing

A fit test is used to determine which respirator fits the user adequately and to ensure that the user knows when the respirator fits properly. After a risk assessment is conducted to validate the need for respiratory protection, perform fit testing during the initial respiratory protection program training and periodically thereafter and in accordance with federal, state, and local regulations.

Fit testing provides a means to determine which respirator model and size fits the wearer best and to confirm that the wearer can don the respirator properly to achieve a good fit. Periodic fit testing for respirators used in environments where there is a risk of *M. tuberculosis* transmission can serve as an effective training tool in conjunction with the content included in employee training and retraining. The frequency of periodic fit testing should be supplemented by the occurrence of a) risk of transmission of *M. tuberculosis*, b) a change in facial features of the wearer, c) medical condition that would affect respiratory function, d) physical characteristics of respirator (despite the same model number), or e) a change in the model or size of the assigned respirator (*283*).

G. Inspection and maintenance

Respirator maintenance should be an integral part of an overall respirator program. Maintenance applies both to respirators with replaceable filters and to respirators that are classified as disposable but that are reused. Manufacturers' instructions for inspecting, cleaning, maintaining, and use (or reuse) of respirators should be followed to ensure that the respirator continues to function properly (*280*).

When respirators are used for protection against noninfectious aerosols (e.g., wood dust) that might be present in the air in heavy concentrations, the filter can become obstructed with airborne material. This obstruction in the filter material can result in increased resistance, making breathing uncomfortable. In health-care settings where respirators are used for protection against biological aerosols, the concentration of infectious particles in the air is probably low. Thus, the filter in a respirator is very unlikely to become obstructed with airborne material. In addition, no evidence exists to indicate that particles impacting on the filter material in a respirator are reaerosolized easily. For these reasons, the filter material used in respirators in health-care settings may remain functional for weeks. Because electrostatic filter media may degrade, the manufacturer should be contacted for the product's established service life to confirm filter performance.

Respirators with replaceable filters are reusable, and a respirator classified as disposable may be reused by the same HCW as long as it remains functional and is used in accordance with local infection-control procedures. Respirators with replaceable filters and filtering facepiece respirators may be reused by HCWs as long as they have been inspected before each use and are within the manufacturer's service life. If the filter material is physically damaged or soiled or if the manufacturer's service life criterion has been exceeded, the filter (in respirators with replaceable filters) should be changed or the disposable respirator should be discarded according to local regulations. Infection-control personnel should develop standard procedures for storing, reusing, and disposing of respirators that have been designated for disposal.

H. Evaluation

The respirator program must be evaluated periodically to ensure its continued effectiveness.

Table 19 here
Table 20 here

SUPPLEMENT 6: CLEANING, DISINFECTING, AND STERILIZING PATIENT-CARE EQUIPMENT AND ROOMS

I. General

Medical instruments and equipment, including medical waste, used on patients who have TB disease are usually not involved in the transmission of *M. tuberculosis* (*477-479*). However, transmission of *M. tuberculosis* and pseudo outbreaks (e.g., contamination of clinical specimens) have been linked to inadequately disinfected bronchoscopes contaminated with *M. tuberculosis* (*87,88,167,170,171,173*). Guidelines for cleaning, disinfecting, and sterilizing flexible endoscopic instruments have been published (*480-484*).

The rationale for cleaning, disinfecting, or sterilizing patient-care instruments and equipment can be understood more readily if medical devices, equipment, and surgical materials are divided into three general categories(*485*). These categories--critical, semicritical, and noncritical--are based on the potential risk for infection if an item remains contaminated at the time of use.

A. Critical medical instruments

Instruments that are introduced directly into the bloodstream or other normally sterile areas of the body (e.g., needles, surgical instruments, cardiac catheters, implants) are critical medical instruments. These items should be sterile at the time of use.

B. Semicritical medical instruments

Instruments that may come into contact with mucous membranes but do not ordinarily penetrate body surfaces (e.g., noninvasive flexible and rigid fiberoptic endoscopes or bronchoscopes, endotracheal tubes, anesthesia breathing circuits) are semicritical medical instruments. Although sterilization is preferred for these instruments, high-level disinfection that destroys vegetative microorganisms, most fungal spores, mycobacteria (including tubercle bacilli), and small nonlipid viruses may be used. Meticulous cleaning of such items before sterilization or high-level disinfection is essential (*480*). When an automated washer is used to clean endoscopes and bronchoscopes, the washer must be compatible with the instruments to be cleaned (*480,486*). High-level disinfection can be accomplished with either manual procedures alone or use of an automated endoscope reprocessor with manual cleaning (*87,480*). In all cases manual cleaning is an essential first-step in the process to remove debris from the instrument.

C. Noncritical medical instruments or devices

Instruments or devices that either do not ordinarily touch the patient or touch only the patient's intact skin (e.g., crutches, bed boards, blood pressure cuffs) are noncritical medical instruments. These items are not associated with transmission of *M. tuberculosis*. When noncritical instruments or equipment are contaminated with blood or body substances, they should be cleaned and then disinfected with a hospital-grade, Environmental Protection Agency (EPA)-registered germicide disinfectant with a label claim for tuberculocidal activity (i.e., an intermediate-level disinfectant). Tuberculocidal activity is not necessary for cleaning agents or low-level disinfectants that are used to clean or disinfect minimally soiled noncritical items and environmental surfaces (e.g., floors, walls, table tops, surfaces with minimal hand contact).

II. Disinfection

The rationale for use of a disinfectant with tuberculocidal activity is to ensure the killing of other potential pathogens with less intrinsic resistance than that of mycobacteria. A common misconception in the use of surface disinfectants in health care relates to the underlying purpose of products labeled as tuberculocidal germicides. Such products will not interrupt and prevent transmission of *M. tuberculosis* in health-care settings because TB is not acquired from environmental surfaces. The tuberculocidal claim is used as a benchmark by which to measure germicidal potency. Since mycobacteria have the highest intrinsic level of resistance among the vegetative bacteria, viruses, and fungi, any germicide with a tuberculocidal claim on the label (i.e., an intermediate-level disinfectant) is considered capable of inactivating a broad spectrum of pathogens, including much less resistant organisms, such as the bloodborne pathogens (e.g., hepatitis B virus, hepatitis C virus, and HIV). It is this broad spectrum capability, rather than the product's specific potency against mycobacteria, that is the basis for protocols and regulations indicating the appropriateness of tuberculocidal chemicals for surface disinfection.

Policies of health-care settings should specify whether cleaning, disinfecting, or sterilizing an item is necessary to decrease the risk for infection. Decisions about decontamination processes should be based on the intended use of the item, not on the diagnosis of the patient for whom the item is used. Selection of chemical disinfectants depends on the intended use, the level of disinfection required, and the structure and material of the item to be disinfected.

The same cleaning procedures used in other rooms in the health-care setting should be used to clean AII rooms. However, personnel should follow AII practices while cleaning these rooms when the rooms are still in use. Personal protective equipment is not necessary during the final cleaning of an AII room after a patient has been discharged if the room has been ventilated for the appropriate amount of time (Supplement 4, Table 8).

DRAFT

SUPPLEMENT 7: FREQUENTLY ASKED QUESTIONS (FAQs)

I. Tuberculin Skin Testing
II. Treatment for Latent Tuberculosis Infection (LTBI)
III. Risk Assessment
IV. Environmental Controls
V. Respiratory Protection
VI. Cough-Inducing and Aerosol-Generating Procedures

I. Tuberculin Skin Testing

1. ***Is there any risk in having more than one TST placed in one year?***
   No, there is no risk of having a TST placed more than once a year. HCWs (and others) may safely receive TSTs multiple times a year during an outbreak investigation (potential ongoing transmission) or if a HCW is newly hired or transfers to a workplace that requires baseline two-step TSTs. Two step-skin testing requires a second TST to be placed 1–3 weeks after the first TST result was read. (Efforts to contact the HCW's previous employer for prior TST results should be attempted and permitted.) Repeated TSTs will not cause a TST conversion in persons without exposure to mycobacteria. And a previous TST is not a contraindication to having a subsequent TST unless the test was associated with severe ulceration or anaphylactic shock, which are very rare adverse events. Redness or itching after a previous TST is not a contraindication to the application of another TST.

2. ***How often can TSTs be given?***
   HCWs (and others) may safely receive TSTs multiple times a year. If a TST is administered incorrectly (i.e., too deeply or too shallow), a new TST should be placed immediately. It is preferable to apply the second TST on the other arm or in a different area of the same arm ($\geq$2 inches from the first site) so that the TST result will be easier to read. Educators who teach TST placement may voluntarily have multiple TSTs placed during a calendar year for instructional purposes.

3. ***What procedure should be followed for a new HCW who had a negative TST result three months ago at their previous job?***
   A newly hired HCW who has a documented negative TST result three months ago at their previous job (or a documented negative TST result anytime within the previous 12 months) should receive one TST upon hire (ideally before the HCW begins assigned duties). The negative TST result from three months prior should be considered the first-step of the baseline two-step TST. If the HCW does not have documentation of any TST result, the HCW should be tested with two-step baseline TSTs (one upon hire and one placed 1–3 weeks after the first TST result was read).

4. ***Can repeated TSTs by themselves cause the TST result to convert from negative to positive?***
   No, in the absence of a mycobacterial infection or BCG vaccination, repeated TSTs will not cause a TST conversion without exposure to mycobacteria.

5. ***If someone does not return for a TST reading within 48–72 hours, when can a TST be placed on them again?***

A TST may be administered again as soon as possible. If the second test of a two-step TST is not read within 48–72 hours, administer a third test as soon as possible (even if many months have passed) and ensure that the result is read within 48–72 hours.

6. ***What defines a negative TST result?***
   A TST result of 0 mm or anything below the defined cut point for each criteria category is considered a negative TST result (Table 11).

7. ***What defines a positive TST result?***
   A TST result of any mm reading above or at the defined cut point for each criteria category is considered a positive TST result (Table 11). This cut point may vary according to the purpose of the test (e.g., infection control surveillance versus medical and diagnostic evaluation; or contact investigation versus baseline testing).

8. ***What defines a false-negative result?***
   A false-negative TST or QuantiFERON-TB test (QFT) result is one that is interpreted as negative for a particular purpose (i.e., infection control surveillance versus medical and diagnostic evaluation) in a person who is actually infected with *M. tuberculosis.* A false-negative TST result may be due to incorrect TST placement (too deeply or too shallow), incorrect reading of the TST result, use of an incorrect antigen or if the person tested is anergic (i.e., unable to respond to the TST due to an immunocompromising condition), or if the person is very sick with TB disease.

9. ***What defines a false-positive TST or QFT result?***
   A false-positive TST or QFT result is one that is interpreted as positive for a particular purpose (i.e., infection control surveillance or medical and diagnostic evaluation) in a person who is actually not infected with *M. tuberculosis*. This is more likely to occur in persons who have been vaccinated with BCG or who are infected with nontuberculous mycobacteria (NTM), also known as mycobacteria other than TB (MOTT). A false-positive TST result could also be due to incorrect reading of the TST result, or use of incorrect antigen such as tetanus toxoid-containing vaccines.

10. ***Is it safe to place a TST on a nursing mother?***
    Yes, it is safe to place a TST on a nursing mother.

11. ***A pregnant HCW in our setting is reluctant to get a TST. Should we encourage her to have the test done?***
    Yes, the HCW should be educated that pregnancy is not a contraindication to having a TST performed and that skin testing does not affect the fetus or the mother. Tens of thousands of pregnant women have received TSTs since the test was developed, and no documented episodes of TST-related fetal harm have been reported. The importance of the setting's infection control program should be emphasized to the HCW. In the event of an investigation of a potential or known exposure to *M. tuberculosis*, the TST should never be postponed due to pregnancy. For the protection of both the fetus and the mother, the TST should be performed as regularly scheduled (depending on the setting's risk assessment) so that TB infection can be detected and referral for medical diagnosis and evaluation for possible treatment can be started, if needed, without delay. Guidelines issued by the American College of Obstetricians and Gynecologists (ACOG) emphasize

that postponement of applying a TST as indicated, and postponement of the diagnosis of infection with *M. tuberculosis* during pregnancy is unacceptable.

