

Original Research Article

Determinants of tuberculosis in central region of Eritrea: a matched case-control study

Filmon G. Mebrahtu¹, Meron M. Ghezze², Eden H. Belew³, Daniel N. Berhe⁴,
Eyasu H. Tesfmaria⁵, Tesfit N. Berhane⁵, Kiflu T. Sengal⁵, Henok G. Woldu⁶,
Habtemichael M. Teklemariam^{7*}

¹Integrated Diseases Surveillance and Response (IDSR), Ministry of Health, Asmara, Eritrea

²Barentu Zonal Referral Hospital, Ministry of Health, Asmara, Eritrea

³Northern Red Sea, Health Promotion Unit, Ministry of Health, Asmara, Eritrea

⁴Dekemhare District Officer, Ministry of Health, Asmara, Eritrea

⁵Orotta College of Medicine and Health Sciences, Department of Community Medicine and Primary Health Care, Asmara Eritrea

⁶The Center for Health Analytics for National and Global Equity (CHANGE), Columbia, MO, USA

⁷Tesseney Hospital, Ministry of Health, Asmara, Eritrea

Received: 13 March 2023

Revised: 21 April 2023

Accepted: 02 May 2023

*Correspondence:

Dr. Habtemichael M. Teklemariam,

E-mail: habtshfortruth@gmail.com

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Background: The WHO has recommended the need for holistic approach towards TB, including addressing the underlying socio-economic determinants in conjunction with direct observed treatment short-course (DOTS). However, there is lack of epidemiological data in Eritrea regarding factors that are associated with TB and this study aimed to assess such factors.

Methods: A matched case-control study was used to assess factors that are associated with TB in the Central Region of Eritrea. A structured questionnaire was used to collect data about socio-demographic characteristics, living status, housing conditions, and medical history of the study participants. All TB patients in the eight DOTS treatment centers and two age-and-sex-matched controls for each case were included. Bivariate and multivariable conditional logistic regression models were used to identify the main risk factors of TB.

Results: The study recruited 67 cases and 134 controls. Bivariate analyses indicated that BCG vaccination scar, past alcohol drinking habit, history of hospital admission, previous history of TB, and family history of TB were found to be factors associated with TB. Moreover, results of multivariable analysis showed that, absence of BCG vaccination scar, family history of TB, past drinking habit, and history of hospital admission were found to be factors associated with TB among the study participants.

Conclusions: This is the first study in the Central Region of Eritrea that assessed the determinant of tuberculosis. Absence of BCG vaccination scar, family history of TB, past alcohol consumption and history of hospital admission were found to be independent risk factors for TB.

Keywords: Eritrea, Tuberculosis, Case-control, Socio-economic, End TB

INTRODUCTION

According to the WHO estimates, the global incidence rate of TB in 2018 was 132 per 100,000 population. TB is

a preventable and treatable disease that infected 10 million people and caused the death of 1.2 million people in 2018.¹ Even though the incidence and mortality of TB have been decreasing successively since 2000 by about

1.6% per annum, still a significant challenge remains in the fight against the disease.¹ *Mycobacterium tuberculosis*, the main causative agent of TB is a necessary, but not a sufficient cause of TB.² Several factors affect the risk of exposure, progression to active tuberculosis, and then cure.³

The main strategies employed by WHO to combat TB were ensuring equitable delivery of quality assured technologies for the appropriate diagnosis and treatment of TB. However, preventive efforts were less considered in this approach and their combination with curative efforts to address determinants of TB was given less emphasis.⁴ As TB is declining at a slow rate failing to meet the goals set by the End TB strategy (4-5% reduction in incidences per annum till 2020), there is a need for a renewed interest in finding new TB control strategies.^{1,5} There is increasing evidence that factors such as the social, economic, and political conditions in which people are born, grow, live and work are prominent in TB epidemiology.⁶⁻⁸ Structural determinants such as global socio-economic inequalities, high population mobility, and rapid urbanization influence key social determinants of TB such as malnutrition, food insecurity, poor environmental conditions, financial, cultural, and geographical factors. These social determinants can in turn affect the four stages of TB pathogenesis: exposure to infection, progression to disease, diagnosis and treatment, as well as adherence and success.⁶

