IJID Regions 9 (2023) 1–6

Contents lists available at ScienceDirect

IJID Regions

journal homepage: www.elsevier.com/locate/ijregi

Prevalence, drug-susceptibility pattern and associated factors of *Mycobacterium tuberculosis* infection among prisoners in western Arsi zonal prisons, Oromia, South West Ethiopia

Girma Hordofa [a], Getamesay Mulatu [b], Deresse Daka [b,*]

[a] *Oromia region West Arsi Zone, Ethiopia*
[b] *Hawassa University, College of Medicine and Health Sciences, Hawassa, Ethiopia*

ARTICLE INFO

Keywords:
Prevalence
Mycobacterium tuberculosis
Drug-resistance
Prison
Ethiopia

ABSTRACT

Objectives: Each year, tuberculosis (TB) in prisons is a major worldwide health concern that results in millions of diseases. It is particularly prevalent in low socio-economic countries like Ethiopia because of the poverty, overcrowding, starvation, lack of access to basic healthcare services, and high prevalence of HIV infection in these countries.

Methods: A cross-sectional study with 259 prisoners was carried out in the western Arsi zonal prison from November to January 2021. The sputum samples were taken from suspected TB patients and evaluated using the Gene Xpert Mycobacterium tuberculosis/rifampcine test. Line probe assay was used to assess the molecular drug susceptibility of isolates from positive sputum. A bivariate and multivariate logistic regression was analyzed using SPSS version 24 packages. Odds ratio (OR) and corresponding 95% CI were used to quantify the degrees of association between target potential risk factors and *Mycobacterium tuberculosis* positivity. *P*-value of less than 0.05 was considered statistically significant.

Results: The prevalence of undiagnosed pulmonary TB (PTB) verified positive cases was 5.4% (95% CI 2.7, 8.5) out of 259 research participants that were recruited in this study. One (0.38%) occurrence of mono-drug resistance to isoniazid was found among them. In this study, variables that were significantly linked with PTB positive were age ≥30 years, smoking (adjusted OR [AOR] = 0.087, 95% CI = 0.01-0.93, $P = 0.043$), body mass index 18.5 kg/m^2, cough duration 4 weeks (AOR = 0.03, 95% CI = 0.1-0.13 $P = 0.001$), and coughing before incarceration (AOR = 6.2, 95% CI = 3.6-10.59, $P = 0.004$).

Conclusion: In West Arsi zonal prisons, PTB and mono-drug resistance for isoniazid were found to be more common than in the general population.

Background

Tuberculosis (TB) is a chronic infectious disease which is caused by bacteria called *Mycobacterium tuberculosis*. Pulmonary TB (PTB) illness in humans is mostly caused by TB and affects the lungs. In 2019, there were around 10 million new cases of TB worldwide, while the disease itself was blamed for 1.2 million recorded fatalities [1]. There are a number of key demographic groups, such as the prisoner population, where the risk of infection is greater than it is for the general public. People who have PTB release tubercle bacilli into the air while coughing, sneezing, speaking, or singing [2].

Prisoners are more likely than the general population to develop tuberculosis. Prison staff, visitors, and family members may come into everyday contact with inmates. TB can continue to spread after a prisoner is freed if it is not properly diagnosed, treated, or connected to community-based care [3,4].

The prevalence of *M. tuberculosis* (multi-drug resistance TB [MDR-TB]) among prisoners in the Democratic Republic of the Congo and Ethiopia has been estimated to be between 8.5% and 9.5% [5,6]. This study aimed to identify the prevalence, drug-susceptibility pattern, and related variables of MDR-TB in prisoners in West Arsi zonal prisons, Oromia, South West Ethiopia.

Objective

The purpose of this study was to determine the prevalence, drug-susceptibility pattern methodology, and related factors of PTB among prisoners in the western Arsi zonal prisons in Oromia, Ethiopia.