12. ***A pregnant HCW in our setting has a positive TST result and is reluctant to get a chest radiograph. Should we encourage her to have the chest radiograph done?***
Pregnant women with positive TST results or who are suspected of having TB disease should not be exempted from recommended medical evaluations and radiography. Rather, shielding consistent with safety guidelines should be used even during the first trimester of pregnancy. TB disease is dangerous to both mother and fetus.

13. ***Are periodic chest radiographs recommended for HCWs who have positive TST results?***
No, HCWs with a baseline positive or newly positive TST (or QFT) result should receive one chest radiograph to rule out TB disease. After this baseline chest radiograph is performed and documented, further chest radiographs are not needed unless the patient has symptoms of TB disease or unless ordered by a physician for a specific diagnostic examination. Instead of participating in serial skin testing, pregnant HCWs with positive TST results should receive a medical evaluation to review symptoms of TB disease. The frequency of this medical evaluation should be determined by the risk assessment for the setting. HCWs who have a previously positive TST result and who change jobs should carry documentation of the TST result and the results of the baseline chest radiograph (and documentation of treatment history for LTBI or TB disease, if applicable) to their new employers.

14. ***Are periodic chest radiographs recommended for patients or institutional residents with positive TST results?***
No, persons with positive TST results should receive one chest radiograph to rule out TB disease. After this baseline chest radiograph is performed and documented, further chest radiographs are not needed unless the patient has symptoms of TB disease, or unless ordered by a physician for a specific diagnostic examination.

15. ***What is "boosting?"***
Boosting is a phenomenon in which some persons who receive a TST many years after infection with *M. tuberculosis* have a negative (false-negative) TST result, followed by a positive subsequent TST result. The positive TST result is caused by a boosted immune response of prior sensitivity rather than by a new infection. This is considered to be a false-positive TST conversion.

16. ***Why is a two-step TST important for the baseline?***
Performing two-step TSTs at baseline (at the beginning of an HCW's employment) minimizes the possibility that boosting will lead to suspicion of transmission of *M. tuberculosis* in the setting during a later contact investigation. Two-step testing can also avert an unnecessary contact investigation for a source case if a TST conversion due to boosting (false-positive result) is detected during serial TST screening.

17. ***Are there any health-care settings or areas of the country in which baseline two-step skin testing for newly hired HCWs is not needed?***
No, all newly hired HCWs should receive baseline two-step TSTs to avoid boosting. A newly hired HCW might have lived elsewhere or have a boosted response because of

prior exposure. If there is potential for boosting among even 1% of HCWs, a setting could be falsely reclassified as having potential ongoing transmission if two-step testing was omitted. Furthermore, subsequent contact investigations may falsely detect TST conversions in HCWs with a boosted response.

18. ***Should my private home health-care service employees have baseline two-step TSTs?***
Yes, all newly hired HCWs who do not have documentation of a positive TST result or previously treated LTBI or TB disease should receive baseline two-step TSTs to minimize the possibility that boosting will lead to suspicion of transmission of *M. tuberculosis* in the setting during a later contact investigation or serial testing (false-positive TST conversions). Once a negative baseline TST result is established, further skin testing should be conducted if the risk assessment classifies the setting as medium-risk or potential ongoing transmission.

19. ***We hire workers to provide health-care in homes. These persons are not medically trained. Two-step skin testing is difficult because of the requirement to return for testing and reading several times. May we omit the two-step TST?***
Ideally, all HCWs who do not have a previously documented positive TST result or treated LTBI or TB disease should receive two-step baseline skin testing in settings that have elected to use tuberculin skin testing for screening. (QFT baseline is a single test procedure.) Baseline testing for *M. tuberculosis* infection will ensure that TB disease or LTBI is detected before employment begins and treatment for LTBI or TB disease is offered, if indicated. Documentation of baseline two-step TST results will reduce the chances that a boosted TST reaction from being incorrectly interpreted as a TST conversion during subsequent contact investigations. Two-step TSTs can also avert an unnecessary contact investigation for a source case if a TST conversion due to boosting is detected during serial TST screening.

20. ***When performing two-step skin testing, what should be done if the second test is not placed in 1–3 weeks?***
Perform the second-step TST as soon as possible.

21. ***May we accept a TST reading of 10 mm (or more) after 13 days?***
If the TST was not read between 48–72 hours, another TST should be placed as soon as possible and read within 48–72 hours. However, some studies indicate that positive TST reactions may still be measurable from four up to seven days after the TST was placed. If the reaction is read as a definite positive result (≥15 mm), the mm result can be recorded. Ideally, if a patient fails to return in 72 hours and has a negative test result, the TST should be repeated.

22. ***Should gloves be worn when placing TSTs?***
Specific recommendations do not exist around this topic. If your local area indicates that universal precautions should be practiced with skin testing, the local areas should determine what precautions should be followed at their setting. Glove use is not addressed in other CDC documents.

23. ***Is TST quality control (QC) important?***
Yes, performing QC for HCWs during training and retraining of placing and reading TSTs is important in order to avoid false-negative and false-positive TST results.

24. ***If the longitudinal reading of the induration of the TST result is 12 mm and the horizontal reading is 8 mm, what should be recorded?***
The correct TST reading would be 8 mm (not 12 mm or 8x12 mm). For purposes of standardization, only record the mm of induration that is measured transversely (longitudinally), or perpendicular, to the long axis of the forearm. Erythema (redness) around the TST site might develop but should not be read as part of the TST result. Consideration should be given to retesting if the selected area for placement was on or near a muscle margin, scar, heavy hair, veins, or sores which could be barriers to reading the TST result.

25. ***Should HCWs who report upon hire that they have had a positive TST result or have been previously treated LTBI or TB disease receive baseline two-step TSTs when beginning work at a new health-care setting?***
Yes, in general, unless the HCW has documentation of a positive TST result or previously treated LTBI or TB disease, they should receive baseline two-step testing prior to starting duties. If documentation is available of a positive TST result, that result may be considered as the baseline TST result for the HCW at the new employment setting, and additional testing is not needed. Recommendations for testing HCWs transferring from one setting to another where the risk assessment may be different are in Recommendations, Section B.3.

26. ***If an HCW has a baseline first-step TST result that is between 0–10 mm, does a second-step TST need to be placed?***
Yes, for any baseline first-step TST result that is <10 mm, which is the positive cut point for most HCWs, a second-step TST should be applied 1–3 weeks after the first TST result was read to establish a reliable baseline. If the baseline first-step TST result is ≥10 mm, the HCW is considered to have LTBI and a second-step or further TSTs are not necessary.

27. ***An HCW in our setting, which is classified as medium-risk, who had a two-step baseline TST result of 8 mm is retested a year later for serial TB screening and found to have a TST result of 16 mm. There was no known exposure to M. tuberculosis. Although the TST is now >10 mm, there was not a ≥10 mm increase in the TST result to meet the criteria for a TST conversion. How should this be interpreted?***
The TST needs to be interpreted from two perspectives: 1) administrative and 2) individual medical interpretation. Since there is not an increase by ≥10 mm, this would not be classified as a TST conversion for administrative purposes. However, this HCW should be referred for a medical evaluation. There are two criteria for determining whether a TST result is positive or negative considering individual clinical grounds: 1) absolute measured induration (i.e., >5, >10 or >15 mm induration depending on the level of risk and purpose of testing) and 2) the change in the size of the TST result. Usually, these two criteria agree. Occasionally, there can be discrepancy, as in this example. When this occurs, expert advice may be sought from the local or state health department. The interpretation of this TST result will take into account the change in TST result size, time frame of the change, risk of exposure, if any, and the occurrence of other documented TST conversions in the setting. For HCWs at low risk for LTBI, TST results of 10–14 mm may be considered negative from a clinical standpoint, and these HCWs should

not have repeat TSTs because additional increase in induration ≥10 mm will not be useful in determining likelihood of LTBI.

28. Is a baseline TST needed for HCWs who begin jobs that involve little contact with patients (e.g., medical records staff)?

In most cases, unless the HCW has documentation of a positive TST result or previously treated LTBI or TB disease, they should receive baseline two-step TSTs prior to starting duties. However, in some settings, there may be a choice not to perform baseline TST on HCWs who will never be in contact with or share air space with patients who have TB disease, or who will never be in contact with clinical specimens (e.g., telephone operators in a separate building from patients). Otherwise, all HCWs who may share air space with patients should have documented baseline two-step TST results. A baseline TST protects other HCWs and patients by facilitating the diagnosis and treatment of LTBI or TB disease acquired before the current job and is helpful in the event of a possible exposure to *M. tuberculosis* and determining the need for testing in the context of a contact investigation.

29. Our setting conducts skin testing annually on the anniversary of each HCW's employment. Last year, several TST conversions occurred in April, so all HCWs were skin tested during that month. Do we now have to test them all annually in April from now on?

No, skin testing HCWs on the anniversary of their employment or on their birthday (rather than testing all HCWs at the same time each year) is best since it increases the opportunity for early recognition of infection-control problems that can lead to TST conversions. Therefore, after a contact investigation it is preferable to revert to testing HCWs on their employment anniversaries, even though some HCWs may end up being tested more than once in the 12 months following a contact investigation.

30. We are hiring an HCW from a country in which BCG is routinely given. She states that BCG will make her TST result positive and that she should not have a TST. Should this HCW be exempted from a baseline TST?

No, unless she has documentation of a positive TST result or previously treated LTBI or TB disease, she should receive baseline two-step TSTs, and serial testing is indicated. Many persons who received BCG never have a positive TST result. For many others, the positive reaction wanes after a few years. Thus, many HCWs who received BCG will have a negative baseline TST result and will be able to participate in serial TST screening. Those with a positive TST result require evaluation for TB disease and LTBI. Since BCG does not protect against acquiring infection with *M. tuberculosis* if exposed, U.S. guidelines state that a positive TST result in a person who received BCG should be interpreted as indicating LTBI. The HCW in this example should receive two-step baseline TSTs, especially given that BCG vaccination is a risk factor for boosting, and serial testing as indicated.

31. Does BCG affect TST result and interpretation?

Intracutaneous inoculation with BCG is currently used in many parts of the world as a vaccine against TB. BCG may cause a positive TST result initially, however, tuberculin reactivity caused by BCG vaccination generally wanes after a few years, but can be boosted by subsequent TSTs. Periodic skin testing may prolong reactivity to tuberculin in vaccinated persons. No reliable method has been developed to distinguish tuberculin

reactions caused by vaccination with BCG from reactions caused by natural mycobacterial infections, although TST reactions of ≥20 mm of induration are not likely caused by BCG.

32. What should we do with an HCW who has had a BCG vaccination within the past 12 months? When should the TST be placed?

A TST may be placed after a recent BCG vaccination, but a positive TST result after a recent BCG vaccination is more likely to be a false-positive result. If QFT is not available (QFT avoids cross reactivity with BCG), then a TST could be useful for future serial screening (including two-step testing to determine a baseline TST result). If either one of the two-step TST results is positive, attempt to exclude TB disease by performing a chest radiograph.

32. An HCW at our hospital has not had a TST in 18 months because she was on maternity leave and missed her normal anniversary date for her annual TST. She has been employed at the hospital for the past five years. Is two-step testing necessary for her next skin test date?

No, two-step TSTs are needed only to establish a baseline for a specific setting for newly hired HCWs or for persons who will receive serial TSTs, such as residents of long-term care facilities. Once a baseline TST result has been established, any change of TST result from negative to positive should be interpreted as potential health-care–associated transmission. An HCW who misses the anniversary date for an annual TST should have a single TST upon returning to work. After that, the HCW should resume a regular testing schedule with a single TST placed on the next normal TST anniversary date.

33. Should two-step testing be performed in a contact investigation for HCWs who have not had a TST within the past 12 months?

No, two-step testing should only be used for baseline TST screening and has no role in a contact investigation. In a contact investigation, a follow-up TST should be placed 8–10 weeks after an initial negative TST result is read. When an HCW has been exposed to a person with TB disease, a change in a TST result from negative to positive should be interpreted as a TST conversion and never as a boosted reaction.

