Outbreak column 21: Tuberculosis (TB): Still a nosocomial threat

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Abstract

This outbreak column explores the epidemiology and infection prevention guidance on tuberculosis (TB) in the UK. The column finds that, at present, national guidance leaves UK hospitals ill-prepared to prevent nosocomial TB transmission. Reasons for this conclusion are as follows: (1) while TB is predominantly a disease that affects people with 'social ills', it has the potential to infect anyone who is sufficiently exposed; (2) nosocomial transmission is documented throughout history; (3) future nosocomial exposures may involve less treatable disease; and (4) current UK guidance is insufficient to prevent nosocomial transmission and is less than that advocated by the World Health Organization and the Centers for Disease Control and Prevention.

Keywords

Tuberculosis, outbreak, nosocomial

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Introduction

Winter 2016–2017 was extremely challenging for those working in and using the NHS. The term 'corridor nurse' (a nurse who cares for people located in a corridor) entered the lexicon. Acknowledging the absence of fundamentals, i.e. safe places to care for people, this Outbreak Column extends the essentials wish list and asks for improved facilities and guidance for patients with, or suspected of having, tuberculosis (TB). The reasons for advocating such developments in the face of a decreasing TB incidence are as follows:

1. while TB is predominantly a disease that affects people with social-ills, it has the potential to infect anyone who is sufficiently exposed;
2. nosocomial transmission is documented throughout history;
3. future nosocomial exposures may involve a much less treatable disease; and
4. current UK guidance is insufficient to prevent nosocomial transmission and not as advocated by the World Health Organization (WHO) and Centers for Disease Control and Prevention (CDC).

The case for TB being an infectious disease to which we are all potentially vulnerable is presented first.

TB is not always or just a disease of the poor

'Yet the captain of all these men of death... was the consumption, for it was that that brought him [Mr Badman] down to the grave.' (Bunyan, 1905)

The reason for once again referring to this well-cited work is to counter the argument that it is only the Mr Badman's of the world who develop TB. In a time when the disease was endemic, notable well-fed, well-dressed and well-moneyed people acquired TB; this includes kings, queens, the Brontës and Eleanor Roosevelt. Such prominent people provide evidence that this disease has, for all its proclivity for populations with multiple social ills (e.g. poverty, homelessness), TB has the potential to infect anyone who is sufficiently exposed (Potter, 2013). People in poor social circumstances are often less inclined, or less able, to access healthcare. Thus, while *Mycobacterium tuberculosis*

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consumes their lungs, those whose access to healthcare is delayed or denied become increasingly ill and infectious. If they live in overcrowded accommodation, this further aids the wider dissemination of TB to vulnerable others. The poor, therefore, have a greater exposure to TB, and sometimes a lower resistance to it. The bacterium multiplies slowly, and although many may encounter the organism, most will not succumb. However, for all that it is undeniably a disease of poverty, the truth remains, it is an airborne disease to which, depending on its prevalence and our exposure, we are all vulnerable. The message from this synopsis is clear. Failure to trace, and effectively treat, all people with TB could lead to increased dissemination of the disease among people.

TB is a nosocomial disease of the past and present

Nosocomial disease is the transmission within a care setting from either a healthcare worker (HCW) to patients, from patients-to-patients, or a patient-to-HCWs. Early investigations of possible increased HCW risk from patients with TB often involved student nurses tested on entry and on completion of their training. A 1934 *Lancet* editorial confirmed an increased nosocomial TB hazard for HCWs stating ‘The risk of infection taken by nurses whose duties bring them into contact with TB patients must always exercise the minds of those responsible for training’ (Anon, 1934). Patients are also at risk from HCWs with TB. Ahn et al. (2015) report an outbreak in a neonatal intensive care unit in Seoul where four of 108 infants were treated for latent TB, which had been acquired from a nurse.

Hospital laboratory staff were also noted to be at increased risk when compared to the general population. One study identified a ninefold increased risk in those attending a postmortem (Reid, 1957). This risk in pathology laboratories is much reduced today, not so much because infection control has improved, rather, combined with a falling TB incidence, the number of postmortems performed has also declined.

