

8. Contact Tracing

Contact tracing is a systematic process with three main objectives:

- To identify and initiate treatment of secondary cases
- To identify TB infected contacts in order to offer treatment for LTBI
- To identify those not infected for whom BCG vaccination may be appropriate.

Contact tracing may also be undertaken to find a source of infection or any co-primary cases where there is evidence of recent infection, as indicated by infection in children.

Current Irish epidemiological data indicate that between 6 and 10% of TB cases are diagnosed by contact tracing.^{19;20;262} UK studies from the 1990s have shown that up to 10% of TB cases are diagnosed by contact tracing, that disease is detectable in about 1% of all screened contacts,²⁶³⁻²⁷⁰ and is normally found in non-BCG vaccinated close contacts of pulmonary smear positive cases during the initial round of investigation.²⁶³⁻²⁶⁷

Early case detection as a result of contact tracing reduces the period in which cases are infectious and the risk of infection being transmitted to others. Evaluation of highest risk contacts can infer recent transmission if infection or disease is detected. Evidence of recent infection supports the extension of the contact investigation to progressively lower-risk contacts. Screening should be concluded when levels of infection detected in the tiers of at risk contacts equate to those in the general community.

Recommendation:

Contact tracing should be conducted according to the concentric circle approach,²⁷¹ whereby contacts with greatest exposure to the index case are prioritised for screening.

8.1 Factors Predicting TB Transmission

TB is spread by airborne droplet nuclei (approximately 1 to 5 microns in diameter, containing 1 to 10 bacilli) which are released in an aerosol from an individual with infected pulmonary sites when they cough, sneeze or sing. Sociability of the index patient may contribute to disease transmission because of the increased number of contacts and the intensity of exposure.⁵¹ The amount of contact necessary for TB infection to be transmitted is variable. It depends on the infectiousness of the source case, the susceptibility of the person in contact with the case and the environment in which contact occurs. Factors that predict likely transmission of TB are outlined below and it is important to consider all these factors together when evaluating the infectiousness of a case.²⁷²

Infectiousness of the source case

Anatomical site of disease

Cases with TB in pulmonary and laryngeal sites primarily transmit infection.^{273;274} In such cases, determining whether or not AFB are present on microscopic examination of sputum is an important factor in establishing infectiousness. Infectious pulmonary and laryngeal cases should be considered a priority for contact investigation.

Cases of extrapulmonary TB are typically non-infectious and contact investigations should be aimed at identifying a source of infection in those with greatest exposure to the case (especially where there is evidence of recent infection e.g. TB in a child). This is especially important if the case appears to have resulted from recent transmission e.g. meningeal TB in a child. Diseased tissues are not usual infection sources, although aerosol-producing procedures (e.g. autopsy, embalming and irrigation of a draining abscess) undertaken without infection control precautions are considered an infection risk.^{227;275-278}

Sputum bacteriology

A case of TB whose sputum is smear positive, defined as a patient with minimum of one sputum specimen

positive for AFB by microscopy is thought to be six to 10 times more contagious than a smear negative case, while laryngeal TB cases are four to five times more contagious than smear positive pulmonary cases.^{30;279}

Table 8.1: Definition of an infectious TB case

Infectious TB case	TB case presumed infectious for contact tracing purposes
<ul style="list-style-type: none"> • Sputum smear positive pulmonary TB • Laryngeal TB 	<ul style="list-style-type: none"> • BAL positive: (see below)

The relative infectiousness of positive bronchial washings or BAL is unknown but some consider such specimens equivalent to sputum.²⁸⁰ The US approach is to consider all BAL positive patients as infectious as those who are sputum smear positive⁵¹ (table 8.1). It is recommended that a precautionary approach should be taken with BAL smear positive cases.

Recommendation:

- Infectious pulmonary and laryngeal cases are priorities for contact investigation. A precautionary approach should be taken with BAL smear positive cases
- Those BAL smear positive cases with cavitation on chest X-ray, MDR-TB or XDR-TB or where contacts are immunosuppressed or are under 5 years of age should be presumed infectious for contact tracing purposes
- The determination of infectivity of all other BAL smear positive patients should be considered on a case-by-case basis (clinical/microbiology/public health input).

Radiographic findings

Patients who have lung cavities observed on a chest radiograph typically are more infectious than those with non-cavitary disease.^{278;281;282} This is an independent predictor after bacteriological findings are taken into account.

Age

Children younger than 10 years of age with pulmonary TB are rarely contagious because their pulmonary lesions are small (paucibacillary disease), cough is not productive, and few or no bacilli are expelled.¹⁰⁹ Generally, contact tracing investigations involving young children should be geared towards identifying the source and co-primary cases. However, although unusual, transmission from young children has been recorded.^{283;284}

Recommendation:

Young children under 10 years of age with pulmonary disease are rarely infectious. Such contact tracing investigations should be focused on finding a source and co-primary cases.

Susceptibility of Contacts

Age

Children under five years of age are more likely to develop disease following recent infection.¹¹⁰ The incubation period is usually short, and severe forms of TB are common. Children under five years of age should be assigned a high priority for contact investigation.

Immunosuppression

Immunosuppressed individuals should be assigned a high priority for contact investigation. TB patients who are HIV-infected with low CD4 T-cell counts frequently have chest radiographic findings that are not typical of pulmonary TB. Atypical radiographic findings increase the potential for delayed diagnosis which increases transmission.

Indoor environment

Transmission is rarely thought to occur outdoors. Risk of transmission is greatest where there is prolonged, close contact with a case in an indoor environment; small volumes of shared indoor air, limited ventilation of the airspace with outdoor air and recirculation of air in closed circulation heating or air conditioning systems. Indoor environments that are poorly ventilated, dark or damp, can lead to increased concentration and survival of *M. tuberculosis*.²⁸⁵⁻²⁸⁷

Duration of exposure ^{281;288-290}

The likelihood of transmission of *M. tuberculosis* increases with the intensity, frequency and duration of exposure to a case. Usually it takes many hours or days to transmit an infectious dose, but casual/short exposures may lead to transmission if the case is infectious and environmental air conditions are favourable.²⁹¹ Exposure duration of less than eight hours is generally considered not to be significant. Current US and UK guidelines^{26;51} cite cumulative contact of eight hours or more for contact investigation.

8.2 Initiating the Contact Investigation

Prompt notification of active TB cases is crucial, allowing for the early initiation of contact tracing (table 8.2). Rapid evaluation of close contacts allows timely identification of those who have active disease and, if active disease has been excluded, allows initiation of treatment of LTBI for newly infected contacts before disease occurs.

