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# Prevalence of Tuberculosis in HIV-positive Prisoners: A Systematic Review and Meta-analysis

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## ABSTRACT

***Tuberculosis (TB) and HIV constitute the main burden of infectious diseases worldwide. Imprisonment is an important risk factor for contracting TB, especially among those living with HIV. This systematic review summarizes the available data on the prevalence of TB among HIV-positive prisoners; which may support improved targeted TB/HIV prevention plans. We electronically examined published studies up to December 2017 with the aim of finding articles that investigated the prevalence of TB in HIV-positive prisoners. MEDLINE, SCOPUS, Embase, and Web of Science electronic databases were searched with no restriction on language or time. A random effects model was used to conduct the meta-analysis and generate a summary estimate for the global prevalence of TB among HIV-positive prisoners; and subgroup estimates by continent. The meta-analysis included 22 studies published from 1992 to 2016. In total, 2,465 articles were retrieved and 22 papers met inclusion criteria. Eligible papers contained 220,101 prisoners, with 1,611 cases of TB in 6,126 HIV-positive subjects. Globally, the pooled prevalence of TB in HIV-positive prisoners was 32.6% [95% confidence interval (CI): 27.5% to 38.2%; p-value for heterogeneity = 0.001]. Results of the subgroup analysis by continent were as follows: Africa, 14% (CI: 8% to 24%); North/South America, 37% (CI: 31% to 44%); Asia, 35% (CI: 12% to 68%); and Europe, 25% (CI: 12% to 45%). Conclusions: The prevalence of TB among HIV-positive prisoners is high worldwide. Screening of TB in this population is essential for the treatment of both diseases. Syndemics of TB and HIV in prisoners during the past three decades have created an alarming situation across the world. Hence, coordinated policies are essential for the early identification and effective treatment of this vulnerable population.*** **(AIDS Rev. 2018;20:114-124)**

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## Key words

***Tuberculosis. HIV. AIDS. Prison. Prevalence. Co-infection. PLWH.***

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# Introduction

Tuberculosis (TB) and human immune deficiency virus (HIV) infections are two major public health concerns in many parts of the world[1,2]. TB is considered a major cause of death in people living with HIV (PLWH), and in 2016, the World Health Organization (WHO) estimated that 40% of HIV deaths were caused by TB[3]. Co-infection of TB and HIV in prisons, as a worldwide health problem, has been on the rise[4]. HIV and TB act synergistically: HIV infection promotes reactivation from latent to active TB[5,6]; and TB infection impedes the immune response to HIV and accelerates progression to AIDS[7,8]. To bring the TB/HIV epidemic under control and to reach the ambitious global targets outlined by the WHO's End TB strategy[9], including reducing TB incidence by 80% and TB mortality by 90%, countries are being encouraged to focus their efforts on screening, diagnosis, and treatment of TB in PLWH and other vulnerable groups, including prisoners[10].

Prisoners have a well-defined right to access to standard healthcare and effective services for HIV/TB prevention and treatment[10,11]. However, a large body of empirical evidence documents that a history of imprisonment is a major risk factor for TB among PLWH[12]. Additionally, TB is concentrated among individuals with high-risk behaviors for HIV infection, such as people who inject drugs[13]; who may face criminal charges leading to incarceration and onwards transmission of TB. The prevalence of TB among HIV-positive prisoners poses risks not only to the prisoners themselves but also to prison staff and even to society[14,15]. Several studies have documented TB outbreaks in the broader population that can be attributed, at least in part, to contact with prison populations[4,11,14]. Recent studies using genetic epidemiology have provided important new insights into the role that prisons play in community outbreaks of TB[16].

However, knowledge on the worldwide prevalence of TB among HIV-positive prisoners is not well documented. This is partly because, based on available evidence, prisons often have very restricted access to basic TB diagnostic and screening services[14,17]. There is currently no pooled data available presenting the prevalence of TB in prisons among PLWH globally or the variations across different settings. To address this, we performed a systematic review and meta-analysis of the published literature, to estimate the prevalence of TB among HIV-positive prisoners.

# Methods

The present systematic review and meta-analysis has been described according to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) Statement[18].

## *Protocol and registration*

The purpose of the present review was to determine the prevalence of TB in HIV-positive prisoners. The study protocol was registered in the international prospective register of systematic reviews database (PROSPERO) in December 2016 with the registration number of CRD42017054710.

## *Search strategy and selection criteria*

A systematic search was performed with the aim of finding cross-sectional and cohort articles that investigated the prevalence/incidence of TB in HIV-positive prisoners. To this end, we searched MEDLINE, SCOPUS, Embase, and Web of Science (ISI) databases by combining three sets of related MeSH and Non-MeSH terms: 1) "tuberculosis" OR "TB", 2) "HIV", "AIDS", "acquired immune deficiency syndrome" and 3) "prison", "inmate" to search titles, abstracts, or keywords until December 2017, with no limitation regarding language and time.

