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Prevalence of Latent Tuberculosis Infection [LTBI] in Prison Officers: A Systematic Review and Meta-Analysis

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Abstract

This study aimed to perform a systematic review and meta-analysis to determine the LTBI prevalence in prison officers worldwide. A systematic search was performed in PubMed, WoS, Embase, and BVS, including all articles related to LTBI prevalence and risk factors. After critical evaluation and qualitative synthesis of the identified articles, a meta-analysis was used. Five studies carried out between 2012 and 2022 were included, with a total sample size of 1718 prison officers. The overall LTBI prevalence was 50% [95% confidence interval [CI]: 48% - 52%; n = 816], with high heterogeneity between studies. Smoking [OR = 1.76; CI 95% = 1.26 - 2.46] and males [OR = 2.08; CI 95% = 1.31 - 3.31] were positively related to a higher LTBI prevalence among prison officers. Thus, preventive measures and the rapid and accurate diagnosis of new cases should be emphasized to ensure tuberculosis control, especially among risk groups such as prison officers.

Keywords

Latent Tuberculosis, *Mycobacterium tuberculosis*, Meta-Analysis, Prevalence, Occupational Exposure

1. Introduction

Tuberculosis is one of the main infectious diseases in the world and represents a

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challenge for public health, especially in countries with low social conditions [1]. The emergence of resistant strains and the close relationship between infections and housing conditions and access to health services are among the main limitations to its control [1]. In recent years, the Covid-19 pandemic represented an additional difficulty in accessing diagnosis and treatment [2].

The latent form of the disease represents a major obstacle to controlling the infection in populations around the globe [1] [2] [3] [4]. In general, there is a high prevalence in low- and middle-income countries and populations living in crowded places with poor air circulation [3]. Prison populations represent a more susceptible group than the common population [4] because of the sanitary conditions of prisons, associated with overcrowding and poor ventilation of the spaces where prisoners live, making prisons reservoirs of *Mycobacterium tuberculosis* [1]. Consequently, the general health conditions in prisons are problematic around the world due to various factors as cited previously [*i.e.*, crowded and poorly ventilated spaces, nutritional problems, drug usage, and inadequate access to medical care] [3].

In summary, tuberculosis still poses a serious public health issue affecting many regions, particularly low- and middle-income countries; this is due to the fact that the incidence of tuberculosis is reducing very slowly over the years, coupled with the fact that its control is confronted by drug-resistant forms of the disease [1]. Additionally, professionals who deal with incarcerated prisoners are frankly exposed to the risk of infection, as they share the same environmental conditions with inmates. Therefore, knowing the incidence of latent TB in these professionals and the associated factors are necessary to guarantee the managers of the prison and health systems subsidies for diagnosis, prevention, and treatment actions. This study aimed to perform a systematic review and meta-analysis to determine the LTBI prevalence in prison officers worldwide.

2. Methodology

The systematic review and meta-analysis were reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses [PRISMA] [5] and registered on the PROSPERO platform [CRD42023382167].

The Population, Intervention, Comparison, and Outcomes [PICO] model was adopted to help formulate the research problem [5]. The population [P] was defined as "prison officers," intervention [I] as "positive result for latent tuberculosis infection," comparison [C] as "negative results of tests for latent tuberculosis infection," and outcomes [O] as "prevalence and factors associated with latent tuberculosis in prison officers." Thus, the research question was determined as: What are the prevalence and factors associated with latent tuberculosis infection in prison officers?

Eligibility criteria

Table 1 shows the inclusion and exclusion criteria that were applied to all studies. Thus, only studies that fit the criteria could be elected for this systematic review. All languages were accepted.

Table 1. Characteristics and information on prevalence studies of latent tuberculosis and associated factors in correctional officers.

