

# Investigating the prevalence of latent Tuberculosis infection in a UK remand prison

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## ABSTRACT

**Background** Tuberculosis (TB) remains a major global public health issue and in low-incidence countries guidance identifies the need to screen for and treat latent tuberculosis infection (LTBI) with the prison environment recommended as a setting to perform LTBI screening. This study describes the findings of a LTBI screening programme which took place on entry to a remand prison in the UK.

**Methods** Testing for LTBI was undertaken alongside screening for blood borne viruses in 567 men. During the screening process, information was collected on demographic variables and also specific risk factors based on World Health Organization recommendations. LTBI analysis was performed using Interferon-Gamma Release Assay (IGRA) technique.

**Results** In total, 40 men returned an IGRA positive result (7.1%). However, irrespective of IGRA/LTBI status there was a substantial burden of risk factors present including previous prison stay, history of substance misuse and no BCG vaccination. Non-White ethnicity, a history of substance misuse and age over 34 years were the most significant factors in identifying individuals who would require treatment for LTBI (Positive IGRA result).

**Conclusions** The study further demonstrates that the prevalence of LTBI remains increased within the prison environment and is a setting that still requires effective LTBI management.

**Keywords** health protection, infectious disease, prisons, tuberculosis

## Introduction

Tuberculosis (TB) remains a major global public health issue, and the importance of eradicating this disease is acknowledged by the World Health Organization (WHO) through their Sustainable Development Goals (SDGs<sup>1</sup>). The WHO has also set the ambitious target of a 90% reduction in the incidence of new TB cases by 2035.<sup>2</sup> Although the rates of TB infection are a greater challenge in developing countries,<sup>3</sup> there is still evidence of active infection in more developed countries in Europe such as the UK which would need to be addressed to meet this reduction.

In order to reduce the number of new TB cases, global strategies,<sup>2</sup> regional<sup>4</sup> and national guidance<sup>5</sup> all identify the requirement to screen for and treat latent tuberculosis infection (LTBI). LTBI screening and management in low-incidence countries is particularly important given that

reactivation accounts for the majority of new TB cases in these countries.<sup>6,7</sup> For individuals with positive LTBI, there is a 5–15% chance of reactivation in their lifetime,<sup>8</sup> and treatment of these individuals would directly impact on the global prevalence of TB.<sup>9</sup>

One of the recommended settings to manage LTBI through screening programmes is the prison environment.<sup>4,5</sup> There is global evidence to suggest that the rates of TB infection in prisons are higher than that of the respective national populations.<sup>10</sup> The increased rates of TB transmission could be attributed to, amongst other factors,

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overcrowding, high turnover of individuals and a disproportionate number of individuals already exhibiting risk factors associated with TB.<sup>10</sup> There have been some recent examples of LTBI screening programmes on entry to prisons in Europe and the USA that have demonstrated a prevalence of LTBI between 6% and upwards to over 50%.<sup>11–13</sup> However, despite some emerging research, gaps in the evidence base remain,<sup>14,15</sup> one such example focusses on whether a universal or targeted screening programme is the most appropriate method to undertake within the prison setting.

This study describes the findings of a LTBI screening programme which took place on entry to a remand prison in the UK. The study provides an overview of the prevalence of LTBI, the prevalence of TB specific risk factors (universal) and an identification of the most significant risk factors in positive LTBI men (targeted).

## Methods

### Study population

The study took place in an inner-city male remand prison. The prison serves the local courts and at the time of the study had an operational capacity of 804. All participants in this study were men admitted between the dates of 1 February 2018 and 28 March 2018. During this time period, the prison received 699 new admissions, of which 584 males were screened for LTBI (83.5% sample rate) and of these records, 17 could not be verified leaving a sample of 567 men.

### Risk assessment/questionnaire

As per national guidelines,<sup>5</sup> testing for LTBI was undertaken alongside the already established opt-out screening for blood borne viruses (BBVs) within 48 h of admission to HMP Cardiff. The risk assessments were performed by the prison healthcare staff who had received educational training in the weeks prior to the introduction of the LTBI assessments. The training covered an overview of TB which included information on the symptoms, diagnosis, referral and treatment. During the risk assessment, information was collected on demographic variables (age, community postcode of residence, ethnicity, country of birth) and also specific risk factors based on WHO recommendations (history of travel in last two years outside of Western Europe, North America or Australasia; history of substance misuse; history of alcohol abuse; currently homeless; history of homelessness in past 5 years; close contact with TB; previous BCG vaccination; previous TB illness and/or treatment; previous prison stay).

The final component of the risk assessment was obtaining a venous blood sample from the men to be analysed for LTBI.