* Corresponding author:
E-mail address: drsdk200@gmail.com (D. Daka).

https://doi.org/10.1016/j.ijregi.2023.08.008
Received 18 May 2023; Received in revised form 10 August 2023; Accepted 12 August 2023

Methods and materials

A cross-sectional study was conducted between November 01, and January 30, 2021, in the prisoners of the western Arsi Zonal, in the towns of Shashemene and Dodola, which are, respectively, 255 and 330 km from Addis Abeba, the capital city of Ethiopia. Sixty-four public hospitals, one NGO hospital, three private hospitals, 84 health centers, 224 small and medium clinics, and 334 health posts are among the 641 public and private health institutions in the West Arsi Zone. With a capacity of 600 prisoners, the Shashemene prison was bigger and located in Shashemene Town. However, it presently houses about 2200 prisoners, of which 82 are female. Dodola prison, which is presently home to 504 prisoners, including 12 females, is smaller than Shashemene prison. About seven prisoners were receiving anti-TB treatment at Shashemene prison during the research period. Each prison has a clinic, which is staffed by a nurse practitioner and members of the health committee, however, there are no laboratory services in any facility.

Sample size determination

The sample size was calculated by using the formula to estimate a single population proportions $n = (Z_{\alpha/2})^2 \times p \times (1-p)/d^2$, n = sample size, $Z_{\alpha/2}$ = significance level at $\alpha = 0.05$, p = established prevalence from previous studies of the topic of interest prevalence of PTB among prisoners cross-sectional study, (p = 19.4%) [7] d = margin of error of 0.05, with the assumptions of 95% CI. Hence, the sample size may be computed as:

$$n = \frac{(1.96)^2 \times 0.194 \times (1 - 0.194) = 241}{(0.05)^2}$$

Considering a 10% non-respondent rate, the total sample size will be 265.

Sampling procedure and technique

During the period of the study, there were a total of about 2704 prisoners imprisoned in both institutions. Of these, 265 study participants were selected including a 10% non-respondent rate by a convenient sampling technique. The number of study participants selected from each study area was calculated by the following sampling proportional allocation methods as follows: number of prisoners at Shashemene prison (n1) = $nf/N \times n1 = 265/2704 \times 2200 = 216$ and number of prisoners in Dodola prison ($n2$) = $nf/N \times n2 = 265/2704 \times 504 = 49$ where nf is the final sample size, ni is the size of that prison, and N represents total prisoners at both prisons.

All adult prisoners who have a cough ≥2 weeks, chronic patients, and patients with a history of TB treatment with more than 1-week cough duration were selected and ordered to collect sputum samples. A morning sputum sample was collected after instructions were given on how to collect the sample for each inmate. In total, 259 sputum samples were collected from both prisons using a sterile falcon tube. The sample was checked for quality and transported by ice box at 2-8°C within 1 day of collection to Shashemene Referral and Melka Oda General Hospital Laboratory. The sample was examined by Gene Xpert Mycobacterium tuberculosis/Rifampcine (MTB/RIF) assay. Then after, Genotype Mycobacterium tuberculosis drug resistance (MTBDR) plus assay was used to evaluate for positive sample detected for *M. Tuberculosis* complex by Xpert MTB/RIF assay. Morning sputum samples were collected from positive prisoners for line probe assay (LPA) assay.

LPAs for RIF and Isoniazid (isonicotinic acid hydrazide) **(**INH) resistance detection were based on the knowledge that resistance to RIF and INH in MTB is most often attributed to mutations in the rpoB, katG, and inhA genes. Genotype MTBDR plus assay (Hain Life Science, Nehren, Germany®) methods were used to assess drug-resistance patterns of *M. tuberculosis* isolated from a direct sputum sample at Adama Regional Laboratory according to the manufacturer's instructions and SOP.

The quality of the data collection, sample storage, and transportation were checked regularly. Prisoners diagnosed with TB-positive results were linked to the directly observed treatment short-course clinics of the nearby health facilities where they were registered and started the treatment according to the national guidelines.

Data collection procedure

Data was collected by a structured questionnaire which has four sections: demographic, clinical history of prisoners, knowledge of PTB infection, and prison-related factors. The questionnaire was adopted from a study conducted in Ethiopia [8] and the World Health Organization (WHO), TB control of infection in prisoners guideline [9]. The questionnaire was prepared in English and translated into Afan Oromo and then back to English and compared for consistency. Data was collected by trained prison clinic health officers by interviewing study participants after getting consent from each study participant.

