Risk of Tuberculosis to Healthcare Workers

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What is the risk of tuberculosis to healthcare workers?

The global upsurge in tuberculosis (TB), fuelled by the human immunodeficiency virus (HIV) pandemic, and the increase in multidrug-resistant (MDR) TB, has made TB a serious occupational hazard for healthcare workers (HCWs) worldwide[1,2]. Recent reports have confirmed a significant risk of occupational infection with *Mycobacterium tuberculosis* among HCWs[3,4,5] medical students,[6] attendants at autopsy[7] and community hospital workers[8]. TB transmission usually occurs over a prolonged period in the orders of days and months of exposure. Compared to household contacts, HCW exposure is comparatively brief but a HCW can be subjected to multiple exposures in the healthcare setting.

A single cough or person talking for 5 minutes may produce 3000 infectious units[9]. The risk of infection increases with proximity and duration of exposure to the source patient in addition to a high concentration of infectious droplet nuclei in the air[10]. Characteristics of the TB patient that enhance transmission include:-

a) disease in the lungs, airways or larynx;
b) presence of cough or other forceful expiratory manoeuvres;
c) presence of acid-fast bacilli (AFB) in the sputum;
d) failure of the patient to cover the mouth and nose when coughing or sneezing;
e) presence of cavitation on chest radiograph;
f) inappropriate or short duration of chemotherapy; and
g) administration of procedures that can induce coughing or cause aerosolization of *M. tuberculosis* (e.g., sputum induction, aerosol treatment such as aerosolised pentamidine treatment, bronchoscopy, endotracheal intubation and suctioning, open abscess irrigation, and autopsy)[11] .

Environmental factors that enhance the likelihood of transmission include :

a) exposure in relatively small, enclosed spaces;
b) inadequate local or general ventilation that results in insufficient dilution and/or removal of infectious droplet nuclei; and
c) re-circulation of air containing infectious droplet nuclei[11].

Nosocomial transmission of *M. tuberculosis* to patients and HCWs

Nosocomial transmission of TB is usually a consequence of hospitalised patients with unrecognised pulmonary or laryngeal TB who are not receiving effective anti-tuberculosis therapy and have not been placed in respiratory isolation[11]. MDR-TB poses an even more serious hazard to patients and HCWs. Patients with MDR-TB can remain infectious for prolonged periods, which increases the risk for nosocomial and/or occupational transmission of *M. tuberculosis*. Fortunately, MDR-TB is not yet a major problem in Malaysia. The greatest risk of nosocomial transmission is to immunocompromised patients, including those who are infected with the human immunodeficiency virus (HIV)[12-14]. Transmission of *M. tuberculosis* to HIV-infected persons is of particular concern because these individuals are at high risk for developing active TB if they become infected with the bacteria. While in general, persons who become infected with *M. tuberculosis* have approximately a 10% risk for developing active TB during their lifetimes, individuals with latent TB infection who become co-infected with HIV have approximately an 8-10% risk per year for developing active TB[15]. On the other hand, the atypical presentation of patients infected with *M. tuberculosis* and HIV can cause delays in diagnosis and result in nosocomial spread of TB to other patients and HCWs[16]. For TB-exposed HCWs in the United States, the Centers for Disease Control and Prevention (CDC)

recommends regular tuberculin skin testing followed by preventive therapy or chemoprophylaxis with isoniazid for 6 to 12 months for skin-test convertors[17]. However, previous bacille Calmette-Guerin (BCG) vaccination in the majority of Malaysians makes the interpretation of tuberculin skin test reaction difficult and indiscriminate chemoprophylaxis is not an appropriate practice in a country with a high prevalence of TB.

