Centers for Disease Control and Prevention
CDC 24/7: Saving Lives. Protecting People.™

Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Health-Care Settings, 2005

Recommendations and Reports
December 30, 2005 / 54(RR17);1-141
Prepared by

Paul A. Jensen, PhD, Lauren A. Lambert, MPH, Michael F. Iademarco, MD, Renee Ridzon, MD
Division of Tuberculosis Elimination, National Center for HIV, STD, and TB Prevention

The material in this report originated in the National Center for HIV, STD, and TB Prevention, Kevin Fenton, MD, PhD, Director; and the Division of Tuberculosis Elimination, Kenneth G. Castro, MD, Director.

Corresponding preparer: Paul A. Jensen, PhD, Division of Tuberculosis Elimination, National Center for HIV, STD, and TB Prevention, 1600 Clifton Rd., NE, MS E-10, Atlanta, GA 30333. Telephone: 404-639-8310; Fax: 404-639-8604; E-mail: pej4@cdc.gov.

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 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 in this report (see Supplement, Environmental Controls), including detailed information concerning the application of environmental controls.

Local Exhaust Ventilation

Local exhaust ventilation is a source-control technique used for capturing airborne contaminants (e.g., infectious droplet nuclei or other infectious particles) before they are dispersed into the general environment. In local exhaust ventilation methods, external hoods, enclosing booths, and tents are used. Local exhaust ventilation (e.g., enclosed, ventilated booth) should be used for cough-inducing and aerosol-generating procedures. When local exhaust is not feasible, perform cough-inducing and aerosol-generating procedures in a room that meets the requirements for an AII room.

General Ventilation

General ventilation systems dilute and remove contaminated air and control airflow patterns in a room or setting. An engineer or other professional with expertise in ventilation should be included as part of the staff of the health-care setting or hire a consultant with expertise in ventilation engineering specific to health-care settings. Ventilation systems should be designed to meet all applicable federal, state, and local requirements.

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

AII rooms in health-care settings pre-existing 1994 guidelines should have an airflow of *≥6 ACH*. When feasible, the airflow should be increased to ≥12 ACH by 1) adjusting or modifying the ventilation system or 2) using air-cleaning methods (e.g., 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. Ventilation rates for other areas in health-care settings should meet certain specifications (see Risk Classification Examples). If a variable air volume (VAV) ventilation system is used 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 compared with adjacent areas.

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

AII rooms should be checked for negative pressure by using smoke tubes or other visual checks before occupancy, and these rooms should be checked daily when occupied by a patient with suspected or confirmed TB disease. Design, construct, and maintain general ventilation systems so that air flows from clean to less clean (more contaminated) areas. In addition, 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.

Health-care settings serving populations with a high prevalence of TB disease might need to improve the existing general ventilation system or use air-cleaning technologies in general-use areas (e.g., waiting rooms, EMS areas, and radiology suites). Applicable approaches include 1) single-pass, non recirculating systems that exhaust air to the outside, 2) recirculation systems that pass air through HEPA filters before recirculating it to the general ventilation system, and 3) *room-air recirculation units with HEPA filters and/or UVGI systems.*

Air-Cleaning Methods

High-Efficiency Particulate Air (HEPA) Filters HEPA filters can be used to filter infectious droplet nuclei from the air and must be used 1) when discharging air from local exhaust ventilation booths or enclosures directly into the surrounding room or area and 2) 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).

HEPA filters can be used to remove infectious droplet nuclei from air that is recirculated in a setting or exhausted directly to the outside. HEPA filters can also be used as a safety measure in exhaust ducts to remove droplet nuclei from air being discharged to the outside. Air can be recirculated through HEPA filters in areas in which 1) no general ventilation system is present, 2) an existing system is incapable of providing sufficient ACH, or 3) 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.

Recirculation of HEPA filtered air can be achieved by 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. In addition, *recirculation can be achieved by filtering air through HEPA recirculation systems installed on the wall or ceiling of the room or filtering air through portable room-air recirculation units.*

To ensure adequate functioning, install HEPA filters carefully and maintain the filters according to the instructions of the manufacturer. Maintain written records of all prefilter and HEPA maintenance and monitoring (114). Manufacturers of room-air recirculation units should provide installation instructions and documentation of the filtration efficiency and of the overall efficiency of the unit (clean air delivery rate) in removing airborne particles from a space of a given size.

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) and is installed in a duct to irradiate air passing through the duct (duct irradiation) or incorporated into room air-recirculation units. 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. *Effective use of UVGI ensures that M. tuberculosis, as contained in an infectious droplet nucleus is exposed to a* ***sufficient dose*** *of ultraviolet-C (UV-C) radiation at 253.7 nanometers (nm) to result in inactivation*. Because *dose is a function of* ***irradiance and time****, the effectiveness of any application is determined by its ability to deliver* ***sufficient irradiance for enough time*** *to result in inactivation of the organism within the infectious droplet*. *Achieving a sufficient dose can be difficult for airborne inactivation because the exposure time can be substantially limited; therefore, attaining sufficient irradiance is essential.*

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.

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 ultraviolet (UV) radiometers 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.

UVGI tubes should be changed and cleaned according to the instructions of the manufacturer or when irradiance measurements indicate that output is reduced below effective levels. In settings that use UVGI systems, education of HCWs should include 1) basic principles of UVGI systems (mechanism and limitations), 2) potential hazardous effects of UVGI if overexposure occurs, 3) potential for photosensitivity associated with certain medical conditions or use of certain medications, and 4) the importance of maintenance procedures and record-keeping. 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.