Other more recent studies failed to find an increased risk of nosocomial TB risk among HCWs (Riley et al., 1997). Also, Raitio and Tala (2000) tracked the decreasing incidence of nosocomial TB in Finland during 1966–1995, which fell from 57.9 per 100,000 HCWs to 6.1. This was a similar fall to that observed in the general population in the same time period. The authors noted the lack of impact/incidence of HIV, drug resistance and immigration in their populations (Raitio and Tala, 2000).

In the latest UK TB epidemiology report, among adults (aged 16–64 years), 34.6%, the largest majority, were not in education or employment (Public Health England [PHE], 2016). Only two occupations are specified by PHE (2016), those in education (as students or tutors) comprised (11%)—this includes students from overseas; and HCWs,

who comprised 7%. All other occupations together comprised 47.4%. There is no narrative to accompany this statement, i.e. how much HCW TB is, or is not, due to their occupation is unstated. The WHO acknowledges TB as a nosocomial disease (WHO, 2009). More importantly, although drug-sensitive disease is markedly decreasing worldwide, as stated earlier drug-resistant disease is increasing, of which only 20% are being treated (WHO, 2016). Therefore, even though the incidence is low and decreasing, healthcare settings should still be prepared to prevent nosocomial TB transmission. As drug-resistant TB is expected to increase, a failure to prepare could expose HCWs to untreatable infections.

Meredith et al. (1996) studied the specific HCW TB risk by comparing the UK occupation notification rates (HCWs vs. others) in 1988 and 1993 using denominators from the 1991 census. The adjusted relative risk for HCW acquisition was 2.4 (confidence interval [CI] 2.0–3.0). The authors attribute some of the increased HCWs to better detection and notification among HCWs. However, they state the implication from their comparison is that ‘*tuberculosis remains a hazard for HCWs and highlights the importance of ensuring that occupational health monitoring and protection of workers are not neglected*’. The authors also commented that: ‘*As many HCWs are unlikely to be exposed to TB, those who are may be at much greater risk than has been estimated*’ (Meredith et al., 1996). A more recent study by Davidson et al. (2016) set out to determine if UK HCWs were still at increased risk of TB using a retrospective cohort population comparison (HCWs with TB vs. non-HCW adults aged 16–64 years with TB) during 2009–2013. The study concluded that when stratified by place of birth, nosocomial HCW risk was absent. This study identified only ten nosocomial transmission events, of which only two involved transmission to patients (Davidson et al., 2016).

However, these results merit further examination. First, the study compared HCWs (i.e. professionals) to all other adults of working age (of whom 35% were not in education or employment) (PHE, 2016: 22). Also, HCWs themselves are a diverse population; just as the prevalence of TB is uneven in the UK, so will there also be an uneven exposure risk between HCWs who work in different geographical locations and for different populations. A better study design would have been to determine if there is an increased risk where there is a higher exposure risk. Second, the study involved 2320 HCWs with TB, of whom only 667 (30%) were culture-positive; therefore, there could be no further analysis on two-thirds of HCW cases. Davidson et al. (2016) showed that albeit low, HCW acquisition still happens. What is preventing significantly sized outbreaks today is not excellence in infection prevention and control, but a low incidence in the UK population. However, we need to take note of the situation today in South Africa, a country with a high incidence of TB, HIV and drug-resistant disease (WHO, 2016).

In a paper full of highlights and insights, the reality of the TB situation in a high-incidence country with inadequate health resources is laid bare (von Delft et al., 2015). The authors provide reasons for the high nosocomial transmission, the first being an erroneous assumption of safety: HCWs believing they are not at risk and thus they omit using personal protective equipment (PPE). Second, HCWs care for people with TB of whom an unknown number have drug-resistant disease, and while these patients' sensitivity results are awaited, the patients will remain infectious and exposing HCWs and patients. Third, there are professional risks in making public the failings of the healthcare system. Thus, inadequacies in the environment, equipment and procedure go unrectified. In a precarious job market, it seems people are less inclined to discuss a lack of equipment and facilities. Finally, the stain of stigma associated with TB has a delaying effect on HCWs seeking a diagnosis and treatment; admitting a TB diagnosis opens suspicion among colleagues of possible co-infection with HIV (von Delft et al., 2015). These factors combine to promote nosocomial acquisition. (This delay in HCWs seeking medical attention was also noted in the Davidson et al. (2016) paper.)

