Journal of Community Health (2023) 48:600–605
https://doi.org/10.1007/s10900-023-01201-z

ORIGINAL PAPER

# Latent Tuberculosis Infection Diagnosis Using QuantiFERON-TB Gold Plus Kit Among Correctional Workers: A Cross-Sectional Study in Francisco Beltrão-PR, Brazil

**Maico Trevisol[1] · Thiago Poss Moreira[2] · Gustavo Henrique Baraca Sanvezzo[2] · Sthefanny Josephine Klein Ottoni Guedes[3] · Danilo Rodrigues Pereira da Silva[4] · Guilherme Welter Wendt[5] · Harnoldo Colares Coelho[6] · Lirane Elize Defante Ferreto[5]**

Accepted: 2 February 2023 / Published online: 16 February 2023
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## Abstract

Correctional workers form a high-priority group for tuberculosis control measures because of their high exposure and risk. This cross-sectional study conducted in April and May 2022 included 71 criminal police officers from the State Penitentiary of Francisco Beltrão-PR, Brazil. Their sociodemographic and laboratory data were collected. Latent tuberculosis infection (LTBI) was assessed using a QuantiFERON-TB Gold Plus in-tube test kit. Binary logistic regression was applied to calculate the odds ratios (ORs) and 95% confidence intervals (CI) of the LTBI predictors. The prevalence of LTBI was 22.6% (95% CI, 12.8–32.2%). Factors associated with LTBI were age > 43 years (OR, 0.18; 95% CI, 0.04–0.70; $p < 0.014$) and the use of medications (OR, 5.13; 95% CI, 1.40–18.87; $p < 0.014$). The prevalence was close to that estimated worldwide for LTBI in correctional workers, reinforcing the need for occupational health control measures consisting of regular screening and treatment of positive cases of latent infection among correctional workers to reduce the risk of illness and spread of infection in the penitentiary system and community.

**Keywords** Prison · *Mycobacterium tuberculosis* · Occupational health · Latent tuberculosis

## Introduction

Tuberculosis (TB) has historically been associated with poverty, malnutrition, overcrowding, immunosuppression, and insufficient access to health care [1]. TB is among the leading causes of morbidity and mortality from a single infectious agent worldwide, ranking above human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome [2, 3]. It is estimated that in 2021, 10.6 million people (95% confidence interval [CI], 9.9–11 million) became ill with TB, a 4.5% increase compared to 2020, and the burden of drug-resistant TB has increased during this period [3], generating economic losses for patients, their families, and the country due to the reduction of the national productive force [4].

Considering the Brazilian commitment to eliminate TB by 2035 [3], it is essential to identify and treat cases of latent TB infection (LTBI) in occupational environments and workplaces that present a greater risk to occupational health [5, 6], such as correctional facilities. These environments

✉ Lirane Elize Defante Ferreto
lferreto@gmail.com

1 Health Sciences Center, Postgraduate Program in Applied Health Sciences, Western Paraná State University (UNIOESTE), Francisco Beltrão, Brazil

2 Health Sciences Center, Faculty of Medicine, Public Health Lab and Biosciences and Health Lab, Western Paraná State University (UNIOESTE), Francisco Beltrão, Brazil

3 Faculty of Medicine, Western Paraná State University (UNIOESTE), Cascavel, Brazil

4 Faculty of Health Sciences, Universidad Autónoma de Chile, Providencia, Chile

5 Health Sciences Center, Postgraduate Program in Applied Health Sciences, Public Health Lab and Biosciences and Health Lab, Western Paraná State University (UNIOESTE), Francisco Beltrão, Brazil

6 Department of Pharmacy, University of São Paulo, Ribeirão Preto, Brazil

are responsible for an increase of approximately 5% per year in cases of latent infection among inmates and may be responsible for the transmission of *Mycobacterium tuberculosis* to the community [2, 7, 8] as well as to correctional workers [9–12].

Globally, high rates of TB are frequently observed among incarcerated people [13–17]. In Brazil, the incidence of TB in prisons is approximately 20 times higher than in the general population, with the prevalence of active and latent TB among incarcerated persons is estimated at 2–9% and 40–73%, respectively [18].

The work activity of prison officers in correctional facilities, where they have close and prolonged contact with detainees, exposes them to *M. tuberculosis* and makes them possible facilitators of the spread of TB in the community [8]. Many studies of LTBI in prisoners have been conducted in Brazil [18, 19] versus few in correctional workers [10–12]; such studies are also scarce internationally [2, 9, 20, 21].