The body mass index (BMI) of each prisoner was measured to know the nutritional status of study participants. Based on the WHO standard, BMI <18.5 kg/m^2 malnutrition and (BMI = 18.5-25 kg/m^2) is normal [10].

Data quality assurance

For Gene Xpert MTB/RIF assay sample processing control, probe check control, and internal quality control have been done by the machine itself. External quality control is checked by known samples regularly for each Xpert facility for new batches. Quality control for each LPA strip has five control zones which are conjugate control, amplification control, and three locus control zones on rpoB, katG, and inhA promoter regions are used to monitor the quality of the tests.

Data processing and analysis

Data was entered into SPSS version 24 for analysis. Descriptive statistics and bivariate logistic regression were used to examine the relationship between the proposed predictors and the prevalence of PTB. Variables with *P*-value <0.25 in bivariate were included in multivariate analysis. Multivariate logistic regression was used to identify variables independently associated with the prevalence of PTB. An OR was used to assess the statistical significance of association among the variables with 95% CI. A *P*-value of less than 0.05 was used as a cut-off value to see the presence of a statistically significant association.

Result

Of 259 study participants enrolled in this study, 14 (5.4%) (95% CI 2.7, 8.5) of undiagnosed PTB cases were confirmed positive using Xpert MTB/RIF assay with a 6 (97.7%) response rate. Almost all detected PTB-confirmed patients (13 [92.8%]) were from Shashemene prison whereas one case was detected from the Dodola prison site. Only one case (0.38%) of mono-drug resistance TB for INH was detected in this study by using LPA from the Shashemene prison setting, thereafter, it was evaluated for a second LPA and it was confirmed susceptible.

Socio-demographic characteristics of study participants

From a total of 2704 prisoners within two prisons during the study period, 259 prisoners were enrolled in this study. About 158 (61%) of study participants were those with age ≤30 years. The mean age of the prisoners was 31.6 years with a range of 18 to 78 years. More than three-fourths of the study participants (211[81.5%]) were from the Shashemene prison site. More than half, about 160 (61.8%) of study participants, were from rural areas and about 236 (91.1%) study participants were male, 137 (52.9%) were married, 216 (83.4%) were unemployed, and 142 (54.9%) were attended primary education (Table 1).

Table 1
Socio-demographic status of study population in West Arsi zonal prisons, Shashemene and Dodola, Oromia, Ethiopia, 2021(N = 259).

Variables	Categories	Prison site		Total
		Shashemene (N = 211)	Dodola (N = 48)	
Age	Less than or equal to 30	132 (62.6%)	26 (54.2%)	158 (61%)
	greater than 30	79 (37.4%)	22 (45.8%)	101 (39%)
Gender	Male	189 (89.6%)	47 (97.9%)	236 (91.1)
	Female	22 (10.4%)	1 (2.1%)	23 (8.9%)
Marital status	Single	88 (41.7%)	22 (45.8%)	110 (42.5%)
	Married	112 (53.1%)	25 (52.1%)	137 (52.9%)
	Divorced	11 (5.2%)	1 (2.1%)	12 (4.6%)
Place of residence	Rural	96 (37.1%)	33 (12.7%)	129 (49.8%)
	Urban	115 (44.4%)	15 (5.8%)	130 (50.2%)
Educational status	Cannot read and write	0 (0.0%)	1 (2.1%)	1 (0.4%)
	Can read and write	34 (16.1%)	7 (14.6%)	41 (15.8%)
	Primary (1-8)	109 (51.7%)	32 (66.7%)	141 (54.4%)
	secondary and above	68 (32.2%)	8 (16.7%)	76 (29.3%)
Occupation status	Employee	40 (19%)	3 (6.3%)	43 (16.6%)
	Unemployed	171 (81%)	45 (93.8%)	216 (83.4%)

Table 2
Behavioral factors of study participants in West Arsi zonal prisons, Shashemene and Dodola, Oromia, Ethiopia, 2021 (N = 259).