Preventive therapy for latent TB infection (chemoprophylaxis)

Isoniazid preventive therapy is effective in preventing later reactivation of the disease in 93% to 98% of previously healthy exposed individuals[18]. The prescription of isoniazid can protect an individual from clinical TB caused by the exposure that converted the tuberculin skin test but it would not be expected to protect the same individual from subsequent exposures once the course of isoniazid is completed. Furthermore, the proportions of HCWs who agree to isoniazid preventive therapy and adhere to it are low; in one study it was only 45%[19]. This together with the difficulty in differentiating TB disease from TB infection means the indiscriminate use of single drug prophylaxis carries the risk of promoting drug resistance. In general, close clinical monitoring rather than chemoprophylaxis is recommended. It should also be noted that isoniazid preventive therapy will not work if the HCW was exposed to isoniazid-resistant *M. tuberculosis.*

BCG vaccination

Immunisation with the BCG strain of *Mycobacterium bovis* can protect a HCW from both drug-sensitive and drug-resistant *M. tuberculosis* over many years and following possible multiple exposures. The protection afforded by BCG vaccination, however, is not absolute and cases of TB can occur in vaccinated individuals. Vaccination with BCG does not affect the risk for infection; rather, it decreases the risk for progressing from latent TB infection to active disease. The many studies attempting to measure the efficacy of BCG immunisation have yielded protective efficacy estimates that have ranged from 0% to 80%[20]. A British survey documented a 77% to 84% protective efficacy for BCG in a 20-year follow-up period[21]. Three recent meta-analyses of the large number of studies showed that BCG vaccination was 50% effective in preventing clinical TB and is more effective in preventing the disseminated forms of tuberculosis in children than pulmonary tuberculosis in adolescents or adults[20,22,23]. The reasons for the vast differences in efficacy in the published studies are unclear but strain variations among BCG vaccines, nutritional status of the vaccinees, and protection afforded by nontuberculous mycobacterium infection are possible factors. The reluctance to use BCG immunisation to protect HCWs is understandable when the trials have reported conflicting results. Some authors feel that revaccination with BCG does not confer more benefit than initial vaccination, and repeat vaccinations should be discontinued[24]. Some authors feel that BCG vaccination generally is not recommended in HCWs despite their exposure to *M. tuberculosis*, including MDR-TB. In 1995, the United States Advisory Council for the elimination of TB saw no role for BCG vaccination[25]. However, not everyone agrees. In a comparison of tuberculin screening strategy with BCG vaccination in hospital medical officers, Greenberg et al[19] found that BCG requires only an efficacy rate of 13.1% to prevent more cases of TB than the tuberculin skin test conversion strategy in surveillance programmes. Nettleman and her colleagues[26] recently published a decision analysis demonstrating that the use of a vaccine that was 50% effective would be less costly and more effective in preventing cases of TB in HCWs than tuberculin skin test surveillance programmes. Brewer and Colditz[27] analysed many trials and suggested that BCG vaccination is effective in reducing the incidence of TB among HCWs. These cohort studies suggest that BCG vaccination may be protective in HCWs whose tuberculin skin tests are negative[27]. Other American researchers are also suggesting the use of BCG vaccination as a possible means to protect HCWs and other at-risk groups from TB[28,29]. The emerging threat of MDR-TB has also rekindled interest in the utility of BCG vaccination, in the absence of a more effective vaccine, as a strategy to reduce the risk of transmission of TB[24]. Indeed, the United States CDC now has recommended BCG vaccination, but only for some HCWs specifically at risk of exposure to isoniazid- and rifampicin-resistant *M. tuberculos* is strains[30].

