HMP Parc TB Outbreak

2019-2020

Report of the Outbreak Control Team

Agencies involved:

HMP Parc

Public Health Wales

Cwm Taf Morgannwg University Health Board

SRS Cardiff, Vale of Glamorgan and Bridgend Local Authorities

Her Majesty's Prison and Probation Service

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- Public
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Contents

Abbreviations

BCG	Bacille Calmette Guérin vaccine (TB Vaccine)
CDSC	Communicable Disease Surveillance Centre (part of Public Health Wales
CI	Confidence Interval
CTMUHB	Cwm Taf Morgannwg Health Board
DOT	Directly observed therapy
ETS	Enhanced tuberculosis surveillance
HMP	Her Majesty's Prison
HMPPS	Her Majesty's Prison and Probation Service
IGRA	Interferon-gamma release assays (such as T-spot®)
IMT	Incident Management Team
LTBI	Latent tuberculosis infection
MDT	Multi-disciplinary team (meeting)
NICE	National Institute for Health and Care Excellence
OCT	Outbreak Control Team
PHW	Public Health Wales
TB	Tuberculosis
WDS	Welsh Demographic Service
WGS	Whole Genome Sequencing

1 Executive Summary

In November 2019, newly instituted routine cluster analysis of tuberculosis (TB) cases using Whole Genome Sequencing (WGS) in Wales identified that a recently diagnosed prisoner with potentially infectious TB in HMP Parc was linked to the same cluster as two other prisoners diagnosed with TB in HMP Parc earlier in 2019.

All three prisoners belonged to a larger WGS cluster of around 16 cases to date, geographically concentrated in south-east Wales but including cases in England. WGS sequencing also identified two additional cases in this cluster that were found to have been former inmates in HMP Parc, although they were no longer there at time of their diagnosis. However, the majority of cases in this cluster had never been incarcerated at HMP Parc.

In December 2019, a further prisoner at HMP Parc was notified with infectious TB. WGS on this case subsequently identified him as belonging to the same cluster.

Extensive re-interviewing of available cases and expert opinion concluded that it wasn't possible to determine definitively where and how transmission had occurred between cases connected to HMP Parc. Some community links and/or social/ incarceration risk factors were identified between several of the cases. However, there were at least two cases for whom within-prison transmission was the only plausible hypothesis. As a result, an outbreak was formally declared.

After considering all the information available, including the initial screening results from bed-watch officers cuffed to the index case, and concerned that there had been two recent potentially infectious cases of TB identified in current prisoners within the prison, the OCT made the decision to recommend mass screening of all prisoner-facing staff, other staff on request and all prisoners within the main prison complex.

Despite all the challenges of the COVID-19 pandemic, CTMUHB Health Board actioned this in March 2020, two weeks prior to the national COVID-19 lockdown.

In total, 745 staff and 1065 prisoners were screened. The prevalence of latent TB infection (LTBI) amongst staff was 6.5% and amongst prisoners was 11%. No significant association was found between occupational groups for staff, but being under 30 was a small but significant risk factor.

Screening also identified an additional case of early active pulmonary TB, but this had a different WGS, so was not linked to the outbreak.

The COVID-19 pandemic saw frontline NHS Health Board and PHW staff involved in this outbreak redeployed into essential COVID-19 roles immediately after the screening was undertaken. Nevertheless, by October

2020, follow-up was completed and preventative treatment offered to all eligible and willing staff, and most prisoners, apart from a few who had been released following screening prior to follow-up and could not be traced.

WGS sequencing of TB cases in England and Wales continued throughout the pandemic. To date, there have been 12 cases of TB linked by WGS in prisoners and ex-prisoners of HMP Parc within this cluster. Although epidemiologists are suspicious of there may have been an initial historical seeding event within the prison to account for some of these cases, a source index case has never been identified and community transmission is likely to have also played a part in transmission between current and ex-prisoners.

The evidence is that this outbreak is part of a wider evolving complex community and justice system cluster involving individuals with a high risk of present or future incarceration, many who are likely to be linked by social and potential criminal risk factors. It will require further epidemiological investigation and management to interrupt on-going TB transmission in this population.

Report Recommendations

1. **HMPPS** should advise the justice system that any prisoner identified in a prison in England or Wales who was previously incarcerated in HMP Parch between January 2018-March 2020 and not screened for TB since should have their notes flagged as a potential TB risk/be screened for TB, and if LTBI positive, supervised treatment is advised during incarceration.

2. **Prisons and NHS healthcare providers** should ensure that any prisoner transferred to acute care for assessment with a cough or respiratory symptoms should wear a mask whilst cuffed until TB or other serious respiratory infections are ruled out. Prison officers cuffed to or remaining in the same room as the prisoner should also wear masks*. * Mask type should be as specified by the hospital Infection Prevention and Control Policy, but the default mask in the community would be a surgical mask.

3. **HMPPS** should review their current template risk assessment procedures so that in future, officers are not routinely cuffed to or remain in the same room/cubicle as prisoners with potentially infectious respiratory symptoms (cough, coughing up blood etc.) and should consider reducing shift duration until TB or other serious infectious respiratory conditions are ruled out. If the revised Prison Officer risk assessment is that they have to remain inside the cubicle (for example, for public safety reasons), Infection Control or other suitable staff must offer urgent fit testing (if needed) and appropriate masks for protection to these prison officers.

4. **HMPPS or private prison providers** should consider BCG for frontline prison staff in line with national immunisation guidance. [1]

5. **Health boards** should consider providing X-ray services and/or other solutions within prisons to support active case finding of TB, as recommended by NICE guidance. Use of IGRA tests on admission, as part of blood-borne virus screening, as per NICE guidance, would significantly improve detection.[2]

6. **Prison healthcare** should carry out a repeat symptom check for TB symptoms several weeks after admission, to see if common symptoms on admission initially thought not to be TB persist.

7. **Health boards** should amend their TB policies and operational infection control advice to include:

    - Telling prison escort staff promptly on admission if TB is suspected so they can reassess the risk of cuffing and recording this conversation in the hospital notes

    - An explicit statement that any prison staff guarding a patient with pulmonary TB inside the cubicle are at risk of TB exposure equal to or greater than household contacts. This is a much greater risk of transmission than healthcare staff

    - Medical and nursing staff caring for such prisoners must explicitly warn prison officers of the serious risk for TB exposure as outlined above and record this conversation in the patient's notes. Any HMPPS staff informed of this risk should inform escort staff and it should be recorded on the Bed-Watch Log Handover.

    - If the revised Prison Officer risk assessment is that they have to remain inside the cubicle (for example, for public safety reasons), Infection Control or other suitable staff must offer urgent fit testing (if needed) and appropriate masks for protection to these prison officers.

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/731848/Greenbook_chapter_32_Tuberculosis_.pdf Chapter 32 page 7 accessed 28/07/2021 says:
"There are a number of occupational groups who are working with persons at higher risk of acquiring TB. These include staff working with prisoners, homeless persons, persons with drug and alcohol misuse and those who work with refugees and asylum seekers. BCG vaccination may also be considered for these groups."
[2] https://www.nice.org.uk/guidance/ng33/chapter/Recommendations#preventing-tb

8. **PHW CDSC and Health Protection** should follow up on the outbreak cases identified by WGS post screening and consider undertaking in-depth interviewing to obtain information to inform case-finding and future management of the wider cluster.

9. **PHW CDSC and Health Protection** should collaborate with appropriate colleagues in Public Health England (PHE) to undertake detailed investigation into the wider cluster to identify if any control measures or preventative measures are feasible for case-finding or to prevent on-going transmission.

10. **PHW CDSC and Health Protection** should note:
    - When undertaking epidemiological analysis in the future, including information on specific sites and activities within the prison estate (such as classes, gym use etc.) could provide more nuanced understandings of potential sites of transmission for infections such as TB.

    - It is helpful to have both analytical and epidemiological support present from an early stage in the IMT/OCT process so analysts can be involved in the early design of a data collection tool and both can advise on the best way to gather information to ensure efficient data collection and analysis.

This report was collated by Dr Gwen Lowe of Public Health Wales (OCT Chair) on behalf of and with contributions from the multi-agency Outbreak Control Team and this final version agreed by the core Outbreak Control Team membership. The OCT would like to acknowledge the work of CDSC colleagues Amy Plimmer and Clare Sawyer who undertook the epidemiological analysis.

2 Background

HMP Parc is a Category B prison located within the boundaries of the Cwm Taf Morgannwg University health board (CTMUHB). It holds approximately 1,600 prisoners, including a young offenders unit (40 persons), and a vulnerable persons unit (350 persons). The prison employs approximately 800 members of staff.

In October 2019, Public Health Wales was notified about a hospitalised prisoner from HMP Parc who had been diagnosed with culture positive tuberculosis (TB). Although this individual was smear negative (so low risk for infectivity), an IMT was held as he had been cuffed to prison officers on bedwatch whilst he was in in hospital.

Two other cases of TB had been notified previously in 2019 of individuals in HMP Parc, both were of little or no infection risk. However, newly instituted Whole Genome Sequencing (WGS) cluster routine reporting introduced around the same time as this TB incident identified that all three individuals were linked to a larger related WGS cluster that included cases in south-east Wales and England.

Investigators at this time could not determine if there had been any transmission within the prison setting, or whether infection (latent TB) had been acquired in the community, with symptom onset whilst in prison.

A new case in HMP Parc was notified in December 2019. This case was smear positive, so likely to be of higher infectivity. Between this case and the original identified potentially infectious case, 75 officers subsequently required screening as a result of their potential significant close contact with these cases.

In addition, WGS sequencing identified two further additional cases that on investigation were found to have been former inmates in HMP Parc, although they were no longer there at time of diagnosis.

The Incident Management Team (IMT) reviewed the available epidemiological and microbiological evidence and undertook urgent investigation of links between HMP Parc cases and their links to cases in the community through in-depth re-interviewing of all available cases. The aim was to understand the epidemiology to enable the identification of a reasonable next cohort for screening and investigation purposes, and determine if this was a within-prison or a community transmission issue.

By early January 2021, extensive re-interviewing of available cases and expert opinion concluded that it wasn't possible to determine definitively where and how transmission had occurred between cases. Some community links were identified between several of the cases, but there was at least

two cases for whom within-prison transmission was the only plausible explanation.

As a result, an Outbreak was formally declared and the IMT converted into a formal Outbreak Control Team (OCT) under the arrangements within the Communicable Disease Outbreak Plan for Wales, against the background of the rapidly developing COVID-19 pandemic. Screening of the 75 prison officers in contact with the two potentially infectious cases was undertaken and 15 (20%) were found to be positive for latent TB infection (LTBI).

Therefore OCT made the decision to undertake mass screening of all prisoner-facing and concerned staff and prisoners within the main prison complex, commissioning the mobile unit services of "Find and Treat" from University College in London to undertake this. This took place in early March 2020, two weeks prior to the national lockdown due to COVID-19.

The outbreak relating to HMP Parc was declared over in July 2021.This report is a record of the OCT's investigations and activities in relation to the declared outbreak and contains the epidemiological analysis of the results of the mass screening undertaken. It should be regarded as a final report containing the technical summary of the investigations and findings concerning the 2019 cases linked to HMP Parc and subsequent screening activities in 2020, but it doesn't capture the on-going complexity of the epidemiology around the wider WGS cluster. The OCT has recommended that a new IMT needs to be convened to investigate the wider cluster (recommendation 9).