Table 8.2: Timeframes for completing various stages of the contact investigation

Case notification	Case should be notified as soon as possible, and not later than one working day following diagnosis
Contact tracing interview	Should be conducted no later than: <ul style="list-style-type: none"> o 1 working day after notification of an infectious/presumed infectious case o 3 working days after notification for all other pulmonary and extra-pulmonary cases
Site investigation	Should be conducted no later than 3 working days after the contact tracing interview if deemed appropriate following a risk assessment
First screening of priority contacts	Should be conducted no later than: <ul style="list-style-type: none"> o 7 working days for close contacts of an infectious/presumed infectious case o 14 working days for all other contacts (i.e. casual contacts of infectious cases/contacts of non-infectious cases) after the contact tracing interview

8.3 Investigating the Index Case

Comprehensive information regarding an index patient is the foundation of a contact investigation. When a case of TB is identified, detailed information about the index case should be collated and considered, so that priorities can be established for screening. Criteria for consideration are multiple and include:

- Anatomical site(s) of TB disease
- Symptoms and date of illness onset
- Chest X-ray results (and other results of diagnostic imaging studies)
- Diagnostic specimens that were sent for bacteriological or histological analysis
- Current bacteriological results
- Previous diagnosis/treatment for TB infection or disease
- Concomitant medical risk factors/conditions
- Relevant socio-demographic information
- Names of contacts and
- Exposure locations.

The MOH (in practice regional director of public health/designated medical officer) is responsible for conducting TB contact investigations. Local standard operating procedures for investigation improve the efficiency and uniformity of investigations. Timeframes for completion of specific stages of contact investigation are recommended in table 8.2.

Determining the infectious period

Determining the infectious period focuses the investigation on those contacts most likely to be at risk for infection and sets the timeframe for testing contacts. Cases of pulmonary TB are generally considered to become infectious at the time of onset of cough. If no cough is reported or if the duration is difficult to determine, the time of onset of other symptoms attributable to TB may be used to estimate the onset of infectiousness. In practice, however, it is often difficult to know with certainty when symptoms began. Because the start of the infectious period cannot be determined with precision by available methods, a practical estimation is necessary.

For infectious/presumed infectious cases: (see table 8.1) assessment of the period of exposure should extend to three months before symptom onset or first positive finding consistent with TB disease (e.g. abnormal chest X-ray), whichever is longer. This is consistent with recent guidelines published by the US Centers for Disease Control and Prevention⁵¹ and Canada.³⁰

For cases other than infectious/presumed infectious cases: assessment of the period of exposure should

extend to four weeks before the date that TB was suspected. Again, this is consistent with current CDC and Canadian guidelines.^{30, 51}

The decision about the period of infectiousness, therefore, will need to be determined for each case according to these guidelines and to the clinical situation. Priority should always be given to contact tracing during the period when the TB patient was symptomatic. If the yield of contacts with active disease is found to be higher than expected from tuberculin testing, the period of potential exposure should be further extended.

The period of time in which a patient on effective therapy takes to become non-infectious varies. This can be established in infectious pulmonary patients by monitoring susceptibility to treatment (as demonstrated by smear negative sputum results on three consecutive days)^{30, 51, 52} and diminished symptoms.⁵¹ Respiratory TB patients are usually non-infectious after a minimum of two weeks of treatment.²⁶

8.4 Prioritisation of Contacts

As the circumstances in each contact investigation are unique, and risk of infection and disease to individual contacts cannot be determined precisely, the classification of contacts into 'close' and 'casual' is recommended to guide the decision making process (see table 8.3). Contacts with a cumulative total exposure to an infectious TB case exceeding eight hours within a restricted area should be regarded as close contacts i.e. equivalent to household contacts. A reduced cumulative total exposure time of ≥ 4 hours should be considered for vulnerable contacts such as young children aged less than 5 years and immunocompromised contacts.

Table 8.3: Classification of contacts for prioritising contact tracing

Contact classification	Description
Close contacts	<ul style="list-style-type: none"> • All household contacts (an individual sharing a bedroom, kitchen, bathroom, or sitting room) • All other immunocompetent adult contacts with a cumulative total exposure ≥ 8 hours in a restricted area equivalent to a domestic room (may include girlfriend, boyfriend, close friends, sexual partners, frequent visitors to the home, etc.) • A reduced cumulative total exposure time of ≥ 4 hours may need to be considered for vulnerable contacts exposed in a restricted area such as children aged < 5 years and immunocompromised individuals, immunocompromised either due to disease e.g. HIV or therapies, individuals receiving >15mg prednisone or equivalent for more than four weeks, or other immunosuppressive agents for cancer, chemotherapeutic agents, anti-rejection drugs for organ transplantation and TNF-α antagonists or as defined by the attending consultant. • Individuals exposed during medical procedures (e.g. bronchoscopy, sputum induction or autopsy) where no infection control practices were in place
Casual contacts	<ul style="list-style-type: none"> • Generally all other contacts such as work colleagues, team/club members, etc. (some such contacts may be assessed as being close contacts following risk assessment)

For infectious/presumed infectious cases (see table 8.1): all close contacts should be screened initially. Screening should be extended if there is evidence of infection or disease in close contacts following screening i.e. evidence of transmission.

For cases other than infectious/presumed infectious cases: Screening should be limited to household members only unless there is evidence of recent infection (e.g. TB in child) and the source remains

unknown. In such circumstances, screening by chest X-ray should be considered for those adults in regular contact with the child (e.g. childminder, teachers).

Expanding a contact investigation

Consideration should be given to extending screening if there is evidence of transmission based on any of the following:

- There is an unexpectedly high rate of infection or TB disease in close contacts (e.g. if $\geq 10\%$ of close contacts have TB infection or active disease)⁵¹
- TB disease is identified in a casual contact or a contact with low screening priority
- Infection is identified in any contact (close/casual) under five years of age.

8.5 The Contact Tracing Interview

A newly diagnosed patient should be interviewed by a trained member of staff in the hospital, TB clinic, in the patient's home or anywhere that will ensure the patient's privacy. Interviews should be completed as soon as possible (see table 8.2). The interview provides an opportunity to exchange information, for the patient to acquire information about TB and its control, and for the health professional to learn to adapt treatment and education strategies to the patient's specific requirements. The Centers for Disease Control and Prevention (CDC) developed standard procedures for interviewing TB patients in 1999.²⁹² The following principles as proposed by CDC are recommended for use:

1. **Building rapport** with a case is an important part of contact tracing. This can be achieved by assuring patient privacy, helping the patient decide how to share information about their diagnosis to contacts, and allowing approximately one hour for exchange of information (depending on the patient's health and endurance).
2. **Exchanging information** should allow the interviewer to obtain missing information e.g. date of symptom onset, and the patient to improve their understanding of disease causation/transmission and clarify their treatment plan requirements.
3. **Transmission settings** i.e. places the case attended while infectious should be identified so contacts attending those venues can be identified and prioritised for screening based on time spent by the index case in those settings. Topics for discussion could include where the patients worked, spent their leisure/recreational time, where they visited, ate, spent nights, etc. The interviewer should ask specifically about time spent in congregate settings (e.g. schools, prisons, hospitals/healthcare settings, etc.)
4. **Lists of contacts** should be made for those attending each potential site of transmission, including name of contact, approximate types, frequency and duration of exposure. Recent illness among contacts should be discussed.
5. **Closure:** The interviewer should express appreciation for the patient's contribution, and indicate how screening will proceed, that site visits will be conducted and confidentiality respected.
6. **Follow-up interviews** should be scheduled if further information is required.

