The Wellcome Centre for Clinical Tropical Medicine
Imperial College London

Annual Scientific Meeting
10 & 11 November 2005

Wolfson Pavilion Lecture Theatre
Institute of Infectious Diseases and Molecular Medicine Faculty of Health Sciences, University of Cape Town, South Africa

The prevention of airborne tuberculosis transmission.

R Escombe, M Gil Saavedra, M Navincopa, C Martinez, E Ticona, A Gonzales, D Ramos, LCaviedas, JS Friedland, RH Gilman, CA Evans

1. Guinea pig studies of airborne tuberculosis transmisión.

Airborne tuberculosis transmission was investigated using a guinea-pig facility mechanically ventilated with air from a tuberculosis-HIV ward.

Over 16 months, an average of 92 guinea-pigs were continuously exposed to air from a total of 94 HIV-positive patients with pulmonary tuberculosis, 42 of whom had drug resistant strains accounting for 46% of total pulmonary patient days on the ward. 39 patients were sputum smear-positive. 159 guinea-pigs became positive on skin-testing, an average of 11% per month. Mycobacterial culture and histopathology confirmed tuberculosis. 98% of guinea-pig strains were drug resistant. DNA fingerprinting demonstrated that guinea pig strains originated from only 12 ward patients. The average infectious particle production, q, was calculated as 12 per patient per hour. This was 29 times greater, q=353, for one multi-drug resistant tuberculosis patient who infected 118 guinea pigs during 32 days on the ward (11 of which were without treatment).

These heterogeneous HIV-positive tuberculosis patients produced on average almost ten times as many infectious particles/hour as the patients studied by Riley in the pre-HIV era. DNA-fingerprinting demonstrated a minority of patients caused most transmission. This facility is now being used to evaluate upper room ultraviolet lights and negative air ionizers for preventing tuberculosis transmission. Preliminary results demonstrate a powerful effect of both interventions in reducing airborne TB transmission.

2. Natural ventilation to prevent airborne contagion.

Institutional transmission of airborne infections such as tuberculosis is an important public health problem, especially in resource limited countries where protective measures such as negative-pressure isolation rooms and masks are difficult to implement.

Protection against airborne contagion through natural ventilation was measured by opening windows and doors in 70 clinical rooms, compared with 12 mechanically ventilated negative-pressure rooms. A tracer-gas technique was used in 406 experiments in 8 hospitals in Lima, Peru, and results used to model airborne infection risk.

Opening windows and doors provided median natural ventilation of 2,477m^3/hour (28 air-changes/hour), more than four times that of mechanically ventilated rooms and eighteen times that with windows/doors closed (all $p<0.001$). Facilities built >50 years ago, characterised by large windows and high ceilings, had even greater ventilation than modern naturally ventilated rooms (3,769 *vs.* 1,174m^3/hour; 40 *vs.* 17 air-changes/hour; all $p<0.001$). High natural ventilation was associated using multiple regression with ($p<0.05$): windows/door area open; air through-flow; wind speed; and room volume. Even within the lowest quartile of wind speeds, natural ventilation exceeded mechanical ($p<0.001$). Calculated risk of TB infection for an exposure scenario to infectious untreated TB cases was 39% in mechanically ventilated wards, 33% in modern naturally ventilated rooms, and just 11% in old-fashioned pre-1950 rooms.

Opening windows and doors maximises natural ventilation so that the risk of airborne contagion is much lower than with costly, high-maintenance mechanical ventilation systems. Old-fashioned clinical areas with high ceilings and large windows provide greatest protection, through abundant ventilation augmented by dilution of infectious particles in large spaces. In settings where respiratory isolation is difficult and climate permits, modern building trends should be reversed, high ceilings encouraged, and windows and doors opened to reduce the risk of airborne contagion.