## *Inclusion criteria and data extraction*

The inclusion criteria were a) original studies with observational design; b) study performed in prisons, and c) documented the occurrence of HIV and incident acquisition or prevalence TB among HIV-positive prisoners. Three authors independently reviewed the studies (MD, MGh, and NZ) and discrepancies were resolved by discussing with the fourth author (HJ). The reference list of related articles was also manually reviewed for other possibly related articles that were not found in the electronic search.

## *Quality assessment*

A six-item tool for critically appraising studies of prevalence/incidence of a health problem[19] was used to examined the quality of eligible studies by two independent investigators (NZ and MGh). This tool contained following items; (1) A question about appropriate design and sampling method for the research question (2) Question about appropriate sampling frame (3) And adequate sample size (4) If objective, suitable and standard crite-

ria used for measurement of the health outcome? (5) Is the health outcome measured in an unbiased way? and (6) A question about acceptable response rate. Each item was scored as 1 if a study met the criterion, and all the scores were summed up to reach a total score, ranging from 0 (lowest quality possible) to 6 (highest quality possible). The quality assessment results were also checked by a third investigator (MD).

### *Data extraction*

Three independent researchers (MD, NZ, and MGh) extracted following data from included studies; author, study year, study design, country, gender, mean age of participants, number of prisons, total number of prisoners, number of prisoners per cell, mean duration of incarceration (months), proportion of prisoners with prior history of incarceration, number of HIV cases, type of TB (active or latent), diagnostic method and the frequency and prevalence of TB in HIV-positive prisoners (%). Prevalence of TB among HIV-positive prisoners was directly extracted from the cross-sectional articles and the incidence (reported in cohort studies) was converted to the prevalence using the following formula: *Prevalence = Incidence × Duration of disease*. Based on the literature the average duration of TB was considered to be about 2.5 years in this formula[20].

The extracted data was compared and discrepancies between investigators were discussed to reach a consensus and to ensure the accuracy of data. If the full-text of a study was unavailable or if the reported data was missing key information for data extraction, we contacted the authors by email at least twice, one week apart and also we sent email to publishers (i.e. Elsevier and Wiley online library).

### *TB case definition*

We included articles which defined TB cases based on tuberculin skin test (TST), chest X-ray and sputum specimens. The cases were categorized as: *confirmed* (positive culture for *M. tuberculosis* complex*), probable* (positive microscopy with at least one acid-fast bacilli [AFB] per field, and/or chest X-ray images suggestive of TB), or *possible* (either presence of at least four clinical signs or symptoms as follows: cough lasting for more than two weeks, fever lasting for more than two weeks, recent loss of appetite, chest pain, body mass index lower than 18.5 Kg/m$^2$ or objectified fever with body temperature ≥37.5 °C on physical examination; or at least three clinical signs or symptoms with HIV seropositivity *or* positive direct smear with less than one AFB per field)[21].

### *Statistical analysis*

The number of TB-infected HIV-positive prisoners and the total number of HIV-positive prisoners were used to calculate the logit event rate and its corresponding standard error (SE) which was used as effect size for meta-analysis. The summary prevalence with 95% CI was obtained using the random effects model. *Cochran's Q test* was used to identify the heterogeneity of the results, and it was quantified using the $I^2$ statistic. $I^2$ statistic > 50% or $Q$ statistics with $p < 0.10$ were considered as a significant between-study heterogeneity. Moreover, between-study variance was assessed using the tau-squared ($Tau^2$ or $t^2$) statistic[22]. Subgroup analysis based on the region of the study was performed to explore possible sources of heterogeneity. We pooled the results for the continents of North and South America together, due to the fact that there were an insufficient number of studies to report the continents separately. A meta-regression analysis was conducted to explore the association between the study year and the difference in TB prevalence among HIV-positive prisoners reported across studies. A sensitivity analysis was conducted by removing the studies from meta-analyses one by one. We also evaluated the publication bias using *Begg's* funnel plots and the asymmetry tests (*Egger's* and *Begg's* test). All statistical analyses were performed using Comprehensive Meta-Analysis software (*CMA*; version 2.2.064). *P-values* below 0.05 were considered as statistically significant.

## Results

### *Included studies*

As described in figure 1, a total of 2,465 records were obtained by electronic and hand search of which 1,681 records remained after duplicate references were removed. We excluded 1,538 studies after screening titles/abstracts; therefore, 167 studies remained to be carefully checked by reading their full text. Of the remaining, 147 articles were excluded for the following reasons: no relevant data (n = 87), review article or letter to editor (n = 13), HIV prevalence among TB cases or co-infection was reported (n = 7), study conducted in the general population (n = 14), TB prevalence was only reported among HIV-positive prisoners who were referred to hospitals (modified data) (n = 10) or the study did not report data regarding TB prevalence among HIV-positive prisoners (n = 15). In total, twenty-two articles met inclusion criteria for qualitative synthesis