34. If an HCW is at low risk for TB disease and has a TST result of 13 mm, what should the infection-control program do, and should the HCW be treated?

See email for new answer

36. What length of time should a person with contact to someone with TB disease be included in a contact investigation?

A minimum exposure time for this has not been established. The minimum length of contact time to a person with TB disease necessary for transmission will depend on several factors. This decision can best be made in consultation with the local TB program, which often has experience responding to similar situations. Begin by estimating the duration of the infectious period (Recommendations, Section H.7.2d and CDC self-training modules http://www.phppo.cdc.gov/phtn/tbmodules/modules6-9/m6/6-12.htm). The highest priority for evaluation should go to a) persons with a medical risk factor for TB disease, such as HIV infection or immunosuppressive therapy, b) children <4 years of age, c) household or congregate setting contacts, and d) persons present during medical procedures such as bronchoscopies, sputum induction, or autopsies.

In addition, offer TB screening to all persons named as work or social contacts during the infectious period. Beyond that, determining whether to broaden the investigation will depend on whether evidence of transmission to any of the above contacts exists (positive TST results or TST conversions), the duration of the potential exposure, and the intensity of exposure (e.g., in a poorly ventilated environment versus outdoors). In general, if the exposure was to pulmonary TB that was cavitary on chest radiograph or was associated with positive AFB sputum smear results, the minimum exposure duration for a person to be considered a contact would be shorter. Nevertheless, infection with *M. tuberculosis* nearly always requires some degree of prolonged or regular exposure (i.e., days to weeks, not just a few hours).

37. An HCW in our setting has a latex allergy. Can this person receive a TST?

Yes, a person with a latex allergy can receive a TST when latex-free products are used. Latex allergy can be a contraindication to skin testing if the allergy is severe and the products used to perform the test (e.g., syringe plungers, PPD antigen bottle stopper, gloves) contain latex. Latex-free products are, however, generally available. If a person with a latex allergy does have a TST performed using products or equipment that contain latex, interpretation of the TST results can be difficult because the TST reaction might be the result of the latex allergy, reaction to PPD, or a combination of both. Repeat skin testing using latex-free products may help clarify this.

38. Should the TST site be covered with an adhesive bandage?

No. Avoid covering the skin with anything that may interfere with the reading (e.g., adhesive bandages, cream, ointment, lotion, liquids, medication).

39. When can a TST be placed if you're also administering vaccines (measles, varicella, yellow fever, smallpox)?

A TST should be given either on the same day as vaccination with live virus, or 4–6 weeks later. Vaccines that may cause a false-negative TST result are measles, varicella, yellow fever, smallpox, BCG, mumps, rubella, oral polio, oral typhoid, and live-attenuated influenza.

40. How frequently should people in the general public receive TSTs?

Testing for LTBI in the general public is not necessary unless the person is at risk for infection with *M. tuberculosis*, such as someone who is infected with HIV, or someone who had had contact with a person with TB disease (i.e., if they are involved in a contact investigation).

41. May we use a multiple puncture (Tine®) test to perform a TST?

No, in the United States, the Mantoux method of skin testing is the preferred method because it is more accurate. Multiple puncture or Tine® skin tests should not be used to determine whether a person is infected with *M. tuberculosis.*

42. What if an HCW has a baseline TST result of 16 mm, then one year later the TST result was read as 0 mm?

First, if documentation exists for the first result, it was not necessary for the HCW to receive another TST after the positive TST result. One or both of these TST results could be false results (the first result may have been documented as 16 mm, but actually 16 mm

of erythema was measured instead of induration indicating a false-positive result, but it should have been recorded at 0 mm; or it is possible that the second TST result of 0 mm was administered incorrectly (too deeply or too shallow), or was read and recorded incorrectly, when it was truly positive). In this case, another TST should be placed, or if TB disease is suspected, obtain a chest radiograph.

43. What if the TST is given intramuscularly (IM) instead of intradermally?
Quality control (QC) of administering TSTs is important (Supplement 2, Section A.6). If the TST is given incorrectly (too deeply or too shallow), repeat the test immediately.

44. How are annual TST conversion rates for HCWs calculated?
Annual TST conversion rates are calculated for a given year by dividing the number of persons with newly detected TST conversions with the total number of persons who had TSTs performed and read in that year. By calculating annual TST conversion rates, year to year comparisons can be made to look for transmission of *M. tuberculosis* that was not detected.

45. Where can our setting obtain PPD?
Your local and state health departments may provide PPD antigen for tuberculin skin testing without charge to selected targeted testing and treatment programs. Purchase of the antigen and supplies is regulated by state and local laws related to professional licensure.

46. Where can our setting obtain millimeter (mm) rulers to measure TSTs?
CDC has a TST training kit, which includes a TST training video, facilitator's guide, and a TST mm ruler free of charge. This and other TB education and training materials are available at CDC's website: https://www2.cdc.gov/nchstp_od/PIWeb/TBorderform.asp. Also check with your local or state health department and the TST antigen manufacturer.

47. ***Where can our setting obtain materials for educating HCWs about TB?***
Supplement 8 of this document is a list of TB websites and resources. Your state or local health department should have additional materials and access to resources, and may be able to help develop a setting-specific TB education program.

48. ***Where can our setting obtain self-reading TST cards that allow HCWs to report their own results?***
HCWs and patients should not be allowed to read and report their own TST results, so self-reading cards for reporting TST results are not recommended. All TST results should be read and recorded by a trained TST reader other than the person on whom the TST was placed.

II. Treatment for latent TB infection (LTBI)

1. Who should be treated for LTBI?
Persons with LTBI should be considered eligible for treatment if they have no contraindication. The following groups of persons are recommended to be treated for LTBI because they are at higher risk of developing TB disease once infected: persons infected with HIV, persons infected with *M. tuberculosis* within the past two years, infants and children <4 years of age, persons with any of the following clinical conditions

or immunocompromising conditions: silicosis, diabetes mellitus, chronic renal failure, some hematologic disorders (leukemias and lymphomas), other specific malignancies (e.g., carcinoma of the head, neck, or lung), body weight more than 10% below ideal body weight, prolonged corticosteroid use, other immunosuppressive treatments (including agents that inhibit tumor necrosis factor-alpha), organ transplant, reticuloendothelial diseases, end-stage renal disease (ESRD), intestinal bypass or gastrectomy, chronic malabsorption syndromes, persons with a history of untreated or inadequately treated TB disease, including those with chest radiograph findings consistent with prior TB disease, and persons who will be or have been treated with tumor necrosis factor (TNF) blocking or neutralizing agents. Persons who inject illicit drugs or use tobacco or alcohol may also be at increased risk, but given the many other potential risk factors that commonly occur among such persons, use of these substances has been difficult to identify as separate risk factors for developing TB disease (Introduction, Section B.2).

2. What are contraindications to treatment of LTBI?

Active hepatitis and end-stage liver disease are contraindications to the use of isoniazid for treatment of LTBI. These persons may be eligible for rifampin for four months for treatment of LTBI. Because of the numerous and complex drug-drug interactions between the rifamycins and HIV protease inhibitors (PIs) and non-nucleoside reverse transcriptase inhibitors (NNRTIs), clinicians are strongly encouraged to seek expert advice if the concurrent use of these drugs is being considered. The latest information regarding use of these drugs can be obtained at http://www.cdc.gov/nchstp/tb/tb_hiv_drugs/toc.htm. In persons with HIV infection who are taking HIV PIs or NNRTIs, rifampin is usually contraindicated because drug interactions between rifampin and these agents can lead to increased rifampin levels and decreased PI levels, resulting in increased risk for rifampin toxicity and decreased PI efficacy.

3. Is there an age restriction for being eligible for treatment of LTBI?

No, there is no age restriction for eligibility of treatment for LTBI. Targeted TST programs are conducted among groups at high-risk and targeted TST programs are discouraged for persons or settings considered to be low-risk. Infected persons who are considered to be at high-risk for developing TB disease should be offered treatment of LTBI, regardless of age. However, for infection control programs that conduct active TB screening that includes HCWs who are often at low-risk, proper medical evaluation needs to be conducted when an HCW with a positive TST result is discovered. In this context, age may be a factor in the decision to treat as older persons are at increased risk for hepatic toxicity due to INH.

4. What is the preferred regimen for treatment of LTBI?

Nine months of INH is the preferred treatment regimen for patients who have LTBI and who are eligible for treatment. The 6-month regimen of INH or the 4-month regimen of rifampin are also an acceptable alternatives (Supplement 2, Section II).

5. Why is the two-month regimen of rifampin and /pyrazinamide (RZ) generally not recommended for treatment of LTBI any more?

Although the two-month regimen of rifampin and pyrazinamide (RZ) was previously recommended as an option for the treatment of LTBI, reports of severe liver injury and

death associated with RZ prompted the American Thoracic Society (ATS) and CDC to revise recommendations to indicate that this regimen should generally not be offered for treatment of LTBI.

7. ***Can sputum specimens collected over a two-day period that are reported as negative for AFB be used to exclude a diagnosis of TB disease?***
No. Negative AFB sputum smear results indicate that the risk of infectious TB is low. Results from sputum smears are used as part of the criteria for discontinuing AII for a patient who is a TB suspect. These criteria also include the decision that infectious TB disease is unlikely and another diagnosis is made that explains the clinical syndrome. The sputum specimens must be obtained consecutively and collected at least 8 hours apart, where at least one is an early morning specimen. Importantly, a patient with three negative smear results may have TB disease, demonstrated by a positive culture result several weeks later. Since culture results can take weeks to become positive, TB suspects with negative smear results and in whom another diagnosis that explains the clinical syndrome is not made, should be considered for anti-tuberculosis therapy pending final laboratory results.

8. ***When does an infectious case become noninfectious?***
Historically, many healthcare professionals believed that the effect of anti-tuberculosis therapy to reduce infectiousness is virtually immediate; older texts state simply that patients on anti-tuberculosis treatment are not infectious. Surrogates that are used for noninfectiousness include conversion of positive sputum AFB results to negative AFB results and clinical response to anti-tuberculosis treatment.

III. Risk Assessment

1. ***In some health-care settings, it is very difficult to know how many patients with TB disease were seen. How is the risk classification assigned?***
In some situations, such as in outpatient clinics or emergency medical settings where patients are seen before a hospitalization during which TB disease is diagnosed, it can be difficult to estimate accurately the number of TB patients seen. These situations underscore the importance of an accurate history, complete contact investigation for all persons with suspected or confirmed TB disease, and good communication to all settings where TB patients received care prior to diagnosis. This is accomplished through cooperation between infection-control personnel and the local health department's TB control program.

2. ***Our setting is a hospital with 160 beds. There have been TST conversions in three HCWs over a two-month period. This is usually the number of TST conversions we detect in the hospital in one year. Do we need to classify our setting as potential ongoing transmission and start testing all of our HCWs every three months?***
Yes, unless it can be proven otherwise, there appears to be evidence of ongoing transmission in this setting. If the HCWs with TST conversions can be linked together in some way, either through a type or location of work, or DNA fingerprinting, then the classification of potential ongoing transmission may apply to one group or part of the setting, rather than the entire setting. In either case, a problem evaluation should be undertaken to ascertain the reason for the TST conversions (Recommendations, Section H. Problem Evaluation). Reasons could range from an undiagnosed case of TB in the

setting to incorrect placement or reading of TSTs. Early consultation with the local health department and an expert in TB infection control might be helpful in identifying and resolving the problem.

3. If a health-care setting has a risk classification of potential ongoing transmission, how long should that classification be applied?

The classification of potential ongoing transmission should be assigned only on a temporary basis and always warrants a problem evaluation (Recommendations, Section H). After resolution of problems, settings with a classification of potential ongoing transmission should return to a medium-risk classification for at least one year.

4. We are a pediatric hospital and sometimes one of the parents with the child is diagnosed with TB disease at the same time that the child is diagnosed. For purposes of calculating the number of patients used to determine healthcare setting risk, do we count the parents with TB disease who are visiting?

No, only patients who were evaluated or treated in the healthcare setting count, not visitors who have TB (unless they were diagnosed at the same setting).