Preventing nosocomial TB transmission

In 1994, the United States CDC developed new guidelines for the prevention of transmission of TB in healthcare facilities based on a three-tier hierarchy of controls; including in order of importance, identification and treatment of patients, isolation of patients and use of protective devices by HCWs[11]. Specifically, these controls involve (1) the use of administrative measures to reduce the risk of exposure to persons who have infectious TB, (2) the use of engineering controls to prevent

the spread and reduce the concentration of infectious droplet nuclei, and (3) the use of personal respiratory protective equipment in areas where there is still a risk for exposure to *M. tuberculosis* such as TB isolation rooms and TB treatment rooms[11]. Although completely eliminating the risk for transmission of *M. tuberculosis* in all health-care facilities may not be possible, adherence to these guidelines is expected to reduce the risk to persons in these settings. Developing and low-income countries, however, lack the resources to invest in costly engineering measures for the prevention of nosocomial TB. Protecting HCWs in these healthcare facilities should therefore involve simple, practical and affordable measures[31] related to

a) the early diagnosis, isolation and treatment of infectious cases;
b) educating and teaching patients on cough hygiene such as covering their mouths and noses with tissues when coughing or sneezing and the wearing of surgical masks when not in the isolation room to reduce the expulsion of infectious droplet nuclei into the air;
c) educating, training and counselling HCWs about TB, measures to minimise occupational exposures, symptoms of TB and the importance of seeking prompt medical evaluation if they were to develop such symptoms;
d) appropriate environmental control to reduce the concentration of infectious droplet nuclei in the air by improving natural ventilation and the use of exhaust fans;
e) protecting HCWs from inhaling infectious droplet nuclei by wearing particulate respirators in situations in which the risk for infection with *M. tuberculosis* is relatively high such as TB isolation rooms and TB treatment rooms in which cough-inducing or aerosol generating procedures are performed on TB patients; and
f) perhaps, TB screening of HCWs who are at high risk for TB infection (such as those working in TB clinics or wards) by chest radiography performed annually or once every two years. There is probably no role for regular tuberculin skin testing and isoniazid preventive therapy for HCWs in countries including Malaysia where the prevalence of TB is high in the community.

Effective anti-tuberculosis therapy reduces coughing, the amount of sputum produced and the number of TB organisms in the sputum[32]. The length of time a patient must take effective therapy before becoming non-infectious varies between patients[33]. Isolation of smear-positive patients is generally required for 2 weeks. However, decisions about infectiousness should be made on an individual basis.

The TB respiratory isolation room and treatment room

The primary purposes of TB isolation rooms and TB treatment rooms are to

a) separate patients who are likely to have infectious TB from other persons;
b) provide an environment that will allow reduction of the concentration of droplet nuclei through various engineering methods; and
c) prevent the escape of droplet nuclei from the TB isolation room, thus preventing entry of *M. tuberculosis* into the corridor and other areas of the facility.

TB isolation rooms should be single-patient rooms to prevent super-infection with drug-resistant organisms and should have special ventilation characteristics[11]. The CDC recommends that such rooms should have 12 or more air changes per hour in order to dilute and remove contaminated air[11]. To prevent the escape of droplet nuclei, the TB isolation room and TB treatment room should be maintained under negative pressure. Doors to isolation rooms should be kept closed, except when patients or personnel must enter or exit the room, so that negative pressure can be maintained. Air from TB isolation rooms and treatment rooms should be exhausted to the outside. Upper-room air ultraviolet germicidal irradiation (UVGI) may be used as an adjunct to general ventilation in the isolation room. Air in the isolation room may be re-circulated within the room through high efficiency particulate air (HEPA) filters or UVGI devices. These recommendations should be followed especially if the healthcare facility is centrally air-conditioned.

TB isolation practices[11]

• Patients who are placed in TB isolation should be educated about the mechanisms of *M. tuberculosis* transmission and the reasons for their being placed in isolation. They should be taught to cover their mouths and noses with a tissue when coughing or sneezing, even while in the isolation room, to contain liquid drops and droplets before they are expelled into the air.

•Patients placed in isolation should remain in their isolation rooms with the doors closed. If possible, diagnostic and treatment procedures should be performed in the isolation rooms to avoid transporting patients through other areas of the facility. If patients who may have infectious TB must be

transported outside their isolation rooms, they should wear surgical masks that cover their mouths and noses during transport. Surgical masks are designed to prevent the respiratory secretions of the person wearing the mask from entering the air. Persons transporting the patients do not need to wear respiratory protection outside the TB isolation rooms. When not in a TB isolation room, patients suspected of having TB should wear surgical masks to reduce the expulsion of droplet nuclei into the air. These patients do not need to wear particulate respirators, which are designed to filter the air before it is inhaled by the person wearing the respirator.