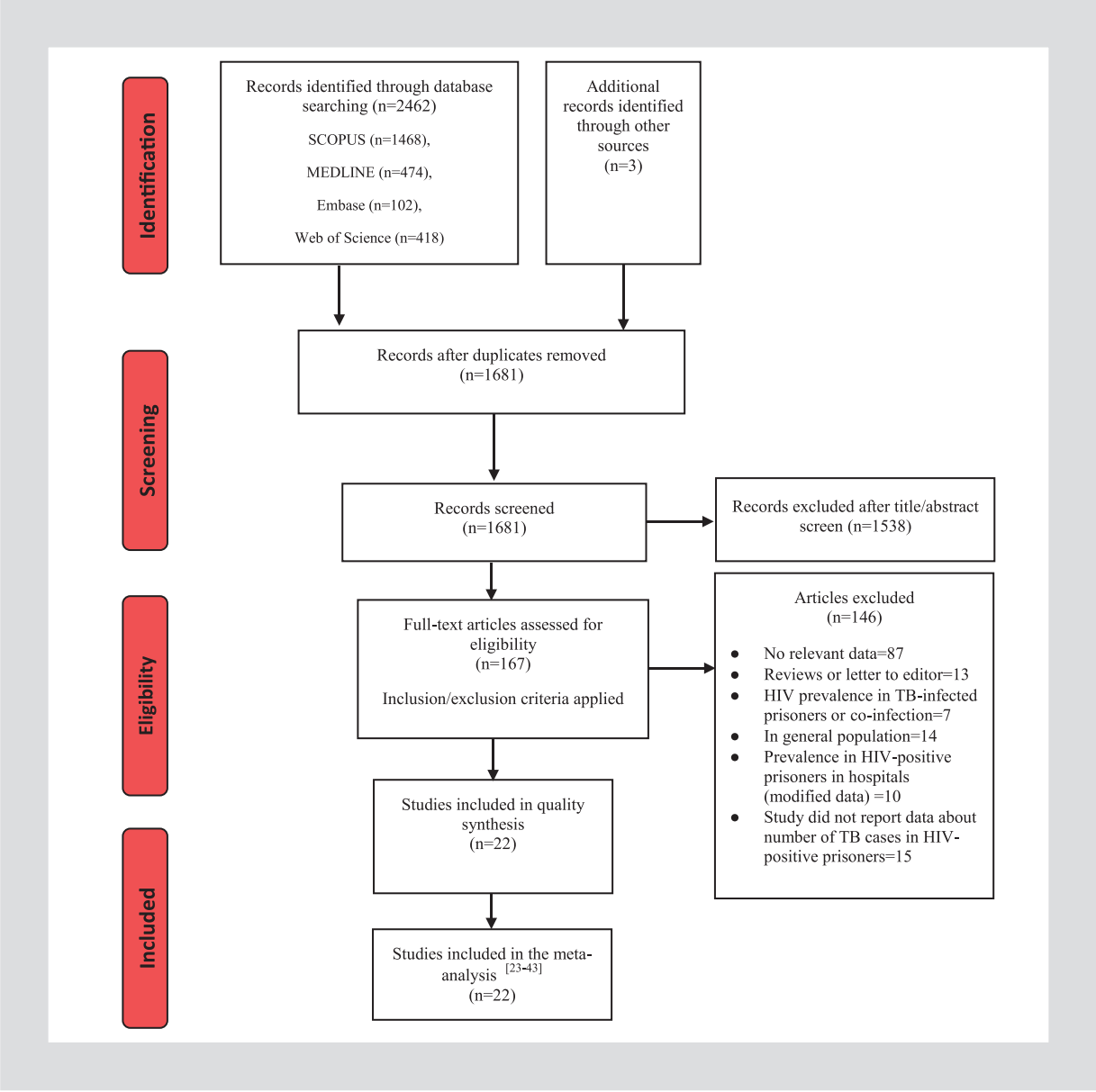


**Figure 1**. *PRISMA flow diagram of the study selection process [Search is updated up to December 2017].*

in the systematic review and the quantitative meta-analysis[23-43].

The characteristics of included studies are presented in table 1. The twenty-two studies were cross-sectional and cohort[29,40] in design and took place from 1992 to 2016. Overall, included studies summarized data from 220,101 prisoners and reported 1,611 cases of TB among 6,126 HIV-positive prisoners. The mean age of prisoners ranged from 30 to 36 years. The number of prisoners per cell varied greatly across studies. The highest congestion was reported from Ethiopia (333 prisoners per cell)[35] and lowest (2 prisoners per call) was reported in the United States[27]. Two other important factors that may play a significant role in TB transmission were the duration of incarceration and having a history of previous incarceration. In the study conducted by Marco et al.[31], the duration of incarceration was very long (60 months) and this was associated with a higher than average TB prevalence (62.5%), and the lowest duration was about 12 months[29,33,40]. Moreover, the history of previous incarceration was noticeably high in Malaysia with 98.4% which was reported by Al-Darraji et al.[43] and Zambia with only 12.61% had the lowest percent of previous incarceration[23].