Variables	Categories	Prison site		Total
		Shashemene (N = 211)	Dodola (N = 48)	
Nutritional status	Under 18.5 kg/m^2	73 (34.6%)	16 (33.3%)	89 (34.4%)
Body mass index	Normal greater than 18.5 kg/m^2	138 (65.4%)	32 (66.7%)	170 (65.6%)
Smoking cigarettes before imprisonment	Yes	28 (13.3%)	3 (6.3%)	31 (12%)
	No	183 (86.7%)	45 (93.8%)	228 (88%)
Chewing chat before imprisonment	Yes	79 (37.4%)	25 (52.1%)	104 (40.2%)
	No	132 (62.6%)	23 (47.9%)	155 (59.8%)
HIV status	Positive	4 (1.9%)	0 (0%)	4 (1.5%)
	Negative	29 (13.7%)	4 (8.3%)	33 (12.7%)
	Unknown	178 (84.4%)	44 (91.7%)	222 (85.7%)
Diabetes status	Yes	4 (1.9%)	2 (4.2%)	6 (2.3%)
	No	207 (98.1%)	46 (95.8%)	253 (97.7%)

Behavioral characteristics of study participants

More than three-fourths of study participants (222 [85.8%]) reported that they did not know their HIV serostatus, 91 (35.1%) participants have BMI ≤18.5 kg/m^2, and 6 (2.3%) study participants reported they were patients with diabetes mellitus. About 104 (40.2%) and 31 (12%) study participants had a history of chewing chat and smoking cigarettes before their imprisonment, respectively (Table 2).

Clinical history of study participants

About 243 (93.8%) study participants had reported cough with a duration of 2-4 weeks and 239 (92.3%) produced a cough after imprisonment. More than three-fourths of study participants (210 [81.1%]) reported that they lost weight in prison, whereas about half of the study participants (127 [49%]) had reported a history of chest pain, and 83 (32%) had a history in difficulty of breathing. Furthermore, about 248 (95.8%) of the study participants reported the symptoms of night sweats, 255 (86.9%) had reported tiredness, and 253 (97%) of the study participants reported fever (Table 3).

Prison-related characteristics of study participants

About 25 (9.7%) of study participants had a history of PTB treatment and 11 (4.2%) reported a history of contact with TB patients at home before their imprisonment. Nearly three-fourths of study participants, 190 (73.4%) had a history of sharing a cell with coughing patients, whereas 66 (25.5%) study participants reported that they shared a cell with TB patients. More than half (159 [61.4%]) of prisoners stayed more than 12 months in the current prison and 58 (22.4%) study participants had a previous history of incarceration in other prisons (Table 4).

Knowledge of study participants' tuberculosis

Regarding knowledge of study participants' tuberculosis showed that most study participants 239 (92.3%) reported that they did not know about the causes of TB and 170 (65.6%) prisoners did not know the mode of transmission of the disease from infected persons to others. More than half (147 [56.8%]) of study participants reported that they did not know the signs and symptoms of the disease, and 85 (32%) study prisoners did not know that TB can be treated. Only 45 (17.4%) study prisoners know that TB can be treated free of charge. Of the study participants, only 90 (34.7%) reported that they know of any danger if TB disease is not treated. In total, 85 (32.8%) study prisoners did not know of any problem when treatment of TB was interrupted and only 59 (22.8%) study participants had knowledge of TB transmission (Table 4).

Discussion

The prevalence of PTB detected among Shashemene and Dodola prisoners in this study was 5.4% (95% CI [2.7, 8.5]) of undiagnosed PTB cases. This finding is lower than the study conducted in North Gondar zone prison, 10.4% [11] in Gamo Gofa zone prison, 19.4% [7] in Wallega zonal prisons, 15.4% [12], in Cameroonian prison, 9.4% [13] in Brazilian prisons, 27% [14] in a study conducted in a Russia prison 38% [15]. The low prevalence of TB in our study setting might be due to the study methodology in which only Xpert MTB/RIF assay was done

Table 3
Clinical history of study participant in West Arsi zonal prisons, Shashemene and Dodola, Oromia, Ethiopia, 2021(N = 259).

Variables	Categories	Frequency	Percent (%)
Cough duration	2-4 weeks	243	93.8
	>4 weeks	16	6.2
Cough occurrence	Before imprisonment	16	6.2
	After imprisonment	243	93.8
Fever in the past	Yes	253	97
	No	6	3
Night sweat	Yes	248	95.8
	No	11	4.2
Weight loss	Yes	210	81.1
	No	49	18.9
Bloody sputum	Yes	7	2.7
	No	252	97.3
Chest pain	Yes	128	49.4
	No	131	50.6
Loss of appetite	Yes	219	84.62
	No	40	15.4
Feeling tired	Yes	225	86.9
	No	34	13.1
Difficulty in breathing	Yes	83	32
	No	176	68

Table 4
Knowledge and prison-related factors of study participants in West Arsi zonal prisons, Shashemene and Dodola, Oromia, Ethiopia, 2021 (N = 259).

