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Guidelines for Preventing the Transmission of Tuberculosis in Health-Care Settings, with Special Focus on HIV-Related Issues

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Summary

The transmission of tuberculosis is a recognized risk in health-care settings. Several recent outbreaks of tuberculosis in health-care settings, including outbreaks involving multidrug-resistant strains of Mycobacterium tuberculosis, have heightened concern about nosocomial transmission. In addition, increases in tuberculosis cases in many areas are related to the high risk of tuberculosis among persons infected with the human immunodeficiency virus (HIV). Transmission of tuberculosis to persons with HIV infection is of particular concern because they are at high risk of developing active tuberculosis if infected. Health-care workers should be particularly alert to the need for preventing tuberculosis transmission in settings in which persons with HIV infection receive care, especially settings in which cough-inducing procedures (e.g., sputum induction and aerosolized pentamidine (AP) treatments) are being performed.

Transmission is most likely to occur from patients with unrecognized pulmonary or laryngeal tuberculosis who are not on effective antituberculosis therapy and have not been placed in tuberculosis (acid-fast bacilli (AFB)) isolation. Health-care facilities in which persons at high risk for tuberculosis work or receive care should periodically review their tuberculosis policies and procedures, and determine the actions necessary to minimize the risk of tuberculosis transmission in their particular settings.

The prevention of tuberculosis transmission in health-care settings requires that all of the following basic approaches be used: a) prevention of the generation of infectious airborne particles (droplet nuclei) by early identification and treatment of persons with tuberculous infection and active tuberculosis, b) prevention of the spread of infectious droplet nuclei into the

general air circulation by applying source-control methods, c) reduction of the number of infectious droplet nuclei in air contaminated with them, and d) surveillance of health-care-facility personnel for tuberculosis and tuberculous infection. Experience has shown that when inadequate attention is given to any of these approaches, the probability of tuberculosis transmission is increased.

Specific actions to reduce the risk of tuberculosis transmission should include a) screening patients for active tuberculosis and tuberculous infection, b) providing rapid diagnostic services, c) prescribing appropriate curative and preventive therapy, d) maintaining physical measures to reduce microbial contamination of the air, e) providing isolation rooms for persons with, or suspected of having, infectious tuberculosis, f) screening health-care-facility personnel for tuberculous infection and tuberculosis, and g) promptly investigating and controlling outbreaks.

Although completely eliminating the risk of tuberculosis transmission in all health-care settings may be impossible, adhering to these guidelines should minimize the risk to persons in these settings. This document was prepared in consultation with experts in tuberculosis, acquired immunodeficiency syndrome, infection-control and hospital epidemiology, microbiology, ventilation and industrial hygiene, respiratory therapy, nursing, and emergency medical services.

I. INTRODUCTION

A. Purpose of Document

The purpose of this document is to review the mode and risk of tuberculosis transmission in health-care settings and to make recommendations for reducing the risk of transmission to persons in health-care settings--including workers, patients, volunteers, and visitors. The document may also serve as a useful resource for educating health-care workers about tuberculosis. Several outbreaks of tuberculosis in health-care settings, including outbreaks involving multidrug-resistant strains of M. tuberculosis, have been reported to CDC during the past 2 years (1; CDC, unpublished data). In addition, CDC has recently received numerous requests for information about reducing tuberculosis transmission in health-care settings. Much of the increased concern is due to the occurrence of tuberculosis among persons infected with HIV (2), who are at increased risk of contracting tuberculosis both from reactivation of a latent tuberculous infection (3) and from a new infection (4). Therefore, in this document, emphasis is given to the transmission of tuberculosis among persons with HIV infection, although the majority of patients with tuberculosis in most areas of the country do not have HIV infection.

These recommendations consolidate and update previously published CDC recommendations (5-10). The recommendations are applicable to all settings in which health care is provided. In this document, the term "tuberculosis," in the absence of modifiers, refers to a clinically apparent active disease process caused by M. tuberculosis (or, rarely, M. Bovis or M. africanum). The terms "health-care-facility personnel" and "health-care-facility workers" refer to all persons

working in a health-care setting--including physicians, nurses, aides, and persons not directly involved in patient care (e.g., dietary, housekeeping, maintenance, clerical, and janitorial staff, and volunteers). B. Epidemiology, Transmission, and Pathogenesis of Tuberculosis

Tuberculosis is not evenly distributed throughout all segments of the population of the United States. Groups known to have a high incidence of tuberculosis include blacks, Asians and Pacific Islanders, American Indians and Alaskan Natives, Hispanics, current or past prison inmates, alcoholics, intravenous (IV) drug users, the elderly, foreign-born persons from areas of the world with a high prevalence of tuberculosis (e.g., Asia, Africa, the Caribbean, and Latin America), and persons living in the same household as members of these groups (5).

M. tuberculosis is carried in airborne particles, known as droplet nuclei, that can be generated when persons with pulmonary or laryngeal tuberculosis sneeze, cough, speak, or sing (11). The particles are so small (1-5 microns) that normal air currents keep them airborne and can spread them throughout a room or building (12). Infection occurs when a susceptible person inhales droplet nuclei containing M. tuberculosis, and bacilli become established in the alveoli of the lungs and spread throughout the body. Two to ten weeks after initial human infection with M. tuberculosis, the immune response usually limits further multiplication and spread of the tuberculosis bacilli. For a small proportion of newly infected persons (usually less than 1%), initial infection rapidly progresses to clinical illness. However, for another group (approximately 5%-10%), illness develops after an interval of months, years, or decades, when the bacteria begin to replicate and produce disease (11). The risk of progression to active disease is markedly increased for persons with HIV infection (3).

The probability that a susceptible person will become infected depends upon the concentration of infectious droplet nuclei in the air. Patient factors that enhance transmission are discussed more fully in section II.B.3. Environmental factors that enhance transmission include a) contact between susceptible persons and an infectious patient in relatively small, enclosed spaces, b) inadequate ventilation that results in insufficient dilution or removal of infectious droplet nuclei, and c) recirculation of air containing infectious droplet nuclei.

Tuberculosis transmission is a recognized risk in health-care settings (13-21). The magnitude of the risk varies considerably by type of health-care setting, patient population served, job category, and the area of the facility in which a person works. The risk may be higher in areas where patients with tuberculosis are provided care before diagnosis (e.g., clinic waiting areas and emergency rooms) or where diagnostic or treatment procedures that stimulate patient coughing are performed. Nosocomial transmission of tuberculosis has been associated with close contact with infectious patients, as well as procedures such as bronchoscopy (16), endotracheal intubation and suctioning with mechanical ventilation (17,18), open abscess irrigation (19), and autopsy (20,21). Sputum induction and aerosol treatments that induce cough may also increase the potential for tuberculosis transmission (22). Health-care workers should be particularly alert to the need for preventing tuberculosis transmission in health-care settings in which persons with HIV infection receive care, especially if cough-inducing procedures such as sputum induction

and AP treatments are being performed. II. General Principles of Tuberculosis Control in Health-Care Settings

A. Approaches to Tuberculosis Control An effective tuberculosis-control program requires the early identification, isolation, and treatment of persons with active tuberculosis. Health-care facilities in which persons at high risk for tuberculosis work or receive care should periodically review their tuberculosis policies and procedures, and determine the actions necessary to minimize the risk of tuberculosis transmission in their particular settings. The prevention of tuberculosis transmission in health-care settings requires that all of the following basic approaches be used: a) preventing the generation of infectious droplet nuclei, b) preventing the spread of infectious droplet nuclei into the general air circulation, c) reducing the number of infectious droplet nuclei in air contaminated with them, d) following guidelines for cleaning, disinfecting, and sterilizing contaminated items, and e) conducting surveillance for tuberculosis transmission to health-care-facility personnel. Experience has shown that when inadequate attention is given to any of these measures, the probability of tuberculosis transmission is increased.