IV. Environmental Controls

1. What is the difference between engineering controls and environmental controls?

"Environmental controls" is a more inclusive term than "engineering controls." Examples of environmental controls are ultraviolet germicidal irradiation (UVGI) and portable air cleaners. Examples of engineering controls are local exhaust ventilation (e.g., booth, hoods, and tents) and general ventilation (including directional airflow, and negative pressure).

2. Is an airborne infection isolation (AII) room the same as a negative-pressure isolation room?

Yes, AII rooms are special negative-pressure rooms for the specific purpose of isolating persons who may have suspected or confirmed TB disease from other parts of the setting. Not all negative-pressure rooms are AII rooms because they might not have the required air flow or differential pressure of an AII room. "AII room" is an accepted term and is used in the American Institutes of Architects (AIA) guidelines that describe the purpose for and details of ventilation of AII rooms.

3. Our TB clinic only treats persons with LTBI. Do we need an AII room and a respiratory protection program?

Ideally, yes. Given the characteristics of patients who receive care in TB clinics (even where only persons with LTBI are treated), this setting poses a potentially high risk for transmission of *M. tuberculosis*. In general, TB clinics should have at least one AII room and a respiratory protection program. An AII room and a respiratory protection program may not be needed if 1) every person treated in the clinic will be adequately screened before admission and determined not to have TB disease, 2) no cough-inducing procedures will ever be performed in the clinic, *and* 3) a system is in place to promptly detect and triage persons who enter the clinic and have symptoms of TB disease.

4. ***Can AII be discontinued for a patient with suspected TB disease who has positive AFB sputum smear results but has a negative nucleic acid amplification test (NAA) for M. tuberculosis?***
Yes, if the presence of inhibitors in the specimen for the NAA test is negative, and dual infection with *M. tuberculosis* and another Mycobacterial species is not clinically suspected, the patient may be released from AII. An NAA test is highly sensitive and specific for the identification of *M. tuberculosis* when performed properly on a patient who has a positive sputum smear result.

5. ***During the winter months at our hospital we do not have enough AII rooms for all of our patients with suspected TB disease. Can we obtain just two negative sputum smears for acid-fast bacilli (AFB) before releasing patients from AII?***
No, the criterion for the release of a patient with suspected infectious TB disease from AII is having three consecutive, negative sputum smear results. Each of the three specimens should be collected 8–24 hours apart (Recommendations, Section D.2) and at least one should be an early morning specimen (because respiratory secretions pool overnight). Generally, this will allow patients with negative sputum smear results to be released from AII in two days. The number of AII rooms in your setting is inadequate; consider adding one or more AII room(s). Before undertaking this expense, however, ensure that the criteria being used to place patients in AII are correct and that the available rooms are not being used for patients in whom infectious TB disease is not suspected. In addition, the following intervals should be reviewed to identify any delays that could be corrected and decrease AII time for patients: time between admission and ordering of sputum specimens for AFB examination; time between ordering and collecting specimens; and time between collection of specimens and receipt of results from the laboratory.

6. ***How many AII rooms are required in a 120-bed hospital?***
The setting's risk assessment will determine how many AII rooms each setting needs, depending on the number of TB patients seen. At least one AII room is needed for settings where TB patients stay while they are being treated, plus one additional AII room for every 200 patient-days of cases of suspected or confirmed TB disease. Additional rooms may be considered if options are limited for transferring patients with suspected or confirmed TB disease to other settings with AII rooms. For a hospital with 120 beds, a minimum of one room is needed, possibly more, depending on how many TB cases are seen in one year.

7. ***Who is responsible for ensuring that negative pressure is achieved in AII rooms?***
Infection control staff at each health-care setting are responsible for ensuring negative pressure is achieved in AII rooms (this responsibility may be delegated to engineering, maintenance or other appropriate staff to perform the actual negative pressure tests). AII rooms should be checked for negative pressure before occupancy by a patient with suspected or confirmed infectious TB disease. When occupied by a patient with suspected or confirmed TB disease, an AII room should be checked daily for negative pressure with smoke tubes or other visual checks.

8. ***What is the difference between VAV and CAV? How do I know what our setting has?***
VAV is variable air volume, and CAV is constant air volume, and the terms refer to how the ventilation system is designed to deliver air to and maintain temperature and relative

humidity control within a room. General ventilation is delivered by either CAV systems or VAV systems. In general, CAV systems are best for AII rooms and other negative-pressure rooms because the negative-pressure differential is easier to maintain. VAV systems are acceptable if provisions are made to maintain the minimum total and outside air changes per hour (ACH) and a negative pressure ≥0.01 inch of water gauge relative to adjacent areas at all times. If uncertain what type of heating, ventilation, and air conditioning (HVAC) system is in your setting, ask your setting's engineer or building manager.

9. Why was the differential pressure requirement for an AII room increased from 0.001 inch of water gauge to ≥0.01 inch of water gauge?

In an ideal, controlled environment, 0.001 inch of water gauge has been shown to ensure negative pressure in an AII room. However, AIA and others have demonstrated that a minimum of 0.01 inch of water gauge is needed in some installations to ensure that negative pressure is consistently achieved.

10. How can a portable HEPA filter unit help control TB?

Portable HEPA filters filtration units recirculate room air and the HEPA filters effectively remove all particles from the air in the size range of droplet nuclei resulting in a dilution of the concentration of infectious particles in the room.

V. Respiratory Protection

1. What is the difference between a NIOSH-certified respirator and a surgical or procedure mask?

Respirators are designed to help reduce the wearer's exposure to airborne particles. The primary purpose of a surgical or procedure mask is to help prevent biological particles from being expelled by the wearer into the environment by patients.

2. How important is the fit of the respirator?

Fit of a respirator is very important. If a respirator does not fit tightly to the face, airborne hazards can penetrate or enter underneath the facepiece seal and into the breathing zone. It is important for the wearer of the respirator to perform a user-seal check on themselves before entering an AII room or a potentially contaminated environment (http://www.cdc.gov/niosh/topics/respirators).

3. What is a respirator fit test and who does fit testing?

Fit testing must be performed by a qualified health professional. A fit test is used to determine which respirator does or does not fit the user adequately and to ensure that the user knows when the respirator fits properly. Perform fit testing during the initial respiratory protection program training and periodically thereafter, based on the risk assessment for the setting, and in accordance with applicable federal, state, or local regulations.

Periodic fit testing for respirators used in TB environments can serve as an effective training tool in conjunction with the content included in employee training and retraining. The frequency of fit testing should also be guided by a change in a) risk of transmission of *M. tuberculosis*, b) facial features of the wearer, c) medical condition that would affect

respiratory function, d) physical characteristics of respirator (despite the same model number), or e) model or size of the assigned respirator.

4. How do I perform a respirator user-seal check?

Performing a user-seal check (formerly called "fit checking") after redonning the respirator each time is important to ensure adequate respiratory protection. The seal checks for respirators are described in the respirator user instructions and should be consulted before using the respirators. In general, the two types of user-seal checks are positive-pressure and negative-pressure checks.

To check positive pressure seal, after donning the respirator, the wearer should cover the surface of the respirator with their hands or with a piece of household plastic film and exhale gently. If air is felt escaping around the facepiece, the respirator should be repositioned and the user-seal check should be performed again. If the wearer does not feel air escaping around the facepiece, the positive pressure user-seal check was successful.

To check negative pressure seal, after donning the respirator, the wearer should gently inhale. This should create a vacuum, causing the respirator to be drawn in slightly toward the face. If the respirator is not drawn in toward the face or you feel air leaking in around the face seal, the respirator should be removed and examined for any defect such as a small hole or poor molding of the respirator to your face (especially around the nose area). If no holes are found, the respirator should be repositioned and readjusted, and a second attempt at negative pressure user-seal check should be made. If the respirator draws in toward the face while the wearer inhales, the negative pressure user-seal check was successful. If the check is not successful, try a new respirator.

5. Is a user-seal check or fit check always necessary to fit check a respirator before each use?

Yes, the term "fit check" has been replaced with "user-seal check." Performing a user-seal check on respirators before each use is important to minimize contaminant leakage into the facepiece. Each respirator manufacturer has a recommended "user-seal check" procedure that should be followed by the user each time the respirator is worn.

6. What kind of respiratory protection should HCWs use when providing care to persons with suspected or confirmed TB disease in the home?

The recommended respiratory protection for HCWs who provide care in the homes of patients with suspected or confirmed infectious TB disease is at least an N95 respirator.

7. What kind of respiratory protection should HCWs use when transporting patients with suspected or confirmed TB disease?

If the setting's risk assessment indicates the need for respiratory protection, drivers or HCWs who are transporting patients with suspected or confirmed infectious TB disease in an enclosed vehicle should wear at least N95 disposable respirators. The risk assessment should consider the potential for shared air. If the patient has signs or symptoms of infectious TB disease (productive cough, or positive AFB sputum smear result), consider having the patient wear a surgical or procedure mask, if possible, during transport, in waiting areas, or when others are present. Patients who cannot tolerate masks because of

medical conditions should observe strict respiratory hygiene and cough etiquette procedures (see Respiratory hygiene and cough etiquette in Glossary).

8. What kind of respiratory protection should be used in the operating room (OR) by HCWs with facial hair or other factors that preclude proper fitting of an N95 respirator? Will wearing a surgical or procedure mask underneath a powered air-purifying respirator (PAPR) solve this problem?

HCWs with facial hair should not wear negative pressure respirators such as N95 disposable respirators that require a tight faceseal. In the OR, HCWs with facial hair who are caring for a person with suspected or confirmed TB disease should consult their infection control committee and respirator manufactures regarding optimal respiratory protection and adequate infection control measures. The HCW in this case could possibly wear a surgical or procedure mask to protect the surgical field underneath a loose-fitting PAPR. However, unless the PAPR's manufacturer tested the PAPR over a surgical or procedure mask or N95 respirator, the user cannot be assured of proper operation. All respiratory protection equipment should be used in accordance with the manufacturer's instructions.

9. Should bacterial filters be used routinely on the breathing circuits of all ventilators and anesthesia equipment on patients with suspected or confirmed TB disease?

Yes, bacterial filters should be used routinely on the exhalation breathing circuits of patients with suspected or confirmed infectious TB disease to prevent exhaled air containing infectious droplet nuclei from contaminating the room air. Filters should be used on mechanical ventilators and also on hand-held ventilating bags (i.e., manual resuscitators, such as ambu-bags®). The bacterial filter should be shown by the manufacturer to filter particles 0.3 μm in size in both the unloaded and the loaded states with a filter efficiency of $\geq$95% (i.e., filter penetration of <5%), at the maximum design flow rates of the ventilator.

10. Who should not wear an N95 respirator?

Any HCW who is restricted from using a respirator due to medical reasons should not wear one, nor should individuals who cannot pass a fit test due to the presence of facial hair or other condition that interferes with the seal of the respirator to the person's face. Visitors may be permitted to wear N95 respirators. They should receive counseling about how to ear it, but they are generally not required by the setting to undergo respirator training or fit testing.

11. How long may I use my respirator for TB exposures before I discard it?

Disposable respirators may be functional for weeks to months and reused by the same HCW. Reuse is limited by considerations of hygiene, damage, breathing resistance, and manufacturers' instructions.

12. Should persons who perform maintenance on and replace filters on any ventilation system that is likely to be contaminated with M. tuberculosis wear a respirator?

Yes, laboratory studies indicate that re-aerosolization of viable mycobacteria from HEPA filters and N95 disposable respirator filter media is unlikely under normal conditions; however, the risks associated with handling loaded HEPA filters in ventilation systems under field-use conditions have not been evaluated. For this reason, persons performing maintenance and replacing filters on any ventilation system that is likely to be

contaminated with *M. tuberculosis* should wear a respirator (Supplement 5) along with local recommendations for eye protection and gloves.

VI. Cough-Inducing and Aerosol-Generating Procedures

1. Should we perform a bronchoscopy on a patient with TB disease?

If possible, bronchoscopy should be avoided in patients with a clinical syndrome consistent with pulmonary or laryngeal TB disease because bronchoscopy substantially increases the risk of transmission either through an airborne route or a contaminated bronchoscope, including in persons with negative AFB sputum smear results. Microscopic examination of three consecutive sputum specimens, obtained 8–24 hours apart, with at least one obtained in the early morning, is recommended instead of bronchoscopy, if possible.