TB prevalence among HIV-positive prisoners ranged from 6%[25,28,41] to 94%[33]. The highest prevalence was reported from a study in Iran (94%)[33] and the lowest prevalence rates were reported from Zambia, Iran and South Africa[25,28,41] (approximately 6%). Figure 2 presents the forest plot of the prevalence of TB in HIV-

**Table 1. Main characteristics of the articles included in the study.**

| Row | Author | Year | Quality category | Type of Study[◊] | Country | Gender[†] | Mean age of participants | # of prisons | Total # of prisoners | # prisoners per cell | Mean Duration of incarceration (Month) | Previous incarceration (%) | # of TB in HIV cases | # of HIV cases | Active or Latent TB | Diagnostic method | Prevalence | Lower limit | Upper limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Al-Darraji et al. (a), [43] | 2016 | Medium | C-S | Malaysia | M and F | 36.4 (SD ± 9.8) | 2 | 559 | 9 | ND | 98.4% | 34 | 142 | Active | CXR [‡] and smear microscopy | 0.239 | 0.176 | 0.316 |
| 2 | Farhoudi et al., [41] | 2016 | Medium | C-S | Iran | M | 30.7 (SD ± 7.9) [£] | 1 | 6900 | ND | 28 months | ND | 5 | 85 | Active | clinically assessed for TB symptoms | 0.059 | 0.025 | 0.134 |
| 3 | Mamani et al., [33] | 2016 | Medium | C-S | Iran | M and F | 30–39 | 1 | 1208 | 20–29 | 12 months | ND | 17 | 18 | Latent | TST [§] | 0.944 | 0.693 | 0.992 |
| 4 | Gebrecherkos et al., [38] | 2016 | High | C-S | Ethiopia | M and F | 35 (SD ± 11.9) | 4 | 3900 | ND | ND | ND | 4 | 17 | Active | Spot-morning-spot sputum samples | 0.235 | 0.091 | 0.486 |
| 5 | Hanifa a et al., [25] | 2015 | High | C-S | South Africa | Male | 32 (IQR: 27–38) | 1 | 871 | 44 | 34 months | 41.7% | 14 | 212 | ND | sputum specimens | 0.066 | 0.039 | 0.108 |
| 6 | Valenca et al., [36] | 2015 | High | C-S | Brazil | M and F | 31.2 (SD ± 68.4) | 1 | 304 | 9 | 26 months | 88.2% | 36 | 87 | Active | Bacteriologically OR CXR | 0.414 | 0.315 | 0.520 |
| 7 | Al-Darraji et al., [30] | 2014 | High | C-S | Malaysia | M and F | 36 [SD ± 7.87] | 11 | 340 | ND | 36 months | 82.5% | 24 | 189 | Latent | TST | 0.127 | 0.087 | 0.182 |
| 8 | Simooya et al., [23] | 2014 | High | C-S | Zambia | M and F | 15-44 | 7 | 2244 | ND | 12-36 months | 12.6% | 85 | 609 | ND | TST | 0.140 | 0.114 | 0.169 |
| 9 | Henostroza et al., [28] | 2013 | High | C-S | Zambia | M and F | 31 (25–37) | 1 | 2514 | ND | ND | 35% | 22 | 342 | Active and Latent | Bacteriologically OR CXR | 0.064 | 0.043 | 0.096 |
| 10 | Margolis et al. (a), [37] | 2013 | High | C-S | Malaysia | M and F | 33.4 (SD ± 7.2) | 1 | 288 | 40–50 | ND | 67.3% | 23 | 137 | Active | TST | 0.168 | 0.114 | 0.240 |
| 11 | Margolis et al (b), [37] | 2013 | High | C-S | Malaysia | M and F | 33.4 (SD ± 7.2) | 1 | 288 | 40–50 | ND | 67.3% | 120 | 137 | Latent | TST | 0.876 | 0.809 | 0.921 |
| 12 | Marco et al., [31] | 2012 | Medium | C-S | Spanish | M and F | 35.7 (SD ± 10.3) | 18 | 378 | 21 | 60 months | 71.2% | 25 | 40 | Active and Latent | ND | 0.625 | 0.468 | 0.760 |
| 13 | Moges a et al., [35] | 2012 | Medium | C-S | Ethiopia | M and F | 32 | 1 | 250 | 333 | 3 years | 10.8% | 9 | 19 | Active and Latent | Sputum-smear microscopy | 0.474 | 0.268 | 0.689 |
| 14 | Diendere a et al., [34] | 2011 | _ € | C-S | Burkina Faso | M and F | 30.1 +/- 8.9 | 1 | 300 | ND | ND | ND | 3 | 15 | Active and Latent | Sputum-smear microscopy | 0.200 | 0.066 | 0.470 |

(Continue)