von Delft et al. (2015) include a picture of four HCW survivors of nosocomial drug-resistant TB who stand together in a call to arms in the belief that TB is still preventable and curable if optimal care (investigations and treatment) is made available and optimal prevention (early diagnosis, early isolation early effective treatment, PPE for HCWs, surgical masks for patients) happens (von Delft et al., 2015). Effective treatment is itself correctly viewed as a control measure for reducing exposure to others (von Delft et al., 2015). As people with professional and personal experience of nosocomial TB, they need no convincing of the importance of the required actions. It is those of us who have been thus far lucky enough to avoid a colleague (or patient) succumbing that need convincing that TB is a nosocomial disease to which we are all vulnerable.

Current TB epidemiology: decreasing incidence of drug-sensitive TB, increasing drug-resistant disease

Due to the phenomenal, coordinated and well-directed work of the WHO, since 1990 TB mortality has fallen by 47% (WHO, 2015). Key estimated data from the WHO 2016 TB report are as follows:

- 10.4 million people fell ill with TB;
- 60% arose in just six countries;
- 1.8 million people died from TB;
- 580,000 people had drug-resistant TB, of whom only one-fifth received treatment;
- TB remains one of the top ten causes of death worldwide (WHO, 2016).

The predicament is that the health gains achieved from a decreasing TB incidence are, to some extent, offset by a marked increase in drug-resistant disease. The European Centres for Disease Control indicate on colour-coded maps the incidence per country of all monitored resistant drug/bug combinations; countries coloured red have the highest incidence. The distribution of many infectious disease, including TB is, however, uneven within countries, cities and even between hospitals. The overall TB incidence in England is declining and is at a low of 10.5 per 100,000 people (PHE, 2016). The incidence in many parts of England is in the range of 0–4.9 cases per 100,000 – while four London boroughs have rates above 50 cases per 100,000. The incidence among non-UK born people is 15 times higher, and 73% of all new cases were born abroad (PHE, 2016). A relatively new initiative of pre-entry screening, for people wishing to enter and stay in the UK longer than six months who are arriving from countries with an incidence of > 40 cases per 100,000, has proved successful. In 2006, TB was identified in 380 people identified as such; in 2016, with pre-entry screening that number had decreased to just 88 (PHE, 2016).

In the UK, the reasons for the decline in TB is a well-coordinated (and largely under-acknowledged) strategy which includes, in addition to pre-entry screening: improving access and earlier diagnosis; high-quality diagnostics; improved treatment; comprehensive contact tracing; improving BCG vaccination uptake; improving service to under-served populations; strengthening surveillance; and ensuring an appropriate workforce to deliver TB control (PHE, 2016). Further work towards the elimination of TB in low-incidence countries is presented by Lonnroth et al. (2015). This action framework omits steps to prevent nosocomial transmission.

The highest rate in the UK is still low when compared to countries, including South Africa, which have the highest incidence of > 500 cases per 100,000 (WHO, 2015). However, it would be erroneous to assume that, as most people with TB disease live outside the UK, and that pre-entry screening is proving so effective, that is where the problem will remain. The world's population is on the move. There are over 3 billion air passengers who traverse the globe per annum. And the refugee crisis provides optimal conditions for the transmission of TB: the countries from which many of the people in this human tragedy are escaping have some of the highest rates of disease. Further, refugee centres tend to be overcrowded and the people therein may be unable or disinclined to access healthcare. For example, one study designed for active TB case-finding among asylum seekers screened 6347 migrant people: 891 reported possible TB symptoms/history; 546 were referred; and TB was identified in 11. Of note, however, almost 47% of those referred failed to attend (Schepisi et al., 2016). The UK TB strategy will be unable to identify all people with TB entering the country.