2. For ORs without an AII room, post operative recovery is usually done in the OR suite. Is this acceptable?

Yes, if the OR has an anteroom. Reversible flow rooms (OR or isolation) are not recommended by CDC, AIA or ASHRAE.

SUPPLEMENT 8: TB WEBSITE LINKS

Centers for Disease Control and Prevention (CDC)
http://www.cdc.gov

- Division of Tuberculosis Elimination (DTBE)
  http://www.cdc.gov/tb
  - Major TB Guidelines
    http://www.cdc.gov/nchstp/tb/pubs/mmwrhtml/maj_guide.htm
  - State TB Program Contact Information
    http://www.cdc.gov/nchstp/tb/pubs/tboffices.htm
  - TB Education and Training Resources Web Site
    http://www.findtbresources.org
  - TB Program Web sites
    http://www.cdc.gov/nchstp/tb/tbwebsites.htm
- Division of AIDS, STD, and TB Laboratory Research
  http://www.cdc.gov/ncidid/dastlr/TB/default.htm
- National Center for Infectious Diseases (NCID)
  http://www.cdc.gov/ncid
- National Institute for Occupational Safety and Health (NIOSH)
  http://www.cdc.gov/niosh/homepage.html
  - Respirator information
    http://www.cdc.gov/niosh/npptl/topics/respirators/
  - CDC/NIOSH Certified Equipment List (CEL)
    http://www.cdc.gov/niosh/npptl/topics/respirators/cel/
  - CDC/NIOSH-Approved Disposable Particulate Respirators (Filtering Facepieces)
    www.cdc.gov/niosh/npptl/respirators/disp_part/particlist.html
- Division of Healthcare Quality Promotion
  http://www.cdc.gov/ncidod/hip/enviro/guide.htm
- Emergency Preparedness and Response
  http://www.bt.cdc.gov

Other U.S. Federal Government Web sites

- National Institutes of Health (NIH)
  http://www.nih.gov

- National Heart, Lung, and Blood Institute
  http://www.nhlbi.nih.gov/funding/training/tbaa/index.htm

- National Institute of Allergy and Infectious Diseases (NIAID)
  http://www.niaid.nih.gov/dmid/tuberculosis/

- AIDSinfo
  http://www.aidsinfo.nih.gov/guidelines/

- Occupational Safety and Health Administration (OSHA)
  http://www.osha.gov; www.osha.gov/qna.pdf

  – Tuberculosis (OSHA)
    www.osha.gov/SLTC/tuberculosis/index.html

  – Recordkeeping (OSHA)
    http://www.osha.gov/SLTC/respiratoryprotection/index.html

  – Respiratory Protection (OSHA)
    http://www.osha.gov/recordkeeping

- Ryan White Care Act/Wisconsin HIV/AIDS Program
  http://www.dhfs.state.wi.us/AIDS-HIV/Resources/Overviews/AIDS HIV.htm

- U.S. Food and Drug Administration (FDA)
  http://www.fda.gov

- Safety Information and Adverse Event Reporting System (FDA-AERS)
  http://www.fda.gov/medwatch

- FDA and CDC Public Health Advisory: Infections from Endoscopes Inadequately Reprocessed by an Automated Endoscope Reprocessing System
  http://www.fda.gov/cdrh/safety/endoreprocess.html

National Tuberculosis Model Centers

- Francis J. Curry National Tuberculosis Center, San Francisco, California
  http://www.nationaltbcenter.edu/

- Heartland Regional Training Center, San Antonio, Texas
  http://www.

- New Jersey Medical School National Tuberculosis Center, Newark, New Jersey
  http://www.umdnj.edu/ntbcweb/

- Southeast Regional Training Center, Gainesville, Florida
  http://www.

Organizations

- American Lung Association (ALA)
  http://www.lungusa.org/diseases/lungtb.html

- American Thoracic Society (ATS)
  http://www.thoracic.org

- Association for Professionals in Infection Control and Epidemiology, Inc. (APIC)
  http://www.apic.org

- HIV Drug Interactions Organization
  http://www.hiv-druginteractions.org

- Infectious Disease Society of America/Bioterrorism and Information Resources (IDSA)
  http://www.idsociety.org/bt/toc/htm

- National Prevention Information Network (NPIN)
  http://www.cdcnpin.org/scripts/index.asp

- National TB Controllers Association (NTCA)
  http://www.ntca-tb.org

- PharmWeb: Rapid Screening of Tuberculosis Pharmaceuticals
  http://www.pharmweb.net/pwmirror/library/pharmwebvlib.html

International Organizations

- International Union Against Tuberculosis and Lung Disease (IUATLD)
  http://www.iuatld.org/full_picture/en/frameset/frameset.phtml

- Stop TB Initiative
  http://www.stoptb.org

- Tuberculosis Research Center, India
  http://www.trc-chennai.org

- World Health Organization (WHO) Global TB Program
  http://www.who.int/gtb/

DRAFT

State TB and HIV websites

AL	http://www.adph.org
AK	http://www.epi.alaska.gov
AZ	http://www.hs.state.az.us/phs/oids/tuberculosis/index.htm
CA	http://www.dhs.ca.gov/ps/dcdc/TBCB/tubindex.htm
CO	http://www.cdphe.state.co.us/dc/tb/tbhome.asp
CT	http://www.dph.state.ct.us/
DE	http://www.state.de.us/dhss/dph/dpc/tuberculosis.html
FL	http://www.doh.state.fl.us/disease_ctrl/tb/WorldTBDay/2004/WTD2004main.html
GA	http://www.health.state.ga.us/epi/
HI	http://www.hawaii.gov/doh/resource/comm_dis/tb/index.htm
IA	http://www.idph.state.ia.us/ch/tb_control.asp
IN	http://www.in.gov/isdh/programs/tb
KS	http://www.kdhe.state.ks.us/tb/index.html
KY	http://www.chs.state.ky.us/publichealth/TB.htm
LA	http://www.oph.dhh.state.la.us/tuberculosis/index.html
MA	http://www.state.ma.us/dph/cdc/tb/
MD	http://www.edcp.org/tb/index.html
ME	http://www.maine.gov/dhs/boh/ddc/tuberculosis.htm
MI	http://www.michigantb.org
MN	http://www.health.state.mn.us/tb
MT	http://www.dphhs.state.mt.us
NC	http://www.schs.state.nc.us/epi/tb
ND	http://www.ndmtb.com
NE	http://www.hhs.state.ne.us/cod/Tuberculosis/tbindex.htm
NH	http://www.dhhs.state.nh.us/DHHS/DHHS_SITE/default.htm
NV	http://www.health2k.state.nv.us
NYC	http://www.nyc.gov/html/doh/html/tb/tb.html
OH	http://www.odh.state.oh.us/
OK	http://www.health.state.ok.us
OR	http://www.dhs.state.or.us/publichealth/tb
PA	http://www.dsf.health.state.pa.us
RI	http://www.health.ri.gov/disease/communicable/tb_data.htm
SC	http://www.scdhec.net/hs/diseasecont/tb/html/
SD	http://www.state.sd.us/doh/tb
TN	http://www2.state.tn.us/health/CEDS/index.htm
TX	http://www.tdh.state.tx.us/tb
UT	http://health.utah.gov/els/hivaids/tb/tbrefugee.html
VA	http://www.vdh.virginia.gov/epi/tb
WA	http://www.doh.wa.gov/cfh/tb
WI	http://dhfs.wisconsin.gov/tb
WY	http://www.wdh.state.wy.us/tb
Puerto Rico	http://www.salud.gov.pr

SUPPLEMENT 9: GLOSSARY

Acid-fast-bacilli (AFB) examination: A laboratory test that involves microscopic examination of a stained smear of a patient specimen (usually of sputum) to determine if mycobacteria are present. A presumptive diagnosis of pulmonary TB can be made with a positive AFB sputum smear result; however about half the patients with TB disease of the lungs have negative AFB sputum smear results. The diagnosis of TB disease is usually not confirmed until *M. tuberculosis* is identified in culture. A positive nucleic acid amplification (NAA) test or culture result is needed for confirmation of *M. tuberculosis* complex.

Administrative controls: Managerial measures that reduce the risk for exposure to persons who may have TB disease. Examples include coordinating efforts with the state or local health department, conducting a TB risk assessment of the setting, developing and instituting a written TB infection-control plan to ensure prompt detection, airborne infection isolation (AII), and treatment of persons who may have or confirmed TB disease, and screening and evaluating HCWs who are at risk for TB disease or who might be exposed to *M. tuberculosis* (Introduction, Section D.1).

Aerosol: Aerosols are dispersions of particles in a gaseous medium such as air. Droplet nuclei are an example of particles that are expelled by a person with an infectious disease (e.g., by coughing, sneezing, or singing); for *M. tuberculosis* they are considered to be around 1 to 5 micron in size. Because of their small size, the droplet nuclei can remain suspended in the air for long periods of time and can transmit *M. tuberculosis* to other persons.

Air change rate (equivalent): Ratio of the volumetric air loss rate associated with an environmental control (or combination of controls), such as an air cleaner or UVGI system, divided by the volume of the room where the control has been applied. The equivalent air change rate is useful for describing the rate at which bioaerosols are removed by means other than ventilation. See Equivalent ACH.

Air change rate (mechanical): Ratio of the airflow to the space volume per unit time (normally expressed in air changes per hour [ACH]; Supplement 4, A.3).

Air changes per hour (ACH): Air change rate expressed as the number of air exchange units per hour. See Mechanical ACH and Equivalent ACH.

Air change rate: Ratio of the airflow in volume units per hour to the space volume in identical volume units (normally expressed in air changes per hour [ACH]).

Airborne infection isolation (AII): AII refers to the isolation of patients infected with organisms spread via airborne droplet nuclei <5 µm in diameter. See AII room. This isolation area receives numerous ACH (≥12 ACH for new construction as of 2001; ≥6 ACH for construction before 2001), and is under negative pressure, such that the direction of the air flow is from the outside adjacent space (e.g., the corridor) into the room. The air in an AII room is preferably exhausted to the outside, but may be recirculated provided that the return air is filtered through a high-efficiency particulate air (HEPA) filter.

Airborne infection isolation room (AII room): A room designed to maintain AII. Formerly called negative pressure isolation room, an AII room is a single-occupancy patient-care room

used to isolate persons with suspected or confirmed infectious TB disease. Environmental factors are controlled in AII rooms to minimize the transmission of infectious agents that are usually spread from person to person by droplet nuclei associated with coughing or aerosolization of contaminated fluids. AII rooms should provide negative pressure in the room (so that air flows under the door gap into the room); *and* an air flow rate of 6-12 ACH; *and* direct exhaust of air from the room to the outside of the building or recirculation of air through a HEPA filter.

American Institute of Architects (AIA): Professional organization that develops standards for building ventilation.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE): Professional organization that develops guidelines for building ventilation.

Aminotransferases: Also termed transaminases. Used to assess for hepatotoxicity in persons taking anti-tuberculosis medications and include aspartate aminotransferase (AST) serum glutamic-oxalacetic transaminase (SGOT) and alanine aminotransferase (ALT) serum glutamic-pyruvic transaminase (SGPT).

Anemometer: An instrument used to measure the velocity (speed) of air.

Anergy: A condition in which a person has a diminished ability to exhibit delayed T-cell hypersensitivity to antigens because of a condition or situation resulting in altered immune function. When referring to inability to react to a skin test, the correct term is "cutaneous anergy." Skin tests for anergy (i.e., "control antigens") have poor predictive value and are not recommended.

Anteroom: Small room leading from a corridor into an AII room. It is separated from both the AII room and the corridor by doors. An anteroom can act as an airlock, preventing the escape of contaminants from the AII room into the corridor

Apical: Relating to or located at the tip (an apex).

Assigned Protection Factor (APF): The minimum anticipated protection provided by a properly worn and functioning respirator or class of respirators.

Asymptomatic: Neither causing nor exhibiting signs or symptoms of disease.