Author/Year	Country	Study Design	Age/Gender	Population	Diagnostic Test	Prevalence	Associated Factors
Filipek-Czerska *et al.* [7]	Poland	Cross-sectional	20 - 57 years [M ± SD = 36.4 ± 7.9 years] male and female	84	QuantiFERON-TB Gold in Tube [QFT-GIT]	16.6% [14/84]	Chronic diseases [p = 0.0014]; Length of employment in the prison [p = 0.0010]
Arroyave *et al.* [8]	Colombia	cohort	20 - 41 years; Masculino e feminino	155	Tuberculin Skin Test [TST]	48.4% [75/155]	Use of drugs at least once in life [PR: 1.75; 95% CI 1.42 - 2.15]; Gender male [PR: 2.16; IC 95% 1.01 - 4.62]
Nogueira *et al.* [9]	Brazil	Cross-sectional	18 - 60 or older; Male and female	945	Tuberculin Skin Test [TST]	37.6% [356/945]	Contact with inmate [OR = 2.12, 95% CI 1.21 - 3.71]; Male gender [OR = 1.97, 95% CI 1.19 - 3.27]; Between 30 and 39 years [OR = 2.98, 95% CI 1.34 - 6.63]; 40 to 49 years [OR = 4.32, 95% CI 1.94 - 9.60]; 50 to 59 years [OR = 3.98, 95% CI 1.68 - 9.43]; Non-white ethnicity [OR = 1.89, 95% CI 1.29 - 2.78]; Smoker [OR = 1.64, 95% CI 1.05 - 2.55]
Bussato *et al.* [2017] [12]	Brazil	Cross-sectional	18 - 50 or older; mean age of 38.6 years. Male and female	114	Tuberculin Skin Test [TST]	27.9% [12/43]	Tuberculin test positivity and region [OR = 6.6 [1.3 - 50.9]; p < 0.05]. Length of employment in the prison [15.3 vs. 4.1 years] [p = 0.01]
Al-Darraji *et al.* [11]	Malaysia	Cross-sectional	21 e 64 years [mea age of 30 years, IQR 26 - 42]; Male and female	420	Tuberculin Skin Test [TST]	81% [340/420]	Smoking [Adjusted OR [95% CI] - 1.94 [1.17 to 3.22]; p = 0.01] Length of employment in the prison [≥12 months] [Adjusted OR [95% CI] - 4.95 [1.54 to 15.93]; p = 0.007]

Research information and strategies

A search for studies in the format of scientific articles published in the last 10 years on the subject of latent tuberculosis infection, specifically among prison officers, was carried out. The digital search was performed in four databases [PubMed, WoS, BVS, and Embase]. Identification of studies in each database was performed using the combinations of terms: ["latent tuberculosis" OR "tuberculosis"] AND ["correctional officers" OR "prison staff" OR "prison employees"] AND ["prevalence" OR "risk factor"].

Searches were performed on November 8, 2022, in the PubMed, WoS, and BVS databases and on November 22, 2022, in the Embase database. We considered all observational studies that reported sufficient data to calculate LTBI prevalence, without language restriction, age, or gender. Case reports and series were excluded because they were unable to provide the denominator for calculating prevalence. References of included articles were examined as potential sources for additional studies, and duplicate studies were manually excluded. Titles and abstracts of the studies were evaluated by applying the inclusion and exclusion criteria. Subsequently, the selected studies were read in full, and the eligibility criteria were applied again.

Selection of studies

The studies accepted for evaluation were those involving investigations into the prevalence of latent tuberculosis infection in prison officers and, preferably, those that also evaluated the factors associated with the infection. All studies that met these characteristics and followed the inclusion and exclusion factors were considered.

Data collection

After selection, the articles were compiled in electronic spreadsheets [Microsoft Excel 365®] and duplicates were removed. The selection of articles based on title and abstract was carried out independently by two reviewers [T.P.M. and G.H.B.S.], with disagreements addressed through discussions with other researchers [L.S.O. and L.E.D.F.] to reach a consensus. Subsequently, the final inclusion of the articles was decided based on the full texts evaluated independently by the two authors. The following data were extracted from the included articles: author's name, year of publication, country [where the study was carried out], study design, age and gender, study population, type of tests used, prevalence, and associated factors. A consensus and/or evaluation by a third judge was sought in the comparison of the extracted results in case of divergence.

Risk of bias

The quality assessment tool "Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies," developed by the National Heart, Lung, and Blood Institute [6], was used. In this step, two independent researchers [T.P.M. and G.H.B.S.] evaluated the risk of bias. Fourteen points of possible bias were evaluated for each study, such as the clarity in exposing the objectives, the clear definition of the study population, the justification of the sample size, and the time window to observe the effect. In addition, we also evaluated whether the study participation rate within the populations was at least 50%, whether the participants were chosen from the same sample and the exclusion criteria applied equally to all, whether the exposure of interest was defined before obtaining the results, and whether the outcome measure was clearly defined and applied consistently for all study participants. From the evaluation, the articles were classified as good, regular, or bad, considering the details of each study and making a critical evaluation.