Specific actions to reduce the risk of tuberculosis transmission should include the following: --Screening patients for active tuberculosis and tuberculous infection. --Providing rapid diagnostic services. --Prescribing appropriate curative and preventive therapy. --Maintaining physical measures to reduce microbial contamination of the air. --Providing isolation rooms for persons with, or suspected of having, infectious tuberculosis. --Screening health-care-facility personnel for tuberculous infection and tuberculosis. --Promptly investigating and controlling outbreaks.

B. Preventing Generation of Infectious Droplet Nuclei

1. Early identification and treatment of persons with tuberculous infection

Early identification of persons with tuberculous infection and application of preventive therapy are effective in preventing the development of tuberculosis (5). Persons at increased risk of tuberculosis (see section I.B.), or for whom the consequences of tuberculosis may be especially severe, should be screened for tuberculous infection to identify those for whom preventive treatment is indicated. The tuberculin skin test is the only method currently available that demonstrates infection with M. tuberculosis in the absence of active tuberculosis (11). 2. Early identification and treatment of persons with active tuberculosis

An effective means of preventing tuberculosis transmission is preventing the generation of infectious droplet nuclei by persons with infectious tuberculosis. This can be accomplished by early identification, isolation, and treatment of persons with active tuberculosis. Tuberculosis may be more difficult to diagnose among persons with HIV infection; the diagnosis may be overlooked because of an atypical clinical or radiographic presentation and/or the simultaneous occurrence of other pulmonary infections (e.g., Pneumocystis carinii pneumonia (PCP)). Among persons with HIV infection, the difficulty in making a diagnosis may be further compounded by

impaired responses to tuberculin skin tests (23,24), low sensitivity of sputum smears for detecting AFB (25), or overgrowth of cultures with Mycobacterium avium complex (MAC) among patients with both MAC and M. tuberculosis infections (26).

A diagnosis of tuberculosis should be considered for any patient with persistent cough or other symptoms compatible with tuberculosis, such as weight loss, anorexia, or fever. Diagnostic measures for identifying tuberculosis should be instituted among such patients. These measures include history, physical examination, tuberculin skin test, chest radiograph, and microscopic examination and culture of sputum or other appropriate specimens (11,27). Other diagnostic methods, such as bronchoscopy or biopsy, may be indicated in some cases (28,29). The probability of tuberculosis is increased by finding a positive reaction to a tuberculin skin test or a history of a positive skin test, a history of previous tuberculosis, membership in a group at high risk for tuberculosis (see section I.B.), or a history of exposure to tuberculosis. Active tuberculosis is strongly suggested if the diagnostic evaluation reveals AFB in sputum, a chest radiograph is suggestive of tuberculosis, or the person has symptoms highly suggestive of tuberculosis (e.g., productive cough, night sweats, anorexia, and weight loss). Tuberculosis may occur simultaneously with other pulmonary infections, such as PCP.

a. Tuberculin skin test. The Mantoux technique (intradermal injection of 0.1 ml of purified protein derivative (PPD) containing 5 tuberculin units (TU)) should be used as a diagnostic aid to detect tuberculous infection. Although tuberculin skin tests are less than 100% sensitive and specific for detection of infection with M. tuberculosis, no better diagnostic method has been devised. Tuberculin skin tests should be interpreted according to current guidelines (5,11). For persons with HIV infection, a reaction of greater than or equal to 5 mm is considered positive.

A negative skin test does not rule out tuberculosis disease or infection. Because of the possibility of a false-negative result, the tuberculin skin test should never be used to exclude the possibility of active tuberculosis among persons for whom the diagnosis is being considered, even if reactions to other skin-test antigens are positive. Persons with HIV infection are more likely to have false-negative skin tests than are persons without HIV infection (23,24,30). The likelihood of a false-negative skin test increases as the stage of HIV infection advances (CDC/Florida Department of Health and Rehabilitative Services/New York City Department of Health, unpublished data). For this reason, a history of a positive tuberculin reaction is meaningful, even if the current skin-test result is negative.

b. Chest radiograph.

The radiographic presentation of pulmonary tuberculosis among patients with HIV infection may be unusual (31). Typical apical cavitary disease is less common among persons with HIV infection. They may have infiltrates in any lung zone, often associated with mediastinal and/or hilar adenopathy, or they may have a normal chest radiograph.

c. Bacteriology.

Smear and culture examination of three to five sputum specimens collected on different days is the main diagnostic procedure for pulmonary tuberculosis (11). Sputum smears that fail to demonstrate AFB do not exclude the diagnosis of tuberculosis. Studies indicate that 50%-80% of patients with pulmonary tuberculosis have positive sputum smears. Sputum smears from patients with HIV infection and pulmonary tuberculosis may be less likely to reveal AFB than those from immunocompetent patients, a finding believed to be consistent with the lower frequency of cavitary pulmonary disease observed among HIV-infected persons (23,25).

A positive sputum culture, with organisms identified as M. tuberculosis, provides a definitive diagnosis of tuberculosis. Conventional laboratory methods may require 4-8 weeks for species identification; however, the use of radiometric culture techniques and genetic probes facilitates more rapid detection and identification of mycobacteria (32,33). Mixed mycobacterial infection (either simultaneous or sequential) may occur and may obscure the recognition of M. tuberculosis clinically and in the laboratory (26). The use of genetic probes for both MAC and M. tuberculosis may be useful for identifying mixed mycobacterial infections in clinical specimens.

3. Determining infectiousness of tuberculosis patients

The infectiousness of a person with tuberculosis correlates with the number of organisms that are expelled into the air, which, in turn, correlates with the following factors: a) anatomic site of disease, b) presence of cough or other forceful expirational maneuvers, c) presence of AFB in the sputum smear, d) willingness or ability of the patient to cover his or her mouth when coughing, e) presence of cavitation on chest radiograph, f) length of time the patient has been on adequate chemotherapy, g) duration of symptoms, and h) administration of procedures that can enhance coughing (e.g., sputum induction).

The most infectious persons are those with pulmonary or laryngeal tuberculosis. Those with extrapulmonary tuberculosis are usually not infectious, with the following exceptions: a) nonpulmonary disease located in the respiratory tract or oral cavity, or b) 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 (19). Although the data are limited, findings suggest that tuberculosis patients with acquired immunodeficiency syndrome (AIDS), if smear positive, have infectiousness similar to that of tuberculosis patients without AIDS (CDC/New York City Department of Health, unpublished data).