Variables	Categories	Frequency	Percent (%)
TB treatment history	Yes	25	9.7
	No	234	90.3
Home contact with TB patient	Yes	12	4.6
	No	247	95.4
Sharing cell with TB patient	Yes	66	25.5
	No	193	74.5
Sharing cell with coughing patient	Yes	190	73.4
	No	69	26.6
Previous imprisonment in another prison	Yes	58	22.4
	No	201	77.6
Food support from family	Yes	117	45.2
	No	142	54.8
Length of stay in prison	≤12 months	100	38.6
	>12 months	159	61.4
Know the causes of TB	Yes	20	7.7
	No	239	92.3
Know TB transmission mode	Yes	89	34.4
	No	170	65.6
Know signs and symptoms of TB	Yes	112	43.2
	No	147	56.8
Know TB can be treated	Yes	174	67.2
	No	85	32.8
TB, tuberculosis. TB treatment free of charge	Yes	45	17.4
	No	214	82.6
Know any danger if TB not treated	Yes	169	65.3
	No	90	34.7
Know of any problem if TB treatment is interrupted	Yes	174	67.2
	No	85	32.8
Know the means of TB prevention	Yes	59	22.8
	No	200	77.2

in our study while the gold standard culture and cytology testing was included in another study setting. In all study participants, 1 week of cough duration was included in the study, whereas, in our study, cough duration ≥2 weeks was included. Other possible reasons may be due to the study area and study period because the prevalence of TB decreased in the general population in the past few years in Ethiopia [2] and our study was done many years later after many efforts to control TB have been done. The possible reason for this might be also due to different study settings, and different study populations, and might be due to the high prevalence of TB in the general population in these countries when compared with Ethiopia [2]. Another possible explanation for this may be due to a better TB-control strategy in Ethiopia than in these countries [2] and our study was done during COVID-19 periods when overcrowding was decreased, health education was given frequently for prisoners, and all prisoners and other staff were wearing masks for COVID-19 protection which may decrease TB transmission in the prison setting (Table 5).

Our study findings showed a high prevalence of TB when compared with a study conducted in a Malawi prison (0.7%) [16], and a study conducted in Ugandan prisons (2.3%) [17]. The possible explanation for this may be due to better TB-control strategy in the prison setting of these countries than in Ethiopia. Another reason for this may be due to the low TB prevalence in the general population in those countries than Ethiopians.

Table 5
Multivariable binary logistic regression analysis of study participants in West Arsi zonal prisons, Shashemene, and Dodola, Oromia, Ethiopia, 2021 (N = 259).

Variables	Categories	PTB positive (N = 14)	PTB negative (n = 245)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)	*P*-value
Age	≤ 30	3(1.16)	157(60.6	1	1	
	> 30	11(4.3)	88(33.9)	**0.043(006,0.34)**	**0.087(0.01,0.93)**	**0.04**[a]
Body mass index	< 18.5 kg/m^2	12(4.6)	77(29.7)	**0.76(0.02,0.35)**	**0.143(0.03,0.79)**	**0.026**[a]
	≥ 18.5 kg/m^2	2(0.77)	168(64.8)	1	1	
Cigarette smoking	Yes	10(3.9)	21(8.1)	**0.038(0.01,0.13)**	**0.064(0.02, 0.26)**	**0.015**[a]
	No	4(1.5)	224(86.4)			
Diabetic mellitus	Yes	4(1.5)	4(1.5)	0.014(0.09,0.19)	0.039(0.045, 3.5)	0.403
	No	10(3.86)	241(93.1)	1		
Cough duration	2-4 weeks	6(2.31)	237(91.5)	1	1	
	>4 weeks	8(3.0)	8(3.0)	**39(11.1,141)**	**0.03(0.1,0.13)**	**0.001**[a]
Time of cough	Before prison	8(3.0)	8(3.0)	**0.03(0.01,0.09)**	**62(3.6,1059)**	**0.004**[a]
occurrence	After prison	6(2.31)	237(91.5)	1	1	
Chest pain	Yes	11(4.2)	116(44.78)	0.25(0.0,0.91)	0.41(0.1,1.7)	0.214
	No	3(1.16)	128(49.2)	1	1	
Previous TB history	Yes	5(1.93)	20(7.72)	0.16(0.5,0.5)	1.06(0.21,5.4)	0.094
	No	9(3.47)	225(86.9)	1	1	
Prison frequency	Once	5(1.93)	194(74.9)	1	1	
	more than once	9(3.47)	51(19.7)	6.85(2.2,21.32)	3.50(1, 12)	0.070