Site investigation

Site visits may need to be undertaken to complement interviews. It is important that consideration is given to the index case's lifestyle so that places of intense contact other than the household may be determined (e.g. work or leisure sites). Site visits may add contacts to the list and are the most reliable source of information regarding transmission settings.²⁸⁸ Physical conditions at each setting can contribute to transmission. At congregate settings, the size of the room(s), ventilation system and airflow patterns should be considered along with information about how long and how often the patient was in that setting. Failure to visit all potential sites of transmission has contributed to TB outbreaks.^{293;294} Visiting the index patient's residence is especially helpful for finding children who are contacts. Certain sites (e.g. congregate settings) require special arrangements to visit. Communication and liaison with management in congregate settings is an essential component of site investigation. Maintaining confidentiality for an index patient can be difficult. The index case should be informed that information needs to be shared with management. Every effort should be taken to maintain patient confidentiality.

8.6 Screening Tools

The TST using the Mantoux technique (2TU) is the primary tool used in contact tracing²⁹⁵ (chapter 2). IGRA testing is an additional diagnostic method for screening of LTBI.

Guides to evaluating contacts of active TB cases are shown in figures 8.1 (for contacts of active TB cases) and 8.2 (for children between four weeks and five years who are contacts of infectious TB cases). These guidelines do not fit every circumstance and additional considerations beyond those discussed in these guidelines may need to be taken into account for specific situations. It is important to monitor attendance, to identify those contacts who fail to attend and to ensure that the contact's GP is informed of repeated failures to attend.

In the future, the rapidly expanding evidence base will provide more reliable information on the sensitivity and specificity of IGRA tests and their comparability to the TST. Evidence gathered to date suggests that the IGRA tests are at least as sensitive as the TST in diagnosing LTBI and more specific in populations that include previously BCG vaccinated individuals. However, discordant results between IGRA and the TST have been observed, leading to difficulties interpreting the results.⁶⁰

In theory, a two-step strategy, using TST (with its high sensitivity) followed by IGRA testing (with its high specificity) should be an optimal approach for screening an individual exposed to a TB case.²⁶ The chest X-ray is generally reserved as a means of confirming pulmonary disease following recent contact with TB or in the presence of suggestive symptoms.

Canadian guidelines^{60,296} on IGRA published in 2007 and updated in 2008 summarised current evidence in the context of contacts of a case of infectious TB and IGRA use as follows:

- IGRA correlated with exposure better than TST in BCG vaccinated contacts. There were significantly fewer positive results in low-exposure groups with the IGRA than with the TST
- In the absence of BCG, the IGRA and TST appeared to have similar rates of positivity, although there were discordant results.

Those guidelines conclude that, given that several studies have found significant discordance between TST and IGRA results (both TST positive/IGRA negative and the reverse) and because the biological basis of this discordance is uncertain, the reliance on IGRA should depend on the clinical context.

The Canadian guidance with regard to IGRA use in contact tracing is recommended.

Canadian guidance on IGRA for adult and child contacts of a case of active infectious TB tuberculosis⁶⁰

IGRA may be used as a confirmatory test for a positive TST in contacts (adult or child) who on the basis of an assessment of the duration and degree of contact with an active infectious case are felt to have a low pre-test probability of recently acquired LTBI and who have no other high or increased risk factors for progression to active disease if infected.

For close contacts or those contacts who have high or increased risk of progression to active disease if infected, a TST (or both TST and IGRA) should be used and if either is positive the contact should be considered to have LTBI.

If both TST and IGRA testing will be used, it is recommended that blood be drawn for IGRA on or before the day when the TST is read.

Repeating TST in contact investigations

The interval between acquisition of infection and tuberculin conversion is an important issue. This determines the interval between the first and second TST in contact investigations i.e. the so-called window period. Traditionally this had been considered to be 12 weeks but all available evidence from

BCG vaccination and natural infection points to a shorter interval. After inadvertent vaccination with *M. tuberculosis* (the Lubeck Disaster), children developed positive reactions in three to seven weeks. Other studies have shown clinical illness with a positive tuberculin test from 19-57 days after exposure with a mean of 37 days.²⁹⁷

