Infection control guidelines for the management of patients with suspected or confirmed pulmonary tuberculosis in healthcare settings

Chris Coulter and the National Tuberculosis Advisory Committee

Introduction

Tuberculosis is caused by the bacterium *Mycobacterium tuberculosis*. Globally, *M. tuberculosis* is responsible for an estimated 9.6 million new tuberculosis (TB) cases per annum with 1.5 million deaths estimated in 2014.[1] In Australia, there are around 1,200 to 1,400 cases of TB each year.[2] Worldwide, TB incidence is slowly declining and it is estimated that 43 million lives have been saved between 2000 and 2014.[1] TB disease can occur in pulmonary and extrapulmonary sites. Persons with extrapulmonary disease are usually not infectious unless the TB disease is located in the larynx or the oral cavity or if the extrapulmonary disease includes an open abscess or lesion where drainage fluid may be aerosolised.[3] Laryngeal tuberculosis should be considered as having the same or greater risk of transmission as smear positive pulmonary tuberculosis.

The risk of transmission in healthcare settings is increased when healthcare workers and patients come in contact with persons who:

- have unsuspected pulmonary TB;
- are not receiving adequate treatment; and, or
- who have not been isolated from others.[4]

These guidelines provide recommendations for healthcare workers to manage patients who are confirmed or suspected of having pulmonary TB.

Transmission

TB is spread via inhalation of small particle aerosols (airborne route). When a person with pulmonary TB coughs, sings, laughs or sneezes, *M. tuberculosis* is generated and carried in droplet nuclei particles that are approximately 1–5 μm in size.[4] Depending on the environment, tubercle bacilli can remain suspended in the air for prolonged periods and air currents can carry them throughout a room or building.[4]

Infectivity is directly related to the magnitude of viable organism load in respiratory secretions. The risk of transmission increases with duration of exposure. Household members are at greatest risk of acquiring TB from an index case of pulmonary tuberculosis. In healthcare settings, the duration is often considered significant after eight accumulative hours of exposure have occurred but this is not an absolute cut off for decision making. Intensity of smear positivity, mechanical factors (e.g. aerosol generating procedures) and host vulnerability must all be taken into account. *M. tuberculosis* is transmitted only through air containing microdroplets of TB organisms. It is not transmitted by touching surfaces such as bed linen, toilet seats, shaking hands etc.

Importance of early detection

The most effective measure to control TB in a healthcare setting is early detection. By having a high level of vigilance for TB, appropriate isolation can occur at an early stage. The early flags for TB, as listed in the Series of National Guidelines for TB[5] are:

- a chronic cough, sometimes accompanied by haemoptysis;
- fever and night sweats;
- loss of weight; and
- feeling generally tired and unwell.

Clinical suspicion of TB should be high in any person with exposure risk factors and a respiratory infection unresponsive to standard treatments or an unexplained non-respiratory illness. This particularly includes:

- new arrivals and recently returned travellers from high incidence countries;
- contacts of an active case within the past 5 years;
- those with a history of previous TB treatment;
- Indigenous Australians in localised areas (e.g. as occurs in parts of the Northern Territory and Queensland);
- patients with HIV or other immuno-compromised states; and
- elderly Australians.

It is important that clinicians specifically request that the laboratory stains for acid fast bacilli and performs TB culture. Rapid molecular tests should be utilised where clinically appropriate. Where multidrug-resistant TB is suspected, an Xpert MTB/RIF assay should be requested as this can detect the presence of rifampicin resistance as well as the presence of *M. tuberculosis* directly from sputum and some extrapulmonary specimens (including cerebrospinal fluid).

Transmission based precautions

Transmission based precautions are additional work practices used in situations where standard precautions alone may be insufficient to prevent infections.[4] They are based on the use of personal protective equipment (PPE) appropriate to the mode of disease transmission and should always be used in conjunction with standard precautions.

When to use airborne precautions

Airborne precautions are a subset of transmission based precautions and are used to prevent transmission of microorganisms that remain infectious over time and distance when suspended in the air. These agents may be inhaled by susceptible individuals who have not had face-to-face contact with (or been in the same room as) the infectious individual.[4]

Airborne precautions are indicated for all patients where pulmonary TB is suspected or proven. Patients with HIV TB co-infection may not have typical symptoms: pulmonary TB should be considered in the differential diagnosis of HIV positive patients epidemiologically at risk of TB (e.g. from higher burden TB countries) with respiratory symptoms or undiagnosed systemic illness.