3 Timeline

Significant Events

7/11/19 PHW notified of a hospitalised potentially infectious case of TB in a prisoner at HMP Parc

13/11/19 IMT 1

28/11/19 IMT 2

17/12/19 IMT 3

8/1/20 IMT 4: OUTBREAK DECLARED

10/01/20 Whole Staff briefing by OCT Chair and communications to residents

10/01/20 Press statement released

16/01/20 CTMHB Operational group meeting to plan mass screening

20/1/20 Screening by G4S begins of identified 75 bedwatch/escort Prison Officers and identified staff who were potential close contacts

21/1/20 OCT 5

11/2/20 OCT 6

19/02/20 Whole staff briefing by OCT Chair and communication to residents

20/02/20 Press statement Released

29/01/20 CTMHB Operational group meeting to plan mass screening

03/03- 05/03/20 Prison staff screening

09/03/20 – week of Prisoner screening

22/03/20 National lockdown due to COVID-19

All clinical OCT HB and PHW staff redeployed to support COVID-19 response

12/08/20 – OCT 7

Update communication to staff and residents

20/07/21- Final OCT meeting

4 Context: Screening Close Contacts for TB

National Guidelines

The standard national guidance document used by all TB specialist staff and respiratory teams is the National Institute for Health and Care Excellence (NICE) Tuberculosis guidelines [NG33] published date: January 2016. This guidance covers preventing, identifying and managing latent and active tuberculosis (TB) in children, young people and adults and is updated electronically as required.

Definition of a close contact

NICE defines close contacts as: *'People who have had prolonged, frequent or intense contact with a person with infectious TB. For example, these could include 'household contacts' – those who share a bedroom, kitchen, bathroom or sitting room with the index case. Close contacts may also include boyfriends or girlfriends and frequent visitors to the home of the index case [NICE Tuberculosis Guideline – NG33].*

A rule of thumb for defining a group that needs screening is a total cumulative total of eight hours close contact with an infectious case of TB. For example, with hospital inpatients, NICE recommends *'Regard patients as at risk of infection if they spent more than eight hours in the same bay as an inpatient with smear-positive TB who had a cough'.* However, it is the closeness and intensity of contact and the infectiousness of the index case that is the most important determinant of the need for screening.

In incidents such as these therefore, there are no absolute rules as to who is a close contact needing screening. NICE recommends a risk assessment, looking at the potential infectivity of the index case and the duration and closeness of contact to this case by others. This is often done by multidisciplinary and multiagency collaboration.

Stone in the pond principle

The 'Stone in the Pond' principle refers to a published scientific paper that recommended TB screening should be carried out in 'ripples', with the stone representing the index case and the widening water ripples representing groups of contacts with less and less exposure to the index case whilst infectious. It recommended that the closest ripple is screened first and if no TB transmission is detected (LTBI positivity being used as a proxy for this, although LTBI may have been acquired from another source), there is no need to screen the next circle of contacts. If transmission is detected, screening is carried out sequentially in ripples until no transmission is detected.

In terms of Case 4, the closest ripples were any identified cell-mates and those bedwatch prison officers cuffed to case 4 whilst he was in hospital. Although case 4 was smear negative, so not of high infectivity, the closeness and duration of cuffed bedwatch contact was still judged to be included in the first 'ripple'. Case 5 was smear positive, so infectious, and the first ripple included any staff who were named as providing individual input. As 20% of the officers screened for cases 4 and 5 were found to be LTBI positive, the OCT defined the next 'ripple' as covering all prisoner-facing staff and all the main prison.

Type and sensitivities of screening tests

There are two main tests for detecting latent TB, the Mantoux tuberculin skin test (TST) and the IGRA blood test. Neither of these are perfect and false positive and false negative results are common. A function of any screening test is that the rarer the disease in the underlying population, the lower the positive predictive value, in other words, the rarer the disease, the more likely it is that the screening result is a false positive result.

In addition, the tests can't reveal when a person became infected, so for those contacts with positive tests, it is impossible to tell if they were exposed to TB as a child, a number of years ago or as a result of recent exposure to the index case in this outbreak. In addition, the Mantoux skin test can be positive as a result of previous BCG (TB vaccination). Interpreting the meaning of a positive test is thus problematic. TB nurses look at other potential risk factors in an individual's past before making an assessment, but this is necessarily difficult.

Latent TB Infection (LTBI)

People with latent TB infection are infected with *M. tuberculosis*, but do not have TB illness. They are completely well and do not have any symptoms. The only sign of TB infection is a positive reaction to the tuberculin skin test or TB IGRA blood test. People with latent TB infection are not infectious and cannot spread TB infection to others.

Overall, without treatment, about 5 to 10% of people with latent TB will develop TB disease at some time in their lives. The remaining 90% will remain well and will never develop TB in their lifetime. Previously, it was thought that about half of those people who develop TB will do so within the first two years of infection, more recent evidence suggests most individuals who will go onto develop active disease from LTBI do so within 2 years of exposure, and rarely after this time.[3]

Diagnosis of TB

People with TB may have any of the following symptoms:

- Unexplained weight loss
- Loss of appetite
- Night sweats
- Fever
- Fatigue

If TB disease is in the lungs (pulmonary), symptoms may include:

- Coughing for longer than three weeks
- Hemoptysis (coughing up blood)
- Chest pain

[3] Revisiting the timetable of tuberculosis Marcel A Behr, Paul H Edelstein, Lalita Ramakrishnan BMJ. 2018; 362: k2738. Published online 2018 Aug 23. doi: 10.1136/bmj.k2738

If TB disease is in other parts of the body (extra pulmonary), symptoms will depend on where the infection occurs.

A number of tests may be carried out:

The Mantoux tuberculin skin test (TST) or the TB IGRA blood test: These may also be positive in a case of TB illness. However, additional tests are required to confirm TB disease.

Chest X-ray: Abnormalities may suggest TB, but cannot be used to definitively diagnose TB. A chest X-ray may be used to rule out the possibility of pulmonary TB in a person who has had a positive reaction to a TST or TB blood test and no symptoms of disease.

Microbiology tests: The presence of acid-fast-bacilli (AFB) by looking under the microscope at sputum stained by a special dye often indicates TB disease. However, this does not confirm a diagnosis of TB because some acid-fast-bacilli are not *M. tuberculosis*. Therefore, a **culture** is done on all initial samples to confirm the diagnosis. A positive culture for *M. tuberculosis* confirms the diagnosis of TB disease.

Investigating whether LTBI is linked to a TB cluster

Unless LTBI infection is found in a household cluster or in a young child known to be in close contact with a pulmonary case of active TB disease, it is usually difficult to conclude whether any particular case of LTBI infection is linked to any particular case of active TB disease.

This is because:

- It is not usually possible to identify when someone has become infected with LTBI- infection may be recent or due to exposure many years previously
- LTBI infection can't be typed or undergo WGS, so if a positive test is found (unless that individual has a recent previous negative test), it isn't possible to identify when the individual acquired infection.
- Active TB can present in a variable time period after infection, from several months to many years later, so it may not be possible to identify the source.

Therefore, cases of LTBI cannot be definitively linked to any particular index case unless active TB develops subsequently in the person with LTBI and WGS or typing is available for both cases.

5 Epidemiological Methods

Final Case Definitions

As defined in OCT meeting 21/1/20

***Probable**: Person who has been resident (or working) at Parc prison on or after 1/1/2018, with a diagnosis of confirmed or treated TB (ETS definition).*

***Confirmed**: Probable case with genome sequence within 12 SNP of index case*

Case Ascertainment

Cases linked to this outbreak were actively identified through the mass screening undertaken and through the regular reporting of confirmed cases with near-indistinguishable WGS from England and Wales. In addition, awareness was raised of TB symptoms with both prison healthcare staff and prisoners during the acute phase of this incident.

Analytical Epidemiological Methods

To provide the OCT with a summary of the prevalence and risk factors associated with being positive with LTBI to inform any future decision-making required, colleagues from Public Health Wales Communicable Disease Surveillance Centre analysed the characteristics of those screened with the following objectives:

- To measure prevalence of latent and active TB in prison officers;
- To measure prevalence of latent and active TB in prisoners;
- To describe cases by their personal characteristics (age, ethnicity), location in prison and any risk factors (previous drug and alcohol use, history of homelessness etc.);
- To identify any risk factors associated with active or latent TB identified through screening

Screening strategy and data collection

Screening of inmates and staff at HMP Parc was led by CTMUB with support from Oxford Immunotech and 'Find and Treat' TB Services. Staff were screened 3rd – 5th March 2020, whilst prisoners were screened 9th -13th March 2020. Individuals were asked to complete a questionnaire in addition to having a T-spot® blood test and a chest x-ray. Two questionnaires were developed: one for staff and one for prisoners (see appendix). Data were entered by CTMUHB staff directly into EpiData datasheets.

Complete questionnaire data were imported into STATA version 14.2 and cleaned. Questionnaire data were combined with the results of T-spot® blood tests as provided by Oxford Immunotec using the unique ID code developed for this screening exercise. The blood data was cleaned in STATA 14.2 and matched with demographic data available on the Welsh Demographic Service (WDS) to improve data quality and inform clinical action.

All documents and files containing patient identifiable information were handled and stored in compliance with the Data Protection Act (1998) and GDPR (2018), as well as by guidelines established by the local Caldicott guardian.

Analytical methods

Individuals were included in this analysis if a screening questionnaire had been completed. In the staff cohort, the results for 21 of the 75 individuals who were screened in January 2020 were included in the analysis as they had completed the subsequent March screening questionnaire, along with the results from the mass screening event in March 2020. In the univariate analysis, only positive and negative LTBI results are included in the outcome variable. Borderline positives, borderline negatives, missing and "indeterminate" results are not included.

In order to achieve the objectives outlined above, the following methods were used:

- To describe cases by their personal characteristics (age, ethnicity), location in prison and any risk factors (previous drug and alcohol use, history of homelessness etc).

For this objective, descriptive analysis was performed to describe the two cohorts (prisoners and prison staff) in terms of personal characteristics (age, ethnicity, sex for prison guards), smoker status, their place of work/residence within the prison and for prisoners, prison external risk factors, including drug use, homelessness and prison history.

- To identify any risk factors associated with active or latent TB

Positivity (% LTBI positive) by characteristics including age, sex (for prison staff) and place of birth was calculated as well as by area of work/residence in the prison in order to identify any potential groups who were disproportionately positive and therefore potential risk factors for LTBI.

Prevalence ratios, 95% confidence intervals around the prevalence ratio and a test of significance were also calculated for this purpose.

6 Environmental Investigations

Detailed cell movements and timelines for each prisoner case of active TB who had been incarcerated within HMP Parc for any time period from January 2018 onwards were obtained from HMPPS in Wales. These were analysed by PHW investigators seeking to identify any common trends or common wings occupied by cases.