**Table 1. Main characteristics of the articles included in the study (Continued).**

| Row | Author | Year | Quality category | Type of Study◊ | Country | Gender† | Mean age of participants | # of prisons | Total # of prisoners | # prisoners per cell | Mean Duration of incarceration (Month) | Previous incarceration (%) | # of TB in HIV cases | # of HIV cases | Active or Latent TB | Diagnostic method | Prevalence | Lower limit | Upper limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | Drobniewski a et al., | 2005 | High | C-S | Russia | Male | Median (IQR) 31 (21–39) | 1 | 1345 | ND | ND | 83.3% | 164 | 1344 | Active and Latent | Microscopy and bacteriological culture | 0.122 | 0.106 | 0.141 |
| 16 | Carbonara et al., [24] | 2005 | Low | C-S | Italy | M and F | 36 (IQR: 30–45) | 9 | 4,251 | 3 | 2.5 years | 19.9% | 2 | 27 | Active and Latent | TST | 0.074 | 0.019 | 0.252 |
| 17 | Lobato et al., [39] | 2003 | Medium | C-S | United States | M and F | median age of 30 years | 49 | 198,102 | ND | ND | ND | 768 | 1991 | Latent | TST | 0.386 | 0.365 | 0.407 |
| 18 | McLaughlin et al., [27] | 2002 | High | C-S | United States | M | 36 (range 21–57) | 1 | 323 | 2 | ND | ND | 104 | 233 | Active and Latent | TST | 0.446 | 0.384 | 0.511 |
| 19 | Martin Sánchez et al., [29] | 2001 | High | Ch | Spain | M and F | 25–34 | 1 | 3081 | ND | 12 months | ND | 16 | 127 | Latent | TST and CXR | 0.244 ɪ1 | 0.177 | 0.326 |
| 20 | Ferreira Marizete, et al., [40] | 1996 | High | Ch | Brazil | F | 29 (range 18-59) | 1 | 350 | ND | >12 months | 39% | 20 | 87 | Active | TST | 0.230 ɪ2 | 0.153 | 0.330 |
| 21 | Sanchez et al., [32] | 1995 | Medium | C-S | Spain | M and F | 29.9 (SD±8.9) | 1 | 1314 | ND | ND | 62% | 84 | 180 | Active | TST | 0.467 | 0.395 | 0.540 |
| 22 | Carbajal et al., [26] | 1992 | - € | C-S | Spain | ND | ND | 1 | 135 | ND | ND | ND | 17 | 88 | Active | ND | 0.193 | 0.124 | 0.289 |

*ND: No data*
*†M: Male, F: Female.*
*‡ CXR: chest radiography.*
*§ TST: tuberculin skin test≤According to the author's declaration (email to authors).*
*◊ C-S: Cross-sectional, Ch: Cohort.*
*ɪ1= Incidence cases 12.60 person/year (p/y) * 2.5y. ɪ2=9.9 p/y * 2.5y.*
*€: Email to the publishers and there was no full text available.*
*IQR: Interquartile Range*