Despite the high prevalence of LTBI among inmates and evidence of continued transmission within prisons [22], correctional workers are not routinely screened. To move toward TB elimination, it is imperative to focus on high-risk populations as well as populations with direct contact. Thus, this investigation aimed to estimate the prevalence of and factors associated with LTBI among correctional workers in Paraná.

## Methods

This cross-sectional prospective study performed in April and May 2022 included correctional workers at the State Penitentiary of Francisco Beltrão-PR. The reported 29.1% prevalence of LTBI in correctional unit workers was used as reference [11]. The sample size was calculated in Epi Info [23], using a population of 104 professionals, with an expected prevalence of 29.1%, variation of 1%, power of 80%, and alpha of 5%. An extra 10% of professionals were included to account for anticipated loss due to refusal to participate, resulting in a final sample of 85 employees. Only workers in direct contact with inmates participated in the study. Workers with at least 1 year of experience of either sex or any age and on a work schedule were included, and a sample of biological material was obtained from each. Workers on leave or with a medical certificate, who had returned to the sector for less than 1 year, who were pregnant, or who were previously diagnosed with or treated for TB were excluded.

The participants were informed about the purpose and stages of the research, after which they signed an informed consent form and answered a self-administered questionnaire that contained questions about personal characteristic data, work information, and TB. Subsequently, 4 mL of blood was collected from each participant. All samples were sent to Hermes Pardini Laboratory, processed with a QuantiFERON-TB Gold Plus in-tube test kit (lot no. 56,907,193; expiration date, 02/03/2024; Qiagen, Hilde, Germany), using enzyme-linked immunosorbent assay. The results were interpreted according to the manufacturer's instructions. The cut-off value for a positive test was 0.35 UI/mL of interferon-γ in the plasma after stimulation regardless of the nitrogen control result. The test result was considered indeterminate if an antigen-stimulated sample tested negative and the positive control value was < 0.5 IU/mL after subtraction of the negative control value.

All correctional workers were informed through an orientation letter about the results and mechanism of the disease. For those with a positive Interferon Gamma Release Assay (IGRA) result, an appointment was scheduled with a pulmonologist, and a chest computed tomography scan was performed. A rapid test for HIV due to its correlation with TB, an HIV1/2/O Tri-line test (Hangzhou Economic & Technological Development Area, Hangzhou, 310,018, P.R. China), and other complementary tests were also performed to confirm the diagnosis. The medical professional established the conduct based on the Ministry of Health protocols for LTBI [24], and a return visit was scheduled for all positive cases for a 6-month new evaluation.

After collection, the data were tabulated in Excel software and analyzed in the SPSS program (version 25.0; IBM, Arlington, NY, USA). First, the database was inspected for typographical errors and edge cases. Descriptive statistical analyses were performed, including mean, standard deviation, range, frequency (%) and CI. Fisher's exact test and Pearson's chi-squared test were used to identify bivariate associations. The independent variables that presented values of $p < 0.20$ in that stage were entered into the logistic regression models. Finally, the independent variables that presented values of $p < 0.05$ after the adjustment for the other variables remained in the final multivariable model. The variables were manually inserted to define the final model.

The study complied with the ethical precepts of research involving human beings as established by Resolution 466/2012 of the National Health Council and was approved by the Research Ethics Committee of the University of Western Paraná (opinion no. 5.346.101).

## Results

Of the calculated sample of 85 workers from correctional units, 71 agreed to participate, with losses and refusals comprising 16.47% (n = 14). Among the 71 correctional workers, the mean age was 42.91 ± 6.07 years (range, 30–59 years). The average income was R$11,591.50 ± 5,558.98 (range, R$2,000.00–24,000.00). Of the interviewees, the average time in the profession was 8.57 ± 3.01 years (range, 1–14 years), while the average working time in the investigated penitentiary was 6.77 ± 2.73 years (range, 1–10 years). Of the interviewees, nine (12.7%) claimed to have arterial hypertension, six (8.5%) had dyslipidemia, five (7%) had hyperthyroidism, four (5.6%) had viral hepatitis B or C, and one each (1.4%) had diabetes mellitus and osteoporosis.

The criminal police work schedules are 24 × 48 and 12 × 60 h, with 3% working at 24 × 48 and 24 × 72 h. The mean body mass index of male correctional workers was 28.35 ± 3.60 (range, 21.38–38.51), while that of female correctional workers was 26.44 ± 4.98 (range, 21.05–34.63). Officers of both sexes had high percentages of overweight and obesity (84.1% of men, 50% of women); that is, 80% (95% CI, 71.0–89.5%) of the participants were overweight or obese (n = 57).