7 Epidemiological Results

At the time of writing this report, 12 confirmed cases fulfil the case definition. Six of these were identified at the point at which mass screening was implemented. Subsequently, another six cases have been identified by WGS of individuals who had been in HMP Parc at some point after January 2018, but who were not in this establishment at the time of their diagnosis. An additional case met the probable case definition.

Table 1: Line list of cases meeting the case definition

Case	**Symptom onset**	**Date notified**	**Infectivity status at diagnosis**	**In Parc when diagnosed**	**When in Parc if not at diagnosis**
1	Apr 2019	May 2019	Smear negative Culture positive Low infectivity	Yes	In Parc
2	Feb 2019	Jun 2019	Smear positive: Infectious	No	Jan-Jun 2018
3	Jun 2019	Jul 2019	Extra-pulmonary: Not Infectious	Yes	In Parc
*4	Aug 2019	Oct 2019	Smear negative Culture positive Low infectivity	Yes	In Parc
5	Sept 2019	Dec 2019	Smear positive Infectious	yes	In Parc
6	Dec 2019	Dec 2019	Extra-pulmonary: Not infectious	No	May 18 -Jun 19
7	Dec 2019	Apr 2020	Smear negative Culture positive Low infectivity	No	2018-May 19

8	Apr 2020	Jul 2020	Culture positive	No	Unconfirmed
9	Aug 2020	Sept 2020	Smear Positive	No	Feb 18-Oct 19
10	Dec 2019	Sept 2020	Extra-pulmonary Not infectious	Yes	Nov 19-Dec 20
11	Aug 2020	Feb 2021	Not reported	No	Oct 18-Mar 19
12	Mar 2020	Mar 2021	Culture Positive	No	Jun 18-Jun 19
Probable Case					
Probable case	Dec 2019	N/A	Extra-pulmonary- no culture available	Yes	In Parc

*Case 4 is the Index case for identification of this outbreak

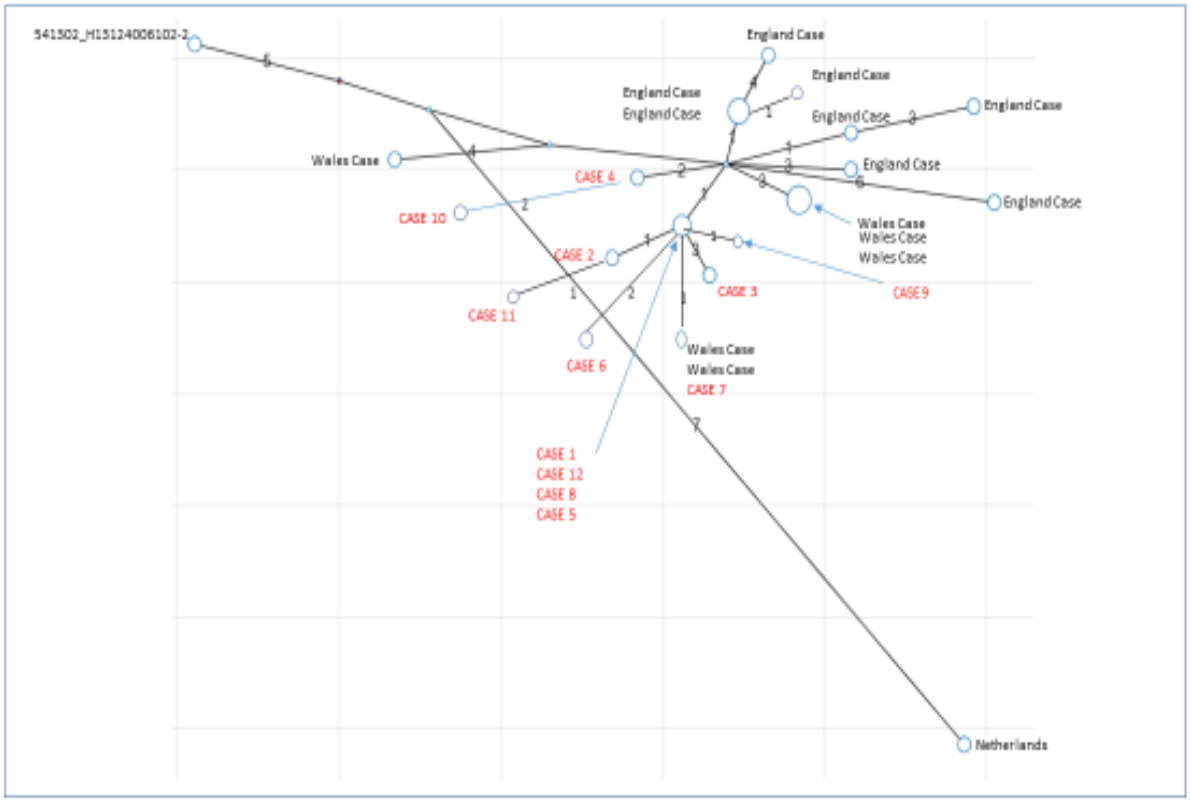
Wider case Cluster

As well as the cases linked by time spent in HMP Parc, other cases have been identified as connected to this cluster by whole genome sequencing who have never been in HMP Parc.
The cluster has therefore been divided into three groups for investigation as follows:
1. Those known to have served time in HMP Parc [fitting the outbreak case definition]
2. Other (community) cases in Wales
3. Other cases in England

The anonymised cluster diagram ('blobogram') below (original kindly provided by Public Health England) demonstrates how the 12 cases meeting the outbreak case definition fit together with the other cases identified by WGS as being part of this cluster. Each line represents a different clade, with the number on the line outlining how many SNPs that clade differs from the other clades it connects to. As the TB bacilli passes through each successive person, there will be natural mutation, so it is expected to see SNP differences between linked cases.

It can be seen that all outbreak cases fall within 12 SNP of each other, which is the accepted definition limit of linked cases. However, it can be seen that other Wales cases are also well within 12 SNPs of outbreak cases, as are some England cases, although these are slightly more distant. However, it should also be noted that cases 9-12 are almost identical to other Parc outbreak cases, although these are in prisons in England at the time of their diagnosis.

Figure 1: Cluster diagram or 'blobogram' demonstrating connections between cases



Screening Results

One early case of active (non-infectious) TB was detected in a prisoner on the mass screening in HMP Parc in March 2020: this was subsequently sequenced to a different WGS result, so was not part of the HMP Parc WGS cluster cohort and did not meet the outbreak case definition. In addition, another IGRA positive prisoner was subsequently found to have extra-pulmonary TB on follow-up.

Table 2: IGRA (T-spot®) Results from screening

	Total Screened	Initial Positive IGRA tests	Initial Borderline IGRA Tests	Additional Positives on retesting those with Borderline results	Total Positive IGRA tests	Total Followed up with Positive tests
Staff*	745[1]	54[2]	75 (+2 indeterminate)	1	55	
Men	1065[3]	122	114 (+1 indeterminate)	2	124	

*Jan and March screening events combined
1: 691 questionnaires available for epi analysis
2: 44 questionnaires available for epi analysis
3: 1,111 questionnaires available for epi analysis, 46 prisoners did not provide blood samples for IGRA

Epidemiological analysis of screening results based on the questionnaire survey

Results – Staff

Staff cohort overview

In total, questionnaires were completed for 691 individuals, 687 of whom also had blood results (Table 3).

These figures and the analysis include results of those individuals screened in the first round of close contact screening in January 2020 who also completed the subsequent March screening questionnaire (n=21), as well as all staff members who participated in the mass screening undertaken in March 2020 (n=670). Denominators were not available for staff groups, so it is not possible to ascertain whether one staff group was over or under represented in this survey.

The final screening result has been used following any re-test of individuals initially identified as "borderline positive/negative".

Table 3: Blood results for staff screened, HMP Parc

Result	**Number**	**Overall %**
Positive	45	6.51
Negative	613	88.7
Borderline Positive	11	1.59
Borderline Negative	3	0.43
Indeterminate	2	0.15
N/A*	17	2.46
Total	**687**	100

*N/A figures includes "did not attend", "could not attend", "discharged" and missing blood results.

Of 691 staff screened, just under half were male (male = 49.8%). The median age of staff screened was 38 years (range 19-84 years, mean age = 40.4 years)

Almost all staff members reported being born in the UK (97%). Of those not born in the UK, countries of birth included Jordan, Mauritius, Pakistan and Poland (total non-UK born n=19). Around a third of individuals specifically reported being born in Wales (33.6%, n=237).

The median duration of employment by staff at HMP Parc was 4 years (range 1 month – 24 years (mean = 7 years). The median duration of employment at any of Her Majesty's Prisons in the UK was 4 years and 9 months (range 1 month to 40 years, mean duration = 7 years and 9 months).

The majority of staff screened were prison guards (41%), but staff from all areas of the prison were screened (Table 4). Denominators were not available in order to identify if one staff group was over-represented. Information on job roles was available for 390 individuals.

Table 4: Reported occupations by screened staff

Occupation in HMP Parc	Number	Percent
Prison officer	285	41.2
Education	92	13.3
Facilities	74	10.7
Healthcare workers	68	9.8
Administration	66	9.6
Case worker	59	8.5
Directors & Management	37	5.4
Catering	9	1.3
No information	1	0.1
Total	**691**	**100**

Symptoms reported by staff

In total, 30% (n=206) of staff reported having at least one symptom compatible with tuberculosis (Table 5). The most commonly reported symptoms were cough for over three weeks (17%, n=117) and sweating at night (14%, n = 96). None of these were found to have active TB.

Table 5: Symptoms of TB reported by **all** screened staff

Symptoms	Number	Percent (%)
Cough +3 weeks	117	16.9
Sweating at night	96	13.9
Shortness of breath	74	10.7
Weight loss	9	1.3
Coughing up blood	8	1.2

Descriptive and univariate analysis

The aim of this section of the analysis is to identify any risk factors which are associated with an increased prevalence of LTBI positivity in staff employed at HMP Parc.

For the purpose of univariate analyses, the final T-spot® results following any re-screens of borderline or indeterminate cases was used. Borderline and indeterminate results were excluded from the analysis.

In total, positive or negative results from LTBI blood tests were available for 658 individuals.

Demographics and LTBI positivity in staff

Table 6: Demographics of staff screened

Exposures	Total	T-spot negative		T-spot positive		Prevalence ratio	95% CI	P-Value
	n	n	%	n	%			
Staff	658	613	93.2	45	6.8			
Sex								
Male	330	303	91.8	27	8.2	1.46	0.82 - 2.60	0.192
Female (ref)	322	304	94.4	18	5.6			
UK Born								
UK Born	638	594	93.1	44	6.9	1.38	0.20 - 9.52	0.741
Not UK Born (ref)	20	19	95.0	1	5.0			
Age								
Under 29	128	116	90.6	12	9.4	2.94	1.06 - 8.14	0.037
30 - 39	157	152	96.8	5	3.2	REF	-	-
40 - 49	85	80	94.1	5	5.9	1.85	0.55 - 6.20	0.321
50 - 59	120	111	92.5	9	7.5	2.36	0.81 - 6.85	0.116
60- 69	30	28	93.3	2	6.7	2.09	0.43 - 10.29	0.360
70+	4	4	100.0	0	0.0	1.00	-	-

There was no evidence of an association between sex and the prevalence of LTBI - similarly, there is no evidence for any difference in the prevalence of LTBI between employees who were born in the UK, compared to those born outside of the UK (Table 6).