Effect measures

Prevalence data for all articles, odds ratio [OR], prevalence ratio [PR], corresponding confidence interval [95% CI], and significance levels [p-value] were collected. Subsequently, the data from the studies were standardized to carry out statistical analyses.

Synthesis methods and reporting bias

The software Stata 15 was used to perform the meta-analysis. The reporting bias test could not be performed due to the low number of articles included, and the use of these techniques is recommended for meta-analyses with ten studies or more, as recommended in the literature [7].

Assessing the certainty of the evidence

The GRADE [Grading of Recommendations, Assessment, Development, and

Evaluation] tool was used to assess the primary outcomes [framework methodology] [8]. The author [L.SO.] assessed the certainty of the evidence and another author reviewed it [L.E.D.F].

Data analysis

The software [STATA/SE 12.1, StataCorp, College Station, TX, USA] was used for data analysis. Random effects meta-analysis using the "metaprop" command was used to calculate pooled LTBI prevalence and 95% confidence interval [CI]. I^2 was calculated to assess effect size homogeneity across studies. According to the availability of data from the studies, we evaluated that the subgroups "smoking" and "males" could be formed for sensitivity analysis. Subgroups were used to assess differences in the prevalence of latent tuberculosis.

3. Results

Selection of studies

The search strategy in the databases and the gray literature search resulted in a total of 414 studies. Five studies [9] [10] [11] [12] [13] were selected after independently screening and duplicate selection to compose this review [**Figure 1**].

Among the studies found in the databases, four were read in full and included [9] [11] [12] [13] while one was selected from the gray literature [10]. Among