### Interferon-gamma release assay analysis

Analysis of LTBI status was performed using interferon-gamma release assay (IGRA) technique (T-Spot.TB, Oxford Immunotec Ltd, Abingdon, UK). Blood samples were collected in the morning and couriered to a laboratory the same afternoon, the samples were processed and the results returned the following week.

### Clinical measurements/treatment pathways

Those males who were found to have a positive IGRA result following analysis were placed on 'medical hold' to prevent them from being transferred to another prison before undergoing a chest X-ray to determine active TB infection. The chest X-rays took place within the prison grounds in a purpose built screening vehicle commissioned for the purposes of this pilot. If active TB infection was observed, the individual in question was put into isolation and recognized clinical protocols followed. All males who were found to have a positive IGRA result but no evidence of active infection were referred to the local specialist TB services who provided clinics and offered pharmacological (chemoprophylaxis) treatment within the prison.

### Statistical methods

This study examined both the prevalence of established TB risk factors and also explored differences between risk factor prevalence for both age groups (18–24 years, 25–34 years, 35–44 years, 45 years and older) and LTBI status (Positive vs. Non-positive). Odds ratios were used to examine differences between these respective groupings. Logistic regression analysis, adjusted for age (groups/median) and established TB risk factor was further performed on the LTBI positive individuals to investigate which characteristics were most significant in these cases. The logistic regression analysis was also repeated to investigate the significant characteristics in the positive BBV cases. All statistical analysis was performed using SPSS (v24).

## Results

### Demographics/prevalence

The median age of the men in this study was 31 years old, with the age range between 18 and 69 years old. The majority of men identified themselves of White ethnicity (469/567; 82.7%) born within the UK (predominantly England or

Wales), for those individuals who provided information on ethnicity and/or country of birth, the main ethnicities stated were denominations of Asian or Black with only a small number of individuals stating that they were born in a country with high risk of TB (over 40 cases per 100 000 population,<sup>16</sup>). Of the postcode data provided ( $n = 513$ ), a number of men stated that they currently had no fixed abode ( $n = 79$ ). The vast majority of the men provided a postcode which was located within the most deprived two quintiles of deprivation ( $n = 215$  and  $n = 101$  for Quintiles 1 and 2, respectively). Of the remaining data, 58, 32 and 28 men provided a postcode located in Quintile 3, 4 and 5 (least deprived), respectively.

With regards to the IGRA results, 21 were indeterminate/insufficient, 483 negative, 16 borderline negative, seven borderline positive and 40 were positive for LTBI, thus resulting in a prevalence of 7.1% in the men. Of the 40 men who were positive, all underwent chest X-ray for further clinical examination and one individual was found to have a case of active TB although appeared asymptomatic. The median age of the men who were found to have an IGRA positive result was 34 years, and the range of ages stretched from 18 years (youngest) to 60 years (oldest). The lowest prevalence was observed in the youngest age group (6.0%; 18–24 years) and the highest prevalence observed in the 35–44 years age group (9.8%). However, despite these observations there was no significant relationship between increasing age groups and prevalence of LTBI positive cases (Table 1).

### Risk factors

There was a substantial prevalence of established risk factors for TB in the men, irrespective of IGRA result/LTBI status (Table 2). Over three quarters of men reported that they had a previous prison stay, whilst over half of the men reported history of substance misuse and/or no BCG vaccination. Around one quarter of men reported that they had experienced a period of homelessness in the past 5 years and/or reported a history of alcohol abuse. Although, not great numbers of individuals, there was still some reporting

**Table 1** Prevalence of and odds ratios of LTBI by age groups

	IGRA positive	Odds ratio	95% CI
Age group <sup>†</sup>			
18–24 years	8/134 (6.0%)	Reference	
25–34 years	14/228 (6.1%)	1.030	0.421–2.524
35–44 years	13/133 (9.8%)	1.706	0.683–4.262
45 years and older	5/72 (6.9%)	1.175	0.370–3.734

<sup>†</sup>Median age of LTBI/IGRA positive cases was 34 years [18–60 years].

of travel to potentially ‘high risk’ countries and some history with TB reported either through close contact or the individual themselves having previously been treated for TB. A positive BBV result was observed in 41 men (7.2%) and the majority of these positive cases were for Hepatitis C.

### Positive vs. non-positive LTBI status

Examining the differences in risk factors for TB infection between IGRA Positive and Non-positive men revealed a number of interesting observations (Table 3). The most significant risk factors in a positive IGRA result were observed to be Non-White Ethnicity/Country of Birth (High Risk Region), where those individuals were 4.5 times more likely to return a positive LTBI result. The men who had indicated previous close contact with an individual who had an active TB infection were three times more likely to have a positive LTBI result than a non-positive result. Men who returned a positive BBV result were almost twice as likely to have a positive LTBI result than men who had no evidence of BBVs. Men who had a recent history of homelessness or no evidence of a BCG vaccination were equally as likely to return a positive LTBI result as a non-positive LTBI result. All individuals with a previous TB illness were found to be IGRA Positive.