There is evidence of an increased prevalence of LTBI in individuals employed by the prison who are under 29 years of age (PR = 2.94, CI: 1.06 – 8.14, p = 0.04) compared to those who are 30-39 years old (REF).

It is possible that this may be associated with a smaller proportion of this age group receiving a BCG vaccination. Under 40% of staff under 29 years old reported receiving a BCG vaccination, compared with over 50% for all other age groups (data not shown). BCG vaccination was routinely offered to all 10-14 year olds in the UK from 1953-2005, after which time, rates in the population were low enough that universal TB vaccination was not considered necessary[4]. It is possible that younger staff members fell outside the cohort to receive a BCG vaccination routinely. NHS Wales recommends BCG vaccination for persons under the age of 35 who are at increased occupational risk of TB exposure, including prison officers[5].

[4]BCG Vaccination: Vaccine Knowledge Project, Oxford University, https://vk.ovg.ox.ac.uk/vk/bcg-vaccine accessed 3rd June 2021

[5] When is the BCG vaccine needed? NHS 111 Wales, https://111.wales.nhs.uk/livewell/vaccinations/bcgtbwhen/, accessed 3rd June 2021

External risk factors (i.e. not prison based) and LTBI positivity in staff

Table 7: Prevalence ratios and 95% confidence intervals (CI) for exposures reported external of the prison setting

Risk Factors (external to prison)	Total	T-spot negative		T-spot positive		Prevalence ratio	95% CI	P-Value
	n	n	%	n	%			
Staff	658	613	93.2	45	6.8			
Immunosuppressed?								
Yes	32	28	87.5	4	12.5	1.91	0.73 - 5.00	0.193
No	626	585	93.5	41	6.5			
BCG?								
Yes	414	387	93.5	27	6.5	0.86	0.49 - 1.66	0.663
No	159	147	92.5	12	7.5			
Previous history of TB?								
Yes	8	1	12.5	7	87.5	14.7	9.83 - 22.09	<0.05
No	640	602	94.1	38	5.9			
Ever Smoked/Vaped								
Yes	320	301	94.1	19	5.9	0.77	0.44 - 1.37	0.373
No	338	312	92.3	26	7.7			
Current Tobacco smoker								
Yes	94	86	91.5	8	8.5	1.30	0.62 - 2.70	0.488
No	564	527	93.4	37	6.6			
Current vaper								
Yes	80	77	96.3	3	3.8	0.51	0.16 -1.62	0.240
No	576	534	92.7	42	7.3			

Staff who reported being immunosuppressed had a 1.9 times higher prevalence of LTBI than staff who reported that they were not immunocompromised – though there was weak evidence for this being a statistically significant association (CI 0.7– 5.0, p=0.19) (Table 7).

Staff who reported having had a previous diagnosis of TB had a 14.7 times higher prevalence of LTBI than staff who reported that they had not previously been diagnosed with TB. This result was also statistically significant (CI: 9.8 – 22.1, p<0.05). However, this is not surprising, as the T-spot® is likely to remain positive for life after converting. Furthermore, of the seven staff T-spot® positive, the five who reported that they had been diagnosed with TB in 2020 were individuals identified as LTBI positive in the screening of the 75 close contacts in January 2020, but did not have active TB disease. The other two were diagnosed in 1971 and 2015 respectively and completed treatment.

Staff who reported being a current tobacco smoker had 1.3 times the prevalence of LTBI than staff who reported that they did not currently smoke (tobacco). Staff who reported being current vapers had half the prevalence of LTBI of those who were not currently vapers. However in both instances, there was little evidence that this is a true association as it did

not meet the threshold for statistical significance (Tobacco CI: 0.62-2.70, p=0.488; Vaper CI: 0.16 – 1.62, p=0.24).

Internal risk factors (i.e. prison based) and LTBI positivity in staff

Table 8: Prevalence ratios and 95% confidence intervals (CI) for occupational groups

Exposure	Total	T-spot negative		T-spot positive		Prevalence ratio	95% CI	P-Value
	n	n	%	n	%			
Staff	658	613	93.2	45	6.8			
Role in Prison								
Adminstration	62	59	95.2	3	4.8	REF	-	-
Case worker	55	55	100.0	0	0.0	-	-	-
Catering	9	9	100.0	0	0.0	-	-	-
Management	35	33	94.3	2	5.7	1.18	0.21 - 6.73	0.851
Education	89	81	91.0	8	9.0	1.86	0.51 - 6.73	0.345
Facilities	71	67	94.4	4	5.6	1.16	0.27 - 5.00	0.838
Healthcare worker	65	62	95.4	3	4.6	0.95	0.20 - 4.55	0.953
Prison officer	271	247	91.1	24	8.9	1.83	0.57 - 5.89	0.310

No association between specific occupational groups was found to be statistically associated with having a higher LTBI prevalence (Table 8). The highest prevalence (as proportions) were found in people who worked in education (8/89 9%) and prison guards (24/271, 8.9%).

Table 9: Prevalence ratios and 95% confidence intervals (CI) for specific areas of work within HMP Parc

Exposure	Total	T-spot negative		T-spot positive		Prevalence ratio	95% CI	P-Value
	n	n	%	n	%			
Staff	658	613	93.2	45	6.8			
Block worked in								
A block	43	39	90.7	4	9.3	1.02	0.31 - 3.42	0.970
Admin	6	6	100.0	0	0.0	1.00	-	-
Admissions and Custody	16	15	93.8	1	6.3	0.69	0.09 - 5.32	0.720
B block	26	26	100.0	0	0.0	1.00	-	-
C block	15	15	100.0	0	0.0	1.00	-	-
Catering	10	9	90.0	1	10.0	1.10	0.15 - 8.21	0.926
D block	19	17	89.5	2	10.5	1.16	0.25 - 5.28	0.850
Education	65	59	90.8	6	9.2	1.02	0.35 - 2.99	0.978
Facilities	70	67	95.7	3	4.3	0.47	0.12 - 1.81	0.273
Healthcare	33	30	90.9	3	9.1	1.00	0.27 - 3.75	1.000
Offender Management	21	21	100.0	0	0.0	1.00	-	-
Other	15	14	93.3	1	6.7	0.73	0.10 - 5.65	0.766
Site Wide	71	67	94.4	4	5.6	0.62	0.18 - 2.10	0.442
T block	124	115	92.7	9	7.3	0.80	0.30 - 2.15	0.655
Visitor's Centre	16	16	100.0	0	0.0	1.00	-	-
Vulnerable Persons Unit	41	36	87.8	5	12.2	1.34	0.44 - 4.12	0.608
Young Persons Unit	66	60	90.9	6	9.1	REF		

There were no areas of the prison which individuals reported working in for which there was evidence of a statistically significant association with an increased prevalence of LTBI (Table 9). However the proportion of positive results was highest in the Vulnerable Persons' Unit (VPU) (5/41, 12.2%), Block D (2/19, 10.5%), catering (1/10, 10%) and Block A (4/41, 9.8%).

Table 10: Prevalence ratios and 95% confidence intervals (CI) for HMP Parc specific exposures

Exposures	Total	T-spot negative		T-spot positive		Prevalence ratio	95% CI	P-Value
	n	n	%	n	%			
Staff	658	613	93.2	45	6.8			
Time employed at HMP Parc								
Less than 1 year	90	82	91.1	8	8.9	1.37	0.59 - 3.14	0.464
1-5 years	255	240	94.1	15	5.9	0.90	0.45 - 1.83	0.778
5-10 years	97	89	91.8	8	8.2	1.27	0.55 - 2.92	0.579
Over 10 years	215	201	93.5	14	6.5	REF	-	-
Time employed at prisons								
Less than 1 year	85	78	91.8	7	8.2	1.32	0.55 - 3.17	0.529
1-5 years	250	234	93.6	16	6.4	1.03	0.51 - 2.06	0.937
5-10 years	97	89	91.8	8	8.2	1.33	0.57 - 3.06	0.509
Over 10 years	225	211	93.8	14	6.2	REF	-	-
Close contact with someone with								
Yes	222	201	90.5	21	9.5	1.83	1.02 - 3.27	0.039
No	406	385	94.8	21	5.2			

The proportion of LTBI positive individuals was higher in those who had been employed at HMP Parc/any of Her Majesty's Prisons for less than 1 year (8.9% in HMP Parc and 8.2% in prisons in general), although there was little evidence of this association statistically (Table 10).

Table 11: Prevalence ratios and 95% confidence intervals (CI) for exposures associated with contact with a case of TB

Exposures	Total	T-spot negative		T-spot positive		Prevalence ratio	95% CI	P-Value
	n	n	%	n	%			
Staff	658	613	93.2	45	6.8			
Was close contact a prisoner in HMP Parc?								
Yes	181	167	92.3	14	7.7	0.46	0.20 - 1.08	0.074
No	42	35	83.3	7	16.7			
Average hours per day in close contact								
Under 1 hour	45	43	95.6	2	4.4	0.51	0.11 - 2.31	0.383
1 to 4 hours	42	38	90.5	4	9.5	1.10	0.35 - 3.44	0.876
5 + hours	92	84	91.3	8	8.7	REF	-	-
Unsure	2	2	100.0	0	0.0	1.00	-	-
Average days in close contact								
Less than 7 days	108	98	90.7	10	9.3	REF	-	-
7-13 days	12	11	91.7	1	8.3	0.90	0.13 - 6.44	0.916
14-30 days	32	32	100.0	0	0.0	1.00	-	-
Over 30 days	22	19	86.4	3	13.6	1.47	0.44 - 4.92	0.529
Handcuffed to person with TB?								
No	96	89	92.7	7	7.3	REF	-	-
Yes - Short chain	10	9	90.0	1	10.0	1.37	0.19 - 10.05	0.756
Yes - Long chain	59	55	93.2	4	6.8	0.93	0.28 -3.04	0.904
Yes - Both short & long chain	7	5	71.4	2	28.6	3.92	0.99 - 15.44	0.051
Wear a mask when in same room as person with TB?								
None of the time	109	99	90.8	10	9.2	1.47	0.20 - 10.71	0.705
All the time	22	22	100.0	0	0.0	1.00	-	-
Less than half of the time	24	21	87.5	3	12.5	2.00	0.23 - 17.57	0.532
More than half of the time	16	15	93.8	1	6.3	REF	-	-
Did the person with TB wear a mask when in same room?								
None of the time	126	113	89.7	13	10.3	1.96	0.27 - 14.14	0.504
All the time	19	18	94.7	1	5.3	1.00	-	-
Less than half of the time	16	16	100.0	0	0.0	1.00	-	-
More than half of the time	11	11	100.0	0	0.0	REF	-	-

Around 33% (n=222) of employees included in the analysis reported having had "close" contact with someone with TB. An association between being a close contact of someone with TB and LTBI positivity was identified – though the confidence intervals include 1 (PR: 1.83, CI: 1.02 – 3.3, $p < 0.05$)(Table 10).

Of those who reported close contact, over 80% reported that this "close contact" had been a prisoner at HMP Parc (181/222, 81.1%) (Table 9).