Regarding LTBI, the highest frequency of criminal police officers were ≤ 43 years of age, were White, had > 9 years of schooling, were married or had a stable partner, were overweight or obese, had been immunized for hepatitis B, had > 9 years' experience working in a penitentiary unit, had a history of transfer from correctional units, and had serological scarring for Bacillus Calmette-Guérin. All workers with a positive LTBI result had contact with inmates with symptoms of active TB, but the results were not statistically significant *(*Table 1*)*.

The prevalence of LTBI in the study population was 22.6% (95% CI, 12.8–32.2%). We did not observe any indeterminate QuantiFERON-TB Gold Plus in-tube test kit results among the correctional workers in our study.

Table 2 presents the crude and adjusted binary logistic regression models after the bivariate analyses. Of all variables considered in the model, only two remained significant and were independently associated with LTBI. We observed that age > 43 years decreased the risk of a positive LTBI test result by 82%, while medication use increased the likelihood of LTBI by 413%.

## Discussion

There are few studies of correctional workers diagnosed with latent *M. tuberculosis* infection using the IGRA test with an interferon-γ release assay [25], and most have used the tuberculin skin prick test [2, 9–11, 20, 21, 26, 27].

The prevalence identified in our study (22.6%) was close to that calculated in a systematic review of 110,192 correctional workers from five countries in 1986–2015 of 26% (95% CI, 12–42%) [2], lower than that of the Brazilian study in 12 prison units in the municipality of Franco da Rocha, SP of 33.7% (95% CI, 30.8–36.5%) [11] and the estimated prevalence in Colombia of 39.1% in two prisons and 55.8% in one prison [27]. These estimates are worrisome, as the disease can reactivate at any time in approximately 5% of people infected with *M. tuberculosis*, although this is usually within the first 5 years after infection or by being exposed to new sources of infection [28, 29]. It is estimated that, in the prison population, the working environment of the correctional worker, the incidence is up to 28 times higher [2, 30] than in the general population [2, 19, 30] and responsible for the increase of 8.5% and 6.3% of all TB cases in community settings in high-income countries, respectively [9]. Given this risk, the latency of the bacillus is a main challenge preventing TB eradication and prevention, especially in high-risk groups [31].

Other studies presented contradictory findings that describe older age as a factor associated with LTBI [2], which we identified as a protective factor. We identified that the correctional workers in our study were younger and had a history of transferring between correctional units in the previous year, which corroborates the plausibility of the nature of occupational transmission [5, 6], especially in Brazil, a country with a high TB burden whose environment prison environment is favorable for increasing the prevalence of LTBI among inmates [9, 10, 12, 19, 20, 26].

Correctional workers who use medication are more likely to have a positive LTBI result; among them, most worked long hours in an environment with unhealthy conditions, stress, and work overload, demonstrating the extent to which the work environment influences health [32] and makes them more susceptible to contracting TB [33].

The limitations of this study are the fact that it was cross-sectional and the data collection of exposure and outcomes occurred simultaneously, making it difficult to understand the temporal relationship between them. The small number of national and international studies using the same diagnostic method with the same target population limits the comparability of our findings with those of other studies.

The prevalence observed in the present study was close to that estimated worldwide for LTBI among correctional workers, reinforcing the need for occupational health