At the point of first contact with a medical service, ideally designed engineering controls may not be available. In this setting the following is recommended:

- place the patient in an area that can be contained (i.e. a single room);
- ask the patient to wear a surgical mask when not in a single room or if air from the single room recirculates to other areas of the building, until advised to remove it by attending staff;
- if not wearing a surgical mask, cough etiquette should be used (covering mouth when coughing using disposable tissues, or hand followed by hand hygiene); and
- the door to the single room remains closed.[4]

Airborne precautions should also be used if any procedure involving aerosolisation is to be performed and tuberculosis is a diagnostic possibility.

Airborne precautions are not necessary for persons with extrapulmonary (where there is no evidence of pulmonary TB as well) and latent TB infection.

Non-tuberculous mycobacteria are not transmissible person to person. However, recent data suggesting the possibility of person to person transmission of *Mycobacterium abscessus* complex strains between patients with cystic fibrosis (CF) in the United Kingdom is acknowledged.[6] Until more information is available for other settings, infection control requirements for CF patients with *M. abscessus* complex isolates should be determined by local experts involved in CF care and infection control.

Accommodation

Ideally patients with pulmonary TB should be accommodated in negative pressure rooms or Type 5 (respiratory isolation) rooms that are equipped with environmental controls to reduce the risk of transmission of airborne diseases. If this is not possible then the patient should be placed in a single room with en suite from which the air does not circulate to other areas.[4]

Environmental controls

Environmental controls consist of engineering technologies that are designed to prevent the spread and reduce the concentration of infectious TB droplet nuclei in the air.[4] These engineering strategies include ventilation and high-efficiency particulate air (HEPA) filtration.[7]

The Australian standard is that all hospitals, irrespective of their size, should have at least one Type 5 (respiratory isolation) room and should aim to provide between 1% and 3% of all available beds for respiratory isolation.[8]

The final estimates of the number of rooms required for infection control purposes including the containment of TB should be made in consultation with clinicians, engineers, architects and the infection control committee.[8] Infection surveillance data collected for more than 12 months will assist in determining peak needs and marked seasonal variations recognising that other diseases may also require respiratory isolation.[8]

Type 5 (respiratory isolation room) air-handling requirements

The supply and exhaust of Type 5 (respiratory isolation) rooms should provide a negative pressure, relative to the corridor and adjacent areas. To obtain the negative pressure, the exhaust flow rate should be a minimum of 10% greater than the supply air with all doors and openings closed.[8]

For a new building, air from Type 5 (respiratory isolation) rooms ideally should not be reticulated via, or to, any other ventilation system, i.e. it should be a single pass system. Air from these rooms should be exhausted directly to the outside of the building. The discharge points should be located as far as possible from air-intakes, persons and animals. It is recommended that the discharge point be positioned above the roof and at such a height and velocity that exhausted air is unlikely to re-enter the building or its ventilation system.[8]

Alternatively, where existing facilities do not allow external exhausting, air that is to be re-circulated should be directed through HEPA filters.[8] The door to the room should remain closed at all times. For Type 5 (respiratory isolation) rooms, air change rates greater than or equal to 12 air changes per hour with a minimum of 2 air changes per hour of outside air, whichever results in the greater air quantity, should be achievable when the filters have reached their maximum pressure drop.[8]

For further information on Type 5 (respiratory isolation) rooms and facility requirements please refer to Standards Australia, HB 260: Hospital acquired infections-Engineering down the risks.[8]

Non-conventional settings

In non-conventional facility-based and congregate settings without a central ventilation system, natural ventilation can be useful.[7] Natural ventilation relies on open doors and windows to bring in air from the outside. When using natural ventilation, facility staff should be aware of the direction of airflow. If the air direction is known, staff should sit near the fresh air source and clients should sit near the exhaust location.[7]

Prioritising type 5 (respiratory isolation) rooms

On occasions, certain patients may need to be prioritised for Type 5 isolation, including patients with other respiratory infectious diseases. Where there are two or more patients with TB, prioritisation should be given to smear positive over smear negative, drug resistance over pan susceptible, confirmed untreated smear positive over suspected. Decisions on prioritisation based on a combination of these parameters should be made in consultation with the local infection control service and the local TB service.