### Logistic regression

Table 4 presents the final logistic regression models and significant risk factors for IGRA and BBV positive cases, respectively. In the final IGRA model, four risk factors were included which were ethnicity, a history of substance misuse, aged 34 years and older and a history of alcohol abuse. Three of the four risk factors (ethnicity, history of substance

**Table 2** Prevalence of established TB risk factors in the men (all age and LTBI status)

Risk factor	All ages (n = 567)
Previous prison stay	445 (78.5)
No previous BCG vaccination	340 (60.0)
History of substance misuse	324 (57.1)
Homeless in the past 5 years	156 (27.5)
History of alcohol abuse	147 (25.9)
Currently homeless	130 (22.9)
Non-White ethnicity/country of birth (high risk region)	45 (7.9)
Positive BBV result	41 (7.2)
Travelled outside Western Europe, North America or Australasia	37 (6.5)
Close contact with TB	23 (4.1)
Previous TB illness	4 (0.7)

**Table 3** Prevalence of and odds ratios for LTBI risk factors

Risk factor	IGRA result (LTBI)		Odds ratio	95% CI
	Positive	Non-positive		
Non-White Ethnicity/Country of Birth (High Risk Region) <sup>†</sup>	10/38 (26.3%)	35/477 (7.3%)	4.5	2.0–10.0
Close contact with TB	4/40 (10.0%)	19/527 (3.6%)	3.0	1.0–9.2
Positive BBV result	5/40 (12.5%)	36/527 (6.8%)	1.9	0.7–5.3
Travelled outside Western Europe, North America or Australasia	4/40 (10.0%)	33/527 (6.3%)	1.7	0.6–5.0
History of substance misuse	26/40 (65.0%)	298/527 (56.5%)	1.4	0.7–2.8
Previous prison stay	33/40 (82.5%)	412/527 (78.2%)	1.3	0.6–3.1
Homeless in the past 5 years	11/40 (27.5%)	145/527 (27.5%)	1.0	0.5–2.1
No previous BCG vaccination	24/40 (60.0%)	316/527 (60.0%)	1.0	0.5–1.9
Currently homeless	9/40 (22.5%)	121/527 (23.0%)	1.0	0.5–2.1
History of alcohol abuse	6/40 (15.0%)	141/527 (26.8%)	0.5	0.2–1.2
Previous TB illness	4/40 (10.0%)	0/527 (0.0%)	–	–

**Table 4** Logistic regression models of predictive factors for LTBI and BBV [positive cases]

Characteristic/risk factor	Adjusted odds ratio	95% CI	P-value
IGRA positive model			
Non-White Ethnicity/Country of Birth (High Risk Region)	5.3	2.3–12.3	<0.001
History of substance misuse	2.2	1.0–4.7	0.040
34 Years and older (median age IGRA Positive)	1.9	1.0–3.7	0.064
History of alcohol abuse	0.4	0.2–1.1	0.079
BBV positive model			
Aged 35–44 Years	16.4	2.1–127.4	0.007
Aged 45 Years and older	13.4	1.5–117.2	0.019
History of substance misuse	12.4	2.9–53.0	0.001
Aged 25–34 Years	7.8	1.0–60.9	0.049
Previous prison stay	4.6	0.6–35.5	0.142

misuse, and advancement in age) increased the risk of a positive LTBI result when adjusted for the other risk factors. A history of alcohol abuse appeared to have a somewhat 'protective' effect against positive LTBI results. When the findings of the LTBI model are compared with the results of the final BBV model, the only shared risk characteristic is a history of substance misuse. The BBV model also suggests that a positive result is more likely in ages lower than that of the LTBI model and also highlights a previous prison stay as a significant risk factor.

## Discussion

### Main finding of this study

This study provides an important current insight into the health and wellbeing of men who have been recently

admitted to a UK prison and more specifically the burden of established TB risk factors in this population. The most prevalent of these established risk factors was that over three quarters of the men who participated in the study indicated that they had a previous prison stay on their record. Interestingly, as touched upon previously, the high turnover of individuals in the prison setting could contribute to increased rates of TB.<sup>10</sup> There was substantial evidence of other risk factors such as a history of substance misuse and homelessness which were previously attributed to the increased circulation of TB infection in the prison environment.<sup>10</sup>