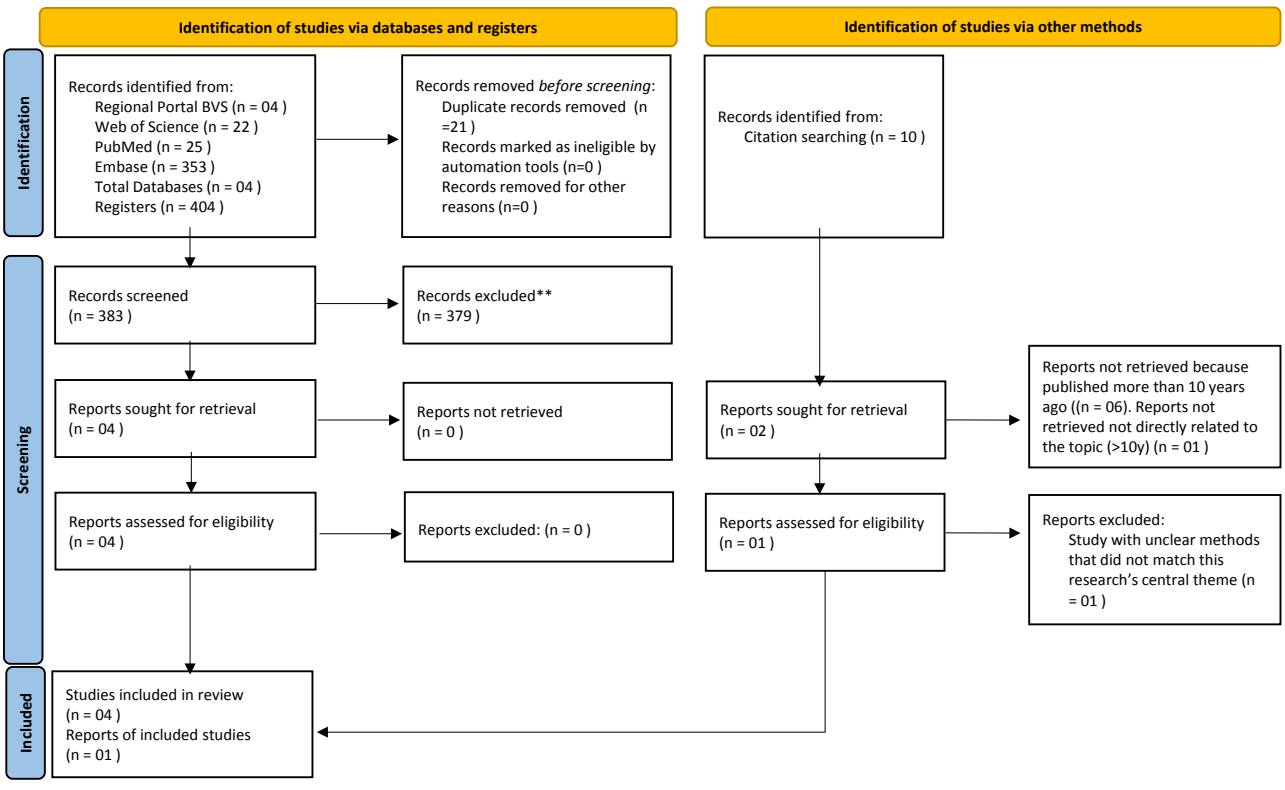

Figure 1. Flow Diagram PRISMA [2020] about studies of ILTB. Source: Adapted from PRISMA 2020. From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, *et al.* The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021; 372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/ Adapted from PRISMA 2020.

the studies found in the gray literature, six were excluded for not meeting the criteria of having been published in the last ten years [14]-[19], one was excluded because it consisted of a systematic review [20], one was excluded because it did not directly address latent tuberculosis [21], and one was excluded because it was a conference abstract that did not meet the quality criteria due to lack of information [22].

Characteristics of the studies included in the review

The studies included in the review totaled a sample of 1718 prison officers, which were included for the systematic review and sensitivity analyses. The particularities of each study can be verified in the characteristics table of the included studies [**Table 1**].

Two out of the five articles were conducted in Brazil and the others in Colombia, Poland, and Malaysia. One of them was a cohort study [10] whereas the others consisted of cross-sectional studies. None of them made gender restrictions among the participants. Among the methods used for diagnosis, only one used the quantiFERON-TB Gold in Tube test [9] and the others used the tuberculin skin test [PPD]. All presented values of the prevalence of latent tuberculosis infection in prison officers and the associated factors [**Table 1**]. Regarding the statistical analyses, the associated factors were shown by the articles with standardized effect measures [percentage, OR, CI, and p-value], except for one article [10], which presented the prevalence ratio [PR] value for the associated factor "males," which was standardized to perform the statistical analyses.

Quality of the studies included in the meta-analysis

Only one study Oliveira *et al.* [22] was classified as poor [**Supplementary Table S1**], as it had a lot of incomplete information and did not meet the minimum requirements of the systematic reviews and, therefore, it was removed from the analyses. The other studies were classified as good.

According to the analysis tool, question 10 "Was the exposure assessed more than once over time?" should be answered as "no" in cross-sectional studies, as it does not apply to this study design, justifying the reason why the articles received the "NO" classification. Therefore, this application did not reduce the quality of the studies.

Nogueira *et al.* [11] mentioned that 49.4% of employees attended and agreed to participate in the study, totaling a tuberculin test reading in 945 professionals, which is a high sample number and justifies its good quality category.

Importantly, for questions 13 "Was loss to follow-up after baseline 20% or less?" and 14 "Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure and outcome" of the quality assessment, studies Filipek-Czerska *et al.* [9], Nogueira *et al.* [11], Busatto *et al.* [12], Oliveira *et al.* [22], and Al-Darraji *et al.* [13] had a cross-sectional design, which made it impossible to verify the same sample at two-time points [beginning and end], as cross-sectional studies analyze only one-time point.

Sensitivity analysis of LTBI prevalence

Figure 2 shows the effect estimate calculated to determine the overall prevalence of global LTBI.

Data for the "smoking" subgroup were extracted from studies by Nogueira *et al.* [11] and Al-Darraji *et al.* [13] and those for the "males" subgroup were extracted from Nogueira *et al.* [11] and Arroyave *et al.* [10]. Figure 3 and Figure 4 show the prevalence of latent tuberculosis in the subgroups.

Assessment of certainty of the evidence

The certainty analysis of the evidence of the estimated effect of the LTBI prevalence in prison officers was considered moderate due to confounding factors, low for the effect of smoking estimation, and moderate for males. Table 2 shows these results.