[a] *P* <0.05CI, confidence interval; PTB, pulmonary tuberculosis; 1, Reference.

The current study finding is comparable with the result of a PTB with a study done in the East Gojam zone prison (4.3%) [8], and in the North Gondar zone prison (5.3%) [18]. The similarity might be due to similar study methodology used for screening, and diagnostic methods, and also may be due to similar TB-control strategies within these prison settings in Ethiopia.

The prevalence of drug-resistant TB observed in this study was one (0.38%) of mono-resistance for INH which is lower than the Democratic Republic of Congo prison (8.5%) [5], and Russia prison (38%) [15]. The reason for the difference might be due to study methods in which culture was not used in our study finding whereas culture was used for diagnosis in other studies. Another explanation, for this reason, may be due to the high prevalence rate of MDR-TB in these countries when compared with Ethiopia [2].

Our study found comparable drug-resistance TB with a study conducted in the East Gojam zone prison [8] which detected one (0.4%) MDR-TB, and in the Benshangul Gumuz region in which one MDR-TB was detected [19], and a study done in Hawassa prison in which one MDR-TB was detected [20]. The possible reason might be due to study methods and similar distribution of MDR-TB in Ethiopian communities.

This study showed that age was a significant risk factor for PTB. This study finding showed that prisoners who were <30 years of age were 11 times more protected from TB infection when compared to those prisoners >30 years old. Another study, conducted in a Malaysian prison, also reported that prisoners of older age were at significantly higher risk when compared with younger age groups [21]. The reason for this finding might be due to an age-related decline of immunity and a higher chance of exposure of older age to TB infection. However, another study conducted in an Ethiopian prison [22] reported that prisoners of younger age were more likely affected by PTB when compared with the older group, which contradicted our study findings.

Although smoking cigarettes was forbidden in prison settings, those who were active smokers before their imprisonment have a significant association with PTB disease in this study finding. Another similar study, conducted in Gamo Gofa zone prison [7] also revealed that smokers were more affected with PTB disease when compared with non-smokers. The possible reason for this might be due to lungs damaged by smoking and reduced body immune function systems, making smokers more susceptible to TB infection.

BMI status was also significantly associated with PTB infection in this study finding. Similar study findings were reported in Wolaita Zone prison [23], in Gamo Gofa zone prison [7], and a study conducted in the Benshangul Gumuz region [19] that showed that BMI <18.5 kg/m^2 was a significant factor in TB infection. The possible explanation for this might be due to a low immune system which leads to the activation of latent TB infection to active TB or it may be due to re-infection of the disease due to lack of micro and macro-nutrients on cell-mediated immunity [24].

The cough duration of study participants had a significant association with PTB infection in our study finding which was in line with studies reported in Gamo Gofa zone prison [7] and the study conducted in Hawassa prison [20,25]. Prisoners who had a higher cough duration for more than 4 weeks had a higher risk of PTB infection when compared with those who had 2-4 weeks of cough duration. This might be due to a decrease in the body's immune system and reactivation of latent TB into active TB disease.

In this study finding, the time of occurrence of cough before imprisonment showed a significant association with PTB positivity which was similar to a study conducted in Bangladesh [25] which showed that many prisoners developed TB within a short period of their imprisonment. The possible reason for significance might be due to most of the prisoners coming from marginalized risk groups before their imprisonment, hence, they may already infected with the disease or due to additional risk factors in the prison setting for the progression of latent TB to active TB infection among prisoners who have cough before imprisonment when compared with those who have no any cough before their imprisonment.