Bacille Calmette-Guérin (BCG): A vaccine for TB named after the French scientists Calmette and Guérin. The vaccine is effective in preventing disseminated and meningeal TB disease in infants and young children. It may have approximately 50% efficacy for preventing smear-diagnosed pulmonary TB disease in adults. BCG is used in many other countries where TB disease is endemic.

Baseline TB screening: Screening HCWs for LTBI and TB disease at the beginning of employment. TB screening includes a symptom screen for all HCWs, and TSTs or QFT for those with prior negative test results for *M. tuberculosis* infection.

Baseline TST or baseline QFT: The TST or QFT given at the beginning of employment to newly hired HCWs. If the TST method is used, for HCWs who have not had a documented

negative test for *M. tuberculosis* during the preceding 12 months, the baseline TST result should be obtained by using the two-step method (see Two-step skin testing). QFT baseline testing does not need a two-step method.

Biological safety cabinet (BSC): A ventilated box that provides HCWs with a degree of protection against hazardous aerosols that are generated within it. A BSC is the principal device used to contain infectious splashes or aerosols generated by many microbiology processes. It provides physical barriers and directional airflow to carry hazards away from the HCW. Maintenance is an important part of ensuring of BCS function.

Biosafety in Microbiological and Biomedical Laboratories (BMBL): A publication of the U.S. Public Health Service that describes the combinations of standard and special microbiology practices, safety equipment, and facilities constituting Biosafety Levels (BSL) 1–4, which are recommended for work with a variety of infectious agents in laboratory settings. The recommendations are advisory and intended to provide a voluntary guide or code of practice.

Biosafety level (BSL): Four biosafety levels (BSLs) are described in Section III of Biosafety in Microbiological and Biomedical Laboratories (BMBL), which consist of combinations of laboratory practices and techniques, safety equipment, and laboratory settings.

Blinded independent duplicate reading (BIDR): Two or more consecutive TST readers immediately measure the same TST result by standard procedures (may use suggested procedural observation checklist, Supplement 2, Table 13) without consulting or observing one another's readings and record results independently. BIDRs help ensure TST readers continue to read TST results correctly.

Boosting: When nonspecific or remote sensitivity to tuberculin (PPD in the skin test) wanes or disappears over time, subsequent TSTs can restore the sensitivity. This is called “boosting” or the “booster phenomenon.” An initially small TST reaction size is followed by a larger reaction size on a later test, and this can be confused with a “conversion” or a recent *M. tuberculosis* infection. Two-step testing is used to distinguish new infections from boosted reactions in infection-control surveillance programs. See Two-step skin testing.

Bronchoscopy: A procedure for examining the lower respiratory tract. It requires inserting the end of the endoscopic instrument through the mouth or nose (or tracheostomy) and into the respiratory tree. It can be used to obtain diagnostic specimens. Bronchoscopy also creates a high risk of *M. tuberculosis* transmission to HCWs if it is done on a patient who has TB disease (even if the patient has negative AFB smear results), because it is a cough-inducing procedure.

Case: A particular instance of a disease (e.g., TB). A case is detected, documented, and reported.

CAV: See Constant air volume.

Cavity (pulmonary): A hole in the lung parenchyma, usually not involving the pleural space. Although a lung cavity can develop from many causes, and its appearance is similar regardless of its cause, in pulmonary TB disease cavitation results from the destruction of pulmonary tissue by direct bacterial invasion and an immune interaction triggered by *M. tuberculosis*. A tuberculous cavity large enough to see with a normal chest radiograph predicts infectiousness.

Chest x-ray: See Radiography.

Clinical examination: An in-person evaluation of the clinical status of a patient by a physician or equivalent practitioner.

Close contact (TB): A person who has shared the same air space in a household or other enclosed environment for a prolonged period of time (days or weeks, not minutes or hours) with a person with suspected or confirmed TB disease. Close contacts have also been referred to as "high-priority contacts" since they have the highest risk for infection with *M. tuberculosis.*

Cluster (TB): A group of patients with LTBI or TB disease that are linked by epidemiologic, location, or genotyping data. Two or more TST conversions within a short period of time can be a cluster of TB disease, and may suggest transmission within the setting. A genotyping cluster is two or more cases whose isolates have an identical genotyping pattern.

Combination product surgical mask/N95 disposable respirator: Product certified by CDC/NIOSH and cleared by FDA that provides both respiratory protection and bloodborne pathogen protection.

Conditionally positive QFT result: *M. tuberculosis* infection likely if risk identified but not likely for low-risk individuals.

Constant air volume (CAV): A descriptor for an air-handling system which, as the name implies, supplies and exhausts air at a constant flow rate. The flow rate does not change over time based on temperature load or other parameters.

Contact (TB): Refers to someone who was exposed to *M. tuberculosis* infection by sharing air space with an infectious TB patient. See Contact investigation.

Contact investigation: Procedures that occur when a case of infectious TB is identified, including identification of people (contacts) exposed to the case, testing and evaluation of contacts to identify LTBI or TB disease, and treatment of these individuals, as indicated.

Contagious: Describes a characteristic of a disease that can be transmitted from one living being to another through direct contact or indirect contact; communicable. The agent responsible for the contagious character of a disease is also described as being "infectious", the usual culprits being microorganisms.

Contraindication: Any condition, especially any condition of disease, which renders some particular line of treatment improper or undesirable.

Conversion: See TST conversion.

Conversion rate: The percentage of a population with a converted test result (TST or QFT) for *M. tuberculosis* within a specified time period. This is calculated by dividing the number of conversions among eligible HCWs in the setting in a specified period of time (numerator) by the number of HCWs who received tests in the setting over the same period of time (denominator) multiplied by 100.

Culture: Growth of microorganisms in the laboratory performed for detection and identification in sputum or other body fluids. This test usually takes 2–4 weeks for mycobacteria (2–4 days for most other bacteria).

Cough etiquette: See Respiratory hygiene.

Cross contamination: When organisms from one sample are introduced into another sample causing a false-positive result.

Delayed-type hypersensitivity (DTH): Cell-mediated inflammatory reaction to an antigen, which is recognized by the immune system, usually because of previous exposure to the same antigen or similar ones. Cell-mediated reactions are contrasted with an antibody (or humoral) response. DTH typically peaks at 48–72 hours after exposure to the antigen.

Differential pressure: A measurable difference in air pressure that creates a directional airflow between adjacent compartmentalized spaces.

Directly observed therapy (DOT): Adherence-enhancing strategy in which a HCW or other trained person watches a patient swallow each dose of medication and is accountable to the public health system. DOT is the preferred care for all patients with TB disease, and is a preferred option for patients treated for LTBI.

Disposable respirator: A respirator that is meant to be used and then discarded, also known as a filtering-facepiece respirator. Respirators should be discarded after excessive resistance, physical damage or hygiene considerations.

DNA fingerprinting: Deoxyribonucleic acid (DNA) fingerprinting is a clinical laboratory technique used to distinguish between different strains of *M. tuberculosis* and to help assess the likelihood of TB transmission.

Droplet nuclei: Microscopic particles produced when a person coughs, sneezes, shouts, or sings. These particles can remain suspended in the air for prolonged periods of time, and can be carried on normal air currents in the room and beyond to adjacent spaces or areas receiving exhaust air.

Drug-susceptibility test: A laboratory determination to assess whether an *M. tuberculosis complex* isolate is susceptible or resistant to anti-tuberculosis drugs that are added to mycobacterial growth medium. The results predict whether a specific drug is likely to be effective in treating TB disease caused by that isolate.

Effusion: See Pleural effusion.

Enabler: A practical item given to a patient for making adherence (e.g., to treatment or to clinic appointments) easier.

Environmental control measures: Physical or mechanical measures (as opposed to administrative control measures) used to reduce the risk for transmission of *M. tuberculosis*. Examples include ventilation, filtration, ultraviolet lamps, AII rooms, and local exhaust ventilation devices (Introduction, Section D.2).

Epidemiologic cluster: Closely grouped series of cases in time or place.

Equivalent ACH: Rate of removal or inactivation of airborne microorganisms related to air change rate.

Erythema: Abnormal redness of the skin. Erythema may develop around a tuberculin skin test (TST) site, but should not be read as part of the TST result.

Expert TST trainer: A qualified HCW who has received training on placing and reading multiple TST results.

Exposed cohorts: Groups of people (e.g., family members, co-workers, friends, club, team or choir members, people in correctional facilities, or homeless shelter residents) who shared the same air space with the suspected case patient with TB disease during the infectious period. A person in the exposed cohort is a contact. See Contact and Close contact.

Exposure: The condition of being subjected to something (e.g., an infectious agent) that could have an effect. A person exposed to *M. tuberculosis* does not necessarily become infected. See Transmission.

Exposure period: The coincident period when a contact shared the same air space the index TB case during the infectious period.

Exposure site: A location that the index patient visited during the infectious period; for example, a school, a bar, a bus, or a residence.

Extrapulmonary TB: TB disease in any part of the body other than the lungs (e.g., the kidney, spine, or lymph nodes.) The presence of extrapulmonary disease does not exclude pulmonary TB disease.

False-negative TST or QFT result: A TST or QFT result that is interpreted as negative in a person who is actually infected with *M. tuberculosis*.

False-positive TST or QFT result: A TST or QFT result that is interpreted as positive in a person who is not actually infected with *M. tuberculosis*. This is more likely to occur in persons who have been vaccinated with BCG or who are infected with nontuberculous mycobacteria (NTM).

Facility: A physical building or set of buildings.

Filtering facepiece respirator: A type of air purifying respirator which uses a filter as an integral part of the facepiece or with the entire facepiece composed of the filtering medium.

Fit check: See User-seal check.

Fit factor: A quantitative estimate of the fit of a particular respirator to a specific individual, and typically estimates the ratio of the concentration of a substance in ambient air to its concentration inside the respirator when worn.

Fit test: The use of a protocol to qualitatively or quantitatively evaluate the fit of a respirator on an individual. (See also Qualitative fit test QLFT and Quantitative fit test QNFT.)

Flutter strips: Physical indicators used to provide a continuous visual sign that a room is under negative pressure. These simple and inexpensive devices are placed directly in the door and can be useful in identifying a pressure differential problem.

Health-care–associated: Acquired in a hospital or health-care setting. The term "health care–associated" is used instead of "nosocomial" in this text.

Health-care setting: A place where healthcare is delivered.

Health-care workers (HCWs): All paid and unpaid persons working in health-care settings.

Heating, ventilation, air conditioning (HVAC): Mechanical systems that provide either collectively or individually, heating, ventilating, or air conditioning for comfort within or associated with a building.

High-efficiency particulate air (HEPA) filter: A filter that is certified to remove > 99.97% of particles 0.3 microns in size, including *M. tuberculosis* containing droplet nuclei may be either portable or stationary. Use of HEPA filters in building ventilation systems requires expertise in installation and maintenance.

High-pressure liquid chromatography (HPLC): Laboratory method used to identify *Mycobacterium* species by analysis of species-specific fatty acids called mycolic acids present in the cell walls of mycobacteria.

HIV infection: Infection with the human immunodeficiency virus (HIV), the virus that causes AIDS (acquired immunodeficiency syndrome). A person with both LTBI and HIV infection is at high risk for developing TB disease.

Hemoptysis: The expectoration or coughing up of blood or blood-tinged sputum; one of the symptoms of pulmonary TB disease. Hemoptysis can also be seen in other pulmonary conditions such as lung cancer.

Hypersensitivity: A state in which the body reacts with an exaggerated immune response to a foreign substance. Hypersensitivity reactions are classified as immediate or delayed, types I and IV, respectively. See Delayed-type hypersensitivity.

Immunocompromised and immunosuppressed: Conditions in which at least part of the immune system is functioning at less than normal capacity. According to some style experts, "immunocompromised" is the broader term, and "immunosuppressed" is restricted to conditions with iatrogenic causes, including treatments for another condition.

Incentive: A gift given to patients to encourage or acknowledge their adherence to treatment.

Incidence: The number of new events or cases of disease that develop during a specified time period.

Index case: The first person with TB disease who is identified in a particular setting and who The may be an indicator of a potential public health problem. See Source case.