This study reports the current prevalence of LTBI in a prison environment in a country of low TB incidence. The prevalence of positive LTBI as measured using the IGRA technique was 7% which is similar to the rates observed in

previous US<sup>11</sup> research, although was observed to be lower than the 11.5% prevalence from a previous UK study.<sup>12</sup> One case of active TB was also observed in this study, which without such a screening programme would have gone undetected. These findings in particular are important when considering the World Health Organization's End TB strategy<sup>2</sup> which requires the treatment of LTBI individuals to meet the reduction targets and further strengthens the significance of screening programmes on prison entry. The prevalence of risk factors and LTBI further provide further evidence to the pre-existing requirement for governmental support and financial assistance to enable prison-based healthcare to reach the standards of community-based healthcare.<sup>15</sup>

### What is already known on this topic

As previously discussed, existing literature reports LTBI prevalence in prisons at a similar level to the findings of our study<sup>11</sup> and also discusses the prevalence of TB risk factors in the prison population such as substance misuse, homelessness and alcohol abuse<sup>10</sup> which are also observed in the men in this study. Consistent with previous research, some of the more significant risk factors that were observed in our research (born in a 'high risk' country, and/or previous LTBI/TB treatment) were also identified in a Canadian prison environment.<sup>17</sup> However, the Canadian research also identified an absence of BCG vaccination is an important consideration whereas in our UK population, this risk factor was not significant. An advancement in age has also been previously demonstrated to be a significant predictor in the incidence of LTBI,<sup>13,17</sup> although there was no overall relationship with age in our study, those men aged 34 years and older were found to be at an increased risk of LTBI.

### What this study adds

Whilst this study does not identify any new risk factors for TB per se, the study does reveal the burden of established risk factors within the prison settings. These risk factors, specifically, those individuals who identified as non-white or their country of birth was a 'high risk' region and those individuals with a history of substance misuse, reinforce the importance of screening this population on entry. The risk factors just discussed have been previously demonstrated to be a cost-effective approach to target in European prisons.<sup>4</sup> It is also important to consider that the men in this study who were found to be LTBI positive appear to be a different demographic at ill health than those who presented as positive for a blood borne virus (Hepatitis B, Hepatitis C or HIV), only a history of substance misuse was a shared significant risk factor in the logistic regression models for

LTBI and BBV, respectively. Of the men who were LTBI positive, only five of these were co-infected (i.e. also displayed evidence of a BBV) which effectively demonstrates the previous point.

This study serves as an effective example of translating national guidance<sup>5</sup> into clinical practice, as recommended the LTBI testing took place in parallel with BBV testing and for the short duration of the project (2 months) at least, the two screening programmes ran in tandem together. Our study is not the first to adopt IGRA testing on entry in the prison, with previous studies in North America<sup>11,17</sup> and Asia<sup>18</sup> also using the IGRA method. However, our study again can be viewed as another good example of adopting this method in the prison environment and how IGRA testing can be viewed as an acceptable method to screen for LTBI. One note of caution to consider is that although IGRA testing can provide results on the status of LTBI, a chest x-ray is required to assess for active TB infection.

### Limitations of this study

The risk factor questionnaire relied on an element of self-report and in particular the ethnicity and deprivation data was dependent on accurate reporting by the individual. This is simply illustrative of 'real world' scenarios but did lead to some incomplete data fields for both ethnicity and/or deprivation in some individuals. The obvious caveat to the postcode (deprivation) data is that the information provided may not always be accurate, for example, individuals may provide a postcode for their parents address, or provide a postcode for a property that was their last fixed residence. It should also be considered that the men that identified themselves with having no fixed abode did not necessarily identify themselves as homeless, and vice versa. A number of the IGRA results returned were indeterminate or an insufficient sample of blood had been collected which could potentially mean that the prevalence of LTBI in the prison was higher than reported in this study. One other perceived limitation to this study is that all the participants were male, the risk factors identified as significant in the men may or may not also be relevant to females in the prison environment.

In conclusion, this study provides a current overview of the burden of risk factors and LTBI prevalence in a UK prison. The study further demonstrates that the prevalence of LTBI remains increased within the prison environment and is a setting that still requires effective LTBI management. The study also recognizes that the more traditional of the established risk factors, non-White ethnicity and a history of substance misuse are the most significant in identifying individuals who could require treatment for LTBI.

## Acknowledgements

The authors wish to express their gratitude to the healthcare staff at HMP Cardiff for assisting in this study, especially the dedication of nurses Christie Craddock and Alice Gudgeon, and Dr Mair Strinati for her support in the implementation of the pilot. The authors also appreciate the efforts and support of the Cardiff and Vale TB Specialist Team. The authors express their thanks to Dr Christopher Williams and Dr Daniel Thomas for their statistical assistance.

## Funding

This study received funding from Welsh Government.

## Ethical Approval

This study translated the latest clinical guidance into practice, therefore the study was deemed as routine service delivery and no ethical approval was required. All men provided informed consent when completing the risk questionnaire and providing blood samples.

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