Specimen collection

It is very important for healthcare workers to use infection control precautions to control the spread of tubercle bacilli during specimen collection procedures and any other procedures that may cause persons who have pulmonary TB disease to cough.[9]

All cough-inducing and aerosol-generating procedures e.g. induced sputum, nasopharyngeal aspiration should be performed using environmental controls such as in a sputum induction booth/room or a Type 5 (respiratory isolation) room. Patients should be left in the booth/room or Type 5 (respiratory isolation) room until coughing subsides.[4]

Sputum collection from ambulant patients can occur outdoors away from others. Pathology providers or clinicians should provide specific instructions to patients on how to collect a good sputum sample in a safe manner.[10] Private enclosed spaces, e.g. toilets, specimen collection centres, are not adequately ventilated and are potentially dangerous locations for specimen collection.

Another patient or healthcare worker should not be allowed to enter the booth or the Type 5 (respiratory isolation) room until enough time has passed for a sufficient number of air changes to occur for adequate removal of *M. tuberculosis* contaminated air.[7] Consult with your facility plant engineers to determine the air changes per hour for each airborne infection isolation room.[7]

Personal protective equipment

All staff should wear a correctly fitted P2/N95 respirator mask* prior to entering the patient-care area when an airborne transmissible infectious agent is known or suspected.[4] If the patient is ventilated, a filter must be present on the expiratory circuit.[7] Standard Precautions are to be adhered to in addition to transmission-based airborne precautions.

Masks and respirators

Surgical masks are designed to stop droplet nuclei from being generated from exhaled respiratory particles by the person wearing them when they breathe, talk, cough, or sneeze. In the absence of a surgical mask or effective cough etiquette, droplet nuclei form when larger droplets desiccate in the ambient environment following expulsion by cough or other circumstances as mentioned. Persons who are suspected or confirmed of having infectious TB may be given a surgical mask to wear to prevent them from expelling infectious

* P2 is an Australian and New Zealand classification, and N95 North American. Both devices are correctly referred to as particulate respirators. They filter >95% of airborne particles. Due to their appearance they are commonly called “masks.”

droplet nuclei[2] when they are outside of a negative pressure room. It is unnecessary for a patient to wear a P2/N95 mask.[7]

Masks (P2/N95) are designed to protect healthcare workers and other individuals from inhaling droplet nuclei. This can protect these individuals from becoming infected with *M. tuberculosis* when in contact with a person with infectious TB.[4]

In order for a P2/N95 mask to offer the maximum desired protection it is essential that the wearer is properly fitted and trained in its safe use. Healthcare facilities should ensure that they have a respiratory protection program that regularly evaluates the risk to which healthcare workers are exposed and determines which employees are required to undertake fit testing.[4]

Considerations when using a P2/N95 mask include:

- masks should not be touched while being worn;
- masks should be changed when they become moist;
- masks should never be reapplied after they have been removed;
- masks should not be left dangling around the neck; and
- hand hygiene should be performed upon touching or disposing of a used mask.[4]

Healthcare workers who have facial hair (including a 1–2 day beard growth) must be aware that an adequate seal cannot be guaranteed between the P2/N95 mask and the wearer's face.[4]

Fit checking

Healthcare workers must perform fit checks every time they put on a P2/N95 mask to ensure it is properly applied. No clinical activity should be undertaken until a satisfactory fit has been achieved.[4] Fit checks ensure the mask is sealed over the bridge of the nose and mouth and that there are no gaps between the mask and face. Healthcare workers must be informed about how to perform a fit check.[2]

The procedure for fit checking includes:

- placement of the mask on the face;
- placement of the headband or ties over the head and at the base of the neck;
- compressing the mask to ensure a seal across the face, cheeks and the bridge of the nose;
- checking the positive pressure seal of the mask by gently exhaling. If air escapes, the mask needs to be adjusted; and
- checking the negative pressure seal of the mask by gently inhaling. If the mask is not drawn in towards the face, or air leaks around the face seal, readjust the respirator and repeat process, or check for defects in the respirator.[4]

The manufacturer's instructions for fit checking of individual brands and types of a P2/N95 mask should be referred to at all times.[4]

Fit testing

Fit testing is a qualitative or quantitative method that is used to evaluate the fit of a specific make, model and size of mask on an individual[12] and to ensure that it is worn correctly. It also provides an opportunity to ensure healthcare workers are properly trained in the correct use of the mask.[4]

The National Health and Medical Research Council *Australian Guidelines for the Prevention and Control of Infection in Healthcare, 2010*[11] state a risk management approach should be applied and that fit testing should be performed at the commencement of employment for employees who will be working in clinical areas where there is a significant risk of exposure to infectious agents transmitted via the airborne route: assessment of the significance of risk will involve consideration of the location and activities to be undertaken. In the context of tuberculosis, a risk assessment should pay particular attention to factors which heighten:

a. the risk of transmission – duration of anticipated exposure, smear status, aerosol generating procedures, pre-test probability of TB as a cause of undiagnosed respiratory infection; and
b. the consequences of transmission – antimicrobial resistance, host impairment of healthcare worker.