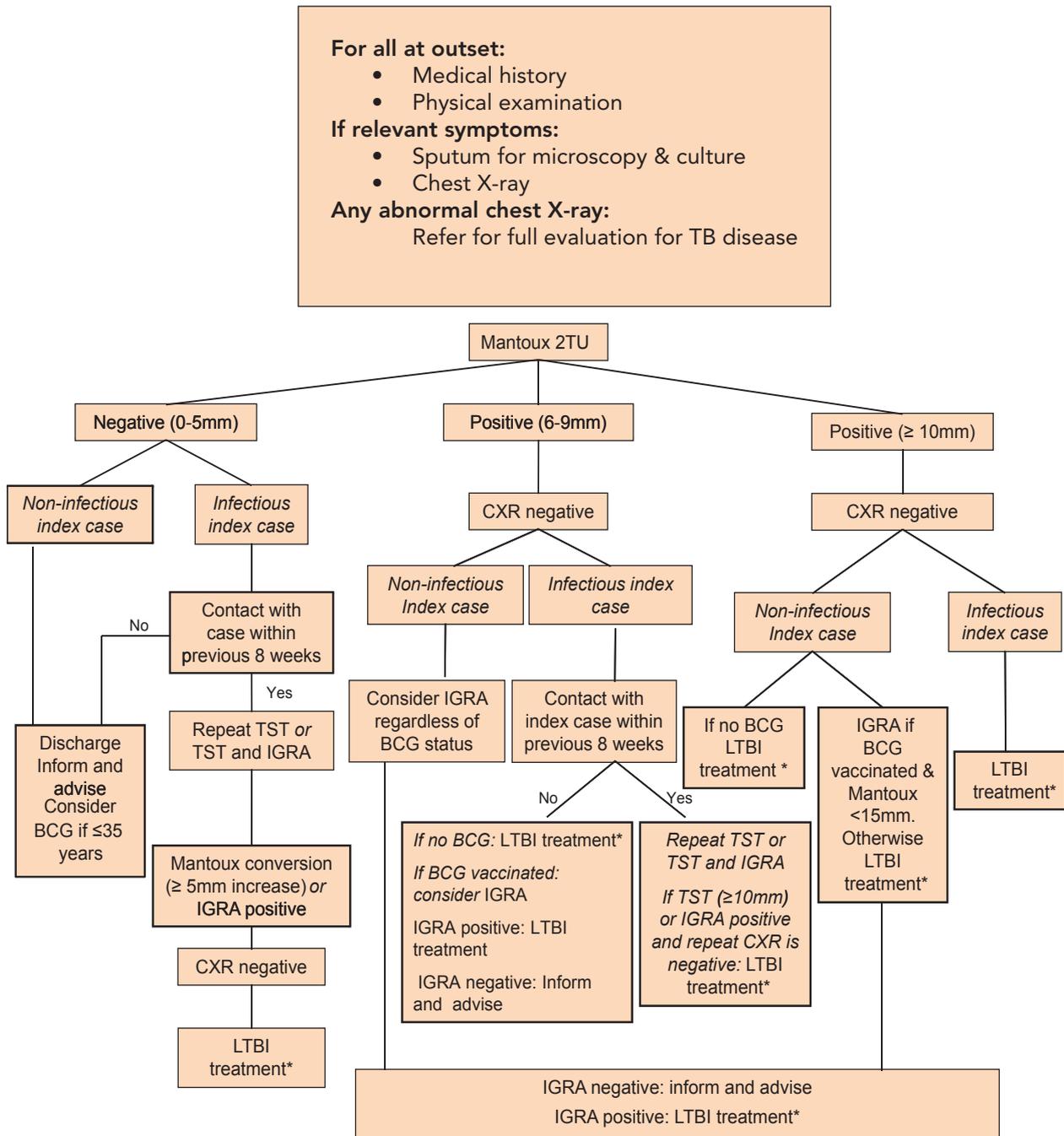
There continues to be international variation in practice. The 2003 New Zealand TB Control guidelines lowered the window period for testing from twelve to eight weeks based on the findings of the studies outlined above.⁵² Current US guidelines⁵¹ cite eight to ten weeks, while the UK advises a six-week interval between tuberculin tests (a recommendation based on consensus opinion of clinicians and experts).²⁶

It is the view of this committee, based on available best evidence, that six-eight weeks constitutes a good timing interval as it is important to leave long enough for conversion to occur but not too long for a delayed diagnosis. Eight weeks is a good compromise and well within evidence for conversion times stated in the literature.

Recommendation:

The recommended interval between first and second screening rounds (TST ± IGRA) in contact investigations is eight weeks. If the last contact with the infectious case exceeded an eight-week period, one TST is sufficient.

Figure 8.1: Algorithm for close contacts (adults and children ≥ 5 years) of all cases of infectious/presumed infectious TB



The algorithm presented here is a guideline only and should be interpreted in accordance with the clinical context.

Note: At present, IGRA are not routinely recommended for children but may be considered in individual situations

*If LTBI treatment is refused: Chest X-ray follow-up at three and 12 months

Contact investigation for patients whose culture converts back to positive

In some instances, a TB patient's culture may convert to negative and then become positive again. This may happen if a patient is lost to follow-up and discontinues medications before completing treatment or if treatment was not adequate because of multidrug resistance.

If the patient is located after a treatment lapse of three months or longer and if the patient's cultures have become positive again or if the patient relapses while on treatment after becoming culture negative, a second window period should be defined and the patient should be re-interviewed. Contacts identified during the initial investigation should be re-evaluated if they were exposed again. If new contacts are identified, they should be tested and evaluated.⁷⁷

Contact investigation among children and adolescents

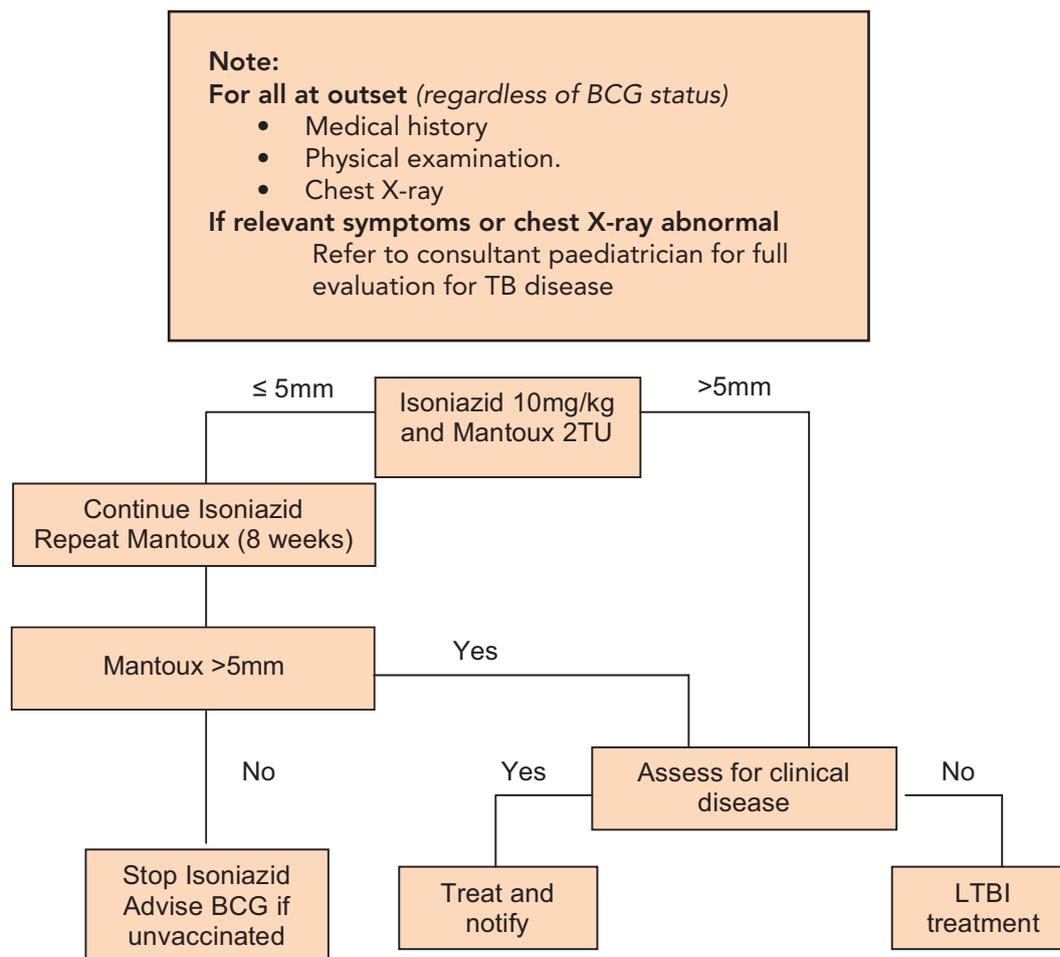
Contact investigations for children with suspected TB are generally conducted to identify the adult source-case. Because TB among infants and young children usually occurs within weeks to months of contracting infection with *M. tuberculosis*, having a child with disease is a marker of recent transmission from someone in the child's environment.⁵¹ Children younger than 10 years with pulmonary TB are rarely contagious because their pulmonary lesions are small (paucibacillary disease), cough is not productive, and few or no bacilli are expelled.¹⁰⁹ However, children or adolescents of any age with characteristics of adult-type TB (i.e. productive cough and cavitary or extensive upper lobe lesions on chest X-ray) should be considered potentially infectious at the time of diagnosis.⁵¹