Induration: The firmness in the skin test reaction. It is produced by immune-cell infiltration in response to the tuberculin antigen which was introduced into the skin. It is measured by palpation transversely, and the result is recorded in millimeters (mm). The measurement is compared to guidelines in order to determine whether the test result is classified as positive or negative.

Infection with *M. tuberculosis*: The term used for persons with positive TST results, negative bacteriologic studies (if done), and no clinical or radiographic evidence of TB disease. In most people who inhale TB bacteria and become infected, the body is able to fight the bacteria to stop the bacteria from growing. Infection with *M. tuberculosis* may or may not progress to TB disease. The bacteria are inactive, but they remain alive in the body and can become active later. See Latent TB infection (LTBI) and Reinfection.

Infectious: See Contagious.

Infectious droplet nuclei: Droplet nuclei produced by an infectious TB patient that can carry tubercle bacteria and be inhaled by others. Although usually produced from patients with pulmonary TB through coughing, aerosol-generating procedures can also generate infectious droplet nuclei.

Infectious period: The time period during which a person with TB disease may have transmitted *M. tuberculosis* organisms to others.

> *For patients with positive AFB sputum smear results* the infectious period begins three months before the collection date of the first positive smear result or the symptom onset date (whichever is earlier) and ends when the patient is placed into AII or the date of collection for the first of consistently negative smear results.
>
> *For patients with negative AFB sputum smear results* the infectious period extends from one month before the symptom onset date and ends when the patient was placed into AII (whichever was earlier).

Isoniazid (INH): A highly active anti-tuberculosis chemotherapeutic agent which is a cornerstone of treatment for TB disease and the cornerstone of treatment for latent infection.

Laryngeal TB: A form of TB disease involving the larynx that can be highly infectious.

Latent TB infection (LTBI): Infection with *M. tuberculosis* and no signs of disease. See Infection.

Manometer: An instrument used to measure pressure differentials (i.e., pressure inside an AII room relative to the corridor of the room).

Mantoux method: Skin test done by intradermally injecting 0.1 ml of PPD tuberculin solution into the volar or dorsal surface of the forearm. This is the recommended method for tuberculin skin testing.

Mask: A device worn over the nose and mouth of a person with suspected or confirmed infectious TB disease to prevent infectious particles from being released into room air.

Mechanical ACH: Air change rate based on only the mechanical ventilation flowrates.

Medical evaluation: An examination to diagnose TB disease or LTBI, to select treatment, and to assess response to therapy. A medical evaluation may include the following:

- Medical history and TB symptom screen
- Clinical or physical examination
- Screening and diagnostic tests (such as TSTs, chest radiographs, bacteriological examination, and HIV testing)
- Counseling
- Treatment referrals

Meningeal TB: A serious form of TB disease involving the meningies, the covering of brain. Meningeal TB can result in serious neurologic complications.

Miliary TB: A serious form of TB disease sometimes referred to as "disseminated TB." A dangerous, and difficult to diagnose, form of rapidly progressing TB disease that extends throughout the body. Uniformly fatal if untreated, sometimes it is diagnosed too late to save a life. Some patients with this condition have normal findings or ordinary infiltrates on the chest radiograph.

Mitogen: A substance that stimulates the growth of certain white blood cells. Mitogen is used as a positive control assay in QuantiFERON®-TB (QFT) tests.

MOTT: See Nontuberculous mycobacteria (NTM).

Multidrug-resistant tuberculosis (MDR TB): TB disease caused by *M. tuberculosis* organisms that are resistant to at least isoniazid and rifampin.

***Mycobacterium tuberculosis* (*M. tuberculosis*):** The namesake member organism of *M. tuberculosis complex*, and the most common causative infectious agent of TB disease in humans. Sometimes, the species name refers to the entire *M. tuberculosis complex*, which includes *M. bovis* and three other related species.

***Mycobacterium (M.) tuberculosis* culture:** A laboratory test to determine the presence of *M. tuberculosis.* In the absence of cross contamination, a positive culture confirms the diagnosis of TB disease.

***Mycobacterium (M.) tuberculosis* infection test conversion rate:** The percentage of a population (e.g., HCWs) that has converted their test result (TST or QFT) from negative to positive within a specified time period. This is calculated by dividing the number of *M. tuberculosis* infection test conversions among HCWs in the setting in a specified period of time (numerator) by the number of HCWs who received tests in the setting over the same period of time (denominator) multiplied by 100.

N95 disposable respirator: Air-purifying, filtering facepiece respirators that are at least 95% efficient at removing 0.3 micron particles and are not resistant to oil. See Respirator.

Negative pressure: The difference in air-pressure between two areas. A room that is under negative pressure has a lower pressure than adjacent areas, which keeps air from flowing out of the room and into adjacent rooms or areas. See AII and AII room. Also used to describe a non-powered respirator.

Nontuberculous mycobacteria (NTM): Refers to mycobacterium species other than those included as part of *Mycobacterium tuberculosis complex.* Although valid from a laboratory perspective, the term can be misleading because certain types of NTM cause disease with pathological and clinical manifestations similar to TB disease. Another term for NTM is mycobacteria other than tuberculosis (MOTT). NTM are environmental mycobacteria.

Nosocomial: Acquired in a hospital. The term "health care–associated" is used in this text.

NTM: See Nontuberculus mycobacteria.

Nucleic acid amplification (NAA): Laboratory method used to target and amplify a single DNA or RNA sequence for detecting and identifying (usually) a microorganism. The NAA tests for *M. tuberculosis* complex are sensitive and specific, and they can accelerate the confirmation of pulmonary TB disease.

Periodic fit testing: Repetition of fit testing done in accordance with Federal, state and local regulations. Additional fit testing should be used whenever a new model of respirator is used, whenever a physical characteristic of the user changes, or if the user or respiratory program administrator is uncertain that the HCW is obtaining an adequate fit.

Pleural effusion: Abnormal accumulation of fluid between the lining of the lung and the chest wall. Persons with tuberculous pleural effusions may also have concurrent unsuspected pulmonary or laryngeal TB disease. These patients should be considered contagious until infectious TB disease is excluded.

Polymerase chain reaction (PCR): A system for in vitro amplification of DNA that can be used for diagnosis of infections.

Positive predictive value: The positive-predictive value of a TST is the probability that a person with a positive TST result is actually infected with *M. tuberculosis.* The positive predictive value is dependent on the prevalence of infection with *M. tuberculosis* in the population being tested, the sensitivity, and the specificity of the test.

Potential ongoing transmission: A risk classification for TB screening, including testing for *M. tuberculosis* infection when evidence of ongoing transmission of *M. tuberculosis* is apparent in the setting. Testing may need to be performed every 8–10 weeks until lapses in infection controls have been corrected and no further evidence of ongoing transmission is apparent. Use *potential ongoing transmission* as a temporary risk classification only. After corrective steps are taken, reclassify the setting as *medium risk.* It is recommended to maintain the classification of *medium risk* for at least one year.

Powered air-purifying respirator (PAPR): A respirator equipped with a tight-fitting facepiece (rubber facepiece) or loose-fitting facepiece (hood or helmet), breathing tube, air-purifying filter,

cartridge or canister, and a fan. Air is drawn through the air-purifying element and pushed through the breathing tube and into the facepiece, hood, or helmet by the fan (Supplement 5). Loose-fitting PAPRs (e.g., hoods or helmets) may be useful for people with facial hair since they do not require a tight seal with the face.

Prevalence: The proportion of individuals in a population who have a disease at a specific time.

Protection factor: General term for three specific terms: Assigned Protection Factor (APF), Simulated Workplace Protection Factor (SWPF), and Workplace Protection Factor (WPF) that refer to different means of defining adequacy of respirator fit. See APF, SWPF, and WPF.

Pulmonary TB: Disease that occurs in the lung parenchyma, usually producing a cough that lasts ≥3 weeks.

Purified protein derivative (PPD) tuberculin: A material used in diagnostic tests for detection of infection with *M. tuberculosis*. In the United States, PPD solution (5 TU per 0.1 ml) is approved for administration as an intradermal injection, as a diagnostic aid for LTBI. In addition, PPD tuberculin was one of the antigens in the first-generation QFT. See Tuberculin skin test (TST).

QFT converter: A change from a negative to a positive QFT result over a two-year period.

Qualitative fit test (QLFT): A pass / fail fit test to assess the adequacy of respirator fit that relies on the individual's response to the test agent.

Quality control (QC): A function to ensure that project tools and procedures are reviewed and verified according to project standards.

QuantiFERON®-TB test (QFT): An *in vitro* cytokine assay that detects cell-mediated immune response (see also "DTH") to *M. tuberculosis* in heparinized whole blood from venipuncture. This test requires only a single patient encounter, and the result can be ready within one day. In 2005, QuantiFERON®-TB is being replaced by QuantiFERON®-TB Gold, which has greater specificity because of its synthetic antigens. QuantiFERON®-TB Gold appears capable of distinguishing between the sensitization caused by *M. tuberculosis* infection and that caused by BCG vaccination.

Quantitative fit test (QNFT): An assessment of the adequacy of respirator fit by numerically measuring the amount of leakage into the respirator.

Recirculation: Ventilation in which all or most of the air exhausted from an area is returned to the same area or other areas of the setting.

Recommended exposure limit (REL): Occupational exposure limit established by CDC's National Institute for Occupational Safety and Health (CDC/NIOSH). RELs are intended to suggest levels of exposure to which most HCWs can be exposed without experiencing adverse health effects.

Reinfection: A second infection that follows recovery from a previous infection by the same causative agent. Often used when referring to an episode of TB disease resulting from a subsequent infection with *M. tuberculosis.*

Resistance: Ability of some strains of mycobacteria, including *M. tuberculosis*, to grow and multiply in the presence of certain drugs that ordinarily kill or suppress them. Such strains are referred to as drug-resistant strains and cause drug-resistant TB disease. See Multidrug resistant TB.

Respirator: A CDC/NIOSH-approved device worn to prevent inhalation of airborne contaminants.

Respiratory hygiene and cough etiquette: Procedures by which patients with suspected or confirmed infectious TB disease can minimize the spread of infectious droplet nuclei by decreasing the number of infectious particles that are released into the environment. Patients with a cough should be instructed to turn their heads away from people and cover their mouth and nose with their hands or preferably a cloth or tissue when coughing or sneezing.

Respiratory protection: The third level in the hierarchy of TB infection-control measures after administrative and environmental controls (Introduction, Section D.3).

Restriction fragment length polymorphism (RFLP): A technique by which organisms may be differentiated by analysis of patterns derived from cleavage of their DNA. The similarity of the patterns generated can be used to differentiate strains one another.

Reversion: A subsequent TST result which is appreciably smaller than a previous test; reversion has been observed to be more likely when the intervening time between TSTs increases.

Screening (TB): Measures used to identify persons who have TB disease or LTBI. See Symptom screen.

Secondary (TB) case: A new case of TB disease that is attributed to recent transmission as part of the scenario under investigation. The time period for "recent" is not defined, but in practical terms usually will be briefer than two years. Technically, all cases are secondary, in the sense that they arise from other contagious cases.

Simulated Workplace Protection Factor (SWPF): A surrogate measure of the workplace protection provided by a respirator.

Smear (AFB smear): Laboratory technique for preparing a specimen so that bacteria can be visualized microscopically. Material from the specimen is spread onto a glass slide (and usually dried and stained). Smear, stain, and microscopy methods for mycobacteria are specific to this genus. The slide can scanned by light or fluorescent high-power microscopy. These methods require ongoing quality assurance for prompt and reliable results. The results for sputum smears usually are reported as numbers of acid-fast bacilli (AFB) per high-powered microscopy field, or else as a graded result, from "no AFB" to "4+ AFB." The quantity of stained organisms predicts infectiousness. See acid-fast bacilli (AFB).

Source case or patient: The case, or the person, that was the original source of infection for secondary cases or contacts. The source case can be, but is not necessarily, the index case.

Source case investigation: An investigation to determine the source case could be conducted in at least two circumstances: when a health-care setting detects an unexplained cluster of TST conversions among HCWs or when a young child is diagnosed with TB infection or disease. The purposes of a source case investigation are to ascertain that the source case has been diagnosed and treated, to prevent further *M. tuberculosis* transmission, and to ensure that other contacts of that source case are also evaluated and, if indicated, provided treatment.