Infectiousness is greatest among patients who have a productive cough, pulmonary cavitation on chest radiograph, and AFB on sputum smear (6). Infection is more likely to result from exposure to a person who has unsuspected pulmonary tuberculosis and who is not receiving antituberculosis therapy or from a person with diagnosed tuberculosis who is not receiving adequate therapy, because of patient noncompliance or the presence of drug-resistant organisms. Administering effective antituberculosis medications has been shown to be strongly associated

with a decrease in infectiousness among persons with tuberculosis (34). Effective chemotherapy reduces coughing, the amount of sputum, and the number of organisms in the sputum. However, the length of time a patient must be on effective medication before becoming noninfectious varies (35); some patients are never infectious, whereas those with unrecognized or inadequately treated drug-resistant disease may remain infectious for weeks or months. Thus, decisions about terminating isolation precautions should be made on a case-by-case basis.

In general, persons suspected of having active tuberculosis and persons with confirmed tuberculosis should be considered infectious if cough is present, if cough-inducing procedures are performed, or if sputum smears are known to contain AFB, and if these patients are not on chemotherapy, have just started chemotherapy, or have a poor clinical or bacteriologic response to chemotherapy. A person with tuberculosis who has been on adequate chemotherapy for at least 2-3 weeks and has had a definite clinical and bacteriologic response to therapy (reduction in cough, resolution of fever, and progressively decreasing quantity of bacilli on smear) is probably no longer infectious. Most tuberculosis experts agree that noninfectiousness in pulmonary tuberculosis can be established by finding sputum free of bacilli by smear examination on three consecutive days for a patient on effective chemotherapy. Even after isolation precautions have been discontinued, caution should be exercised when a patient with tuberculosis is placed in a room with another patient, especially if the other patient is immunocompromised.

C. Preventing Spread of Infectious Droplet Nuclei via Source-Control Methods

In high-risk settings, certain techniques can be applied to prevent or to reduce the spread of infectious droplet nuclei into the general air circulation. The application of these techniques, which are called source-control methods because they entrap infectious droplet nuclei as they are emitted by the patient, or "source" (36), is especially important during performance of medical procedures likely to generate aerosols containing infectious particles.

1. Local exhaust ventilation Local exhaust ventilation is a source-control technique that removes airborne contaminants at or near their sources (37). The use of booths for sputum induction or administration of aerosolized medications (e.g., AP) is an example of local exhaust ventilation for preventing the spread of infectious droplet nuclei generated by these procedures into the general air circulation. Booths used for source control should be equipped with exhaust fans that remove nearly 100% of airborne particles during the time interval between the departure of one patient and the arrival of the next. The time required for removing a given percentage of airborne particles from an enclosed space depends upon the number of air exchanges per hour (Table 1, page 26), which is determined by the capacity of the exhaust fan in cubic feet per minute (cfm), the number of cubic feet of air in the room or booth, and the rate at which air is entering the room or booth at the intake source.

The exhaust fan should maintain negative pressure in the booth with respect to adjacent areas, so that air flows into the booth. Maintaining negative pressure in the booth minimizes the possibility

that infectious droplet nuclei in the booth will move into adjacent rooms or hallways. Ideally, the air from these booths should be exhausted directly to the outside of the building (away from air-intake vents, people, and animals, in accordance with federal, state, and local regulations concerning environmental discharges). If direct exhaust to the outside is impossible, the air from the booth could be exhausted through a properly designed, installed, and maintained high-efficiency particulate air (HEPA) filter; however, the efficacy of this method has not been demonstrated in clinical settings (see section II.D.2.a.). 2. Other source-control methods

A simple but important source-control technique is for infectious patients to cover all coughs and sneezes with a tissue, thus containing most liquid drops and droplets before evaporation can occur (38). A patient's use of a properly fitted surgical mask or disposable, valveless particulate respirator (PR) (see section II.D.2.c.) also may reduce the spread of infectious particles. However, since the device would need to be worn constantly for the protection of others, it would be practical in only very limited circumstances (e.g., when a patient is being transported within a medical facility or between facilities).

D. Reducing Microbial Contamination of Air

Once infectious droplet nuclei have been released into room air, they should be eliminated or reduced in number by ventilation, which may be supplemented by additional measures (e.g., trapping organisms by high-efficiency filtration or killing organisms with germicidal ultraviolet (UV) irradiation (100-290 nanometers)). Health-care-facility workers may also reduce the risk of inhaling contaminated air by using PRs.

Although for the past 2-3 decades ventilation and, to a lesser extent, UV lamps and face masks have been used in health-care settings to prevent tuberculosis transmission, few published data exist on which to evaluate their effectiveness and liabilities or to draw conclusions about the role each method should play. From a theoretical standpoint, none of the four methods (ventilation, UV irradiation, high-efficiency filtration, and face masks) appears to be ideal. None of the methods used alone or in combination can completely eliminate the risk of tuberculosis transmission; however, when used with the other infection-control measures outlined in this document, they can substantially reduce the risk.

1. General ventilation Ventilation standards for indoor air quality have been published by the American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE) (39). Specific recommendations for health-care facilities have been published by ASHRAE (40) and by the Federal Health Resources and Services Administration (41). Meeting these standards should reduce the probability of tuberculosis transmission in clinical settings; however, some highly infectious patients may transmit infection even if these ventilation standards are met.

    a. Dilution and removal of airborne contaminants. Appropriate ventilation maintains air quality by two processes--dilution and removal of airborne contaminants (42).

Dilution reduces the concentration of contaminants in a room by introducing air that does not contain those contaminants into the room. Air is then removed from the room by exhaust directly to the outside or by recirculation into the general ventilation system of the building. Continuously recirculating air in a room or in a building may result in the accumulation or concentration of infectious droplet nuclei. Air that is likely contaminated with infectious droplet nuclei should be exhausted to the outside, away from intake vents, people, and animals, in accordance with federal, state, and local regulations for environmental discharges.

b. Air mixing. Proper ventilation requires that within-room mixing of air (ventilation efficiency) must be adequate (42). Air mixing is enhanced by locating air-supply outlets at ceiling level and exhaust inlets near the floor, thus providing downward movement of clean air through the breathing zone to the floor area for exhaust.

c. Direction of air flow. For control of tuberculosis transmission, the direction of air flow is as important as dilution. The direction of air flow is determined by the differences in air pressure between adjacent areas, with air flowing from higher pressure areas to lower pressure areas.

In an area occupied by a patient with infectious tuberculosis, air should flow into the potentially contaminated area (the patient's room) from adjacent areas. The patient's room is said to be under lower or negative pressure.

Proper air flow and pressure differentials between areas of a health-care facility are difficult to control because of open doors, movement of patients and staff, temperature, and the effect of vertical openings (e.g., stairwells and elevator shafts) (40). Air-pressure differentials can best be maintained in completely closed rooms. An open door between two areas may reduce any existing pressure differential and could reduce or eliminate the desired effect. Therefore, doors should remain closed, and the close fit of all doors and other closures of openings between pressurized areas should be maintained. For critical areas in which the direction of air flow must be maintained while allowing for patient or staff movement between adjacent areas, an appropriately pressurized anteroom may be indicated.

Examples of factors that can change the direction of air flow include the following: a) dust in exhaust fans, filters, or ducts, b) malfunctioning fans, c) adjustments made to the ventilation system elsewhere in the building, or d) or automatic shut down of outside air introduction during cold weather. In areas where the direction of air flow is important, trained personnel should monitor air flow frequently to ensure that appropriate conditions are maintained.