Menzies et al. (1995) suggests that the decline of TB in the population led to a relaxation of infection control practices. Thus, the infection prevention community was caught flat-footed when tuberculosis re-emerged in the 1980s along with a new disease caused by the human immuno-deficiency virus (HIV) (Sepkowitz, 1996). Several nosocomial outbreaks at this time were of drug-resistant disease (Anon, 1991). Outbreak-provoking factors identified included: delays in diagnosis, isolation and appropriate therapy; poor ventilation; aerosol generating procedures; unrecognised drug resistance; and 'multiple lapses in administrative, engineering and personal infection control practices' (Menzies et al., 1996). These nosocomial TB outbreaks re-awoke the CDC, and the NHS, to the problem and what was needed to prevent it (British Thoracic Society, 2000; CDC, 2005). However, the new guidance still presented obstacles to effective infection prevention practice.

Obstacles to optimal infection control in healthcare settings

Preventing transmission in care settings is difficult as Sepkowitz states, 'The determinants of transmissibility for TB remain only partially understood. Incredibly, despite decades of enquiry and hundreds (if not thousands) of reports, it is still not clear why one person with TB is more contagious than the next.' (Sepkowitz, 1996). Examples of the lack of certainty regarding transmission, and thus potential for uncertainty in practice, are illustrated below:

- patients who are smear positive are most infectious – but smear-negative patients can transmit the disease (Tostmann et al., 2008);
- people with the highest exposure more often become infected – but some people with minimal exposure become infected (Sepkowitz, 1996);
- even people with extra-pulmonary disease have transmitted TB disease, e.g. aspiration of a tuberculous abscess (Hutton et al., 1990); one recent report confirmed transmission from a patient with extra-pulmonary disease through whole-genome sequencing (Walker et al., 2016).

In addition, even if a patient is correctly identified as being potentially infectious, other factors can reduce the correct application of TB control measures. Appropriate negative pressure facilities may be unavailable, the opportunities to don respiratory protection missed. Also, when the incidence of TB is low, there may be uncertainty as to what is required. Thus, to prevent and protect HCWs and patients, available and followable evidence-based guidance is needed as a pre-requisite.

Current TB guidance to prevent nosocomial transmission is insufficient

Section 1.5 of NICE National TB Guidance produced is specific to 'Infection Control'. The ideal situation as stated within this guidance (1.5.1.5) is that people with TB should, as far as is possible, be cared for outwith a hospital setting (NICE, 2016). The recommendations for the patients who need admission are as follows:

- 1.5.1.1 requires healthcare settings to 'ensure' that people suspected of having TB can be identified;
- 1.5.1.2 requires that people with, or suspected of having, TB are cared for in a single room 'as a minimum' and 1.5.1.3 advocates minimising visits outwith their single room, e.g. to outpatients;
- 1.5.1.4. necessitates an assessment for multidrug resistance (MDR) and that people at low risk of MDR-TB are to be cared for in a single room 'as a minimum'; those in high-risk care must be provided in a negative pressure room with rapid testing also advocated.

When assessing guidance, it is useful to consider the following: can it be done, should it be done, is it easy to do and is it easy to know what to do. For winter 2016–2017, in an NHS with assigned 'corridor nurses', it was impossible to 'ensure' that even basic care was as it should have been. Even under normal circumstances, 'ensuring' all people with TB are identified is difficult. For example, clinicians may fail to detect TB if patients have multiple pathologies and atypical clinical presentations, or are disinclined / unable to acknowledge relevant symptoms. Any system that relies solely on humans is unquestionably fallible (to err, after all, is human). Thus, the inability to 'ensure' needs acknowledging – and a backup recommendation included.

The NICE guidelines also address the recommendations to 'healthcare settings' (NICE, 2016). The correct address should be to someone or to some people, e.g. to a TB coordinator, a consultant in public health medicine, an ICD, a lead TB nurse or the IPCT. NICE (2016) needs to specify exactly who owns the challenge of creating a safe system to prevent nosocomial TB. More specific issues include what exactly is required regarding accommodation.