Strengths and limitations of the study

This study depended only on Xpert MTB/RIF assay for screening sputum samples, and gold standard culture diagnosis and other screening methods such as x-ray findings were not included in this study.

Conclusion

The prevalence of undiagnosed PTB and mono-drug resistance TB was higher in West Arsi zonal prisons than in the general population. Age, cigarette smoking, BMI ≤18.5 kg/m^2, cough duration ≥2 weeks, and time of occurrence of cough before imprisonment were statistically significant factors to PTB positivity in this study finding.

Declarations of Competing Interest

The authors have no competing interests to declare.

Funding

No funding was received for this study.

Ethical approval

The study was started after ethical clearance was obtained from the Institutional Review Board of Hawassa University under the reference number of Ref. No HU/CMHS/IRB/0146/2020 was signed by a chairperson on September 17/2020. Official letters of permission were obtained from the College of Medicine and Health Science, through the School of Medical Laboratory Science. Then written permissions were also obtained from the West Arsi zonal health bureau and prison administration to conduct the actual research.

Acknowledgments

We would like to thank Hawassa University, School of Medical Laboratory, West Arsi zonal prisons staff authorities, Melka Oda General Hospital, Shashemene Referral Hospital, Shashemene, and Adama Regional Laboratory staff for their support and active participation in conducting this research.

Author contributions

GH: laboratory work, data collection, data analysis, writing the original draft. GM: supervision, data analysis, writing the original draft. DD: conception and design of the study, supervision, data analysis, manuscript preparation and review. All authors read and approved the manuscript.

Data sharing

All empirical data used in this study are made either publicly available or are available from the public domain.

Consent for publication

Not applicable.