A negative TST does not exclude LTBI or TB disease. Approximately 10 to 15% of immunocompetent children with culture-documented disease do not react initially to a TST.¹⁰⁹ Host factors such as young age, poor nutrition, immunosuppression, other viral infections (especially measles, varicella and influenza), recent TB infection and disseminated TB disease can decrease TST reactivity. Many children and adults co-infected with HIV and *M. tuberculosis* do not react to a TST.

In the interpretation of a positive TST among child contacts of contagious TB cases, current US guidelines disregard previous BCG immunisation.¹⁰⁹

Young child contacts aged under five years of an infectious TB case

Following exposure to a case of infectious/presumed infectious TB, children should have a TST and an evaluation for TB disease (chest X-ray and physical examination). Once active TB has been ruled out, children with positive skin tests should receive a full course of treatment for LTBI (chapter 3). Those who have negative skin test results should also receive treatment for presumed LTBI (chapter 3). This intervention is especially critical for infants and toddlers < 3 years but is recommended for all children aged < 5 years.⁵¹ Those with a negative TST result should be retested eight weeks after exposure to infectious TB has ended. If the TST result is still negative in an immunocompetent individual, isoniazid can be discontinued (continue for further 7 months i.e. a total of 9 months if immunocompromised). If the second test is positive, treatment should be continued for a further 7 months i.e. a total of 9 months.^{51;109}

Figure 8.2: Algorithm for children aged between four weeks and five years who are close contacts* of infectious/presumed infectious TB cases

January 2014: The following amendment has been made to Figure 8.2: "Mantoux > 5mm AND increase on initial test > 5mm" changed to "Mantoux > 5mm".

The algorithm presented here is a guideline only and should be interpreted in accordance with the clinical context.

Note: IGRA may be considered on a case by case basis as per the general recommendations in section 2.6.

Management of newborn infant contact of TB¹⁰⁹

Management of the newborn infant is based on categorisation of the maternal (or household contact) infection. Although protection of the infant from TB disease is of paramount importance, contact between infant and mother should be allowed when possible.

Mother (or household contact) with TB disease

Investigation of all household members should be conducted without delay. If the mother has TB disease, the infant should be evaluated for congenital TB. The mother (or household contact) and the infant should be separated until the mother (or household contact) has been evaluated and the mother (or household contact) and infant are receiving appropriate anti-TB therapy, the mother wears a mask, and the mother understands and is willing to adhere to infection control measures. Once the infant is receiving isoniazid, separation is not necessary unless the mother (or household contact) has possible MDR-TB or has poor adherence to treatment and DOT is not possible.

If congenital TB is excluded, it is recommended that isoniazid is given until the infant is three months of age, when a TST should be performed. If the TST result is positive, the infant should be reassessed for TB disease. If TB disease is excluded, isoniazid should be continued for a total of nine months. The infant

* See Table 8.3 for definition of a close contact

should be evaluated at monthly intervals during treatment. If the TST result is negative and the mother (or household contact) has good adherence and response to treatment and is no longer contagious, isoniazid can be stopped. BCG vaccine should then be given provided there are no contraindications.

See chapter 5 for information on anti-TB medications in breastfeeding women.

8.7 TB Outbreaks

A TB outbreak indicates potential extensive transmission. An outbreak implies that the patient was contagious, that contacts were exposed for a substantial period and that the interval since exposure has been sufficient for infection to progress to disease (chapter 1). An outbreak investigation involves several overlapping contact investigations, with a surge in the need for public health resources.

Outbreak definition

Definitions of TB outbreaks are relative to the local context. In general, two or more apparently related cases of TB constitute an outbreak until proved otherwise.²⁹⁸ Outbreak cases can be distinguished from other cases only when certain associations in time, location, patient characteristics or *M. tuberculosis* attributes (e.g. drug resistance or genotype) become apparent. In low-incidence areas, any temporal cluster may be suggestive of an outbreak. In places where cases are more common, clusters can be obscured by the baseline incidence until suspicion is triggered by a noticeable increase, a sentinel event (e.g. paediatric cases) or genotypically-related *M. tuberculosis* isolates. Outbreaks of TB are statutorily notifiable under the Infectious Diseases (Amendment) (No.3) Regulations 2003 (S.I. No.707 of 2003).²¹

Outbreak management

The primary objectives of outbreak management are to:

- Recognise the outbreak
- Define its epidemiological characteristics and aetiology
- Prevent its further spread and recurrence and
- Maintain satisfactory communications with appropriate external agencies and the general public.

For efficient and effective management of an outbreak, an outbreak management plan should be based on the principles that the director of public health/consultant in public health medicine has overall responsibility for investigation and control and for managing the outbreak and that individual members of the outbreak control team (OCT) have responsibility for managing clearly defined aspects of the outbreak. Suitably developed plans should be agreed between the relevant stakeholders in each HSE area.

Outbreak control team

Appropriate representation on the OCT is crucial. In outbreaks affecting more than one area the chair should be agreed.

The main objectives of the OCT will include:

- To investigate the source/cause of the outbreak: epidemiological study including:
 - formulation of hypothesis to explain the most likely source, site and time of infection
 - case definition and
 - case finding (identifying numbers affected/exposed). Methods will vary according to numbers involved and the setting in which the outbreak has occurred. Molecular typing may be of assistance.
- To agree on the implementation of any measures necessary to control the outbreak including the identification and referral of cases, the screening of contacts and other measures as appropriate (e.g. chemoprophylaxis and referral). Potential resource implications will require estimation and addressing.
- To monitor the effectiveness of control measures
- To provide information to patients, patients' contacts, GPs, the general public, the media and appropriate staff
- To liaise with appropriate health bodies and statutory services
- To coordinate the investigation, evaluate the overall work of controlling the outbreak and implement the lessons learned and
- To produce interim reports as required and a final outbreak report at the conclusion of the outbreak.