Associated factors

Table 1 shows the factors associated with LTBI. An evaluation of the length of service was observed by Al-Darraji *et al.* [13], Busatto *et al.* [12] and Filipek-Czerska *et al.* [9], who pointed to a significant prevalence of LTBI in criminal police officers with longer years of service despite the difference in the evaluation methodology. Table 3 shows the data for comparison.

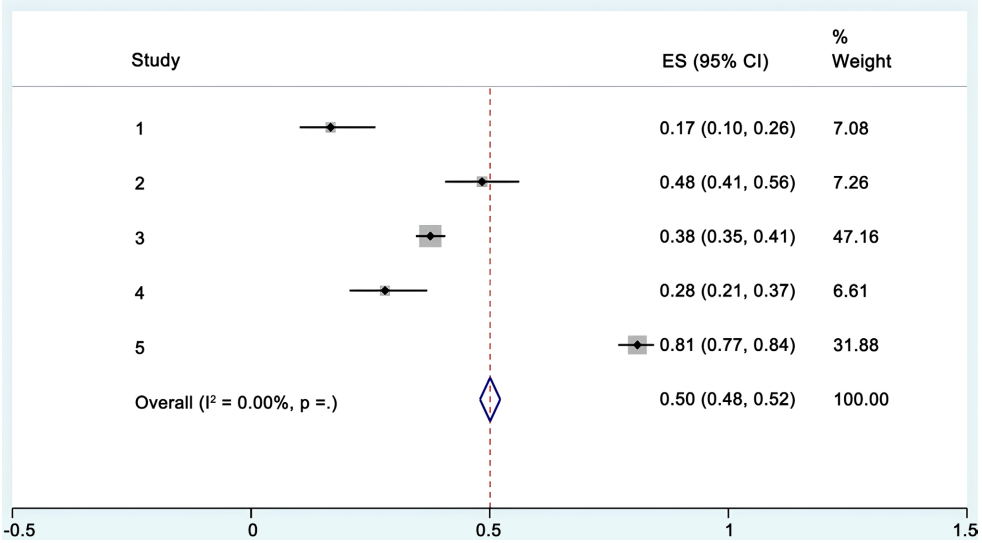

Figure 2. General assessment of the prevalence of latent tuberculosis in prison police officers. 1—Filipek-Czerska *et al.* [7]; 2—Arroyave *et al.* [8]; 3—Nogueira *et al.* [9]; 4—Bussato *et al.* [12]; 5—Al-Darraji *et al.* [11].

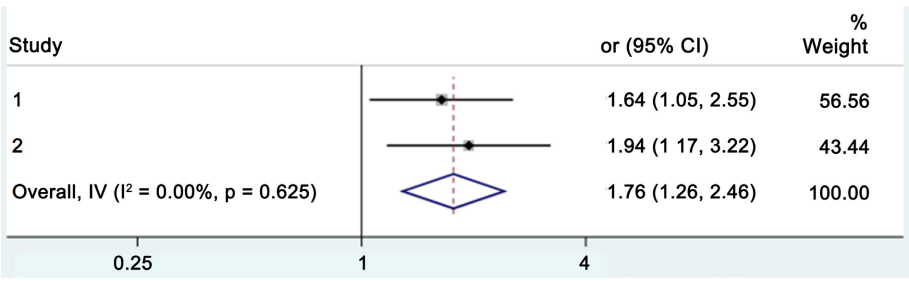

Figure 3. Sensitivity analysis for the prevalence of latent tuberculosis in smokers. 1—Nogueira *et al.* [9]; 2—Al-Darraji *et al.* [11].

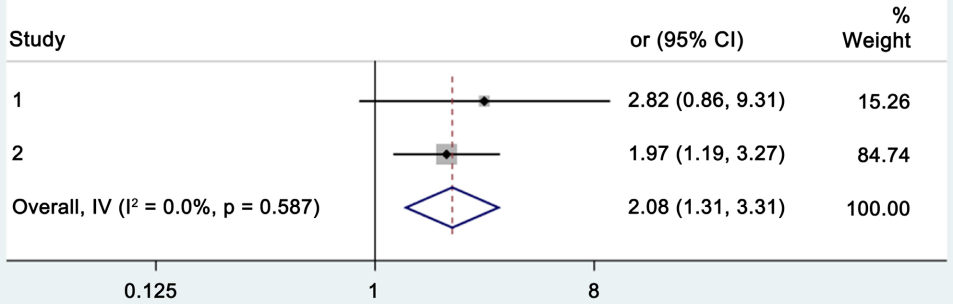

Figure 4. Sensitivity analysis for the prevalence of latent tuberculosis in males. 1—Nogueira *et al.* [9]; 2—Al-Darraji *et al.* [11]; OR = odds ratio; CI = confidence interval.