Examining this closer, the proportion of LTBI positive individuals was higher in those who reported that their close contact with TB was not a prisoner at HMP Parc (7/42, 16.7%).

There was little evidence of a statistical association between a higher prevalence of LTBI for individuals whose close contact was a prisoner compared to those whose contact was not a prisoner at HMP Parc. In fact, there is some statistical evidence to suggest having a prisoner as a close contact, was protective compared to the contact not being a prisoner of HMP Parc (PR = 0.46, CI 0.21-1.1, p=0.07). However, this should be interpreted with caution as the confidence intervals overlap 1 (no difference in LTBI

positivity between groups), and we have no information on the type of non-HMP Parc associated "close" contacts.

There were no LTBI positive individuals identified amongst prison staff who reported wearing a mask 100% of the time that they were in contact with a prisoner they knew to be TB positive (Table 11). A higher proportion of positive LTBI individuals were identified in those who reported that they wore a mask less than half of the time that they were in contact with a prisoner with TB (12.5%) and none of the time that they were in contact with a prisoner with TB (9.2%). Table 12 shows there was no statistical evidence to suggest that wearing a mask when in the same room as someone with TB (for any length of time) reduced the prevalence of LTBI (PR=0.7, CI: 0.2 - 2.1, p = 0.5).

Table 12 suggests there is some statistical evidence to suggest that the individual with TB wearing a mask for any amount of time, compared to none of the time, may be protective against TB transmission (PR=0.21, CI: 0.03 – 1.6, p=0.08) but again, as these confidence intervals overlap 1, this result should be interpreted with caution.

There is some evidence that having been both short and long-chained to a prisoner with TB may increase the prevalence of LTBI (Table 11). However, the numbers are very small and this finding may be due to chance, or explained by duration of contact with an individual with TB. There was little evidence to suggest that there was an association between the time spent with an individual known to have TB and the prevalence of LTBI.

Table 12: Prevalence ratios and 95% confidence intervals (CI) for exposures associated with using a mask

Exposures	Total	T-spot negative		T-spot positive		Prevalence ratio	95% CI	P-Value
	n	n	%	n	%			
Staff	658	613	93.2	45	6.8			
Did the person with TB wear a mask when in same room?								
Yes (any amount of time)	46	45	97.8	1	2.2	0.21	0.03 - 1.57	0.084
No	126	113	89.7	13	10.3			
Wear a mask when in same room as person with TB?								
Yes (any amount of time)	62	58	93.5	4	4.3	0.70	0.23 - 2.15	0.532
No	109	99	90.8	10	11.0			

Summary of analysis of results from staff screening and questionnaire survey

- The overall prevalence in staff for LTBI infection was 6.5%
- No association between specific occupational groups was found to be statistically associated with having a higher LTBI prevalence (Table 6).

The highest prevalence (as proportions) were found in people who worked in education (8/89 9%) and prison guards (24/271, 8.9%).

- There were no areas of the prison which individuals reported working in for which there was evidence of a statistically significant association with an increased prevalence of LTBI
- There is evidence of an increased prevalence of LTBI in individuals employed by the prison who are under 29 years of age (PR = 2.94, CI: 1.06 – 8.14, p = 0.04. It is possible that this may be associated with a smaller proportion of this age group receiving a BCG vaccination. Under 40% of staff under 29 years old reported receiving a BCG vaccination, compared with over 50% for all other age groups.
- Whilst the statistical evidence is weak, wearing a mask when in contact with a known case of TB may reduce the likelihood of transmission in a prison setting. Likewise, ensuring an individual who has tested positive for TB (or who is suspected to have TB) wears a mask, may reduce the likelihood of transmission.

Results – Prisoners

Prisoner cohort overview

In total, 1,111 questionnaires were completed by prisoners. Of these, 1,065 individuals had a T-spot® blood test (Table 13).

Table 13: T-spot® results for prisoners *

T-spot results*	N	Proportion
NEGATIVE	910	81.91
POSITIVE	124	11.16
MISSING	46	4.14
BORDERLINE POSITIVE	14	1.26
BORDERLINE NEGATIVE	7	0.63
NO RESULT	4	0.36
INDETERMINATE	2	0.18
NON REPORTABLE INSUFFICIENT CELLS	2	0.18
TECHNICAL ERROR	2	0.18
Total	1,111	100

*final result following re-screen of initially borderline cases

84.9% of the prisons maximum capacity completed a questionnaire. Coverage of all residential blocks was high (mean coverage=78%, excluding H block due to small numbers) (Table 14).

Table 14: Block location of screened prisoners

Prison block	Questionnaires completed	Population Max. capacity	Coverage (%)
A block	254	355	71.5
B block	261	366	71.3
C block	47	74	63.5
D block	91	91	100.0
H block	3	12	25.0
T block	343	410	83.7
Prisoner work area	50	-	-
Unknown	62	-	-
Total	**1111**	**1308**	**84.9**

Symptoms reported by prisoners

27% (n=302) of prisoners reported at least one symptom consistent with tuberculosis infection. Sweating at night (15%) and shortness of breath (12%) were the most commonly reported symptoms, however these symptoms are very generic and may not be linked to a tuberculosis infection (Table 15).

Table 15: Symptoms reported by screened prisoners

Symptoms	Number	Percent (%)
Sweating at night	163	14.7
Shortness of breath	130	11.7
Cough +3 weeks	95	8.6
Weight loss	78	7.0
Coughing up blood	37	3.3

Descriptive and univariate analysis

The aim of this section of the analysis is to identify any risk factors which are associated with an increased prevalence of LTBI positivity in prisoners at HMP Parc.

For the purpose of this analysis, the final T-spot® results following any re-screens of borderline or indeterminate cases was used. Results that remained borderline and indeterminate were excluded from the analysis.

In total, positive or negative results from LTBI blood tests were available for 1,034 individuals.

Demographics and LTBI positivity in prisoners

Prisoners included in the analysis had a median age of 31 years (range 18-81 years, mean = 32.6 years). 93% of prisoners were born in the UK.

There was no identified association between LTBI positivity in prisoners and age or country of birth (Table 16).

Table 16: Prevalence ratios and 95% confidence intervals (CI) for prisoner demographics

	Total	T-spot negative		T-spot positive		Prevalence ratio	95% CI	P-Value
	n	n	%	n	%			
Prisoners screened	1034	910	88.0	124	12.0			
UK born								
Born Abroad	74	67	90.5	7	9.5	1.29	0.62 - 2.66	0.486
UK born	960	843	87.8	117	12.2			
Age								
18 - 29	469	412	87.8	57	12.2	1.03	0.70 - 1.50	0.891
30 - 39	338	298	88.2	40	11.8	REF	-	-
40 - 49	134	118	88.1	16	11.9	1.00	0.59 - 1.74	0.974
50 - 59	64	56	87.5	8	12.5	1.05	0.52 - 2.15	0.88
60 - 69	14	11	78.6	3	21.4	1.81	0.64 - 5.15	0.265
70 +	3	3	100	0	0.00	1.00	-	-

Medical history, previous exposures and LTBI positivity in prisoners

A statistically significant association between previous history of TB and LTBI positivity in prisoners was identified (PR: 3.64, CI: 1.52 – 8.70, p = 0.012) (Table 17). Of the three T-spot® positive prisoners who reported a previous TB diagnosis:

- One prisoner was diagnosed in 2011 in South Wales
- Two prisoners reported a previous TB diagnosis in 2015 whilst at the same prison in England.
- All three reported that they had received and completed treatment for their diagnosis

Table 17: Prevalence ratios and 95% confidence intervals (CI) for past medical and exposure history

	Total	T-spot negative		T-spot positive		Prevalence ratio	95% CI	P-Value
	n	n	%	n	%			
Prisoners screened	1034	910	88.0	124	12.0			
Immunosuppressed?								
Yes	38	36	94.7	2	5.26	0.43	0.11 - 1.67	0.193
No	996	874	87.8	122	12.3			
BCG?								
Yes	417	369	88.5	48	11.5	0.98	0.67 - 1.42	0.899
No	407	359	88.2	48	11.8			
Unknown	210	182	86.7	28	13.3	-	-	-
Previous history of TB?								
Yes	7	4	57.1	3	42.9	3.64	1.52 - 8.70	0.012
No	1010	891	88.2	119	11.8			
Unknown	17	15	88.2	2	11.8	-	-	-
Close contact w/ someone with TB?								
Yes	134	117	87.3	17	12.7	1.1	0.67 - 1.77	0.717
No	802	709	88.4	93	11.6			
Unknown	98	84	85.7	14	14.3	-	-	-

Reported risk factors and LTBI positivity

Prisoners were asked additional questions regarding lifestyle factors commonly associated with TB diagnosis. All but two of the prisoners screened reported one of homelessness, use of non-prescribed drugs, past or current smoker/vaper, or previous admissions at prisons other than HMP Parc.

Prevalence ratios showed there was some evidence of association between having ever used non-prescribed injectable drugs and LTBI positivity (PR: 1.31 CI: 0.92 – 1.88, p =0.13) but as the confidence intervals overlap 1, this may be due to chance (Table 18).

Outcomes regarding LTBI positivity in current tobacco smokers should be interpreted with caution. Levels of smokers may be under-represented due to smoking regulations on site.

95% of all prisoners screened had been resident at other prisons before HMP Parc. 38% of screened prisoners had been previously incarcerated in HMP Cardiff, and 26% had a history of residence at HMP Swansea.

Table 18: Prevalence ratios and 95% confidence intervals (CI) for social risk factors associated with prisoner population

	Total	T-spot negative		T-spot positive		Prevalence ratio	95% CI	P-Value
	n	n	%	n	%			
Prisoners screened	1034	910	88.0	124	12.0			
Homelessness								
Yes	297	261	87.9	36	12.1	1.02	0.71 - 1.46	0.935
No	737	649	88.1	36	11.9			
Homelessness								
Less than 6 months	120	109	90.8	11	9.17	0.8	0.43 - 1.41	0.408
6-11 months	58	50	86.2	8	13.8	1.17	0.60 - 2.29	0.649
1-2 years	46	39	84.8	7	15.2	1.29	0.63 - 2.62	0.482
2-5 years	49	44	89.8	5	10.2	0.86	0.37 - 2.03	0.739
Over 5 years	18	16	89.9	2	11.1	0.94	0.25 - 3.53	0.929
Use of non-prescribed drugs								
Yes	773	677	87.6	96	12.4	1.16	0.78 - 1.74	0.458
No	253	226	89.3	27	10.7			
Ever injected drugs								
Yes	261	221	84.7	40	15.3	1.31	0.92 - 1.88	0.13
No	653	577	88.4	76	11.6			
Last injected drugs?								
Within last 2 years	87	73	83.9	14	16.1	1.38	0.82 - 2.34	0.226
2-5 years ago	79	66	83.5	13	16.5	1.41	0.82 - 2.43	0.209
More than 5 years ago	87	75	86.2	12	13.8	1.19	0.67 - 2.09	0.557
Ever smoked drugs								
Yes	776	676	87.1	100	12.9	1.08	0.69 - 1.68	0.731
No	176	155	88.1	21	11.9			
Last smoked drugs?								
Within last 2 years	515	452	87.8	63	12.2	1.03	0.64 - 1.66	0.891
2-5 years ago	131	107	81.7	24	18.3	1.55	0.90 - 2.68	0.118
More than 5 years ago	111	98	88.3	13	11.7	0.99	0.51 - 1.91	0.975
Smoking/vaping?								
Ever smoked/vaped	904	797	88.2	107	11.8	0.88	0.54 - 1.41	0.593
Current smoker (tobacco)	40	34	85.0	6	15.0	1.25	0.59 - 2.66	0.571
Current vaper	780	691	88.6	89	11.4	0.80	0.55 - 1.15	0.234
Prison other than HMP Parc?								
Yes	980	864	88.2	116	11.8	0.81	0.38 - 1.73	0.589
No	41	35	85.4	6	14.6			

Reported prison residence and LTBI positivity

Evidence for an association between three blocks of residence and LTBI positivity were identified in this analysis; block A (PR: 1.72, CI: 1.00 – 2.95, p = 0.051), block D (PR: 2.26, CI: 1.11 – 4.02, p=0.024) and block T (PR: 1.79, CI: 1.08 – 3.00, p=0.025) (Table 19).

