**Infection Containment Without Engineering Controls**

1. I have had some experience in Haiti trying to renovated an ED at the main hospital in Port Au Prince. We did not try to tackle the TB problem but were simply trying to get some "clean" air into the building.

There we had electricity so our idea was to positively pressure the whole building. We mounted a large fan on top of the roof that took air in from high up and pushed it down a chase and throughout the building... like a reverse attic fan...and out the windows. Now that was to just try to get some amount of clean air into the facility and to provide positive pressure. In the case of TB of course you need to create negative pressure.

If there is electricity, there are lots of ways to do that with simple exhaust fans, There is also a collapsible unit that Doug Erickson has been promoting that is very cost effective and makes an air lock right over the door to the patient room and discharges through a HEPA filter. It manufactured by Mintie Corp and is on the web. Maybe they would make a donation or a reduced price. It is the least expensive unit we have seen that works very well.

If there is no electricity, then as they say, the "solution to pollution is dilution". This would indicate as much cross ventilation inside the TB areas as possible. Generally, you don't mix those suspected of TB with those not...separate the areas by a covered breezeway for instance. The screened openings are generally place up high on the wall and roof top vents at the apex of the roof. The roof would have large overhangs and since they are tin roofs the cooler air that is drawn into the room at above 5 feet up (to lower humidity a bit) is then naturally heated in the room and circulates up and out through the roof vent. This is typical building in Costa Rica where I lived for several months.

Or a thermal chimney could be designed that would work to bring air into the room from controlled openings and through then convection process expelled high above the ground. I am sure you have seen this kind of solar technology around for years. In this instance the ceiling are generally high like 10 feet and slope up to the roof top. If this is in a humid area, locating the building above the ground, even 5 or 6 feet above the ground increases the chances for ventilation and lower humidity. There are lots examples of this kind of architecture on the web sites.

Hope this helps a little. It is a difficult problem to solve.

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2. Airflow modeling presumes that the air is flowing in the same direction all the time, which we all know isn't assured when it is provided by Mother Nature.

There are three courses of action that we'd recommend, all attempting to achieve an airflow from clean to dirty and protect personnel from hazard:

1. Situate the room(s) to take best advantage of the natural predominant wind direction, i.e. like you might experience in a coastal setting, such that the airflow comes in from staff side and out at patient side. This may require the corridor on the windward side and the patient station on the leeward, with air outlet near the exam table or chair, preferably low wall!

2. Alternately, achieve the same condition as item 1 above by going high to low with roof intake on the windward side and air outlet at low wall or the floor.

3. Seriously consider using a wall-mounted fan low on patient side wall to consistently provide a negative airflow through the space and past the patient. Obviously this requires the electrical infrastructure to support such action.

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3. As I thought about it and asked some questions, the key may be to allow for natural rise of heated air to provide upward flow of particles. The tropics use fans that throw the hot air down and may prolong the contact time with infectious droplets that would naturally rise. The trick will be to deliver air to the floor and let it rise. Some engineering firms I consulted with recently were discussing that concept in US healthcare for potential usage. Deliver air at a certain temp to the room and let it rise naturally and with fan assist. The cooling factor needs to be discussed.

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4. I know from experience with my grandfather's house in Louisiana - they had 14' high ceilings. It was amazing how cool the rooms were in the summer because there is a natural tendency for warm air to rise. I'm not an engineer, but there might be a principle here that could help.

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5. The only contact I have had with TB was the renovation of the VA facility in Alexandria, Louisiana a number of years ago. At that facility, a separate ward on the $2^{nd}$ floor was created. At the end of the ward was a large screened in porch where the patients spent most of their day. The idea then was providing as much fresh air as possible. That approach in Honduras might still be effective.

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6. I remember vaguely when I had visited a TB hospital in India. It is one of the very few exclusively TB hospitals in India. That place is just a one storey high and is designed like a village.

I was a kid then but from what I can recollect from one of the doctors speaking with my dad. There was no mechanical ventilation there. There were huge windows and ventilators for cross ventilation. The weather in that town was very dry. They had planted a certain kind of tree ALL over the campus. It kills airborne germs and purifies the air. It is called the Neem tree.

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7. A Google search of "infection control natural ventilation" turned up the following:
http://www.phppo.cdc.gov/phtn/webcast/SARS/Chiarello-slides.ppt
http://www.hms.harvard.edu/aids/images/2005cfarsympbockppt.ppt

http://www.mrc.ac.za/pressreleases/2005/2pres2005.htm

All seemed to suggest that there is a place for NV in such a facility. Most seem to lean towards propeller type fans in the windows blowing air out. Probably don't want to be putting any TB patients on the ground floor though. Also the term "controlled natural ventilation" comes up a lot. This would probably preclude cross-flow ventilation and would imply solar chimney type NV systems, possibly with a fan assist in the chimney.

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8. I was thinking along the lines of what EDs (should) do in the US. As the patient enters and is registered, they are asked about cough. If they have cough >2-3 weeks, they are kept apart from the rest of the waiting room. An "isolation" waiting room might make sense if 25% of patients have TB.