Table 2. Assessment of the certainty of the evidence.

Certainty assessment		Effect		
Outcome	Number of studies	Relative [95% CI]	Absolute [95% CI]	Certainty
Overall Prevalence	5	**0.5 1.00** [0.48 - 0.52]	**-- per 100** [from -- to --] **-- per 100** [from -- to --]	⊕⊕⊕◯ Moderate
Smokers	2	**OR 1.76** [1.26 to 2.46]	**0 fewer per 100** [from 0 fewer per 0 less]	⊕⊕◯◯ Low
Male	2	**2.08** [1.31 - 3.31]	**2 fewer per 1.000** [de 4 fewer to 1 less]	⊕⊕⊕◯ Moderate

CI: Confidence interval; **OR:** Odds ratio. Observations: The results of the study by Al-Darraji *et al.* [11] with a prevalence higher than 50% were identified as a confounding factor, since there was a serious discrepancy from the other studies, which ended up increasing the result of the estimate.

Table 3. Prevalence of latent tuberculosis in prison police officers according to length of service.

Authors/year	Total Participants	Working Time	p value
Filipek-Czerska *et al.* [7] [2021]	84	>16 years	p = 0.0010
Bussato *et al.* [12] [2017]	43	15.3 years	p = 0.01
Al-Darraji *et al.* [11] [2015]	420	>12 months	p = 0.007

4. Discussion

This study determined the LTBI prevalence and associated factors at global levels since studies from several countries were selected to compose the systematic reviews. We found an overall LTBI ratio of 50% [95% CI: 48 - 52].

According to Pai *et al.* [21], the use of the quantiFERON-TB Gold in Tube test for the diagnosis of latent tuberculosis has gained popularity mainly in high-income countries, which is consistent with what was found in our results, as only the

study by Filipek-Czerska *et al.* [9], developed in Poland, used it. According to Pai *et al.* [21], both the quantiFERON-TB Gold in Tube and the Tuberculin Test are acceptable despite having low predictive value for progression to active tuberculosis. The author also mentions the theoretical risk that the result of the tuberculin skin test might be affected by the BCG vaccine, especially if the vaccine has been applied several times. However, Al-Darraji *et al.* [13] mentioned that the Centers for Disease Control and Prevention recommend the interpretation of the tuberculin test regardless of the history of BCG vaccination.

Grenzel *et al.* [20] conducted a systematic review that evaluated active and latent tuberculosis among prison staff and found a mean prevalence rate of 26% for latent tuberculosis infection and up to 44% in countries with a high load. The research included studies spanning from 1997 to 2017, while our research included studies from 2012 to 2022. Moreover, only one study among those analyzed by these authors had not used the tuberculin skin test, as in our review.

The meta-analysis for the general LTBI prevalence presented no significant result and we cannot rule out that professionals who work in prisons are at higher risk of being infected with *M. tuberculosis*, as the prevalence of the disease among inmates is much higher than that of the population in general [23]. Furthermore, according to Nogueira *et al.* [11], professionals who have direct contact with detainees present a higher risk of becoming infected with *M. tuberculosis*.

A comparison with the other studies shows a discrepancy in the results by Arroyave *et al.* [10], with 48% of ILTB in two male prisons in Colombia, and Al-Darraji *et al.* [13], with 81% infection in Malaysia's largest prison. According to the authors, the high LTBI prevalence among prison officers in Malaysia and Colombia can be attributed to several factors, such as length of stay in prison, location with high occupational risk, overcrowding, and lack of evidence-based tuberculosis control programs, leading to large reservoirs of the disease and increasing transmission between prisoners and staff [10] [13]. In addition to these factors, there is the contribution of smoking and low rates of screening of detainees and prison officers [3]. According to Binswanger *et al.* [19], screening for latent tuberculosis among correctional officers was inconsistent even in the United States, with only 52% of prisons having a written policy on testing officers.