Each area to which an infectious tuberculosis patient might be admitted should be evaluated for its potential for the spread of tuberculosis bacilli. Modifications to the ventilation system, if needed, should be made by a qualified ventilation engineer. Individual evaluations should address factors such as the risk of tuberculosis among the patient population served, special procedures

that may be performed, and ability to make the necessary changes.

Too much ventilation in an area can create problems. In addition to incurring additional expense at marginal benefits, occupants bothered by the drafts may elect to shut down the system entirely. Furthermore, if the concentration of infectious droplet nuclei in an area is high, the levels of ventilation that are practical to achieve may be inadequate to completely remove the contaminants (43). 2. Potential supplemental approaches

a. HEPA filtration. For general-use areas (e.g., emergency rooms and waiting areas) of health-care facilities, recirculating the air is an alternative to using large percentages of outside air for general ventilation. If air is recirculated, care must be taken to ensure that infection is not transmitted in the process. Although they can be expensive, HEPA filters, which remove at least 99.97% of particles greater than 0.3 microns in diameter, have been shown to be effective in clearing the air of Aspergillus spores, which are in the size range of 1.5-6 microns (44-46). The ability of HEPA filters to remove tuberculosis bacilli from the air has not been studied, but tuberculosis-containing droplet nuclei are approximately 1-5 microns in diameter, about the same size as Aspergillus spores; therefore, HEPA filters theoretically should remove infectious droplet nuclei. HEPA filters may be used in general-use areas, but should not be used to recirculate air from a tuberculosis isolation room back into the general circulation.

Applications in preventing nosocomial Aspergillus infection have included using HEPA filters in centralized air-handling units and using whole-wall HEPA filtration units with laminar air flow in patient rooms. In addition, portable HEPA filtration units, which filter the air in a room rather than filtering incoming air, have been effective in reducing nosocomial Aspergillus infections (45,46). Such units have been used as an interim solution for retrofitting old areas of hospitals. Although these units should not be substituted for other accepted tuberculosis isolation procedures, they may be useful in general-use areas (e.g., waiting rooms and emergency rooms) where an increased risk of exposure to tuberculosis may exist, but where other methods of air control may be inadequate.

When HEPA filters are to be installed at a facility, qualified personnel must assess and design the air-handling system to assure adequate supply and exhaust capacity. Proper installation, testing, and meticulous maintenance are critical if a HEPA filter system is used (40). Improper design, installation, or maintenance could permit infectious particles to circumvent filtration and escape into the ventilation (42). The filters should be installed to prevent leakage between filter segments and between the filter bed and its frame. A regular maintenance program is required to monitor HEPA filters for possible leakage and for filter loading. A manometer should be installed in the filter system to provide an accurate means of objectively determining the need for filter replacement. Installation should allow for maintenance without contaminating the delivery system or the area served.

HEPA-filtered, recirculated air should not be used if the contaminants contain carcinogenic

agents. Qualified personnel should maintain, decontaminate, and dispose of HEPA filters. b. Germicidal UV irradiation.

The use of germicidal UV lamps (wavelengths 100-290 nm) to prevent tuberculosis transmission in occupied spaces is controversial. UV lamps installed in the exhaust air ducts from the rooms of patients with infectious tuberculosis were shown to prevent infection of guinea pigs, which are highly susceptible to tuberculosis (34). On the basis of this finding, other studies (47-50), and the experience of tuberculosis clinicians and mycobacteriologists during the past 2-3 decades, CDC has continued to recommend UV lamps (with appropriate safeguards to prevent short-term overexposure) as a supplement to ventilation in settings where the risk of tuberculosis transmission is high (6,8,11,51-54). Their efficacy in clinical settings has not been demonstrated under controlled conditions, but there is a theoretical and experiential basis for believing they are effective (43,55,56). Thus, individual health-care facilities may need to consider, on a case-by-case basis, using these lamps in settings with a high risk of tuberculosis transmission (see section I.B.). UV lamps are less effective in areas with a relative humidity of greater than 70% (57). The potential for serious adverse effects of short- and long-term exposure to germicidal UV has been identified as a major concern (58; NIOSH, unpublished report (Health Hazard Evaluation Report, HETA 90-122-L2073)).

The two most common types of UV installation are wall- or ceiling-mounted room fixtures for disinfecting the air within a room and irradiation units for disinfecting air in supply ducts. Wall- or ceiling-mounted fixtures act by disinfecting upper room air, and their effectiveness depends in part upon the mixing of air in the room. Organisms must be carried by air currents from the lower portion of the room to within the range of the UV radiation from the fixtures. These fixtures are most likely to be effective in locations where ceilings are high, but some protection may be afforded in areas with ceilings as low as 8 feet. To be maximally effective, lamps should be left on day and night (59).

Installing UV lamps in ventilation ducts may be beneficial in facilities that recirculate the air. UV exposure of air in ducts can be direct and more intense than that provided by room fixtures and may be effective in disinfecting exhaust air. Duct installations provide no protection against tuberculosis transmission to any person who is in the room with an infectious patient. As with HEPA filters, UV installations in ducts may be used in general-use areas but should not be used to recirculate air from a tuberculosis isolation room back into the general circulation.

The main concern about UV lamps is safety. Short-term overexposure to UV irradiation can cause keratoconjunctivitis and erythema of the skin (60). However, with proper installation and maintenance, the risk of short-term overexposure is low. Long-term exposure to UV irradiation is associated with increased risk of basal cell carcinoma of the skin and with cataracts (58). To prevent overexposure of health-care-facility personnel and patients, UV lamp configurations should meet applicable safety guidelines (60).

When UV lamps are used in air-supply ducts, a warning sign should be placed on doors that

permit access to the duct lamps. The sign should indicate that looking at the lamps is a safety hazard. In addition, warning lights outside doors permitting access to duct lamps should indicate whether the lamps are on or off. The duct system should be engineered to prevent UV emissions from the duct from radiating into potentially occupied spaces.

Consultation from a qualified expert should be obtained before and after UV lamps are installed. After installation, the safety and effectiveness of UV irradiation must be checked with a UV meter and fixtures adjusted as necessary. Bulbs should be periodically checked for dust, cleaned as needed, and replaced at the end of the rated life of the bulb. Maintenance personnel should be cautioned that fixtures should be turned off before inspection or servicing. A timing device that turns on a red light at the end of the rated life of the lamp is available to alert maintenance personnel that the lamp needs to be replaced. c. Disposable PRs for filtration of inhaled air. 1.) For persons exposed to tuberculosis patients.

Appropriate masks, when worn by health-care providers or other persons who must share air space with a patient who has infectious tuberculosis, may provide additional protection against tuberculosis transmission. Standard surgical masks may not be effective in preventing inhalation of droplet nuclei (61), because some are not designed to provide a tight face seal and to filter out particulates in the droplet nucleus size range (1-5 microns). A better alternative is the disposable PR. PRs were originally developed for industrial use to protect workers. Although the appearance and comfort of PRs may be similar to that of cup-shaped surgical masks, they provide a better facial fit and better filtration capability. However, the efficacy of PRs in protecting susceptible persons from infection with tuberculosis has not been demonstrated.

PRs may be most beneficial in the following situations: a) when appropriate ventilation is not available and the patient's signs and symptoms suggest a high potential for infectiousness, b) when the patient is potentially infectious and is undergoing a procedure that is likely to produce bursts of aerosolized infectious particles or to result in copious coughing or sputum production, regardless of whether appropriate ventilation is in place, and c) when the patient is potentially infectious, has a productive cough, and is unable or unwilling to cover coughs.