**Table 1** Sociodemographic characteristics of the sample (n = 71)

| | Non-Reagent (n = 55) | | Reagent (n = 16) | | |
|---|---|---|---|---|---|
| Variables | n | % | n | % | p value |
| **Sex** | | | | | 0.673 |
| Female | 7 | 12.7 | 1 | 6.2 | |
| Male | 48 | 87.3 | 15 | 93.8 | |
| **Age** | | | | | 0.054 |
| Up to 43 years old | 24 | 43.6 | 12 | 75.0 | |
| Over 43 years old | 31 | 56.4 | 4 | 25.0 | |
| **Skin color** | | | | | 0.434 |
| White | 42 | 76.4 | 10 | 62.5 | |
| Others | 13 | 23.6 | 6 | 37.5 | |
| **Education** | | | | | 0.309 |
| Up to 9 years | 6 | 10.9 | 4 | 25.0 | |
| More than 9 years | 49 | 89.1 | 12 | 75.0 | |
| **Marital status** | | | | | 0.309 |
| Married | 49 | 89.1 | 12 | 75.0 | |
| Others | 6 | 10.9 | 4 | 25.0 | |
| **Income** | | | | | 0.064 |
| Up to R$ 11.000.00 | 37 | 67.3 | 6 | 37.5 | |
| Over R$ 11.000.00 | 18 | 32.7 | 10 | 62.5 | |
| **Time working in a correctional institution** | | | | | 0.360 |
| Up to 9 years | 30 | 54.5 | 6 | 37.5 | |
| Over 9 years | 25 | 45.5 | 10 | 62.5 | |
| **Transfer from correctional facility in the last year** | | | | | **0.015** |
| No | 52 | 94.5 | 11 | 68.8 | |
| Yes | 3 | 5.5 | 5 | 31.3 | |
| **Sexual relationship with a steady partner** | | | | | 0.067 |
| No | 3 | 5.5 | 4 | 25.0 | |
| Yes | 52 | 94.5 | 12 | 75.0 | |
| **Number of sexual partners in the last year** | | | | | 0.127 |
| 1 partner | 51 | 92.7 | 12 | 75.0 | |
| More than 1 partner | 4 | 5.0 | 4 | 25.0 | |
| **Condom use** | | | | | 1.000 |
| No | 52 | 94.5 | 15 | 93.8 | |
| Yes | 3 | 5.5 | 1 | 6.3 | |
| **Alcohol consumption** | | | | | 1.000 |
| No | 27 | 49.1 | 8 | 50.0 | |
| Yes | 28 | 50.9 | 8 | 50.0 | |
| **Scar from the BCG vaccine** | | | | | 1.000 |
| No | 9 | 16.4 | 3 | 18.8 | |
| Yes | 46 | 83.6 | 13 | 81.2 | |
| **Hepatitis B immunization** | | | | | 0.452 |
| No | 14 | 25.5 | 2 | 12.5 | |
| Yes | 41 | 74.5 | 14 | 87.5 | |
| **Body Mass Index (BMI)kg/m$^2$** | | | | | 1.000 |
| Up to 24.9 | 11 | 20.0 | 3 | 18.8 | |
| Over 25 | 44 | 80.0 | 13 | 81.3 | |
| **Hypertension** | | | | | 0.687 |
| No | 49 | 89.1 | 13 | 81.3 | |
| Yes | 6 | 10.9 | 3 | 18.8 | |
| **Medication Consumption** | | | | | 0.063 |
| No | 40 | 72.7 | 7 | 43.8 | |
| Yes | 15 | 27.3 | 9 | 56.3 | |
| **Knows someone with tuberculosis** | | | | | 0.103 |
| No | 34 | 61.8 | 14 | 87.5 | |
| Yes | 21 | 38.2 | 2 | 12.5 | |

**Table 2** Crude and adjusted models of factors associated with the presence of Latent Tuberculosis Infection

| Associated factors | ORcrude[a] (95% CI[b]) | p value | ORadjusted[c] (95% CI) | p value |
|---|---|---|---|---|
| **Age** | | | | |
| Up to 43 years old | 1 | 0.034 | 1 | **0.014** |
| Over 43 years old | 0.26 (0.07–0.90) | | 0.18 (0.04–0.70) | |
| **Income** | | | | |
| Up to R$ 11.000.00 | 1 | 0.037 | --- | |
| Over R$ 11.000.00 | 3.43 (1.08–10.91) | | --- | |
| **Correctional facility work history** | | | | |
| No | 1 | 0.010 | --- | |
| Yes | 7.88 (1.64–38.0) | | --- | |
| **Sexual relationship with steady partner** | | | | |
| No | 1 | 0.034 | --- | |
| Yes | 0.17 (0.03–0.88) | | --- | |
| **Number of sexual partners in the last year** | | | | |
| 1 partner | 1 | 0.062 | --- | |
| More than 1 partner | 4.25 (0.93–19.47) | | --- | |
| **Medication consumption** | | | | |
| No | 1 | 0.036 | 1 | **0.014** |
| Yes | 3.43 (1.08–10.85) | | 5.13 (1.40–18.87) | |
| **Knows someone with tuberculosis** | | | | |
| No | 1 | 0.069 | --- | |
| Yes | 0.23 (0.04–1.12) | | --- | |

[a] ORcrude: Crude odds ratio

[b] 95% CI: 95% confidence interval

[c] ORadjusted: Adjusted odds ratio

control measures with regular screening and treatment of positive cases of LTBI among them [2, 6, 27] to reduce the risk of illness and the spread of TB in the penitentiary system and community.

**Acknowledgements** To the Araucária Foundation of the State of Paraná (ARAUCÁRIA) for the financial assistance (Term of Agreement nº 289/2022).

**Author Contribution** All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Maico Trevisol, Thiago Poss Moreira, Gustavo Henrique Baraca Sanvezzo and Lirane Elize Defante Ferreto. The first draft of the manuscript was written by Maico Trevisol and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

**Data Availability** The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Conflict of Interest** The authors have no competing interests to declare that are relevant to the content of this article.

**Ethical Approval** The study was approved by the Institutional Review Board at the Western Paraná State University [opinion number. 5.346.101]. All participants provided their informed consent to participate in the study.

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