According to the studies integrated for analyses, the smoking factor is positively related to latent tuberculosis infection [OR = 1.76; 95% CI = 1.26 - 2.46] [**Figure 3**]. This result suggests that prison officers who smoke have a higher LTBI prevalence. The male factor was also positively related to the higher LTBI prevalence among prison officers [OR = 2.08; 95% CI = 1.31 - 3.31].

The prevention of tuberculosis crises in prison officers in prisons and neighboring communities depends on the motivation and financial investment of the countries. A recent article concluded that there is robust evidence from around the world pointing to the need, feasibility, and methods of dealing with tuberculosis in prisons. Therefore, they should carry out screening on entry and exit and

routinely on prisoners and staff, regardless of the existence of symptoms [3], given the prevalence rate of LTBI in prison officers, as shown in this systematic review.

Strengths and weaknesses of the study

Some limitations regarding the included studies are that they are mostly cross-sectional studies [only one cohort]. Therefore, although they have a good quality in terms of methodology, they only evaluated the prevalence, without being able to differentiate when the infection occurred.

The certainty of moderate evidence for the non-significant LTBI prevalence in prison officers is justified because most studies have a prevalence of less than 50%. However, the prevalence was higher than 50% in the study by Al-Darraji *et al.* [13], which contributed to an increase in the mean estimate of the effect, thus acting as a potential confounding factor. Therefore, future studies may modify the estimate of the effect and change the confidence of the evidence [24].

The certainty of the evidence of the prevalence rate of LTBI in smoking prison officers was low, that is, it had a weak association, showing that future studies may modify the confidence in the estimate of the effect of this analysis [**Figure 3**] [24]. In addition, it is worth mentioning that the associated factor "males" had a high magnitude of effect and association of the moderate evidence. However, it should be considered that males are prevalent in prisons, which favors infection by diseases compared to females [25].

5. Conclusion

LTBI in prison officers occurs with variable prevalence across the world, with the highest values in Malaysia. LTBI reactivation is responsible for a large proportion of active TB cases. Prison officers have a higher risk of contact with *Mycobacterium tuberculosis* than the general population, given the vulnerability of the daily routine of their activities in the prison environment. Therefore, preventive measures and the rapid and accurate diagnosis of new cases should be emphasized to ensure tuberculosis control, mainly among risk groups such as prison officers.

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Limitations

The variability in sample size across studies may have affected the prevalence and heterogeneity observed among studies.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Supplementary

Supplementary Table S1. Quality assessment "Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies".

Questions	Study quality					
	1°	2°	3°	4°	5°	6°
1. Was the research question or objective in this paper clearly stated?	Yes	Yes	Yes	Yes	Yes	Yes
2. Was the study population clearly specified and defined?	Yes	Yes	Yes	Yes	No	Yes
3. Was the participation rate of eligible persons at least 50%?	Yes	Yes	No***	Yes	No	No
4. Were all the subjects selected or recruited from the same or similar populations [including the same time period]? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	Yes	Yes	Yes	Yes	No	Yes
5. Was a sample size justification, power description, or variance and effect estimates provided?	Yes	Yes	Yes	Yes	No	Yes
6. For the analyses in this paper, were the exposure[s] of interest measured prior to the outcome[s] being measured.	No**	Yes	No**	No**	No**	No**
7. Was the time frame sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	No**	Yes	No**	No**	No**	No**
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome [e.g., categories of exposure, or exposure measured as continuous variables]?	Yes	Yes	Yes	Yes	Yes	Yes
9. Were the exposure measures [independent variables] clearly defined, valid, reliable, and implemented consistently across all study participants?	Yes	Yes	Yes	Yes	No	Yes
10. Was the exposure[s] assessed more than once over time?	No**	Yes	No**	No**	No**	No**
11. Were the outcome measures [dependent variables] clearly defined, valid, reliable, and implemented consistently across all study participants?	Yes	Yes	Yes	Yes	No	Yes
12. Were the outcome assessors blinded to the exposure status of participants?*	N.R	N.R	N.R	N.R	N.R	NR
13. Was loss to follow-up after baseline 20% or less?	N.A	Yes	N.A	N.A	N.A	Yes
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure[s] and outcome[s]?	N.A	Yes	N.A	N.A	N.A	N.A
Quality Rating [Good, Fair, or Poor]	**Good**	**Good**	**Good**	**Good**	**Poor**	**Good**

Note: CD, cannot determine; NA, not applicable; NR, not reported.