• If the TB patient requires radiological imaging he should wear surgical mask and should stay in the radiology department the minimum amount of time possible and he should return promptly to his isolation room.

•The number of persons entering an isolation room should be minimal. All persons who enter an isolation room should wear respiratory protection. The patient's visitors should be given respirators to wear while in the isolation room and they should be given general instructions on how to use their respirators.

Personal respiratory protection

Personal respiratory protection should be used by

a) persons entering rooms in which patients with known or suspected infectious TB are being isolated,
b) persons present during cough-inducing or aerosol-generating procedures performed on such patients, and
c) persons transporting such patients with infectious TB in ambulances[11].

Respiratory protective devices used in healthcare settings for protection against *M. tuberculosis* should have filter characteristics that meet the United States CDC performance criterion of >95% efficiency at 1 micron particle size (i.e., filter leakage of <5%)[34]. The 3M 1860/1860S healthcare particulate respirator type N95 (3M Health Care, St. Paul, MN, United States) which is designed specially for use in the healthcare setting meets the CDC performance specifications for respirators that can be used for TB exposure control. It has been certified by the National Institute for Occupational Safety and Health (NIOSH), Department of Health and Human Services of the United States to be at least 95% efficient in filtering sodium chloride (NaCl) test aerosol. NaCl test aerosol has a count median diameter of 0.005 and 0.095 microns. The filter, therefore, should be more efficient in filtering droplet nuclei containing viable *M. tuberculosis* that are 1 to 5 microns in diameter. Surgical masks have neither the fit nor the filtration properties to provide protection of the wearer from airborne transmission.

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MCQs on Risk of Tuberculosis to Healthcare Workers

1. The characteristics of the tuberculosis patient which increase transmission are
   A. extrapulmonary disease
   B. the presence of cough
   C. presence of acid-fast bacilli in the sputum
   D. presence of cavitation on chest radiograph
   E. co-infection with the human immunodeficiency virus

2. Compared to drug sensitive tuberculosis, multidrug resistant tuberculosis
   A. is resistant to either rifampicin or isoniazid
   B. is associated with higher rates of treatment failure
   C. requires longer hospital stay
   D. remain infectious for a longer period
   E. is associated with a greater risk of transmission

3. The following statements on the prevention of transmission of tuberculosis in healthcare facilities are true
   A. The early identification of the tuberculosis patient and the early institution of effective treatment are the most important control measures
   B. Healthcare workers should wear particulate respirators in situations where the risk of tuberculosis transmission is high
   C. Surgical masks worn by healthcare workers are equally effective in preventing transmission
   D. TB patients should cover their noses and mouths when they cough or sneeze
   E. TB patients must wear particulate respirators when they need to come out from their isolation rooms

4. To reduce the risk of tuberculosis to healthcare workers
   A. BCG revaccination has been proven to be beneficial
   B. There is a Malaysian national policy of regular healthcare worker tuberculin skin testing and chest radiography
   C. Isonaizid chemoprophylaxis should be given to positive tuberculin test reactors
   D. Adequate respiratory precautions should be taken when performing cough-inducing procedures
   E. Healthcare workers should wear particulate respirators when entering tuberculosis isolation rooms

5. If the healthcare facility is air-conditioned
   A. The number of air changes recommended for TB isolation rooms is 6 per hour
   B. Air from TB isolation rooms should be exhausted to the outside
   C. Isolation rooms should have negative pressure relative to the corridors
   D. Upper-room air ultraviolet germicidal irradiation alone is effective in preventing transmission of TB to healthcare workers in TB treatment rooms
   E. Air in the isolation room may be re-circulated within the room through high efficiency particulate air filters