It is worth noting that prisoners may move around multiple blocks during their residence, so these findings are only reflective of those prisoners who were in the blocks at the time of screening. Prisoners are moved between blocks also to attend additional services, such as classes, gyms, access to healthcare and counselling, etc. Due to the high frequency of movement and mixing of the general prison population, it may not be possible to pinpoint one specific 'at risk' location within HMP Parc without in-depth analyses of individual cell movements for affected cases. It is also worth highlighting that D block is linked to the prisons' substance misuse service, so the association between residence of block D and LTBI positivity may be influenced by other risk factors of the residents in this block (i.e. previous history of drug or alcohol misuse).

Table 19: Prevalence ratios and 95% confidence intervals (CI) for cell location at time of screen

	Total	T-spot negative		T-spot positive		Prevalence ratio	95% CI	P-Value
	n	n	%	n	%			
Prisoners screened	1034	910	88.0	124	12.0			
Current Prison block								
A block	234	203	86.8	31	13.3	1.72	1.00 - 2.95	0.051
B block	246	227	92.3	19	7.72	REF	-	-
C block	45	39	86.7	6	13.3	1.73	0.73 - 4.08	0.214
D block	86	72	83.7	14	16.3	2.26	1.11 - 4.02	0.024
H block	1	1	100	0	0.00	-	-	-
Prisoner work area	49	45	91.8	4	8.16	1.06	0.38 - 2.97	0.916
T block	317	273	86.1	44	13.9	1.79	1.08 - 3.00	0.025
MISSING	56	50	89.3	6	10.7	-	-	-

Previous residence and LTBI positivity

Prisoners were asked where they had lived previously prior to arriving at HMP Parc (Table 20). An association between previous residence in Birmingham and LTBI positivity was identified (PR: 2.21, CI: 1.12 – 4.33, p = 0.022). There was some evidence of association with other locations, such as Blaenau Gwent, Pembrokeshire and Swansea, but in all outcomes, confidence intervals overlapped 1, so this should be interpreted with caution.

Table 20: Prevalence ratios and 95% confidence intervals (CI) for residence prior to prison admission

	Total	T-spot negative		T-spot positive		Prevalence ratio	95% CI	P-Value
	n	n	%	n	%			
Prisoners screened	1034	910	88.0	124	12.0			
Reported LA of residence prior to incarceration at HMP Parc								
BIRMINGHAM	39	29	74.4	10	25.6	2.21	1.12 - 4.33	0.022
BLAENAU GWENT	19	15	79.0	4	21.1	1.81	0.69 - 4.74	0.227
BRIDGEND	35	35	100	0	0.0	1.00	-	-
BRISTOL	22	21	95.5	1	4.6	0.39	0.06 - 2.77	0.347
CAERPHILLY	55	47	85.5	8	14.6	1.25	0.58 - 2.68	0.565
CARDIFF	172	152	88.4	20	11.6	**REF**	-	-
CARMARTHENSHIRE	31	27	87.1	4	12.9	1.11	0.41 - 3.03	0.839
CEREDIGION	5	5	100	0	0.0	1.00	-	-
LIVERPOOL	14	12	85.7	2	14.3	1.23	0.32 - 4.73	0.765
LONDON	39	35	89.7	4	10.3	0.88	0.32 - 2.44	0.809
MERTHYR TYDFIL	40	38	95.0	2	5.0	0.43	0.10 - 1.77	0.241
MONMOUTHSHIRE	18	17	94.4	1	5.6	0.48	0.07 - 3.35	0.458
NEATH PORT TALBOT	34	32	94.1	2	5.9	0.51	0.12 - 2.06	0.342
NEWPORT	112	100	89.3	12	10.7	0.92	0.47 - 1.81	0.812
OTHER	125	111	88.8	14	11.2	0.96	0.51 - 1.83	0.909
PEMBROKESHIRE	20	16	80.0	4	20.0	1.72	0.65 - 4.53	0.272
POWYS	13	13	100	0	0.0	1.00	-	-
RHONDDA CYON TAFF	57	52	91.2	5	8.8	0.75	0.30 - 1.92	0.554
SWANSEA	125	105	84.0	20	16.0	1.38	0.77 - 2.45	0.277
VALE OF GLAMORGAN	31	27	87.1	4	12.9	1.11	0.41 - 3.03	0.839
WALES (LA NOT PROVIDED)	26	19	73.1	7	29.9	2.32	1.09 - 4.93	0.029
WREXHAM	2	2	100	0	0.0	1.00	-	-

Summary of analysis of results from prisoner screening and questionnaire survey

- The prevalence of LTBI amongst screened prisoners was 11%. By comparison, an investigation into the prevalence of LTBI in admissions to a UK-based remand prison in 2019 found the LTBI prevalence to be 7.1%[6]. The 2019 study did not report an outbreak or period of increased incidence at the time of data collection. Due to the potential long-term, asymptomatic presentation of LTBI, it is not possible to determine whether the ongoing outbreak at HMP Parc significantly contributed to an increased prevalence of LTBI circulation amongst inmates at the prison.
- No single lifestyle characteristic was significantly linked to LTBI
- Evidence for an association between three blocks of residence and LTBI positivity were identified in this analysis; block A (PR: 1.72, CI: 1.00 – 2.95, p = 0.051), block D (PR: 2.26, CI: 1.11 – 4.02, p=0.024) and block T (PR: 1.79, CI: 1.08 – 3.00, p=0.025). However, it is worth noting that prisoners may move around multiple blocks during their residence, so these findings are only reflective of those prisoners who were in the blocks at the time of screening. In addition, D block is linked to the prisons' substance misuse service, so the association between residence of block D and LTBI positivity may be influenced by other risk factors of the residents in this block (i.e. previous history of drug or alcohol misuse).
- It is possible that this significant prevalence is not truly associated with the location in the prison, but with the characteristics of its residents. These risk factors, along with other social determinants of health such as education and homelessness are often citied in literature as drivers of tuberculosis infections[7,8]
- An association was identified between LTBI positivity and previous residence in Birmingham. In 2020, PHE reported that the main burden of TB disease in England remains concentrated around urban areas, with the West Midlands centre recording one of the highest notification

[6] Gray BJ, Perrett SE, Gudgeon B, Shankar AG. Investigating the prevalence of latent Tuberculosis infection in a UK remand prison. Journal of Public Health (Oxford, England). 2020 Feb;42(1):e12-e17. DOI: 10.1093/pubmed/fdy219.

[7] Nguipdop-Djomo, P., Rodrigues, L.C., Smith, P.G. *et al.* Drug misuse, tobacco smoking, alcohol and other social determinants of tuberculosis in UK-born adults in England: a community-based case-control study. *Sci Rep* **10,** 5639 (2020). https://doi.org/10.1038/s41598-020-62667-8

[8] Lönnroth K, Jaramillo E, Williams BG, Dye C, Raviglione M. Drivers of tuberculosis epidemics: The role of risk factors and social determinants. Social Science and Medicine 2009; 68 :2240–2246

rates in England in 2019 (9.7 per 100,000 population), second only to London (18.6 per 100,000 population)[9].

Limitations of epidemiological analysis based on survey

Staff and prisoners are known to move frequently between residential blocks and work areas across the prison site. The survey used in this report was unable to capture the full breadth of individual's movements across the site.

Similarly, the survey undertaken did not ask about others areas of the prisons where prison staff may congregate, such as rest or break rooms, the canteen, etc. This information would allow a more nuanced understanding of potential areas of transmission for TB between prison staff. Other prisoner – prison staff related exposures were also not captured by the survey, such as the location of close contact (e.g. a gym, yard work, teaching classroom, healthcare setting etc.) which could also affect the likelihood of the transmission of TB.

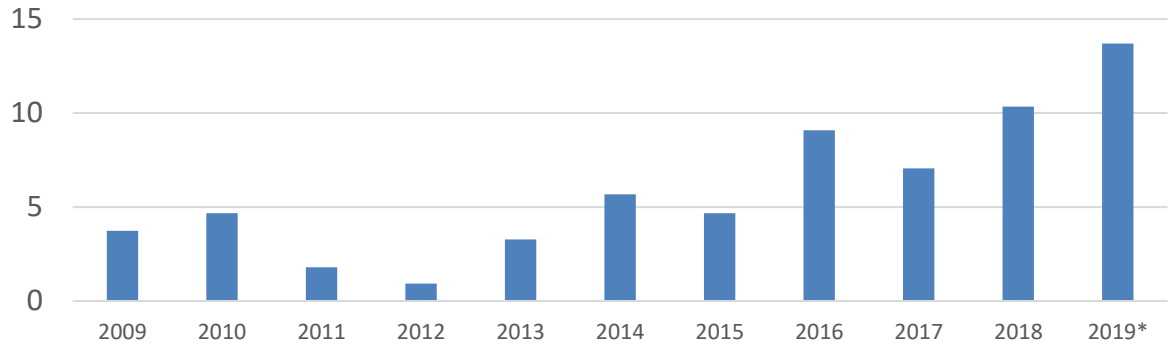
These are all self-reported responses to the questionnaire. There could be reporting bias in the responses. There could be social desirability bias in terms of the frequency of mask use or bias in terms of how much contact with someone known to have TB is reported, as well as in current smoking or vaping behaviours. There could also be over- or underestimation of the time spent with TB positive prisoners.

However, the high levels of completeness of surveys produced a rich dataset of personal information, covering many of the commonly reported risk factors (i.e. substance misuse, homelessness, smoking, medical and exposure history), as well as potential transmission opportunities (i.e. location of cell/work, use of PPE).

Finally, it is worth noting that a history of prison incarceration itself is an independent risk factor for developing active TB disease (see Figure 2 below), so by definition, all prisoners and ex-prisoners will be at a higher risk of being LTBI positive than the general population.

[9] Public Health England. Tuberculosis in England: 2020 report. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/943356/TB_Annual_Report_2020.pdf (Accessed online: 28/05/2021)

Figure 2: Proportion of TB cases with history of being in Prison, Wales; 2009-2019



[*Preliminary data for 2019- data sourced from: Tuberculosis in Wales Annual Report compilation: Public Health Wales Communicable Disease Surveillance Centre.]

