Five Day Evaluation of Ventilation Controls for Preventing Nosocomial Transmission of Tuberculosis

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Introduction

Nosocomial transmission of *Mycobacterium tuberculosis* (MTb) is a recognized risk to health care workers in the U.S. (1,2) In 1994, the U.S. Centers for Disease Control and Prevention (CDC) published Guidelines for Preventing the Transmission of *Mycobacterium tuberculosis* in Health-Care Facilities, 1994. (1) The Guidelines included recommendations for design and operation of MTb isolation rooms. These recommendations include maintaining a negative pressure differential of at least 0.001 inches water column between the patient room and hallway and excess exhaust ventilation of 50 cubic feet per minute or 110% of supply, whichever is greater. An earlier version of the Guidelines recommended maintaining velocity under the door of the patient room at or above 100 feet per minute. (3)

Objectives

The objectives of this study were to evaluate the ventilation system designs in four hospitals used to control tuberculosis and compare these designs to the recommended performance guidelines and to each other. The four hospitals evaluated included a large urban public teaching hospital (Hospital B), a Veterans Administration hospital (Hospital C), a suburban long-term care hospital (Hospital D), and an urban private hospital (Hospital E). A university teaching hospital (Hospital A) was included in other parts of the overall study but is not included in this analysis. The research team monitored at least one room in each facility twenty-four hours per day over a five-day period.

Methods

A research team installed continuous logging data probes in at least one isolation room that was under negative pressure at each of the four hospitals. Each day, the team visited the room(s) to download the collected data. Daily calibration checks were made by measuring smoke direction and air velocity under doors where pressure difference and velocity were measured continuously; wet bulb/dry bulb temperature readings and barometric pressure in each patient room; exhaust and supply air flows; and verifying static and differential pressure readings. In addition, meteorological data was obtained from a local airport to document weather conditions during the sampling period. The following parameters were measured continually during the five-day periods:

- Static pressure in room exhaust fan box/housing, or exhaust duct
- Static pressure in bathroom exhaust duct
- Static pressure in room supply duct
- Static pressure in the ante room supply duct (where applicable)
- Pressure difference between the patient room and the hallway
- Pressure difference between the patient room and the ante room (where applicable)
- Pressure difference between the patient room and bathroom
- Air velocity under the patient room door
- Temperature and relative humidity in the patient room
- Patient room door opening and closing
- Ante room door opening and closing

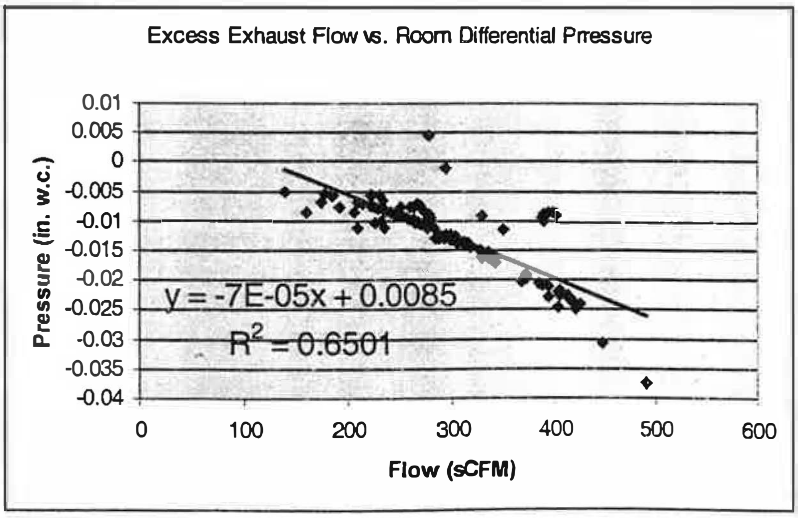
Results

Over the five-day period, none of the control ventilation parameters were met all of the time. For Hospital B, room differential pressure was lost with the opening of the patient room door. The combined exhaust from the fans in the two patient rooms evaluated also created a down draft in the shared bathroom exhaust duct, reversing the airflow. Hospital C never achieved adequate excess exhaust flow rates in either of the two rooms evaluated. This, in turn, resulted in one of the two rooms evaluated to be out of compliance with differential pressure. Hospital D did not have adequate excess exhaust or differential pressure in the room evaluated. Hospital E did not always have adequate excess exhaust in both rooms evaluated nor differential pressure in one of the two rooms evaluated.

In Hospital E, a correlation between excess exhaust and differential pressure could be demonstrated over the five-day evaluation period. No meteorological effects on the measured ventilation system parameters were found at any of the four hospitals.

Discussion

Isolation room design influenced performance and compliance with control criteria. In Hospital B, the rooms did not have anterooms and had no mechanical supply. Opening the patient room door resulted in a loss of established dif-ferential pressure, even with substantial · excess exhaust. In Hospital C, the two rooms have a shared ante-room. The doors have sweeps on the bottom to prevent air from flowing readily into the rooms. The supply and exhaust rates in the room are nearly bal-anced resulting in slight negative pressure



in the rooms. However, the vari-ability of the excess exhaust throughout the day and over the five days studied resulted in the loss of negative pressure. In Hospital D, the anteroom was designed to be positively pressurized with respect to the patient room and the hallway. However, the differential pressure between the anteroom and hallway was mostly negative over the five-day study period establishing a gradient from hallway to anteroom to patient room. The failure of the patient room ventilation to maintain excess exhaust resulted in both the anteroom and patient room losing negative pressure at times over the study period. In Hospital E, the failure to maintain excess exhaust and pressure difference in both rooms resulted in non-compliance with the control guidelines. The meteorological data indicated that wind speed and wind direction did not have an impact on room ventilation performance. In Hospital E, during one of the five days, outdoor temperature seemed to be correlated with a change in room supply airflow. This relationship was not found anywhere else. In addition, no particular cycles in any of the ventilation system parameters were noted to indicate an effect due to time of day.

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