References

[1] World Health Organization *WHO global tuberculosis report*. Geneva: World Health Organization; 2020.
[2] World Health Organization *Tuberculosis report*. Geneva: World Health Organization; 2019.
[3] Dara DC, Grzemska M, Kimerling ME, Reyes H, Zagorskiy A. *Guidelines for control of tuberculosis in prisons*. Cambridge: United States Agency for International Development; 2009.
[4] Biadglegne F, Rodloff AC, Sack U. Review of the prevalence and drug resistance of tuberculosis in prisons: a hidden epidemic. *Epidemiol Infect* 2015;**143**:887–900. doi:10.1017/S095026881400288X.
[5] Kayomo MK, Hasker E, Aloni M, Nkuku L, Kazadi M, Kabengele T, et al. Outbreak of tuberculosis and multidrug-resistant tuberculosis, Mbuji-Mayi Central Prison, Democratic Republic of the Congo. *Emerg Infect Dis* 2018;**24**:2029–35. doi:10.3201/eid2411.180769.
[6] Ali S, Haileamlak A, Wieser A, Pritsch M, Heinrich N, Loscher T, et al. Prevalence of pulmonary tuberculosis among Prison Inmates in Ethiopia, a cross-sectional study. *PloS One* 2015;**10**:e0144040. doi:10.1371/journal.pone.0144040.
[7] Zerdo Z, Medhin G, Worku A, Ameni G. Prevalence of pulmonary tuberculosis and associated risk factors in prisons of Gamo Goffa Zone, south Ethiopia: a cross-sectional study. *Am J Health Res* 2014;**2**:291–7. doi:10.11648/j.ajhr.20140205.21.
[8] Beza MG, Hunegnaw E, Tiruneh M. Prevalence and associated factors of tuberculosis in prisons settings of East Gojjam zone, Northwest Ethiopia. *Int J Bacteriol* 2017;**2017** Article ID3826980.
[9] Curry International Tuberculosis Center *Tuberculosis Contact Investigation in Jail: A Facilitator Guide*. San Francisco: Curry International Tuberculosis Center; 2008.
[10] World Health Organization *Nutrition Landscape Information System (NLiS) country profile indicators: interpretation guide*. Geneva: World Health Organization; 2010.
[11] Moges B, Amare B, Asfaw F, Tesfaye W, Tiruneh M, Belyhun Y, et al. Prevalence of smear positive pulmonary tuberculosis among prisoners in North Gondar Zone Prison, northwest Ethiopia. *BMC Infect Dis* 2012;**12**. doi:10.1186/1471-2334-12-352.
[12] Dibissa KE, Waktole ZD, Tolessa BE. Prevalence of pulmonary tuberculosis and associated factors among prisoners in Western Oromia, Ethiopia: a cross-sectional study. *bioRxiv* 09 December 2019. https://www.biorxiv.org/content/10.1101/869727v1 [accessed 20 July 2021].
[13] Noeske J, Ndi N, Amougou Elo G, Mfondih SM. Tuberculosis incidence in Cameroonian prisons: a 1-year prospective study. *S Afr Med J* 2014;**104**:209–11. doi:10.7196/samj.7384.
[14] Valenca MS, Scaini JLR, Abileira FS, Goncalves CV, von Groll A, Silva PE. Prevalence of tuberculosis in prisons: risk factors and molecular epidemiology. *Int J Tuberc Lung Dis* 2015;**19**:1182–7. doi:10.5588/ijtld.15.0126.
[15] Ruddy M, Balabanova Y, Graham C, Fedorin I, Malomanova N, Elisarova E, et al. Rates of drug resistance and risk factor analysis in civilian and prison patients with tuberculosis in Samara Region, Russia. *Thorax* 2005;**60**:130–5. doi:10.1136/thx.2004.026922.
[16] Kanyerere HS, Banda RP, Gausi F, Salaniponi FM, Harries AD, Mpunga J, et al. Surveillance of tuberculosis in Malawian prisons. *Public Health Action* 2012;**2**:10–14. doi:10.5588/pha.11.0022.
[17] Karamagi SS, Muhire M, Kisamba H, Byabagambi J, Rahimzai M, Mugabe F, et al. Improving TB case notification in northern Uganda: evidence of a quality improvement-guided active case finding intervention. *BMC Health Services* 2018;**8**:954. doi:10.1186/s12913-018-3786-2.
[18] Gebrecherkos T, Gelaw B, Tessema B. Smear positive pulmonary tuberculosis and HIV co-infection in prison settings of North Gondar Zone, Northwest Ethiopia. *BMC Public Health* 2016;**16**:1091. doi:10.1186/s12889-016-3761-y.
[19] Agajie M, Disassa H, Birhanu M, Amante M. Prevalence of pulmonary tuberculosis and associated factors in prisons of BenishangulGumuz region. *Western Ethiopia Int J Soc Relevance Concern* 2018;**6**:34–41.
[20] Merid YW, Woldeamanuel Y, Abebe M, Datiko DG, Hailu T, Habtamu G, et al. High utility of active tuberculosis case finding in an Ethiopian Prison. *Int J Tuberc Lung Dis* 2018;**22**:524–9. doi:10.5588/ijtld.17.0635.
[21] Al-Darraji A, Altice FL, Kamarulzaman A. Undiagnosed pulmonary tuberculosis among prisoners in Malaysia: an overlooked risk for tuberculosis in the community. *Trop Med Int Health* 2016;**21**:1049–58. doi:10.1111/tmi.12726.
[22] Abebe DS, Bjune G, Ameni G, Biffa D, Abebe F. Prevalence and associated risk factors of pulmonary tuberculosis among prisoners in Eastern Ethiopian prisons. *Int J Tuberc Lung Dis* 2011;**15**:668–73. doi:10.5588/ijtld.10.0363.
[23] Begashaw ABM, Legesse T. Prevalence of pulmonary tuberculosis and associated factors among prisoners in Wolaita zone, Southern Ethiopia: cross-sectional study. *Am J Public Health Res* 2016;**4**:142–8.
[24] O'Gradya J, Hoelscherc M, Atund R, Matthew B, Mwabab P, Kapatag N, et al. Tuberculosis in prisons in sub-Saharan Africa–the need for improved health services, surveillance and control. *Tuberculosis (Edinb)* 2011;**91**:173–8. doi:10.1016/j.tube.2010.12.002.
[25] Melchers NVSV, van Elsland SL, Lange JMA, Borgdorff MW, van den Hombergh J. State of affairs of tuberculosis in prison facilities: a systematic review of screening practices and recommendations for best TB control. *PLoS One* 2013;**8**:e53644. doi:10.1371/journal.pone.0053644.