Communications

Communications often present an intensely challenging aspect of outbreak investigation and management. TB outbreak investigations can be complex and protracted. Communications may extend over lengthy periods. Apart from providing regular information to patients, contacts and their families, there are also regular professional and media aspects to be addressed. All media communications should be coordinated by the press officer. The setting up of a helpline to give specific advice and information may need to be considered.

8.8 Congregate Settings

Overall concerns associated with congregate settings include:

- The substantial numbers of contacts
- Incomplete information regarding contact names and locations
- Incomplete data for determining priorities
- Difficulty in maintaining confidentiality
- Collaboration with officials and administrators who are unfamiliar with TB
- Legal implications and
- Media coverage.⁵¹

Increased resources will be necessary when the scope or duration of an investigation is expected to disrupt other essential TB control functions.

Maintaining confidentiality for an index patient is particularly challenging if the patient was conspicuously ill or was absent from the setting while ill. Collaboration with officials at the setting is essential for obtaining access to employee and occupancy rosters, ascertaining contacts, performing on-site testing and offering education to associates (e.g. classmates, friends or co-workers) of the index patient. (see site investigation, section 8.5). For congregate settings, the types of information for designating priorities are site specific, and therefore a customised algorithm is required for each situation. The general concepts of source-case characteristics, duration and proximity of exposure, environmental factors that modify transmission, and susceptibility of contacts to TB should be included in the algorithm. The optimum approach for a setting-based investigation is to interview and test contacts on site. If this is not possible, then the contacts should be invited for evaluation at a designated health facility.

8.9 Workplaces

Many people spend the majority of their waking hours in their workplaces. Duration and proximity of exposure can be greater than for other settings. Details regarding employment, hours, working conditions and workplace contacts should be obtained during the initial interview with the index patient, and the workplace should be visited and examined after accounting for confidentiality and permission from workplace administrators or managers. Employee lists are helpful for selecting contacts, but certain employees might have left the workplace and thus have been omitted from current employee lists. Customers of a business workplace may also need to be considered.⁵¹

Workplace administrators or managers are likely to express concern regarding liability, lost productivity and media coverage. In addition, they might have limited obligations to protect patient confidentiality. All of these issues can be addressed during the planning phase of the investigation.

8.10 Hospitals and other Healthcare Settings

The primary TB risk to other patients and staff in hospitals/healthcare settings is the undiagnosed or unsuspected patient/staff member with infectious TB disease. The issue of potential exposure of patients, some of whom may have reduced immunity, may result in considerable resources being directed at identifying exposed patients many of whom are likely to be at minimal risk. Unnecessary screening of contacts with minimal risk should be avoided as yields from contact investigation in healthcare settings can be low.²⁹⁹⁻³⁰¹

Healthcare-associated transmission of *M. tuberculosis* has been linked to close contact with persons

with TB disease during aerosol-generating or aerosol-producing procedures, including bronchoscopy, endotracheal intubation, suctioning, other respiratory procedures, open abscess irrigation, autopsy, sputum induction and aerosol treatments that induce coughing.²²⁹

Effective contact tracing requires liaison between public health services, hospital infection prevention and control and occupational health services. Coordination of contact tracing is most appropriately led by hospital infection prevention and control (vis. consultant microbiologist) in those healthcare settings where this is in place. This will include the initial alerting of public health and occupational health services. In all other healthcare settings, coordination should be undertaken by the public health service.

Contact tracing should be initiated where:²²⁹

- A person with infectious TB has been examined at a healthcare setting, and TB disease was not diagnosed and reported quickly, resulting in failure to apply recommended TB infection controls
or
- Environmental controls or other infection control measures have malfunctioned while a person with infectious TB was in the setting
or
- A HCW develops infectious TB and exposes other persons in the setting.

Contact tracing should be carried out only for patients for whom the risk is regarded as significant. No two episodes of this kind are likely to be identical in all respects, and narrowly drawn guidelines are thus inappropriate. A repeat risk assessment should also be made if investigation of the household contacts of the index case has an unusually high yield.

Guidance for contact tracing in hospitals and healthcare settings:

1. Infectious TB in a hospital inpatient

- Following diagnosis of infectious TB in a hospital inpatient in an open ward, a risk assessment should be undertaken. This should take into account the degree of infectivity, the length of time before the infectious individual was isolated, the proximity of the contact, and whether other patients were unusually susceptible to infection
- In general, patients should be regarded as at risk of infection if they spent more than eight hours in the same section (rather than the whole ward) as an inpatient with infectious/presumed infectious TB (see table 8.1).³⁰² If patients were exposed to a patient with infectious/presumed infectious TB for long enough to be equivalent to household contacts (as determined by the risk assessment), or an exposed patient is known to be particularly susceptible to infection, they should be managed as equivalent to household contacts (see figure 8.1)²⁶
- Where an inpatient has MDR-TB, or if exposed patients are immunocompromised, specialist expert advice should be sought
- Staff in casual contact with a case of smear positive TB should be reassured and reminded of the possible symptoms of TB to report. Staff who have undertaken mouth-to-mouth resuscitation without appropriate protection, prolonged care of a high dependency patient or repeated chest physiotherapy on a patient with undiagnosed respiratory TB should be managed as close contacts.³⁰²

2. Infectious TB in a HCW

- If the HCW has been at work while infectious, it will be necessary to identify patients, other staff and visitors who may have had significant contact and manage as per contact tracing procedures.

Other healthcare settings

Elderly people residing in nursing homes are almost twice as likely to acquire TB as those living in the community. Certain considerations for control of TB in hospitals apply also to such extended care facilities,²²⁹ including maintaining a high index of suspicion for the disease, promptly detecting cases and diagnosing disease, isolating infectious persons and initiating standard therapy and identifying and evaluating contacts (contact investigation).

8.11 Schools

The notification of a case of TB in a school setting, whether a staff member or pupil, requires particular attention because of the potential for spread of infection and also because of the anxiety that can be generated among pupils, parents, staff and the wider public. The typical features of contact investigations in schools are the potentially substantial numbers of contacts and difficulties in assigning priorities to contacts who have undetermined durations and proximities of exposure.

If the index case is a staff member, the aim of contact tracing is generally to detect secondary cases in the school. This may also be the aim if the index is an infectious adolescent case. If the case is a younger child or a non-infectious adolescent, the main purpose is to detect a source case in addition to the possibility of detecting other secondary cases from a common source.

The NICE guidelines²⁶ attempted to establish whether contact tracing was effective in identifying latent and active TB in school contacts exposed to an index case of TB in the school setting. It found potential difficulties in making recommendations from the identified evidence base including the possibility of publication bias, the fact that the evidence base did not take into account the country of birth or ethnicity of pupils (likely to be a confounding factor), noting that many of the studies conducted outside the UK were carried out in non-BCG vaccinated populations, and that rates of disease were calculated on small denominators and were therefore imprecise. The guidelines here are broadly similar to those produced by the NICE guideline development group.