The NICE TB patient accommodation recommendations

As stated, the NICE guidelines advocate for people with or suspected of having TB the use of a single room 'as a minimum'. This use of an imprecise term 'as a minimum' is problematic. It implies that a single room might (or might not) be sufficient. The use of 'as a minimum' restricts

HCWs to making the best of what they have rather than advocating for what they need. Moreover, the question as to what is meant by a 'single room' also needs clarification – the NICE definitions lack precision here. NICE (2016) details 'three levels of isolation for infection control' (p. 81). The first level is 'negative pressure rooms'. These rooms, NICE states, will have 'air pressure continuously or automatically measured as defined by NHS Property Services'. There is no specific NHS Property Services document listed to confirm this – on looking I could find none. There is a further lack of specifics as to what the continuously or automatic measurement should be reading; and, what should happen if it is not. The second NICE (2016) isolation level is 'single rooms' which 'are not under negative pressure but are vented to the outside of the building'. Having nursed in many wards I am unsure that all single rooms are vented to the outside. Most ward managers would be unaware of the ventilation arrangements of their single rooms – so it must be questioned how they would know if they have, or do not have, suitable single room accommodation. The third isolation level is 'beds on a ward for which no particular engineering standards are needed'. While this is a level of accommodation, it cannot be considered a level of isolation. Consequently, there are shortcomings in the NICE (2016) isolation hierarchy.

Further advice on negative pressure rooms is provided. The required specification is to have the pressure 'at 10 pascals below the ambient air pressure' (NICE, 2016: 82). This leaves the reader with the impression that not only must the room pressure be monitored, but also the ambient air pressure to ensure the correct differential is present. Added advice in the NICE recommendations on MDR-TB are:

'1.5.3.8 Ensure negative pressure rooms used for infection control in multidrug-resistant TB meet the standards of the Interdepartmental Working Group on Tuberculosis and are clearly identified for staff, for example by a standard sign. Keep such signs up to date.'

Retrieval of the Interdepartmental Working Group from the NHS archive site provided the following advice:

'While the direction of airflow is more important, the pressure differences must be measurable. It is difficult to measure pressure differentials below 5 pascals. The USA CDC recommendation of 0.001 inch of water equates to 0.2 pascals, which is not readily measured or monitored. However, if rooms are not well sealed, it may be difficult to achieve greater differentials.' (Department of Health, 1998: 85)

This advice is difficult to follow. The CDC more helpfully specify the following:

'To achieve negative pressure in a room... Although the minimum pressure difference needed for airflow into a room is substantially small (approximately 0.001 inch of water gauge),

a pressure differential of ≥ 0.01 inch of water gauge (≥ 2.5 Pascals [Pa]) is recommended. This higher pressure differential is easier to measure and offers a margin of safety for maintaining negative pressure as the pressure in surrounding areas changes because of the opening and closing of doors, operation of elevators, stack effect (rising of warm air, similar to a chimney).'' (CDC, 2005: 63–64)

NICE omit to include the requirement to keep the doors to any isolation room closed (CDC, 2005). Failure to do so will negate the efficacy of all the engineering controls listed. Specifics of accommodation are contained in the HTM 04 01 building note (and its Supplement) (Department of Health, 2013).

Different infection prevention requirements for the same infectious disease?

Apart from the lack of clarity regarding whether a room is under sufficient negative pressure and deemed suitable to care for a person with MDR-TB, the question as to why control measures vary based on the drug-resistance is unexplained. If a higher level of isolation is required for drug-resistant disease, then logically, ethically and equitably, it must also be necessary for drug-sensitive disease. The transmissibility and pathogenicity remain unchanged regardless of the organism's drug resistance. What changes based on drug-resistance is the ability to treat, the cost of treatment, the toxicity of the treatment and duration of any treatment. That both drug-resistant and drug-sensitive diseases are significant illnesses to be avoided is unquestioned. Thus, the level of isolation required should likewise be the same. The CDC and WHO guidelines make accommodation specifications for people with TB regardless of their drug resistance (CDC, 2005; WHO, 2009).

This unexplained difference in the recommendations is also mirrored with the use of personal respiratory protection. There are no NICE recommendations for respiratory protection for drug-sensitive disease; even though the assessment of drug-resistance is based solely on a risk assessment, and not microbiological confirmation, in the first instance. The requirement for respiratory protection (not a term used in the NICE guidance) is as follows:

*'1.5.3.5 Staff and visitors should wear filtering face piece (FFP3) masks during **contact** with a person with suspected or known multidrug-resistant TB while the person is thought to be infectious.'*

This use of the term 'contact' in the NICE (2016) guidance is incorrect because this is an airborne disease and the recommendation should come into force when the person enters the room, i.e. breathes in (or more accurately avoids breathing) the same air as the patient, and not specifically when physical contact is made with the patient.