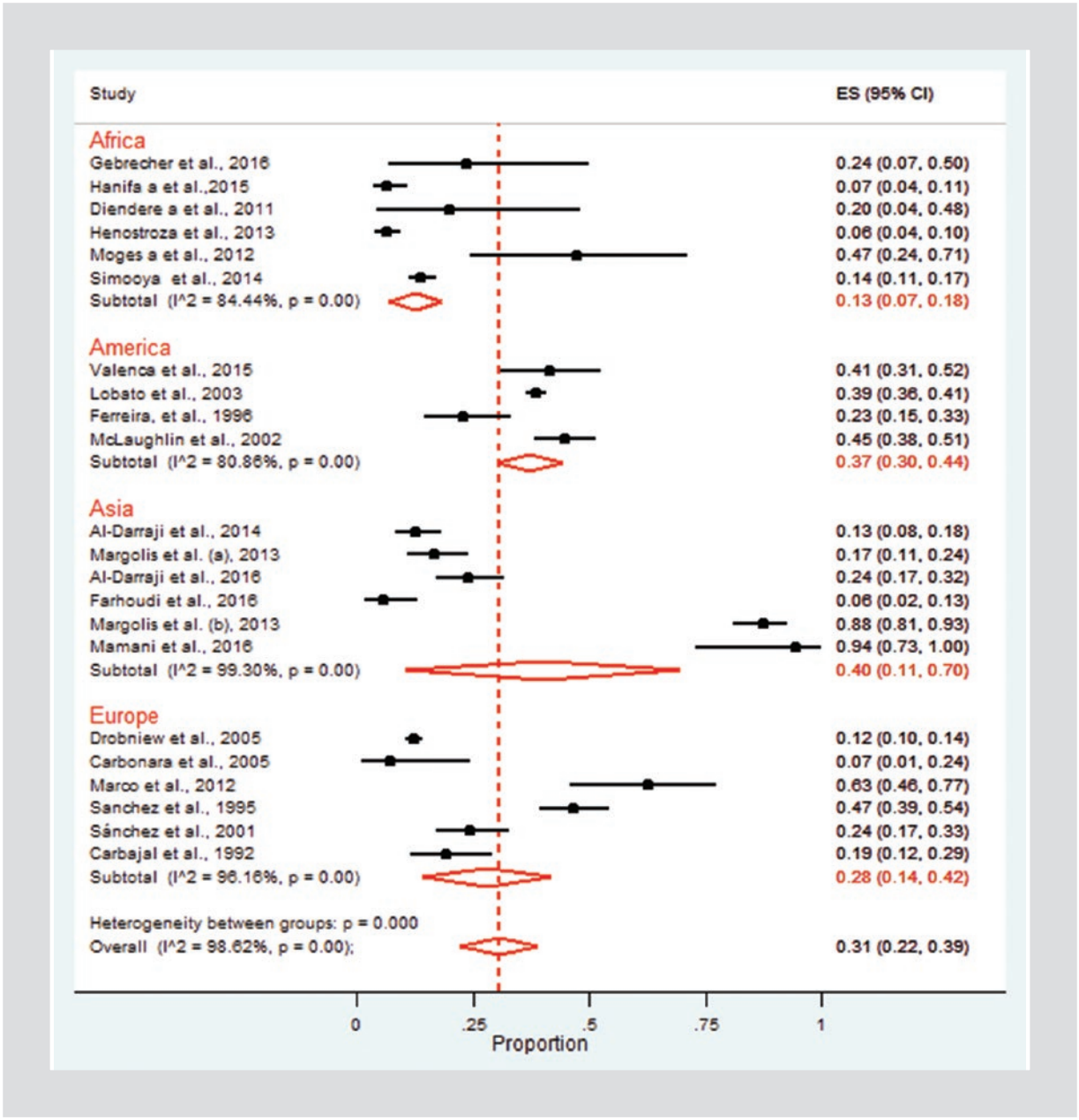


**Figure 2**. *The forest plot of prevalence of tuberculosis in HIV-positive prisoners (all studies were included).*

positive prisoners. The results of the random effects meta-analysis showed that the total TB prevalence in HIV-positive prisoners is approximately 32.6% [95% confidence interval (CI): 27.5% to 38.2%; p-value for heterogeneity = 0.001, $I^2$ = 96.99). When stratified by regions the TB prevalence subgroup pooled estimates were as follows; Africa: 14% (CI: 8% to 24%; n = 6 studies), Europe: 25% (CI: 12% to 45%, n = 6 studies), Asia: 35% (CI: 12% to 68%, n = 6 studies) and North/South America: 37% (CI: 31% to 44%, n = 4 studies).

Study quality as assessed by a six-item tool for studies of prevalence/incidence of a health problem from 1 stars (low quality) to 6 stars (high quality). Overall, there were n = 3 low quality or no full text available, n = 7 medium quality and n = 11 high quality studies. However, after conducting analysis according to quality assessment, there were no significant differences between the results of high/medium quality studies and low or medium-quality studies[24,26,34].

## *Sensitivity analysis, heterogeneity and publication bias*

Results of sensitivity analysis showed that no study significantly influenced the results, with the net effect size varying from 0.23 to 0.27. The Q-test results

showed a significant heterogeneity among the studies ($p < 0.001$). The $I^2$ and tau-squared statistics were 96.58% and 0.78, respectively.

Although a slight asymmetry was seen in the Begg's funnel plot (Fig. 3), no evidence of publication bias was shown using Egger's (p-value = 0.48) and Begg's (p-value = 0.91) asymmetry tests.

### *Meta-regression*

We performed univariate meta-regression analyses to identify possible variables associated with our results. The result of the meta-regression exploring the association between prevalence of TB in HIV-positive prisoners and year of study is shown in Figure 4. The prevalence of TB in HIV-positive prisoners has a significant downward trend, which decreasing TB prevalence rates in recent years ($B$ = -0.05, $tau^2$ = 0.852, p = 0.001).

## Discussion

Present meta-analysis indicated that the worldwide prevalence of TB in HIV-positive prisoners was high; with one in three HIV-positive prisoners infected with TB. Previous studies showed a higher prevalence of HIV and TB among detainees relative to general populations. However, these studies did not provide much information regarding the co-infection of TB and HIV among prisoners[4]. To our knowledge, this study is the first to evidence summary to measure global TB prevalence among HIV-positive prisoners. This is important because the high-risk population of detainees is considered as a major barrier to success in HIV and TB control programs and meeting the related global targets.

The results of the present study showed that the total prevalence of TB among HIV-positive prisoners is 32.6%. The TB prevalence found in our study was very high, which is alarming as it indicates deficits in effective treatment. Additionally, this presents a major obstacle to TB control programs as in many settings incarcerated populations may be a reservoir of TB and once released may be vectors of TB transmission to the outside world.

According to the results the lowest TB prevalence reported from the African continent and the highest one comes from North/South America. Previous studies estimated that TB prevalence falls within the range of figures found in other prison settings across the African continent[21,44-47]. It seems that in the African region, active TB infection is highly associated with overcrowding of prisons, high prisoner turnover rates, long duration of incarceration and high rates and re-incarceration[10,45]. Importantly, the high prevalence of TB is observed