Guidance following notification of a case of TB in a pupil or staff member:

- **Case risk assessment**
 - The case risk assessment should include an early visit to the school to check indoor spaces, observe general conditions and enquire about ventilation.
- **Communication**
 - Early meeting with school management to explain prevention and control measures
 - Early consideration of how to best communicate with the wider school population and how to keep updated
 - Early anticipation of, and planning for, media communication aspects. The presence of TB in schools often generates publicity. Ideally, the public health department should communicate with the school and parents (and guardians) before any media report a story.
- **School pupil with infectious/presumed infectious TB**
 - Screen class (if single class group) or year (who share classes)
 - Screen relevant staff members (class teachers/games/school bus/other)
 - Screen (by symptom enquiry and *single* chest X-ray) all other members of staff in the school if the index case of a school pupil's TB infection is not found. This is especially relevant if evidence of recent infection has been found in fellow pupils in order to exclude a potential index case among staff.
- **School pupil with non-infectious TB**
 - Consider screening by symptom enquiry and *single* chest X-ray all relevant members of staff (in order to exclude a potential index case among staff) in the school (relevant teaching/games/school bus/other) if the index case of a school pupil's TB infection is not found among household members or other immediate contacts outside of school.
- **Teacher with infectious/presumed infectious TB (i.e. including BAL positive)**
 - Screen, where in contact during preceding three months, relevant class pupils/games etc.
 - Screen staff member contacts.
- **Teacher with non-infectious TB**
 - Consider screening other adults in the school by symptom enquiry if the source (index case) is not found outside the school. Otherwise no contact tracing indicated in the school.
- **Screening extension**
 - Contact tracing may need to be extended to include children and teachers involved in extracurricular activities (e.g. sport, school bus travel, etc.) and non-teaching staff on the basis of degree of infectivity of index case/length of time the index case was in contact with others/whether contacts are unusually susceptible to infection/the proximity of contact. Outdoor activities would not normally pose a transmission risk, unless this involved confined spaces for prolonged time periods.

- **Secondary cases**
 - Any secondary cases of sputum smear positive TB should be treated as index cases for the purposes of contact tracing.
- **Further pupil case within 12 months**
 - Should a further case of TB occur in a child within a twelve month period, all adult staff in the school should be screened with a single chest X-ray (in order to exclude a potential index case among staff).

Pre-schools

Children aged < five years who have been identified as contacts of cases of infectious TB should receive a clinical evaluation, including a TST and chest X-ray, to rule out active TB. TB disease in children aged < five years typically indicates that the infection must be recent. For this reason, it is a sentinel public health event. Young children usually do not transmit TB to others and their contacts are unlikely to be infected because of exposure to them.⁵¹ In a source case investigation of a child aged < five years in a pre-school setting, all adults in the facility should be included if the source case has not been found in the family or household.

- **Child < five years with TB**
 - Screen all adults in the pre-school setting by symptom enquiry and single chest X-ray if the source case has not been found in family/household.
- **Adult with infectious/presumed infectious TB**
 - Screen all children (see figure 8.2)
 - Screen all adults as close contacts (see figure 8.1).
- **Adult with non-infectious TB**
 - No contact tracing indicated in the school **or** consider screening by symptom enquiry and single chest X-ray all relevant members of staff (in order to exclude a potential index case among staff) in the school if the index case of the teacher's TB infection is not found among household members or other immediate contacts outside of school
 - Contact tracing of children is not indicated.

8.12 Transportation

Prolonged journeys (i.e. eight hours or longer) in a confined space and recirculation of air on various modes of transport may increase the risk of transmission of *M. tuberculosis*. Although the risk of exposure relative to the frequency and duration of journeys and modes of transport has not been demonstrated, this risk is likely to be similar to that in other circumstances where people are together in confined spaces.

WHO have published guidelines for preventing and controlling TB transmission on aircraft in 2008, which are available at: www.who.int/tb/features_archive/aviation_guidelines/en/.³⁰³ Between 1992 and 1994, CDC conducted seven contact investigations, six of which were undertaken for passengers, and one for an infectious cabin crew member. Evidence of TB transmission (as indicated by the detection of latent infection) was determined in only two investigations: one from a cabin crew member to other crew members with a minimum of 12 hours' exposure, and the other from a passenger to other passengers seated in the same section of the aircraft, on a flight lasting more than eight hours.^{304;305} To date, no case of clinical or bacteriologically confirmed TB disease has been identified as a result of exposure on a commercial aircraft.

The risk of exposure to a case of MDR-TB or XDR-TB during a flight causes considerable concern among travellers, health authorities, airline companies and the media. At present, little evidence exists to suggest that drug-resistant strains of TB would be more easily transmitted during air travel. In other settings drug-resistant TB has been found to be more transmissible than drug sensitive strains.³⁰⁶ However, the consequences of infection with drug-resistant strains are more complex, the outcomes are not as good as for drug-susceptible TB, and therefore the consequences for exposed contacts are also more important. On these occasions, medical authorities, airline representatives and members of the public are advised to seek guidance from the DoHC and HPSC.

To prevent exposure on flights, WHO recommends that infectious TB cases should not travel by public air transportation until at least two weeks of adequate treatment have been completed or until the person is

sputum smear negative. Patients with MDR-TB or XDR-TB should not travel until they have been proved to be non-infectious (i.e. culture-negative). Health authorities and/or physician(s) should conduct a risk assessment of the potential infectivity, potential drug resistance, duration of the proposed flight, and the possible consequences of transmission to other passengers when a TB case wishes to travel. The public health authority and/or physician must give clear advice or instruction on whether or not to travel. Patients intending to travel against this advice should be reported to the MOH of the relevant HSE area for any necessary action.³⁰³

1. Contact tracing of infectious or potentially infectious TB cases on aircraft should be limited to flights which were ≥ 8 hours duration and took place during the previous three months. All cases of respiratory TB who are sputum smear positive and culture positive (if culture available) are deemed infectious. All cases of respiratory TB who are sputum smear negative and culture positive are deemed potentially infectious. The following criteria should also be used when determining the infectiousness of a case at the time of travel: (i) presence of cavitations on chest X-ray, (ii) presence of symptoms at the time of the flight and (iii) documented transmission to close contacts.
2. If the index case is a passenger, obtain contact details of passengers sitting in the same row and the two rows ahead and behind (from one side of the aircraft to the other because of ventilation patterns) the index patient. Inform contacts of possible exposure and advise screening of these flight contacts and cabin crew who serviced the section in which the TB case was seated.
3. If the index case is an aircraft crew member, contact tracing of passengers should not routinely take place. Contact tracing of other members of staff is appropriate, in accordance with the usual principles for screening workplace colleagues.