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From: David Spencer
Sent: 17 January 2006 15:36
To: Mike Malone
Subject: RE: Preventing the spread of TB in a rural Honduras Health Clinic

9. Report of a conversation with Duncan Philips.

1. Winds are not always from the prevailing direction.

2. The waiting area needs to be well ventilated, and the air-flow should be away from the clinical areas. If you can arrange for a ceiling vent/louver in each major region of the hospital to be naturally ventilated that would be ideal. Alternatively, you could have one large solar chimney located in the center of the building with the upper level outlets from the individual rooms feeding into the chimney. The trick here would be to ensure that there is no back flow. This should be possible

3. There should be a triage station outside. The air from this Triage/Waiting Area should not heads towards the doors or intake louvers into the building interior.

4. Don't let air stand at the ceiling level.

5. Ceiling fans that blow down may circulate the stalest, warmest, dirtiest air towards the users.

6. Ceiling fans that draw the air up will help evacuate the stalest, warmest, dirtiest air if there is a means to vent the air at the ceiling. In this case, we are specifically referring to an exhaust fan in the ceiling that vents directly outside. If the fan simply pulls air up to the ceiling level and then lets it recirculate within the room, it is no better than a fan that pushes air downward. The difference is that that fan that pushes air directly downwards at least provides a sense of cooling for people in the air path.

7. It is important to achieve as great as possible delta H between the low vents and the high vents/windows. Vents placed in the 3rd block course should achieve that.

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10. The only contact I have had with TB was the renovation of the VA facility in Alexandria, Louisiana a number of years ago. At that facility, a separate ward on the 2nd floor was created. At the end of the ward was a large screened in porch where the patients

spent most of their day. The idea then was providing as much fresh air as possible. That approach in Honduras might still be effective.

I also agree with others that both CCRD and SSR should be contacted to see if they have had any experience recently with this issue.

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## Tuberculosis Information

The following is from the CDC's Travelers' Health: Yellow book webpage.

http://www2.ncid.cdc.gov/travel/yb/utils/ybGet.asp?section=dis&obj=tb.htm

### Description

Mycobacterium tuberculosis is a rod-shaped bacterium that can cause disseminated disease but is most frequently associated with pulmonary infections. The bacilli are transmitted by the airborne route and, depending on host factors, may lead to latent tuberculosis infection (sometimes abbreviated LTBI) or tuberculosis disease (TB). Both conditions can usually be treated successfully with medications.

### Occurrence

In many other countries, tuberculosis is much more common than in the United States, and it is an increasingly serious public health problem.

### Risk for Travelers

To become infected, a person usually has to spend a relatively long time in a closed environment where the air was contaminated by a person with untreated tuberculosis who was coughing and who had numerous M. tuberculosis organisms (or tubercle bacilli) in secretions from the lungs or voice box (larynx). Infection is generally transmitted through the air; therefore, there is virtually no danger of its being spread by dishes, linens, and items that are touched, or by most food products. However, it can be transmitted through un-pasteurized milk or milk products obtained from infected cattle.

CDC and state and local health departments have published the results of six investigations of possible tuberculosis transmission on commercial aircraft. In these six instances, a passenger or a member of a flight crew traveled on commercial airplanes while infectious with tuberculosis. In all six instances, the airlines were unaware that the passengers or crew members were infected with tuberculosis. In two of the instances, CDC concluded that tuberculosis was probably transmitted to others on the airplane. The findings suggested that the risk of tuberculosis transmission from an infectious person to others on an airplane was greater on long flights (8 hours or more). The risk of exposure to tuberculosis was higher for passengers and flight crew members sitting or working near an infectious person because they might inhale droplets containing M. tuberculosis bacteria.

The following is a link to the CDC's Division of Tuberculosis Elimination
http://www.cdc.gov/nchstp/tb/default.htm

The following is a link to Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC): *Guidelines for Environmental Infection Control in Health-Care Facilities*
http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5210a1.htm GUIDELINES

The following is from the University of Florida College of Medicine Medical Microbiology and Infectious Diseases webpage.
http://medinfo.ufl.edu/year2/mmid/bms5300/bugs/mycotubr.html#AA2

M. tuberculosis is carried in airborne particles called droplet nuclei that can be generated when persons who have pulmonary or laryngeal TB disease cough, sneeze, shout, or sing (30,31). The particles are approximately 1--5 µm; normal air currents can keep them airborne for prolonged periods and spread them throughout a room or building (32). M. tuberculosis is usually transmitted only through air, not by surface contact.

Droplet nuclei are inhaled. One droplet nuclei contains no more than 3 bacilli. Droplet nuclei are so small that they can remain air-borne for extended periods of time. The most effective (infective) droplet nuclei tend to have a diameter of 5 um. Droplet nuclei are generated by during talking coughing and sneezing. Coughing generates about 3000 droplet nuclei. Talking for 5 minutes generates 3000 droplet nuclei but singing generates 3000 droplet nuclei in one minute. Sneezing generates the most droplet nuclei by far, which can spread to individuals up to 10 feet away.

M. tuberculosis is a strictly aerobic bacterium, with a very slow doubling time (12-18 hours)

Tuberculosis is a highly infectious disease contracted most frequently by inhalation of droplet nuclei that are expelled by infected individuals. These droplet nuclei, because of their very small size, dry quickly and remain airborne for long periods of time, increasing the probability of spread.