Comfort influences the acceptability of PRs. Generally, the more efficient the PRs, the greater is the work of breathing through them and the greater the perceived discomfort. A proper fit is vital to protect against inhaling droplet nuclei. When gaps are present, air will preferentially flow through the gaps, allowing the PR to function more like a funnel than a filter, thus providing virtually no protection (61). 2.) For tuberculosis patients.

Masks or PRs worn by patients with suspected or confirmed tuberculosis may be useful in selected circumstances (see section II.C.2.). PRs used by patients should be valveless. Some PRs have valves to release expired air, and these would not be appropriate for patients to use. E. Decontamination: Cleaning, Disinfecting, and Sterilizing

Guidelines for cleaning, disinfecting, and sterilizing equipment have been published (10,62,63).

The rationale for cleaning, disinfecting, or sterilizing patient-care equipment can be understood more readily if medical devices, equipment, and surgical materials are divided into three general categories (critical items, semi-critical items, and noncritical items) based on the potential risk of infection involved in their use.

Critical items are instruments such as needles, surgical instruments, cardiac catheters, or implants that are introduced directly into the bloodstream or into other normally sterile areas of the body. These items should be sterile at the time of use.

Semi-critical items are items such as noninvasive flexible and rigid fiberoptic endoscopes or bronchoscopes, endotracheal tubes, or anesthesia breathing circuits that may come in contact with mucous membranes but do not ordinarily penetrate body surfaces. Although sterilization is preferred for these instruments, a high-level disinfection procedure that destroys vegetative microorganisms, most fungal spores, tubercle bacilli, and small, nonlipid viruses may be used. Meticulous physical cleaning before sterilization or high-level disinfection is essential.

Noncritical items are those that either do not ordinarily touch the patient or touch only intact skin. Such items include crutches, bedboards, blood pressure cuffs, and various other medical accessories. These items do not transmit tuberculous infection. Consequently, washing with a detergent is usually sufficient.

Facility policies should identify whether cleaning, disinfecting, or sterilizing an item is indicated to decrease the risk of infection. Procedures for each item depend on its intended use. Generally, critical items should be sterilized, semi-critical items should be sterilized or cleaned with high-level disinfectants, and noncritical items need only be cleaned with detergents or low-level disinfectants. Decisions about decontamination processes should be based on the intended use of the item and not on the diagnosis of the patient for whom the item was 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.

Although microorganisms are normally found on walls, floors, and other surfaces, these environmental surfaces are rarely associated with transmission of infections to patients or health-care-facility personnel. This is particularly true with organisms such as tubercle bacilli, which generally require inhalation by the host for infection to occur. Therefore, extraordinary attempts to disinfect or sterilize environmental surfaces are rarely indicated. However, routine cleaning (which can be achieved with a hospital-grade, Environmental Protection Agency-approved germicide divided by isinfectant) is recommended (63). The same routine daily cleaning procedures used in other hospital or facility rooms should be used to clean rooms of patients who are on AFB isolation precautions. F. Conducting Surveillance for Tuberculosis Transmission to Health-Care-Facility Personnel

A tuberculosis screening and prevention program for health-care-facility personnel should be established for protecting both health-care-facility personnel and patients. Personnel with

tuberculous infection without evidence of current (active) disease should be identified, because preventive treatment with isoniazid may be indicated (5). In addition, the screening program will enable public health personnel to evaluate the effectiveness of current infection-control practices. Recommendations for screening and surveillance are detailed in section III.A.7. III. Recommendations

The following recommendations are divided into two categories:

a. general recommendations applicable to all health-care settings, including special precautions for cough-inducing procedures, and b) recommendations for selected specific health-care settings. Facilities should adapt these recommendations as appropriate for individual circumstances.

A. Recommendations Applicable to All Health-Care Settings

1. Early identification and preventive treatment of persons who have tuberculous infection and are at high risk for active tuberculosis --Persons belonging to groups at risk for tuberculosis (see section I.B.) should be screened with a Mantoux tuberculin skin test. Those with positive skin tests should be evaluated for preventive therapy according to current guidelines (5). --All persons with HIV infection or with risk factors for HIV infection should be given a Mantoux tuberculin skin test. Those with positive skin tests or histories of positive skin tests, for whom diagnostic evaluation for active tuberculosis is negative, should be evaluated for preventive therapy according to current guidelines (5).

2. Early identification and treatment of persons with active tuberculosis --Vigorous efforts should be made to identify patients with active tuberculosis in a timely manner and to place them on appropriate therapy (see section II.B.2.). Pulmonary tuberculosis should always be included in the differential diagnosis of persons with pulmonary signs or symptoms, and appropriate diagnostic measures should be instituted. --For patients with pulmonary signs or symptoms that are initially ascribed to other etiologies, evaluation for co-existing tuberculosis should be repeated if the patient does not respond to appropriate therapy for the presumed etiology of the pulmonary abnormalities (see section II.B.2.). --In health-care facilities, isolation precautions should be applied for patients who are suspected or confirmed to have active tuberculosis and who may be infectious (see sections II. B.3 and III.B.1.a.). --Procedure-specific precautions should be applied for cough-inducing or aerosol-generating procedures (see section III.A.5.). --Patients with suspected or confirmed tuberculosis should be reported to the appropriate health department so that standard procedures for identifying and evaluating tuberculosis contacts can be initiated.

3. Ventilation --Staff of inpatient facilities should either include an engineer or other

professional with expertise in ventilation or industrial hygiene, or the facility should have this expertise available from a consultant. These persons should work closely with the infection-control committee in the control of airborne infections. --Ventilation for health-care facilities should be developed and maintained in consultation with experts in ventilation engineering who also have hospital ventilation experience. Facility design should meet local and state requirements. Specific recommendations for health-care facilities have been published by ASHRAE and HRSA (40,41) (see section II.D.). --The direction of air flow in health-care facilities should be set up and maintained so that air flows from clean areas to less-clean areas. In areas of a facility in which tuberculosis transmission is a potential problem, direction of air flow should be monitored frequently. Periodic checks with smoke tubes or smoke sticks provide a sensitive indication of air-flow direction (see section II.D.1.c.). --Facilities serving populations with a high prevalence of tuberculosis may need to enhance ventilation or use supplemental approaches in areas of the facility where patients with tuberculosis are likely to be found (e.g., waiting areas, emergency rooms, radiology suites, or treatment rooms) or where skin tests of personnel demonstrate an increased risk of tuberculosis transmission (see section II.D.2.).