The optimal frequency of fit-testing has not been determined although the Australian standard AS1715:2009 recommends annual testing. Re-testing may be indicated if there is a change in facial features of the wearer, or a change in the availability of a model or size of the initially assigned P2 mask.[12] Fit testing should be considered if a seal cannot be obtained or easily recognised with a given model of P2/N95 mask even if the overall risk is considered to be low. There is no published evidence to indicate that nosocomial transmission of TB occurs less frequency when fit testing is implemented compared with when it is not.

Transfer of patients

If transfer of the patient outside the negative pressure room is necessary, e.g. to attend radiology, the patient should be asked to wear a correctly fitted surgical mask while they are being transferred and to follow respiratory hygiene and cough etiquette.[4] It is unnecessary for a patient to wear a P2/N95 mask.[7] The majority of young children are not infectious, and therefore, would not need a mask; however this decision should be done in consultation with a TB specialist.

Visitors

Close household contacts should be assessed for active tuberculosis prior to visiting the facility. Children should be discouraged from visiting infectious patients. Close household contacts should wear the same PPE as hospital staff during patient visits. People who are vulnerable for disease following TB infection e.g. preschool children and the immunosuppressed, should not visit. Exceptional circumstances may include breast feeding and each situation should be considered individually. Visitors other than close household contacts should be discouraged from visiting. If visiting, they should be counselled about their risk and they should wear a P2/N95 mask with good fit characteristics. Instruction should be given on how to perform a fit check.[7] This should include a demonstration of donning, removing and disposing of PPE as required, as well as hand hygiene.[7]

Cleaning

M. tuberculosis is usually transmitted only through air, not by surface contact.[4] Routine environmental cleaning with a facility's standard cleaning product should be sufficient for cleaning the room. The room door must remain closed and negative airflow maintained after patient discharge until all air in the room has been replaced; this will vary based on the number of room air changes per hour. Consult facility plant engineers to determine the air changes per hour for each airborne infection isolation room.[7]

Staff responsible for cleaning the room will need to use appropriate PPE including a P2/N95 mask while performing cleaning if this occurs before the required number of air changes have occurred. Once the room has been thoroughly cleaned and a sufficient number of air changes have occurred the room may be used for subsequent patients.

Bronchoscopy

Bronchoscopy can result in the transmission of *M. tuberculosis* either through the airborne route or via a contaminated bronchoscope.[13,14] If active TB is suspected or part of a differential diagnosis, then sputum collection spontaneously or by induction is a preferred test before bronchoscopy. In the case of confirmed TB, bronchoscopy should be postponed, if at all possible, until treatment has rendered the patient noninfectious.

Bronchoscopy suites should be under negative pressure and have the same minimum number of air exchange and air exhaust provisions as a Type 5 isolation room.[8] If it is necessary to perform bronchoscopy, this should be the last procedure of the day otherwise sufficient time should be allowed for adequate air exchange prior to the next procedure. Meticulous and detailed cleaning and high level disinfection by staff properly trained in bronchoscope reprocessing is the best defence against transmission of mycobacterial infection by flexible bronchoscopy. Australian guidelines for cleaning and microbiological monitoring of bronchoscopes should be followed.[15]

Cessation of respiratory isolation precautions

It is recommended that patients with suspected or confirmed pulmonary TB who are admitted to hospital, should remain isolated in a negative pressure room with airborne precautions applied until criteria are met. In principle these criteria should include:

- a reduction in or absence of cough;
- reduced smear burden or smear negativity;
- assured treatment by direct observation; and
- an appropriate discharge plan.[5]

If drug resistance is suspected then cases should remain in isolation with airborne precautions in place until susceptibility results are confirmed. If sputum remains smear positive, a decision about hospital discharge should be made in consultation with a specialist physician with experience in managing TB and taking into account the social circumstances at home, such as the potential to expose new contacts and the presence of children under 5 years of age.