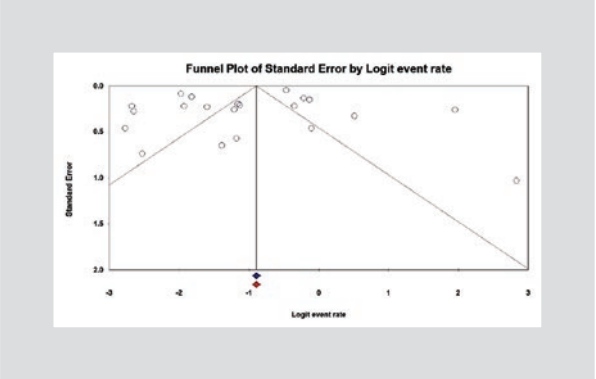


**Figure 3.** *The funnel plot of prevalence of tuberculosis in HIV-positive prisoners.*

after two decades of implementing a program that made TB screening and treatment accessible in the large prisons in Africa[4]. This TB program includes symptom-driven TB screening on admission and whenever the defined symptoms are observed in prisoners. However, the program does not cover the inmates who do not self-declare their symptoms or those who have symptoms but due to high costs or limited access to medical facilities receive no effective medical cares[48]. In the European region, this rate was 25%. A previous study reported that TB treatment completion rates in prisoners are often low, exacerbated by their movement within and in and out of the prison system. For instance, prisoners in Europe and Asia are unlikely to receive adequate treatment for HIV and tuberculosis and this may play a significant role in TB control program and high prevalence of TB among prisoners[21].

In clinical terms, co-infection of TB and HIV occurs when a patient has both HIV infection and either latent or active TB disease[7]. A systematic review reported that mortality in co-infected individuals are also double that of HIV-positive individuals without TB, even when CD4 cell count and antiretroviral therapy are taken into consideration[4]. Globally in 2015, 55% of all notified TB patients had a documented HIV test result. This represents an 18-fold increase in testing coverage since 2004. In the African region, where the burden of HIV-associated TB is the highest, 81% of TB patients had a documented HIV test result[7]. As described by Reader et al., newcomers to a prison are more likely to receive screening tests. This means that when several newcomers enter a prison, the estimated prevalence may be higher than actual prevalence[49]. Prevalence can also be greatly influenced by the case definition. Studies that were entered into this meta-analysis have different case definitions. Overall, prospective studies need to determine the prevalence and incidence of TB in HIV-positive prisoners in order to determine whether

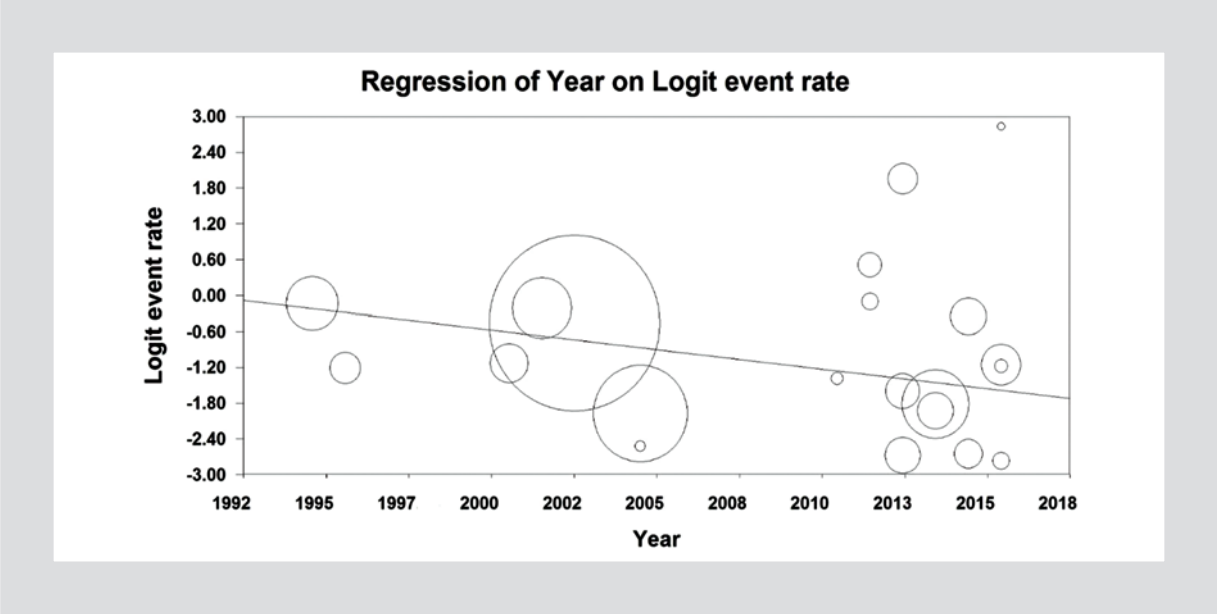


**Figure 4**. *Meta-regression of the association between prevalence of TB in HIV-positive prisoners and year of study.*

HIV patients are at a higher risk of developing TB. However, without a strong surveillance system, it will be almost impossible to achieve this goal.

Our results showed a history of incarceration and population congestion in prisons may have an important role in the acquisition of TB among HIV-positive prisoners. Our findings support the results of the previous research which have documented several factors affecting the chance of acquiring active TB. These factors include several behavioral factors; poor hygiene, smoking and even dietary habits[46,50] and incarceration[51,52]. The risk TB transmission is increased among populations in close contact, and those in confined and poorly ventilated spaces. As the result, transmission of TB among prisoners is much higher compared to that observed in the general population[53]. Accordingly, active TB among those confined in prisons was higher than in the general population in almost all nations. A study on TB in a prison in Brazil estimated that prevalence of active tuberculosis was 40 times higher than in the general population of the country[4].