4. Potential supplemental environmental approaches

    a. High-efficiency filtration If air from potentially contaminated general-use areas (e.g., emergency rooms or clinic waiting areas) cannot be exhausted directly to the outside, HEPA filters with test efficiencies of greater than or equal to 99.97% may be useful for removing infectious organisms from air before recirculation in a room or before return to common supply ducts. If HEPA filters are used, they must be designed, installed, maintained, and disposed of in accordance with all applicable regulations and manufacturers' recommendations (see section II.D.2.a.). HEPA filters should not be used to recirculate air from a tuberculosis isolation room back into the general circulation.

    b. Germicidal UV irradiation For settings in which the risk of tuberculosis transmission is high (see section I.B.), UV lamps have been used to supplement ventilation (see section II.D.2.b.). The decision to use UV lamps should be made on a case-by-case basis. If UV lamps are used, applicable safety guidelines should be followed (see section II.D.2.b.). UV lamps are not recommended for use in small rooms or booths where nebulizing devices will be used. UV units installed in ducts should not be used to recirculate air from a tuberculosis isolation room back into the general circulation.

    c. Disposable PRs for filtration of inhaled air PRs (see section II.D.2.c.)

should be provided by health-care facilities and worn by persons in the same room with a patient whose signs and symptoms suggest a high potential for infectiousness and by those performing procedures that are likely to produce bursts of droplet nuclei, such as bronchoscopy, endotracheal suctioning, and administration of AP. Wearers should be adequately trained in the use and disposal of PRs and should carefully follow manufacturers' instructions. Ideally, a respirator program consistent with the guidelines found in Department of Health and Human Services (DHHS), National Institute for Occupational Safety and Health (NIOSH), Publication No. 87-116, Guide to Industrial Respiratory Protection (64) and the requirements of the Occupational Safety and Health Administration (OSHA) General Industry Occupational Safety and Health Standards (29 Code of Federal Regulations Part 1910.134) should be implemented. Such a program includes training, fit testing, care and maintenance, and medical monitoring. 5. Procedure-specific precautions

d. Diagnostic sputum induction Sputum induction performed on patients who may have tuberculosis should be carried out in an individual room or booth with negative pressure relative to adjacent rooms and hallways, ideally with room or booth air exhausted directly to the outside and away from all windows and air intake ducts (see section II.C.1.). Patients should remain in the booth or treatment room (or go outside, weather permitting) and not return to common waiting areas until coughing has subsided. Time should be allowed between patients so that any droplet nuclei that have been introduced into the air can be removed. This time will vary according to the efficiency of the ventilation or filtration used (Table 1, page 26). Health-care-facility personnel collecting induced sputum should wear PRs if it is necessary for them to be in the room with the patient during the procedure (see section II.D.2.c.).

e. Administration of AP All patients should be screened for active tuberculosis before AP therapy is initiated. Screening should include medical history, tuberculin skin test, and a baseline chest radiograph (see section II.B.2). Before each subsequent AP treatment, patients should be evaluated for symptoms highly suggestive of tuberculosis, such as the development of a productive cough or cough and fever. If such symptoms are elicited, a diagnostic evaluation should be initiated. If active tuberculosis is found or suspected, the patient should be placed on antituberculosis chemotherapy. AP treatments should be administered to patients who may have active tuberculosis only in a room or booth as described for sputum induction. Ideally, AP treatments for all patients should be administered in an individual room or booth as described for sputum induction (see sections II. C.1. and III.A.5.a.). Adequate time should be allowed between patients for removal of residual pentamidine and any infectious organisms from the air

when treatment rooms or booths are to be reused (Table 1, page 26). Workers administering AP should wear PRs whenever they must be in the room or booth during administration of AP to patients who have, or are at high risk of having, tuberculosis (see section II.D.2.c.). After they have received AP, patients should not return to common waiting areas until coughing subsides.

f. Bronchoscopy Bronchoscopy should be performed in rooms that have adequate ventilation, good distribution of air flow, and air exhausted directly to the outside--in accordance with federal, state, and local regulations for environmental discharges--or recirculated through HEPA filters. Ideally, bronchoscopy should be performed in rooms with negative pressure relative to adjacent areas. If bronchoscopy must be performed in positive-pressure rooms (such as operating rooms), the risk of infectious tuberculosis should be ruled out beforehand. Additional protection may be afforded by local exhaust ventilation employed near the patient's head to exhaust most organisms near their source (see section II.C.1.) or by the use of UV lamps in treatment areas where bronchoscopies are performed (see section II.D.2.b.). Persons who must be in the room with the patient during bronchoscopy should wear PRs (see section II.D.2.c.).

g. Endotracheal intubation/suctioning Rooms occupied by intubated patients who may have active tuberculosis should be provided with ventilation as described for patient isolation rooms (see section III.B.1.a.). Persons performing endotracheal suctioning on patients who have suspected or confirmed active tuberculosis should wear PRs.

h. Other procedures Other aerosol treatments, cough-inducing procedures, or aerosol-generating procedures should be administered as described for AP administration (see section II.C.1.). 6. Decontamination: cleaning, disinfecting, and sterilizing --Decisions about decontamination processes should be based on the intended use of the item and not on the diagnosis of the patient for whom the item was used (see section II.E.). --Generally, critical items should be sterilized, semi-critical items should be sterilized or cleaned with high-level disinfectants, and noncritical items need only be cleaned with detergents or low-level disinfectants. Meticulous physical cleaning before sterilization or a high level of disinfection is essential (see section II.E.). --The same routine, daily cleaning procedures used in other hospital or facility rooms should be used to clean rooms of patients who are on AFB isolation precautions (see section II.E.). 7. Conducting surveillance for tuberculosis transmission

i. Surveillance and reporting Health-care facilities providing care to patients at

risk for tuberculosis should maintain active surveillance for tuberculosis among patients and health-care-facility personnel and for skin-test conversions among health-care-facility personnel. When tuberculosis is suspected or diagnosed, public health authorities should be notified so that appropriate contact investigation can be performed. Data on the occurrence of tuberculosis and skin-test conversions among patients and health-care-facility personnel should be collected and analyzed to estimate the risk of tuberculosis transmission in the facility and to evaluate the effectiveness of infection-control and screening practices. At the time of employment, all health-care facility personnel, including those with a history of Bacillus of Calmette and Guerin (BCG) vaccination, should receive a Mantoux tuberculin skin test unless a previously positive reaction can be documented or completion of adequate preventive therapy or adequate therapy for active disease can be documented. Initial and follow-up tuberculin skin tests should be administered and interpreted according to current guidelines (5,11). Health-care-facility personnel with a documented history of a positive tuberculin test, or adequate treatment for disease or preventive therapy for infection, should be exempt from further screening unless they develop symptoms suggestive of tuberculosis. Periodic retesting of PPD-negative health-care workers should be conducted to identify persons whose skin tests convert to positive (11). In general, the frequency of repeat testing should be based on the risk of developing new infection. Health-care-facility workers who may be frequently exposed to patients with tuberculosis or who are involved with potentially high-risk procedures (e.g., bronchoscopy, sputum induction, or aerosol treatments given to patients who may have tuberculosis) should be retested at least every 6 months. Health-care-facility personnel in other areas should be retested annually. Data on skin-test conversions should be periodically reviewed so that the risk of acquiring new infection may be estimated for each area of the facility. On the basis of this analysis, the frequency of retesting may be altered accordingly.

j. Evaluation of health-care-facility personnel after unprotected exposure to tuberculosis In addition to periodic screening, health-care-facility personnel and patients should be evaluated if they have been exposed to a potentially infectious tuberculosis patient for whom the infection-control procedures outlined in this document have not been taken. Unless a negative skin test has been documented within the preceding 3 months, each exposed health-care-facility worker (except those already known to be positive reactors) should receive a Mantoux tuberculin skin test as soon as possible after exposure and should be managed in the same way as other contacts (5). If the initial skin test is negative, the test should be repeated 12 weeks after the exposure ended. Exposed persons with skin-test reactions greater than or equal to 5 mm or with symptoms suggestive of tuberculosis should receive

chest radiographs. Persons with previously known positive skin-test reactions who have been exposed to an infectious patient do not require a repeat skin test or a chest radiograph unless they have symptoms suggestive of tuberculosis.