8 Microbiological results

The cases in the epidemiological cluster and those identified as being related to prisoners in HMP Parc are members of Cluster 6 in Public Health Wales TB Cluster Analysis Reports.

To belong to this cluster, cases need to be within 12 Single Nucleotide Polymorphisms (SNPs) of each other. In those related to HMP Parc the majority are 0-5 SNPs apart.

9 Communications

There were several different aspects to communications in this outbreak. Initially those who required screening were communicated with directly via the service. When it became clear that wider communications were needed for those affected or concerned within the prison, further mass communications were undertaken as in the timetable below.

Communications timetable

Date	**Activity**
13/11/2019	Reactive statement prepared (single case)
29/11/2019	Reactive statement revised (two cases)
20/12/2019	Press release issued confirming four cases, and that screening to take place in January.
10/01/2020	Full staff briefing and communications to residents

	Press release issued confirming six cases, and declaring an outbreak.
19/01/2020	Full staff briefing and communications to residents
20/02/2020	Press release issued confirming numbers remain at six, and extension of screening.
05/11/2020	Reactive statement prepared
09/2021	Update for staff and residents

10 Discussion

Context of outbreak Investigation

This was an extremely difficult situation to investigate for a number of reasons. Firstly, the Chair of the IMT and subsequent OCT unavoidably changed three times over a six month period due to changes in roles, which hampered continuity of the investigation. Secondly, the impact of the pandemic over 2020/21 disrupted all services, which had a major impact on clinical follow up and epidemiological investigation, as all essential staff involved were redeployed to support COVID-facing efforts. And thirdly, this was an extremely complex TB cluster investigation because it was unclear whether this was a community-based problem or a prison-based issue, or if transmission was present in both settings. A history of incarceration is a known social risk factor for being a TB case, but it was hard to disentangle this risk factor from other risk factors.

<u>TB outbreak case investigation</u>

The outbreak investigation began with an incident meeting in November 2019 investigating the potential risks associated with a single low-infectivity case who had been cuffed to bed-watch officers in hospital. However, WGS carried out on the majority of confirmed TB cases in England and Wales became routinely disseminated around the same time. This identified that several previous low-risk TB cases thought to be sporadic cases within HMP Parc were in fact genetically linked.

The WGS findings triggered a wider investigation, particularly as a number of other cases had been identified as all being linked to the same cluster. Contact tracing was undertaken with all cases and there was detailed analysis of cell residency and timelines within HMP Parc. Despite these efforts, for the majority of cases meeting the case definition, there were no obvious direct links between cells occupied/wings occupied in the prison to account for within-prison transmission. Similarly, no prison/ex-prison contacts were identified who subsequently became cases. In fact there were

only two cases where the OCT concluded that within-prison transmission was only plausible source for their illness and could not be explained by other associations.

However, from the WGS data and epidemiological investigation, the OCT concluded that the active TB cases in prisoners and ex-prisoners at HMP Parc were linked by both sequencing and epidemiology. What was less certain was where and when transmission occurred. There is no hard evidence to guide further investigation around this, but the OCT have hypothesised that there may have been a mass (possibly prisoner only) exposure event exposing cases at some point in 2018 or early 2019 that may account for early transmission. Recent research suggests that the incubation period of TB from exposure to active disease is most typically several months to two years, and after that, disease is relatively infrequent, but can still occur.[10] However only up to around 10% of those with LTBI will ever develop active TB disease.

All but three outbreak cases were in HMP Parc in the early part of 2019, but were on a variety of wings with no obvious overlap or common features, and questioning has not identified any commonalities (such a work inside prison, gym use, places of worship etc).

One of the hypotheses considered by the OCT was whether there was a potential chain of transmission from case to case within the prison. However, this was considered a less likely scenario given the movements and the lower/non-infectious nature of some cases making onward spread impossible or unlikely. A mass (possibly prisoner only) transmission event was assessed as a more likely but ultimately unproven hypothesis.

What is also of note is that although we were able to obtain very little contact information for outbreak cases currently in English prisons, several were reported (in the public domain) as being convicted of offenses likely to involve widespread travelling and contact with Wales. Therefore it is possible that the HMP Parc outbreak cluster is linked to others in the wider cluster by these activities, and incarceration in HMP Parc is a consequence of these links in some cases and not a cause of their exposure to TB. It is also possible that cases first met in HMP Parc and subsequent contact and thus exposure occurred outside the prison environment.

[10] Revisiting the timetable of tuberculosis Marcel A Behr, Paul H Edelstein, Lalita Ramakrishnan BMJ. 2018; 362: k2738. Published online 2018 Aug 23. doi: 10.1136/bmj.k2738

Follow up of screened cases

There were heroic efforts throughout the pandemic to do repeat blood testing on individuals with borderline results and review and offer treatment to all those with positive results, despite lockdowns and coronavirus infection risks. By August 2020, most of those testing positive had been assessed and offered treatment. Some declined, and some staff did not attend follow-up appointments, so were referred back to their GP. A group of prisoners were identified who had been released before review, and health protection nurses liaised with HMPPS to track down these individuals and get them reviewed, either with support from probation services, or within the prison system if re-incarcerated for new offenses. Inevitably, a few ex-prisoners were untraceable despite efforts (No Fixed Abode, not in any UK prison, not under probation), but the vast majority have been offered or had treatment at the time of writing this report.

Epidemiological analysis

Epidemiological analysis was much delayed due to essential staff redeployment during the pandemic, but preliminary analysis of staff results has shown that latent positives are in different areas in the prison, and no obvious differences between those in prisoner-facing and non-prisoner-facing roles. With prisoners, there was no obvious area of risk in terms of current location, but more work needs to be done to look at historical risk.

It is inevitable that when an epidemiological analysis of numerous parameters is undertaken that some results will achieve statistical significance (suggesting they are less likely to have occurred by chance) but be of little clinical importance and vice versa, so that some will suggest a clinical importance but not reach statistical significance.

Hence a history of having had TB will be expected to be significantly associated with LTBI (as conversion to being LTBI positive or having had TB means LTBI tests usually remain positive for life). In addition, previous residence in Birmingham, which is known to have much higher rates of TB than Wales, might expect to mean that a prisoner is more likely to have a positive LTBI test.

However, in terms of trying to identify HMP Parc risks associated with a positive LTBI test, the analysis was less helpful. Because prisoners move around the prison, it was hard to identify a single location associated with positivity. There were no self-reported social risk factors associated either.

With regard to staff, a younger age and working in HMP Parc for less than a year was more likely to be associated with a positive test. It is tempting to speculate that lack of BCG vaccination might increase risk, but neither of these reached statistical significance, meaning the association may have

occurred purely by chance. Mask-wearing (particularly by the individual who has TB) is known to reduce the transmission of TB, so it is perhaps not surprising that this is associated with less risk of LTBI, but the evidence here is weak and doesn't reach statistical significance, possibly due to small numbers.

In addition, the epidemiological evidence was not as robust for staff as expected because the screening of the 75 officers identified as being at higher risk of exposure in the first round of screening in January 2020 by G4S used an initial prototype questionnaire. The second screening event used an improved questionnaire format which improved data collection and analysis but meant that the data collected in the two mass screening events were not directly comparable. A third of those screened in January also participated in the March event so also completed the March questionnaire, but as these individuals had a mix of positive, negative and borderline results, there was insufficient collated data to compare the January staff cohort directly with the March staff cohort.

As the staff screened in January had an unexpectedly high prevalence of LTBI infection (20%), sub-analysis of their questionnaires as a separate cohort to compare to the other staff screened would have been useful. Unfortunately, there's not much published literature to act as a direct comparison group, but even within this outbreak, the prevalence in this January group is much higher than screened staff overall (6.5%) and even the prisoners (11%). Currently, questions still remain about why this is so. Was it due to the bed-watches undertaken on case 4 (who was smear negative) or exposure to case 5 (smear positive)? Is it unrelated to the events of 2020, but related to the hypothesised mass exposure event in 2018/19? Or is their infection unrelated to the current outbreak but related to past events or exposures?

Unfortunately, because WGS can't be performed on LTBI infection, it is not possible to have the evidence to conclude which of these hypotheses is the most likely explanation. In addition, the January screening dataset from the prototype questionnaire is of a different format and not sufficiently completed to allow analysis of associated characteristics by comparing these as a subset to the whole staff screening. Had this been possible, it would have helped identify potential increased risks in the January cohort (for example younger age overall, previous history of TB exposure) or helped generate more evidence for hypotheses for the source of their LTBI.

Finally, although there are 12 cases meeting the outbreak definition, the OCT has not been able to acquire much data on the more recent cases within prisons in England. Partly this is because of the impact of COVID, but also may relate to the types of offenses committed, whereby cases are understandably reluctant to divulge contacts and information. Review of these cases may yield further information.

The wider cluster

The investigations so far suggest that the HMP Parc outbreak is part of a wider evolving complex community and justice system cluster involving individuals with a high risk of present or future incarceration, many who are likely to be linked by social and potential criminal risk factors. This report has summarised the investigation and screening undertaken in relation to cases directly linked to HMP Parc from 2018 onwards, which excludes the wider investigation of the other cases in the WGS-linked cluster. It is likely that proactive further epidemiological investigation and management of this cluster is needed to interrupt on-going TB transmission in this high-risk population.

11 Conclusions

1. In total 12 cases of confirmed active TB disease met the outbreak case definition.

2. All active TB disease cases were in prisoners or ex-prisoners, there were no cases of active TB disease in staff.

3. These 12 cases were linked to a larger community cluster of 28 cases identified by WGS of being within 12 SNP of the index case, many of whom had never been incarcerated in HMP Parc or had any known contact with the outbreak cases. Further work is needed on the epidemiology of this cluster, however, many non-outbreak cases in this cluster were linked by having the same social/offending risk factors for TB as some outbreak cases.

4. Repeat incarceration may be a feature of the 12 outbreak cases, four have subsequently been incarcerated in prisons in England.

5. The mechanism for acquiring TB was unexplained for most outbreak cases, there were no obvious common links in time and place within the prison environment for the majority of the cases. In only a few outbreak cases (from the analysis of those who were in HMP Parc at time of diagnosis, the information wasn't available for those in other prisons at time of diagnosis) did the OCT conclude that within-prison transmission was the only or most likely plausible explanation.

6. However, the OCT put forward hypotheses for how much of this transmission may have occurred, including the possibility of a mass prisoner-only transmission event in 2018/early 2019. Further investigation would be required to support/refute this hypothesis.

7. The initial screening of the 75 escort and bed-watch officers cuffed to the potentially infectious (smear negative/culture positive) index case in hospital (or identified as a potential close contact of an infectious case) found a positivity rate for LTBI of 20%, but no cases of active TB disease. It was this finding that triggered the whole prison mass screening consistent with the "stone-in-the-pond" approach to TB screening.

8. It is not possible to determine with any certainty whether these positive latent TB infection results were due to exposure to any of the cases of infectious pulmonary TB in this outbreak or due to other exposures at another point in the individual's lifetime. It is not known if this positivity rate is :
    - a reflection of the wider prisoner-facing activities of this group of officers,
    - a chance unrelated finding due to other exposures,
    - related to the hypothesis of an unknown prior mass transmission event
    - specifically due to this within-prison exposure
    - or a mixture of these hypotheses

9. The screening questionnaire used for this January group was the preliminary prototype questionnaire and the data obtained were incomplete and not sufficiently robust for detailed analysis. Less than a third of this group also completed the subsequent mass screening questionnaire so no analysis was possible on these individuals as a separate group.