A subgroup analysis was performed to identify sources of heterogeneity, but due to the following reasons we were unable to arrive at conclusive results. The heterogeneity observed in this study is likely due in part to the difference between types of prisons. Prisons are diverse, in terms of the total prison population, the number of people in each cell, the demographic characteristics of the prisoners, and other characteristics[4,31,37,54,55]. Also, there was no evidence for publication bias.

With respect to TB surveillance in prison settings, screening using a skin test (tuberculin) or chest x-ray is necessary to identify TB infected prisoners who require isolation and treatment in order to prevent onwards transmission of TB[33,41]. The Centres for Disease Control and Prevention (CDC) has emphasized that the identification and prevention of TB among vulnerable groups is a key action for the elimination of TB[56]. The CDC also recommends additional measures that take into account target group interventions among vulnerable populations such as prisoners, as globally, prisoners are at a higher risk for latent TB infection[57]. Epidemiological studies have reported that prisoners are one of the major endemic sources of TB[58], this is because more than 40% of TB cases may be attributed to close contact (person-to-person) and the recurrence of TB is attributed to a small percentage of the disease[59]. Given the high population density in prisons, the screening and treatment of TB among prisoners is an essential step for towards TB eradication. In addition, retention to TB treatment, according to the latest recommendations and guidelines, for TB in HIV-positive has been recommended. Regarding the HIV treatment among TB individuals, Horsburgh et al. suggested that, in addition to the treatment for TB, HIV-positive patients who have either drug-susceptible or drug-resistant tuberculosis should receive antiretroviral therapy (ART). It has also been recommended that if HIV-positive individuals are not receiving ART at the time of TB diagnosis, that ART is initiated within two weeks of TB treatment for prisoners with a CD4 count ≥50 per $ml^3$ and in eight weeks for those with a CD4 count <50 per $ml^3$. However, we should also consider the possible interactions between TB drugs and ART and this needs special attention, especially among vulnerable groups, including prisoners.

Early case-finding is important for TB control in prisons as it ensures early detection and treatment of the infectious cases. Isolation of cases, initiation of TB treatment soon after HIV treatment and treatment of latent TB infections, particularly among HIV-positive individuals, are essential measures for TB control[61]. However, isolation of infectious prisoners is rare and many prisoners who are isolated live in palling conditions and might not receive proper treatment courses[62]. In addition, TB treatment completion rate in prisoners is often low, partly due to their movement within the prison or release from prison prior to treatment completion. It is suggested that prisoners, even in eastern Europe, are unlikely to receive adequate treatment for HIV and TB[63]. A review of the evidence on the management of TB and management of HIV/TB co-infection in prisons will provide a useful framework for universal drug susceptibility testing, systematic screening of contacts in high-risk groups and access to proper treatments[64]. A study in Uganda found a default treatment prevalence of 12% in people staying in the same prison and 53% for those transferred to another prison, and 81% of prisoners who were on treatment and released were subsequently lost to follow up[61,62]. However, large gaps exist in the implementation of these strategies across all regions[4].

This study has several strengths. In order to include cohort studies, we consider an approximate duration of 2.5 years to reform incident to prevalence and this provide this opportunity to estimate the prevalence of TB in all relevant studies. We took every effort to comprehensively review all the published literature on the topic and had three independent reviewers screen and assess study quality. Finally, we included studies published in languages other than English. The study also has some key limitations; such as a risk of bias across studies due to measurement error. Several different TB diagnostic tests were used across studies and there was no diagnostic gold standard for TB, making results difficult to compare. Additionally, we were unable to identify sources of heterogeneity between studies. Furthermore, several studies did not report on all the data collection elements. To access complete and valid information, we contacted the authors of the reviewed papers, and in two cases we received additional data[23,32].

## Conclusions

In conclusion, our results indicated that the worldwide prevalence of TB in HIV-positive prisoners was high which deserves special attention. Screening of TB among this population should conducted systematically and routinely so that TB cases may be treated and onward transmission can be limited. Prisoners form an important bridge group between prison and the general population for the transmission of HIV and TB. Therefore, to address with this co-infection of HIV and TB, coordinated policies are essential for early identification and effective treatment. Future prospective longitudinal studies should employ gold standard methods to better assess the incidence and prevalence of TB in patients with HIV.

## Conflict of interest

The authors have no competing interests to declare.

## Authors' contributions

All authors contributed extensively to the work presented in this paper. MD designed the study. MD, MGh, and HJ conceived the study. MD, MGh, and NZ created and performed the literature search strategy, MGh built the data extraction file, MD, NZ and MGh performed the data extraction and MD and HJ supervised the process. MD and ShR performed the statistical analyses, and all authors interpreted the data. ZG and MF drafted and revised the manuscript, and all the other authors contributed substantially to the writing and revising of the manuscript. All authors have read and approved the final version of the manuscript.

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