k. Evaluation and management of health-care-facility personnel with positive skin tests or symptoms that may be due to tuberculosis Health-care-facility personnel with positive tuberculin skin tests or with skin-test conversions on repeat testing or after exposure should be clinically evaluated for active tuberculosis (11). Persons with symptoms suggestive of tuberculosis should be evaluated regardless of skin-test results. If tuberculosis is diagnosed, appropriate therapy should be instituted according to published guidelines (65). Personnel diagnosed with active tuberculosis should be offered counseling and HIV-antibody testing (27). Health-care-facility personnel who have positive tuberculin skin tests or skin-test conversions but do not have clinical tuberculosis should be evaluated for preventive therapy according to published guidelines (5,65). Personnel with positive skin tests should be evaluated for risk of HIV infection. If HIV infection is considered a possibility, counseling and HIV-antibody testing should be strongly encouraged (27). All persons with a history of tuberculosis or positive tuberculin tests are at risk for contracting tuberculosis in the future. These persons should be reminded periodically that they should promptly report any pulmonary symptoms. If symptoms of tuberculosis should develop, the person should be evaluated immediately.

l. Routine and follow-up chest radiographs Routine chest films are not required for asymptomatic, tuberculin-negative health-care-facility personnel. After the initial chest radiograph is taken, personnel with positive skin-test reactions do not need repeat chest radiographs unless symptoms develop that may be due to tuberculosis (66).

m. Work restrictions Health-care-facility personnel with current pulmonary or laryngeal tuberculosis pose a risk to patients and other personnel while they are infectious; therefore, stringent work restrictions for these persons are necessary. They should be excluded from work until adequate treatment is instituted, cough is resolved, and sputum is free of bacilli on three consecutive smears. Health-care-facility personnel with current tuberculosis at sites other than the lung or larynx usually do not need to be excluded from work if concurrent pulmonary tuberculosis has been ruled out. Personnel who discontinue treatment before the recommended course of therapy has been completed should not be allowed to work until treatment is resumed, an adequate response to therapy is documented, and they have negative sputum spears on three consecutive days. Health-care-facility personnel who are otherwise healthy and receiving preventive treatment for

tuberculous infection should be allowed to continue usual work activities. Health-care facility personnel who cannot take or do not accept or complete a full course of preventive therapy should have their work situations evaluated to determine whether reassignment is indicated. Work restrictions may not be necessary for otherwise healthy persons who do not accept or complete preventive therapy. These persons should be counseled about the risk of contracting disease and should be instructed to seek evaluation promptly if symptoms develop that may be due to tuberculosis, especially if they have contact with high-risk patients (i.e., patients at high risk for severe consequences if they become infected).

n. Consultation Consultation on tuberculosis surveillance, screening, and other methods to reduce tuberculosis transmission should be available from state health department tuberculosis-control programs. Facilities are encouraged to use the services of health departments in planning and implementing their surveillance and screening programs. B. Precautions for Specific Settings

1. Hospitals and other inpatient facilities

    a. Tuberculosis (AFB) isolation precautions In hospitals and other inpatient facilities, any patient suspected or known to have infectious tuberculosis should be placed in AFB isolation in a private room. ASHRAE (40) and HRSA (41) have published recommendations for ventilation in AFB isolation rooms. These recommendations specify that rooms should have at least six total air changes per hour, including at least two outside air changes per hour, with sufficient within-room air distribution to dilute or remove tuberculosis bacilli from locations where health-care-facility personnel or visitors are likely to be exposed. The direction of air flow should be set up and maintained so that air flows into the room from the hallway (negative pressure) to minimize possible spread of tuberculosis bacilli into the general health-care setting. The direction of air flow should be monitored while the room is being used for AFB isolation. The use of flutter strips provides a means of constantly observing the direction of air flow. Smoke tubes or smoke sticks are also a quick, simple means of determining the direction of air flow. Air from the room should be exhausted directly to the outside of the building and away from intake vents, people, and animals, in accordance with federal, state, and local regulations concerning environmental discharges. Germicidal UV lamps may be considered as a supplement to ventilation to further decrease the number of infectious droplet nuclei in the air (see sections II.D.2.b. and III.A.4. b.). Isolation-room doors must be kept closed to maintain control

over the direction of air flow. Optionally, a separate anteroom may serve as an airlock to minimize the potential for droplet nuclei to spread from the patient's area to adjacent areas. To work effectively, the anteroom must have directional airflow. Persons who enter a room in which AFB isolation precautions are in place should wear PRs (see section II.D.2.c.). The patient should remain in the isolation room with the door closed and should be instructed to cover nose and mouth with a tissue during coughing and sneezing. If the patient must leave the room (e.g., for a medical procedure that cannot be done at the bedside) while potentially infectious, s/he should wear a properly fitted surgical mask or valveless PR (see section II.C.2.). AFB isolation precautions may be discontinued and the patient placed in a private room when s/he is improving clinically, cough has substantially decreased, and the number of organisms on sequential sputum smears is decreasing. Usually, this occurs within 2-3 weeks after tuberculosis medications are begun. Failure to take medications as prescribed and the presence of drug-resistant disease are the two most common reasons for a patient's remaining infectious. When a patient is likely to be infected with drug-resistant organisms, AFB precautions should be applied until the patient is improving and the sputum smear is negative for AFB. Placing a tuberculosis patient in a room with other patients is not advisable, especially immunosuppressed patients, until the sputum smear is free of bacilli on three consecutive days (see section II.B.3.).

b. Transport, radiology, and treatment rooms When a patient who may have infectious tuberculosis must be transported outside the AFB isolation room, s/he should wear a properly fitted surgical mask or valveless PR (see section II.C.2.).. Ideally, an area in the treatment or radiology department should be specially ventilated for AFB isolation patients. If this is not possible, the patient should be returned to the isolation room as soon as is practical. Health-care-facility workers performing procedures on patients with potentially infectious tuberculosis should wear a PR, especially if the procedure itself induces cough (see section II.D.2.c.). Treatment rooms in which patients who have undiagnosed pulmonary disease and who are at high risk for active tuberculosis are evaluated should meet the ventilation standards for AFB isolation rooms. ASHRAE recommends that treatment rooms have at least six air changes per hour (40). Treatment rooms in which cough-inducing procedures are performed should meet the specifications outlined under procedure-specific precautions.

c. Intensive-care units (ICUs) ASHRAE recommends that ventilation in

ICUs should provide at least six total air changes per hour, including at least two outside air changes per hour (40). If air is recirculated in the ICU, it should be passed through properly designed, installed, and maintained HEPA filters before being recirculated. Installation of UV lamps might be considered in ICUs in which there is a high risk of tuberculosis transmission (see section I.B.). Any ICU patient who may have infectious tuberculosis should be placed in a private room in which ventilation meets the recommendations for AFB isolation. Endotracheal suctioning of patients who may have infectious tuberculosis should be carried out as described under procedure-specific precautions (see section III.A.5.d.) ICU patients with undiagnosed pulmonary symptoms who may have infectious tuberculosis should have respiratory secretions submitted for AFB smear and culture (see section II.B.2.).