Source control: Source control is a process for preventing or minimizing emission (e.g., aerosolized *M. tuberculosis*) at the place of origin Examples of source control methods are booths in which a patient coughs and produces sputum, biological safety cabinets (see BSC) in laboratories, and local exhaust ventilation.

Spirometry: A procedure to measure the volume of air entering and leaving the lungs.

Sputum: Mucus containing secretions coughed up from within the lungs. Tests of sputum (e.g., smear and culture) can confirm pulmonary TB disease. Sputum is different from saliva or nasal secretions, which are unsatisfactory specimens for detecting TB disease. However, specimens suspected to be inadequate should still be processed because positive culture results can still be obtained and may be the only bacteriologic indication of disease.

Sputum induction: Method used to obtain sputum from a patient who is unable to cough up a specimen spontaneously. The patient inhales a saline mist, which stimulates coughing from deep within the lungs.

Supervised TST administration: Procedure in which an expert TST trainer supervises a TST trainee who performs all procedures on the procedural observation checklist for administering TSTs (Supplement 2, Table 10 and Table 13).

Supervised TST reading: Procedure in which an expert TST trainer supervises a TST trainee who performs all procedures on the procedural observation checklist for reading TST results (Supplement 2, Table 10 and Table 13).

Suspected TB: A tentative diagnosis of TB that will be confirmed or excluded by subsequent testing. Cases should not remain in this category for longer than 3 months.

Symptomatic: A term applied to a patient with health-related complaints (symptoms) that may indicate the presence of disease. Sometimes the term is applied to a medical condition (e.g., "symptomatic pulmonary TB").

Symptom screen: A symptom screen is a procedure used during a clinical evaluation in which the patient is asked if they have experienced any signs or symptoms of TB disease.

Targeted testing: A strategy to focus testing for infection with *M. tuberculosis* in persons at high risk for LTBI and those at high risk for progression to TB disease if infected.

TB case: A particular episode of clinical TB disease. This term refers only to the disease, not to the person with the disease. According to local laws and regulation, TB cases and suspect TB cases must be reported to the state or local health department.

TB contact: A person who has shared the same air space with a person who has TB disease for a sufficient amount of time to allow possible transmission of *M. tuberculosis*.

TB disease: A clinical condition caused by bacteria called *Mycobacterium tuberculosis (M. tuberculosis).* The bacteria can attack any part of your body, but disease is most commonly found in the lungs. TB disease, including pulmonary disease, may or may not be infectious.

TB exposure incident: A situation in which persons (e.g., HCWs, visitors, inmates) have been exposed to an individual with suspected or confirmed infectious TB disease (or to air containing *M. tuberculosis)* without the benefit of effective infection control measures.

TB infection: See Latent TB infection (LTBI).

TB infection-control program: A program to control transmission of *M. tuberculosis* through early detection, isolation, and treatment of persons with infectious TB through a hierarchy of control measures, including use of 1) administrative controls to reduce the risk for exposure to persons with infectious TB disease and screen HCWs for LTBI and TB disease; 2) environmental controls to prevent the spread and reduce the concentration of infectious droplet nuclei in the air; and 3) respiratory protection in areas where the risk for exposure to *M. tuberculosis* is high, such as in AII rooms. A TB infection-control plan should include surveillance of HCWs who have unprotected high-risk exposure to TB patients or their environment of care.

TB screening: An administrative control measure that performs evaluation for LTBI and TB disease through initial and serial screening of HCWs as indicated. Evaluation may consist of TST, QFT, chest radiograph, and symptom screening. See Symptom screen.

TB screening program: A plan that healthcare settings should implement to provide information that is important in caring for individual HCWs and information that facilitates detection of *M. tuberculosis* transmission. The TB screening program consists of four main components, 1) baseline testing for *M. tuberculosis* infection, 2) serial testing for *M. tuberculosis* infection, 3) serial screening for signs or symptoms of TB disease, and 4) TB training and education.

TB risk assessment: An initial and ongoing evaluation of the risk for transmission of *M. tuberculosis* in a particular health-care setting. A risk assessment considers factors such as the community rate of TB, number of TB patients encountered in the setting, and the speed with which patients with TB disease are suspected, isolated, and evaluated. The TB risk assessment determines the types of administrative and environmental controls and respiratory protection needed for a setting.

TB skin test: See Tuberculin skin test.

Treatment for latent TB infection (LTBI): Treatment that prevents the progression of infection into disease.

TST: See Tuberculin skin test.

TST conversion: A change in the result of a test for *M. tuberculosis* infection that that is interpreted to indicate going from uninfected to infected. An increase of ≥10 mm in induration over a maximum of two years is defined as a TST conversion for the purposes of a contact investigation. A TST conversion is presumptive evidence of new *M. tuberculosis* infection and poses an increased risk for progression to TB disease.

Tubercle bacilli: *M. tuberculosis* organisms.

Tuberculin: A precipitate made from a sterile filtrate of *M. tuberculosis* culture medium.

Tuberculin skin test (TST): A diagnostic aid for finding *M. tuberculosis* infection. A small dose of tuberculin is injected just beneath the surface of the skin by the Mantoux method, and the area is examined for induration by palpation 48–72 hours after the injection. The indurated margins should be read transverse (perpendicular) to the long axis of the forearm. See Mantoux method and PPD.

Tuberculin skin test conversion: See "conversion."

Tuberculosis (TB): Clinically active, symptomatic disease caused by infection with a member the *M. tuberculosis* complex.

Two-step (tuberculin) skin test: Procedure used for the baseline skin testing of persons who will periodically receive TSTs (e.g., HCWs or residents of long-term care facilities) to reduce the likelihood of mistaking a boosted reaction for a new infection. If an initial TST result is classified as negative, a second test is repeated 1–3 weeks later. If the reaction to the second TST is positive, it probably represents a boosted reaction, indicating infection was most likely in the past and not recently. If the second TST result is also negative, the person is classified as not infected. Two-step skin testing has no place in contact investigations or in other circumstances where ongoing transmission of *M. tuberculosis* is suspected.

Tumor necrosis factor-alpha (TNF-α): A small molecule discovered in the blood of animals (and humans) with tumors, but which has subsequently been show to be an important host mediator of infection and inflammation. TNF-α is released when humans are exposed to bacterial products (such as lipopolysaccharide) or Bacille Calmette-Guerin. Drugs (agents) which block human TNF-α have been show to increase the risk of progression to TB disease in persons who are latently infected.

Ultraviolet germicidal irradiation (UVGI): Use of ultraviolet radiation to kill or inactivate microorganisms.

Ultraviolet germicidal irradiation (UVGI) lamp: An environmental control measure that includes a lamp that kills or inactivates microorganisms by emitting ultraviolet germicidal radiation, predominantly at a wavelength of 254 nm (intermediate light waves between visible light and x-rays). UVGI lamps can be used in ceiling or wall fixtures or within air ducts of ventilation systems as an adjunct other environmental control measures.

User-seal check: Formerly called "fit check," procedure performed after every respirator donning to check for proper seal of the respirator the wearers face

Variable air volume (VAV): VAV ventilation systems are designed to vary the quantity of air delivered to a space while maintaining a constant supply air temperature to achieve the desired temperature in the occupied space. Minimum levels are mechanical and outside air are maintained.

Wheal: Small bump that is produced when a TST is administered. The wheal disappears about ten minutes after TST placement.

Workplace protection factor (WPF): A measure of the protection provided in the workplace by a properly functioning respirator when correctly worn and used.

SUPPLEMENT 10: GLOSSARY OF ABBREVIATIONS

ACET	Advisory Council for the Elimination of Tuberculosis
ACGIH	American Conference of Governmental Industrial Hygienists
ACH	Air changes per hour
ACOG	American College of Obstetricians and Gynecologists
AERS	Adverse event reporting system
AFB	Acid-fast bacilli
AIA	American Institute of Architects
AIDS	Acquired immunodeficiency syndrome
AII	Airborne infection isolation
ALA	American Lung Association
ALT	Alanine aminotransferase
ANSI	American National Standards Institute
APF	Assigned Protection Factor
APIC	Association for Professionals in Infection Control and Epidemiology, Inc.
ART	Antiretroviral therapy
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
AST	Aspartate aminotransferase
ATS	American Thoracic Society
BCG	Bacille Calmette-Guérin
BIDR	Blinded independent duplicate reading
BMBL	Biosafety in Microbiological and Biomedical Laboratories
BSL	Biosafety level
BSC	Biological safety cabinet
CAV	Constant air volume
CDC	Centers for Disease Control and Prevention
CEL	Certified equipment list
CFM	Cubic feet per minute
CFR	Code of Federal Regulations
CoV	Corona virus
CPL	Compliance policy directive
CRT	Counseling, referral, and testing
CT	Computed tomography
DHHS	U.S. Department of Health and Human Services
DNA	Deoxyribonucleic acid
DTBE	Division of Tuberculosis Elimination
DOP	Dioctyl phthalate
DOT	Directly observed therapy
DTH	Delayed-type hypertensity
ED	Emergency department
ELISA	Enzyme-linked immunosorbent assay
EMS	Emergency medical service
EPA	Environmental Protection Agency
ESRD	End-stage renal disease
ETL	Electrical Testing Laboratories
FDA	U.S. Food and Drug Administration
FPM	Feet per minute
HAART	Highly active antiretroviral therapy

HCW	Health-care worker
HEPA	High-efficiency particulate air
HIV	Human immunodeficiency virus
HMO	Health maintenance organization
HPLC	High-pressure liquid chromatograph
HVAC	Heating, ventilation, air conditioning
ICU	Intensive care unit
IDSA	Infectious Disease Society of America
IM	Intra-muscular
INH	Isoniazid
IOM	Institute of Medicine
IUATLD	International Union Against Tuberculosis and Lung Disease
JCAHO	Joint Commission on Accreditation of Healthcare Organizations
LTBI	Latent tuberculosis infection
MDR TB	Multidrug-resistant tuberculosis
MOTT	Mycobacterium other than tuberculosis
MTC	Mycobacterium tuberculosis complex
NAA	Nucleic acid amplification
NCID	National Center for Infectious Diseases
NIAID	National Institute of Allergy and Infectious Diseases
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety and Health
NM	Nanometer
NNRTI	Nonnucleoside reverse transcriptase inhibitors
NPIN	National Prevention Information Network
NTCA	National TB Controllers Association
NTM	Nontuberculous mycobacteria
OR	Operating room
OSHA	Occupational Safety and Health Administration
PAPR	Powered air-purifying respirator
PCR	Polymerase chain reaction
PE	Protective environment
PET	Permissible exposure time
PI	Protease inhibitor
PPD	Purified protein derivative
PPE	Personal protective equipment
QC	Quality control
QFT	Currently available QuantiFERON® test
QLFT	Qualitative fit test
QNFT	Quantitative fit test
REL	Recommended exposure limit
RFLP	Restriction fragment length polymorphism
RNA	Ribonucleic acid
RZ	Rifampin and pyrazinamide
SARS	Severe acute respiratory syndrome
SES	Socioeconomic status
SGOT	Serum glutamic-oxalacetic transaminase
SGPT	Serum glutamic-pyruvic transaminase
SPF	Solar-protection factor

SWPF	Simulated workplace protection factor
TB	Tuberculosis
TNF-α	Tumour necrosis factor-alpha
TU	Tuberculin unit
TST	Tuberculin skin test
UL	Underwriters laboratories
UV	Ultraviolet
UVGI	Ultraviolet germicidal irradiation
VCT	Voluntary counseling and testing
WHO	World Health Organization
WPF	Workplace protection factor

Acknowledgements

Drafts of this document have been reviewed by leaders of numerous medical, scientific, public health and labor organizations and others expert in tuberculosis, acquired immunodeficiency syndrome, infection control, hospital epidemiology, microbiology, ventilation, industrial hygiene, nursing, dental practice, or emergency medical services. We thank the many organizations and individuals for their thoughtful comments, suggestions, and assistance.

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