Patients with pulmonary TB who are managed at home should be isolated until assessed as being at minimal risk of transmitting infection. Adequate social support and supervised therapy is essential in the home environment to maintain home isolation. Assessment of other family members should be undertaken as a matter of priority to determine their status and also the possible need for preventive therapy in any children under 5 years of age with no initial evidence of infection. The patient

and family must also be provided with appropriate education and counselling about minimising the risk of transmission of infection; cough hygiene, avoiding new contacts and restricting movements away from home.

Cohorting

It is not recommended that patients with TB are cohorted as there is a risk of cross transmission of different strains between patients. This is of particular concern where strains with drug resistance, including multidrug resistant tuberculosis may be present.

Bacille Calmette-Guérin vaccination

Generally, bacilli Calmette-Guérin (BCG) vaccination is not recommended for healthcare workers although may be considered where there is a high risk of exposure to drug resistant tuberculosis and BCG vaccination is not otherwise contraindicated.[16] BCG vaccination should be given in accordance with the most current edition of *The Australian Immunisation Handbook*[17] (http://www.immunise.health.gov.au/)

Management of healthcare workers and students with tuberculosis

If a healthcare worker or student is diagnosed as having infectious TB and was infectious while at work the healthcare facility should consider convening an expert incident management team to:

- determine the infectiousness of the healthcare worker/student;
- determine the dates the healthcare worker/student was in the facility and infectious;
- determine the areas of the facility that the healthcare worker/student was during the infectious period;
- determine if staff and/or patients need to be contact traced; and
- if required, designate responsibility for contact tracing and screening.

Issues relating to healthcare workers and tuberculosis are addressed in greater detail in the following National Tuberculosis Advisory Committee *Guideline: Management of Tuberculosis Risk in Health Care Workers in Australia* (currently unpublished).

Contact tracing in hospitals

Contact tracing in hospitals should be undertaken in accordance with legislative requirements and should be in conjunction with the appropriate tuberculosis control unit (state or regional). Facilities should ensure that roles and responsibilities between themselves and TB control units are clearly defined in regards to contact tracing and screening within the facility.

This should include designating:

- an appointed position or unit within the facility to be the designated contact for confirmed tuberculosis case notification. These notifications may come directly from the laboratory, from the treating team or via the tuberculosis control unit;
- an appointed position or unit to be responsible for collating a list of contacts including staff, patients and visitors;
- the responsibility for assessing the contacts;
- the responsibility for conducting contact screening of identified contacts as appropriate; and
- a mechanism for documenting and reporting the outcomes of a contact screening investigation.

Glossary of terms

Fit checking	A procedure that the healthcare provider must perform each time a P2/N95 respirator is worn to ensure it fits the wearer's face correctly to provide adequate respiratory protection. The healthcare provider must receive training on how to perform a seal-check correctly.
Fit testing	A qualitative or quantitative method to evaluate the fit of a specific make, model and size of respirator on an individual.
HEPA filter	High efficiency particulate air filter with an efficiency of 99.97% in the removal of airborne particles 0.3 microns or larger in diameter.
Latent TB infection (LTBI)	Refers to the condition when a person is infected with tubercle bacilli but has not developed TB disease. Persons with LTBI carry the organism that causes TB but do not have TB disease symptoms and they cannot spread TB to others.
Non-tuberculous mycobacteria	Mycobacteria that do not cause TB disease and are not usually spread from person to person; one example is *Mycobacterium avium* complex.

Acknowledgements

The author would like to acknowledge the National Tuberculosis Advisory Committee members both past and present (in alphabetical order): Associate Professor Anthony Allworth, Dr Ral Antic, Dr Ivan Bastian, Mr Philip Clift, Dr Jo Cochrane, Dr Chris Coulter (Chair), Associate Professor Justin Denholm, Dr Paul Douglas, Professor

Steve Graham, Clinical Associate Professor Mark Hurwitz, Dr Vicki Krause, Mr Chris Lowbridge, Professor Ben Marais, Ms Rhonda Owen, Ms Tracie Reinten, Dr Richard Stapledon, Dr David Stock, Ms Cindy Toms, Mr Peter Trevan and Dr Justin Waring with the NTAC Secretariat from the Department of Health.

Queensland Health: Mareeka Gray, Communicable Diseases Unit.

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