d. Emergency rooms Ventilation in emergency rooms, including waiting areas, should be designed and maintained to reduce the risk of tuberculosis transmission, (39-41). ASHRAE recommends that emergency room waiting areas have at least 10 air changes per hour (40). In facilities serving populations with a high incidence of tuberculosis (see section I.B.), germicidal UV lamps and/or HEPA filters in the emergency room may provide additional benefit when used to supplement ventilation (see section II.D.2.).

e. Laboratories Laboratories should adhere to previously published recommendations concerning control of tuberculosis transmission (67).

f. Autopsy rooms ASHRAE recommends that autopsy rooms have ventilation that provides at least 12 total air changes per hour (40). In addition, these rooms should have good distribution of air flow in the room, negative pressure with respect to adjacent areas, and room air exhausted directly to the outside of the building. PRs should be worn by personnel performing procedures that may aerosolize infectious particles (e.g., sawing, irrigating).

g. Hospices All tuberculosis-control recommendations for inpatient facilities apply to hospices.

h. Nursing homes Published recommendations for prevention and control of tuberculosis in nursing homes should be followed (68).

i. Correctional facilities Published recommendations for

prevention and control of tuberculosis in correctional facilities should be followed (54). Prison medical facilities should follow the recommendations outlined in this document. 2. Ambulatory-care facilities --Health-care employers in outpatient settings should be aware of the risk of tuberculosis among their patient population. They should be especially aware of the increased risk among persons who have both HIV infection and tuberculous infection, and they should develop infection-control policies accordingly. --Persons who have HIV infection or who are otherwise at risk for contracting tuberculosis should receive a tuberculin skin test, and the results should be noted in the patient's medical record. Tuberculosis diagnostic procedures should be initiated if signs and symptoms of tuberculosis develop (see section II. B.2.). --Ambulatory patients who have pulmonary symptoms of uncertain etiology should be instructed to cover their mouths and noses when coughing or sneezing; they should spend a minimum of time in common waiting areas (see section II.C.2.). --Personnel who are the first point of contact in facilities serving patients at risk for tuberculosis should be trained to recognize, and bring to the attention of the appropriate person, any patients with symptoms suggestive of tuberculosis (see section II.B.2.), such as a productive cough of greater than 3 weeks' duration, especially when accompanied by other tuberculosis symptoms, such as weight loss, fever, fatigue, and anorexia. --Ventilation in clinics serving patients who are at high risk for tuberculosis (see section I.B.) should be designed and maintained to reduce the risk of tuberculosis transmission (39-41) (see section II.D.). This is particularly important if immunosuppressed patients are treated in the same or a nearby area. In some settings, (see section I.B.), enhanced ventilation or air-disinfection techniques (e.g., HEPA filters or germicidal UV lamps, see sections II.D.2.a. and II.D.2.b.) may be appropriate for common areas such as waiting rooms. Air from clinics serving patients at high risk for tuberculosis should not be recirculated unless it is first passed through an effective high-efficiency filtration system. --In outpatient settings where cough-inducing procedures are carried out, procedure-specific AFB precautions should be implemented (see sections II.C. and III.A.5.).

3. Emergency medical services --When emergency-medical-response personnel or others must transport patients with confirmed or suspected active tuberculosis, a mask or valveless PR should

be fitted on the patient. If this is not possible, the worker should wear a PR (see sections II.C.2. and II.D.2.c.). If feasible, the rear windows of the vehicle should be kept open and the heating and air conditioning system set on a nonrecirculating cycle. --Emergency-response personnel should be routinely screened for tuberculosis at regular intervals. They should also be included in the follow-up of contacts of a patient with infectious tuberculosis (see section III.A.7.).

4. Home-health services --For persons visiting the home of patients with suspected or confirmed infectious tuberculosis, precautions may be necessary to prevent exposure to air containing droplet nuclei until infectiousness has been eliminated by chemotherapy. These precautions include instructing patients to cover coughs and sneezes. The worker should wear a PR when entering the home or the patient's room. --Respiratory precautions in the home may be discontinued when the patient is improving clinically, cough has decreased, and the number of organisms in the sputum smear is decreasing. Usually this occurs within 2-3 weeks after tuberculosis medications are begun. Failure to take medications as prescribed and the presence of drug-resistant disease are the two most common reasons for a patient's failure to improve clinically. Home health-care personnel can assist in preventing tuberculosis transmission by educating the patient about the importance of taking medications as prescribed (unless adverse effects are seen). --If immunocompromised persons or young children live in the home with a patient who has infectious pulmonary or laryngeal tuberculosis, temporary relocation should be considered until the patient has negative sputum smears. --If cough-inducing procedures (such as AP) are performed in the home of a patient who may have infectious tuberculosis, they should be administered in a well-ventilated area away from other household members. Persons who perform these procedures should wear PRs while performing them. --Home health-care workers should be included in an employer-sponsored tuberculosis screening and prevention program (see section III.A.7.). --Early identification and treatment of persons with tuberculosis is important. Home health-care personnel and patients who are at risk for contracting active tuberculosis should be reminded periodically of the importance of having pulmonary symptoms evaluated. --Close contacts of any patient with active infectious tuberculosis should be evaluated for tuberculous infection and managed according to CDC and American Thoracic Society guidelines (5,65).

IV. Research Needs

Additional research is needed regarding the airborne transmission of tuberculosis including the following: a) better quantitating the risk of tuberculosis transmission in a variety of health-care settings, b) assessing the acceptability, efficacy, adverse impact, and cost-effectiveness of currently available methods for preventing transmission, and c) developing better methods for preventing transmission. These needs also extend to other infections transmitted by the airborne route. Currently, large numbers of immunosuppressed persons, including patients infected with HIV, are being brought together in health-care settings in which procedures are used that induce the generation of droplet nuclei. Research is needed to fill many of the gaps in current knowledge and to lead to new and better guidelines for protecting patients and personnel in these settings.

V. Glossary of Abbreviations

AFB Acid-fast bacilli--organisms that retain certain stains, even after being washed with acid alcohol. Most are mycobacteria. When seen on a stained smear of sputum or other clinical specimen, a diagnosis of tuberculosis should be considered.

AIDS Acquired immunodeficiency syndrome--an advanced stage of disease caused by infection with the human immunodeficiency virus (HIV). A patient with AIDS is especially susceptible to other infections.

AP Aerosolized pentamidine--drug treatment given to patients with HIV infection to treat or to prevent Pneumocystis carinii pneumonia. The drug is put into solution, the solution is aerosolized, and the patient inhales the aerosol.

ASHRAE American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.

HEPA High-efficiency particulate air filter. HIV Human immunodeficiency virus--the virus that causes AIDS. HRSA Health Resources and Services Administration. PCP Pneumocystis carinii pneumonia--this organism does not cause disease among persons with a normal immune system.

PR A disposable, particulate respirator (respiratory protective device (face mask)) that is designed to filter out particles 1-5 microns in diameter.

Tuberculous infection A condition in which tuberculosis organisms (M. tuberculosis, M. bovis, or M. africanum) are present in the body, but no active disease is evident.

Tuberculosis transmission Spread of tuberculosis organisms from one person to another, usually through the air.

UV Ultraviolet.

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