10. However, it has previously been concluded in another prison TB outbreak in Wales[11] that any prison staff guarding a patient with pulmonary TB inside the cubicle are at risk of TB exposure equal to or greater than household contacts. This is a much greater risk of

[11] Cardiff Prison TB outbreak OCT report 2020

transmission than the risk to hospital healthcare staff looking after the same patient.

11. The mass screening carried out in March 2019 by the mobile Find and Treat service in collaboration with the CTMHB demonstrated the effectiveness of such an approach to mass screening in TB outbreaks within prisons.

12. One case of early active pulmonary TB was detected in a prisoner on mass screening, this had a different WGS from the outbreak cluster so was a serendipitous finding, but demonstrates the significant risk of TB in prisoners. Finding this case early may have prevented subsequent transmission within the prison setting.

13. The analysis of the mass prison screenings (which included the results from the initial bed-watch officer screening) found a final positivity rate for LTBI amongst prison staff of 6.5%. No association between specific occupational groups was found to be statistically associated with having a higher LTBI prevalence. The highest prevalence (as proportions) were found in people who worked in education (8/89 9%) and prison guards (24/271, 8.9%). All had negative results for active TB disease.

14. Whilst the statistical evidence from this survey is weak, wearing a mask when in contact with a known case of TB may reduce the likelihood of transmission in a prison setting. Likewise, ensuring an individual who has tested positive for TB (or who is suspected to have TB) wears a mask, may reduce the likelihood of transmission.

15. The prevalence of LTBI amongst screened prisoners was 11%. No single lifestyle characteristic was significantly linked to LTBI. Due to the potential long-term, asymptomatic presentation of LTBI, it is not possible to determine whether the ongoing outbreak at HMP Parc significantly contributed to an increased prevalence of LTBI circulation amongst inmates at the prison. A statistically significant association was identified between LTBI positivity and previous residence in Birmingham.

16. Evidence for a statistically significant association between three blocks of residence and LTBI positivity was identified in this analysis; blocks A, D and T. However, prisoners may move around multiple

blocks during their residence for different reasons, so these findings are only reflective of those prisoners who were in the blocks at the time of screening.

17. There is evidence of an increased prevalence of LTBI in individuals employed by the prison who are under 29 years of age (PR = 2.94, CI: 1.06 – 8.14, p = 0.04). It is possible that this may be associated with a smaller proportion of this age group receiving a BCG vaccination.

18. It is noted that the COVID pandemic had a major impact on the timeliness of investigations and follow up of screened cases in this outbreak, however the majority of follow up and treatment initiation is now completed.

12 Recommendations

1. **HMPPS** should advise the justice system that any prisoner identified in a prison in England or Wales who was previously incarcerated in HMP Parch between January 2018-March 2020 and not screened for TB since should have their notes flagged as a potential TB risk/be screened for TB, and if LTBI positive, supervised treatment is advised during incarceration.

2. **Prisons and NHS healthcare providers** should ensure that any prisoner transferred to acute care for assessment with a cough or respiratory symptoms should wear a mask whilst cuffed until TB or other serious respiratory infections are ruled out. Prison officers cuffed to or remaining in the same room as the prisoner should also wear masks*. * Mask type should be as specified by the hospital Infection Prevention and Control Policy, but the default mask in the community would be a surgical mask.

3. **HMPPS** should review their current template risk assessment procedures so that in future, officers are not routinely cuffed to or remain in the same room/cubicle as prisoners with potentially infectious respiratory symptoms (cough, coughing up blood etc.) and should consider reducing shift duration until TB or other serious infectious respiratory conditions are ruled out. If the revised Prison Officer risk assessment is that they have to remain inside the cubicle (for example, for public safety reasons), Infection Control or other suitable staff must offer urgent fit testing (if needed) and appropriate masks for protection to these prison officers.

4. **HMPPS or private prison providers** should consider BCG for frontline prison staff in line with national immunisation guidance. [12]

5. **Health boards** should consider providing X-ray services and/or other solutions within prisons to support active case finding of TB, as recommended by NICE guidance. Use of IGRA tests on admission, as part of blood-borne virus screening, as per NICE guidance, would significantly improve detection.[13]

6. **Prison healthcare** should carry out a repeat symptom check for TB symptoms several weeks after admission, to see if common symptoms on admission initially thought not to be TB persist.

7. **Health boards** should amend their TB policies and operational infection control advice to include:

    - Telling prison escort staff promptly on admission if TB is suspected so they can reassess the risk of cuffing and recording this conversation in the hospital notes

    - An explicit statement that any prison staff guarding a patient with pulmonary TB inside the cubicle are at risk of TB exposure equal to or greater than household contacts. This is a much greater risk of transmission than healthcare staff

    - Medical and nursing staff caring for such prisoners must explicitly warn prison officers of the serious risk for TB exposure as outlined above and record this conversation in the patient's notes. Any HMPPS staff informed of this risk should inform escort staff and it should be recorded on the Bed-Watch Log Handover.

    - If the revised Prison Officer risk assessment is that they have to remain inside the cubicle (for example, for public safety reasons), Infection Control or other suitable staff must offer urgent fit testing (if needed) and appropriate masks for protection to these prison officers.

[12] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/731848/Greenbook_chapter_32_Tuberculosis_.pdf Chapter 32 page 7 accessed 28/07/2021 says:
"There are a number of occupational groups who are working with persons at higher risk of acquiring TB. These include staff working with prisoners, homeless persons, persons with drug and alcohol misuse and those who work with refugees and asylum seekers. BCG vaccination may also be considered for these groups."
[13] https://www.nice.org.uk/guidance/ng33/chapter/Recommendations#preventing-tb

8. **PHW CDSC and Health Protection** should follow up on the outbreak cases identified by WGS post screening and consider undertaking in-depth interviewing to obtain information to inform case-finding and future management of the wider cluster.

9. **PHW CDSC and Health Protection** should collaborate with appropriate colleagues in Public Health England (PHE) to undertake detailed investigation into the wider cluster to identify if any control measures or preventative measures are feasible for case-finding or to prevent on-going transmission.

10. **PHW CDSC and Health Protection** should note:
    - When undertaking epidemiological analysis in the future, including information on specific sites and activities within the prison estate (such as classes, gym use etc.) could provide more nuanced understandings of potential sites of transmission for infections such as TB.

    - It is helpful to have both analytical and epidemiological support present from an early stage in the IMT/OCT process so analysts can be involved in the early design of a data collection tool and both can advise on the best way to gather information to ensure efficient data collection and analysis.

Questionnaires

Appendix I: Staff questionnaire

Staff screening questionnaire (priso

Appendix II: Prisoner questionnaire

Prisoner screening questionnaire v3.pd

Evaluation of the outbreak

Outbreak aspect	Element evaluated	Assessment/Evidence of element for current outbreak
Cause of the outbreak	Timeliness	TB exposure and seeding occurred months to several years before the identification of the outbreak. The initial two cases detected in HMP Parc were of no or minimal infectivity so were not responsible for subsequent cases. Earlier availability of routine WGS would have identified these two cases were linked and prompted further investigation, but was not available until late 2019.
	Effectiveness	Despite extensive epidemiological investigation, the source of this outbreak was not able to be identified- therefore action to control the original source or learning from this was not possible.
	Cost	Costs not identified
	Lost opportunities	Routine chest X-ray/IGRA screening of prisoners on admission may have picked up the outbreak index case (case 4) and potentially the infectious case in December 2019 and is likely to have prevented the need for mass screening
	Policies	Infection control and risk assessment policies/procedures don't usually identify that some visitors such as prison officers at very high risk of exposure to TB – greater than healthcare workers if cuffed on bedwatch inside the cubicle. Current questionnaire symptom screening for TB on admission to prison appears poor at identifying infection. Use of IGRA tests on admission, as part of BBV screening, as per NICE guidance would significantly improve detection.[14]
Surveillance and detection	Timeliness	Notification of cases worked well and was prompt, however, past or present incarceration is a common risk factor in TB cases. It was WGS that enabled the first two cases detected within Parc to be linked, apart from incarceration, there were no other common links between them inside the prison. Due to the COVID-19 pandemic response, the resource for detailed public health surveillance into community risks associated with this outbreak was unable to be undertaken.

[14] https://www.nice.org.uk/guidance/ng33/chapter/Recommendations#preventing-tb

	Effectiveness	Routine reporting of WGS enabled much faster and easier linking of cases to detect the outbreak earlier than might have occurred without this.
	Cost	Costs not identified
	Lost opportunities	Routine IGRA screening or CXR on admission to prison is not currently in place. These tests are likely to have significantly improved detection and prevented the need for mass screening.
	Policies	Use of IGRA tests on admission, as part of BBV screening, as per NICE guidance would significantly improve detection.[15] Use of IGRA testing within community substance misuse services, as per NICE guidance, is likely to have detected some cases before admission to prison.
Preparedness	Timeliness	Mass screening on both occasions needed a long lead-in time to prepare- there was no capacity or resource in the system to quickly undertake any mass TB screening rapidly
	Effectiveness	National TB guidance for prisons does not contain enough detail of the occupational risks to prison officers in hospital bedwatch situations
	Cost	Costs not identified
	Lost opportunities	Had to use find and treat bus as no capacity in Wales to deliver this mass screening. If Find and Treat not available in that timescale, screening could not be undertaken.
	Policies	HMPPS and HB policies no awareness of the risks to prison officers of duration and closeness of exposure to TB whilst cuffed to patient.
Management and control of the outbreak	Timeliness	The outbreak was complex and lengthy with further cases presenting a year after mass screening. Despite this, and the impact of the COVID-19 pandemic, the outbreak was managed in a timely fashion.
	Effectiveness	Multiagency collaboration worked well. The mass screening and follow-up has so far been effective in preventing further TB cases in the prison. However, cases with the same WGS sequence have subsequently been detected in other prisons and if the wider cluster isn't investigated, there is the potential for further seeding of TB cases into the prison population.

[15] https://www.nice.org.uk/guidance/ng33/chapter/Recommendations#preventing-tb

	Cost	For HMP Parc alone, costs estimated in excess of £20,240 for screening CTMUHB collating costs for mass screening in March 2020
	Lost opportunities	Implementation of the same standard screening questionnaire for both mass screenings would have allowed valuable data on exposures and risks to be collected. However, the screening questionnaire had to be developed, so a prototype was tested on the January group, which was then improved on for the subsequent mass screening in March. Even if immediate re-administration of the subsequent questionnaire had been possible to the January screened cohort (COVID prevented any immediate review), the data obtained would be potentially less reliable once the screening result was known. Questionnaire data from the IGRA positive individuals in January have been re-examined but are not incomplete and not comparable to the March questionnaire data. A standard dataset would have potentially given some insight as to why the first group screened had 20% positivity for LTBI compared to the overall groups of staff.
	Policies	The Communicable Disease Outbreak Plan for Wales worked well in this outbreak.