Table 8.4: WHO recommendations for contact tracing of infectious TB cases on air flights ≥ 8 hours³⁰³

Clinicians should immediately inform the MOH in the relevant HSE area of any patients with infectious pulmonary or laryngeal TB who have a history of air travel ≥ 8 hours.

The MOH should then inform HPSC of the case. Case and air flight details should also be forwarded to HPSC. HPSC will then verify with the airline(s) that:

1. The patient was on the flight
2. The flight time (≥ 8 hours) and
3. \leq three months have elapsed since the flight.

If the TB patient travelled on more than one airline, HPSC will contact each airline on which the patient travelled on a flight for ≥ 8 hours total flight duration.

Once this is verified, HPSC (as country where the case was reported) will then inform the counterpart public health authorities in all countries where the flight(s) departed and landed. HPSC will then request from the airline(s) the list of relevant flight contacts outlined in figure 8.3 and will also inform the public health authorities of the countries of residence of the identified contacts and advise them of the situation. In countries of residence of the contacts, the public health authorities should follow national policy for TB contact investigation. In some circumstances such cases (as outlined in the WHO TB and Air Travel Guidance) may need to be reported to WHO under the International Health Regulations (IHR).³⁰³

Recommendations on the prevention and control of TB transmission on aircraft is based on best currently available scientific evidence and medical practice. Over time, if new evidence emerges in relation to this, it will be reviewed by the committee and the recommendations revised if deemed appropriate.

8.13 Prisons

Prisons are a significant reservoir of infection.³⁰⁷ Infected inmates can spread TB both within the prison and in the community after release. A 2002 survey of the WHO European region found a mean notification rate

of 232 new cases per 100,000 prisoners (range: 0-17,808). Highest rates were observed in countries of the former Soviet Union, and have been attributed to overcrowding, poor hygiene and ventilation.³⁰⁸

Outbreaks of TB have been reported in prisons in the US and UK.^{15;309} Although TB in prisons was not thought to be a problem in England and Wales in the 1980s,³¹⁰ routine surveillance has recently shown an increase in cases in this setting. Prisons in London have been associated with a large outbreak of isoniazid-resistant TB since 2001.³¹¹ In the US, outbreaks have involved MDR-TB in HIV-infected individuals.³⁰⁹

Maintaining control of TB in prisons is challenging because of difficulties with practicalities such as prompt diagnosis of cases, identification of contacts, screening and compliance with prophylaxis and treatment. Contact tracing is typically complex in prison settings due to short stays and mobility of inmates. A multidisciplinary team, led by the local public health department (who will undertake the contact tracing), should be convened to manage the intervention.^{26;312} In addition to key prison staff and prison medical services, the team may include other staff who have regular contact with prisoners such as social worker/education worker/probation officer representatives. CDC guidelines highlight the important role of correctional information systems (e.g. an inmate medical record system and inmate tracking system) in efficient contact tracing.³¹² Any contacts who are HIV positive or immunosuppressed should be among those receiving the highest priority evaluation for infection.³¹²

If a suspect infectious TB case is encountered on contact tracing there should be prompt transfer out of the facility for diagnostic evaluation if airborne infection-isolation rooms are not available. If the process is delayed, a substantial number of persons might be exposed as a result of the congregate living arrangements that characterise correctional facilities.

Continuity of care following transfer between prisons and release into the community is seen as a major barrier to treatment completion. For this reason, DOT is recommended for all prisoners receiving treatment for LTBI and active disease. Prison medical services in liaison with local public health departments are encouraged to make arrangements to facilitate treatment completion.²⁶

Recommendation:

A multidisciplinary team approach to effectively manage TB contact tracing in prisons is required. This team should be led by the local public health department who will undertake contact tracing.

DOT is recommended for all prisoners receiving treatment for active disease and should be considered for those receiving treatment for LTBI.

8.14 Other High Risk Settings

Homeless shelters are important sites for transmission of *M. tuberculosis* and an important cause of the continuing high incidence of TB among the homeless population.³¹³ Contact investigations may be wide-ranging. Genotyping may help with the rapid identification of clustered cases and sites of transmission.

In addition, epidemiological investigations prompted by an increase in the incidence of TB in a community or by the identification of clusters of cases with identical *M. tuberculosis* genotype patterns have detected transmission in such venues as bars.³¹⁴ Transmission has been identified with social activities including among persons who drink together in multiple drinking establishments.³¹⁵

8.15 Incorporating New Approaches to Contact Tracing

DNA fingerprinting can be used to confirm or disprove suspected linkages between cases. Genotyping also helps to identify case clusters that would otherwise not be recognised.¹¹¹ The Massachusetts Department of Public Health evaluated the impact of DNA fingerprinting on their practice and reported that

genotyping identified enough unexpected links and sites not considered by the concentric circle method to justify consideration of more casual contacts.³¹⁶ Genotyping allows earlier recognition of clusters for timely investigation and institution of control measures. All culture positive isolates are eligible for genotyping at the Irish Mycobacterial Reference Laboratory.

8.16 Evaluation of Contact Tracing

The evaluation of outcomes from contact tracing is important for evaluating the TB control programme, determining the appropriateness of decisions made regarding the contact investigation and future planning. The results of the investigation of each circle of contacts should be evaluated to determine the risk of transmission, attack rates, etc. The following information should be collected:³¹⁷

- The number of contacts identified (particularly close contacts)
- The number of contacts who underwent a full evaluation
- The number of contacts diagnosed with active disease
- The number eligible for preventive therapy and
- The number who accepted and completed preventive therapy.

Recommendation:

Evaluation of all contact tracing activities is recommended. The following information should be collected: (a) number of contacts identified, (b) number of cases of active disease and LTBI and (c) the number of persons who accepted and completed preventive therapy.

8.17 *Mycobacterium bovis*

M. bovis is not frequently isolated from clinical specimens provided by suspected TB patients. Due to milk pasteurisation, the risk of disease from *M. bovis* infection is negligible. Four to five cases of *M. bovis* are reported to the National TB Surveillance System (NTBSS) annually (2002-2006). The mean age of cases over this time period was 62.3 years (range 32 – 86 years).

There is little evidence of cattle-to-human or human-to-human transmission of *M. bovis* in the UK and Ireland. The NICE guidelines have advised using diagnostic tests for LTBI in previously unvaccinated individuals under 16 years of age who have regularly drunk unpasteurised milk from animals with TB udder lesions. Treatment of LTBI should be offered to those with positive results. All individuals in contact with TB-diseased animals should be informed and advised of the signs and symptoms of TB disease.