There is no NICE (2016) recommendation to wear FFP3 masks when HCWs undertake bronchoscopy or other aerosol-generating procedures, which is different to other UK recommendations (Coia et al., 2013).

The recommendation to single out drug-resistant disease for respiratory protection is contrasted with the WHO (2009), which states: *'use of particulate respirators is recommended for health workers when caring for patients or those suspected of having infectious TB'* and the CDC (2005) recommendation which requires: *'All HCWs who enter an AII [airborne infection isolation] room should wear at least N95 respirators'* (p. 19).

Finally, NICE recommendation 1.5.1.10 states *'In people who may have TB, only carry out aerosol-generating procedures such as bronchoscopy, sputum induction or nebuliser treatment in an appropriately engineered and ventilated area (ideally a negative pressure room)'*. The question from this recommendation is: what level of accommodation that is not a negative pressure room could be 'appropriate'? The negative pressure requirements for the bronchoscopy are neither specified or referred to in the guidance.

What is missing from NICE

What is missing from the NICE (2016) guidance which was present in earlier guidelines (British Thoracic Society, 2000) and is currently recommended by the CDC (2005) and WHO (2009) is the requirement the facilities available are based on local epidemiology assessments. For example, the IPCT should advise from their records how many TB patient days are spent per annum per hospital, and the proportion of TB patient days were spent in single room / single room with negative pressure accommodation. The key question that those in charge of TB need to answer is whether there is a risk to people (patients, HCWs and visitors) given the current care of patients with TB. Further, institutions with a very low incidence need a plan if they do not have suitable accommodation, e.g. an agreement with a facility that does. If the assessment finds that arrangements are unsafe, then it should become a priority to make them safe. The imprecision of NICE (2016) allows organisations to, as stated, make the best with what is available rather than strive to have optimal facilities and optimal infection prevention.

The guidance is leading us to be unprepared to prevent nosocomial TB

This assessment of TB risk from the literature and the TB guidance reviewed shows that, despite a falling incidence, TB remains a low nosocomial risk and there is no requirement to have suitable accommodation to prevent transmission in our care settings. If HCWs fail to follow guidance

and harm results, they can be deemed liable for that harm. When HCWs follow recommended procedures and harm results, then the organisation that sanctions the recommendations can be deemed vicariously liable. However, those producing guidance must also take some responsibility when it is insufficient to protect. Labelling guidance 'systematic' implies the recommendations themselves are sufficient and that all vital information has been retrieved and assessed. 'Black-box thinking' is a term used to describe the learning derived from failure (Syed, 2015). After any air-crash, thorough investigations involve all available data sources to determine what happened, why and what is needed to prevent recurrence. News reports concern themselves with finding the black-box so that it can be interrogated. For those writing evidence-based guidance, such black-box data (i.e. outbreak reports) are negated. Outbreak reports need to be considered as black-boxes, not so much with 'serving suggestions' to improve practice, but inclusive of tested hypotheses on the cause of failure and that required to prevent recurrence.

As a failsafe check, when international guidance recommendations differ significantly regarding the safety of people, then perhaps a defence of guidance is needed, i.e. an investigation as to why such differences are manifest (is it a failure to follow a systematic process or failure of the process itself). Unless there are extremely context-specific recommendations, at least one of the guidance producing processes must be flawed.

Final thoughts

The errors which led to nosocomial TB outbreaks in the 1990–2000s involved poor patient placement and were, in part, due to a lack of guidance. The irony today is that although there is guidance it seems inadequate to prevent nosocomial TB (at least drug-sensitive). Given the differences in the infection prevention requirements advocated between the UK and the US / WHO, a further review of the evidence supporting the current UK guidelines is recommended. This should include administrative controls (taking account of local epidemiology), engineering controls and specifics of the personal protection required. The minimal level of precautions (engineering and PPE) to prevent nosocomial transmission needs greater specification. Accepting without question the level of nosocomial transmission is low, preventing transmission is still essential.

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