Currently, it is estimated that latent TB has infected about 1.7 billion individuals worldwide with a 5-10% lifetime risk of progression to an active TB.^{9,10} Understanding how some people develop TB while others don't, has the potential to refocus the search for new public health control strategies.⁵ Therefore, WHO has recommended a holistic approach for the control and elimination of TB, including addressing the underlying socio-economic determinants of TB, in conjunction with the DOTS strategy.³

In recent years, Eritrea has recorded significant success in achieving the health-related millennium development goals and improving the life expectancy of its population. Nonetheless, there is a huge burden of tuberculosis that needs to be addressed. Both incidence rate and mortality rate of TB increased from 67/100,00 in 2017 to 89/100,000 and from 12/100,000 in 2017 to 17/100,000 in 2018, respectively.^{1,11} The notification rate, however, has been declining in the six regions of Eritrea at an average rate of 6.1% per year for the preceding 13 years according to the annual WHO report released in 2020.¹² This indicates more cases that are not identified and shows the enormity of the problem.

With the slow decline of TB incidence worldwide, there is a need to re-examine the characteristics of patients and a more reasonable understanding of the risk factors, to adjust and adapt TB control policies.⁵ To the best knowledge of the researchers, there has not been any

research in Eritrea that assessed the determinants of TB. Therefore, the objective of this study is to assess the determinants of TB in the most densely populated region, the central region of Eritrea.

METHODS

The study was done in the Central Region of Eritrea - in a matched case-control design. The population is estimated to be around 600,000 and the majority of the population resides in the capital city, Asmara. The regional branch of the ministry of health is the main body tasked to oversee the population health and DOTS treatment centers are the main body that renders TB care, control, and prevention activities. All TB patients are taken care of by the public health system which covers their diagnosis and treatment free of charge. This study was conducted in eight DOTS treatment centers in the Central Region of Eritrea between October and December 2019. One DOTS center was excluded from the study as there were no TB patients during the study period. All TB patients who were above 15 years of age and on follow-up for TB treatment for at least 2 weeks in the DOTS centers were included in the study as cases. For each case, two sex and age (within 10 years' band) matched controls were included in the study. A wide age range was used as there were difficulties in finding suitable controls during the study period. Controls were drawn from the attendees of the health facilities for non-TB health problems. Controls with symptoms suggestive of TB were excluded from the study.

A questionnaire was developed by conducting an intensive literature search to identify relevant variables. After discussion with key experts (epidemiologists, biostatisticians, and TB Control program personnel) and amendments to the questionnaire, it was piloted to 20 study subjects (10 cases and 10 controls) in the Southern Region referral hospital to assess its relevance, accuracy in measuring the intended variables. Final amendments were made to the questionnaire by further discussion with key experts. The questionnaire included sections about demographic, living conditions, housing characteristics, behavioral risk factors, past and present medical history, and wealth quintile index. Data captured in the questionnaire was entered into cspro 7.2 (CSpro). Data was analyzed using STATA version 14 statistical software (Window stata inc.). In step one, descriptive statistics was used to describe demographics, living conditions, behavioral risk factors, and medical history. Pearson chi-square test was used to compare the relationship among factors and the respondent's group (case and controls). In step two, bivariate conditional logistic regression was used to assess the association of each covariate with the outcome variable of interest. Finally, a multivariable conditional logistic regression was used to determine the main risk factors for the occurrence of TB in the Central region of Eritrea. Odds ratios (ORs) and the associated 95% confidence intervals (CIs) were extracted from each fitted logistic regression model. Multi-collinearity was checked and variables with

VIF values greater than 5 were excluded from further analysis. A two-sided alpha level of 0.05 was used for all tests to determine statistical significance.

To create the wealth quintile index, firstly variables with frequencies between 5% and 95% were dichotomized. Principal component analysis was conducted on 26 items with orthogonal rotation (Varimax). The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO=0.724, and all KMO values for individual items were >0.5. Bartlett's test of sphericity $X^2(351)=1895.4$, <0.001, indicated the correlation between items was sufficiently large for PCA. An initial analysis was run to obtain eigenvalues for each component in the data. Ten components had eigenvalues over Kaiser criterion of 1 and in combination explained 65.15% of the variance. The wealth quantile index was created by using the first component to generate 5 groups.

Matching during case-control studies is a common practice done for reasons like improving precision and controlling unquantifiable factors that may interfere with the results.¹³ This will improve the efficiency of the result as confounders in the study will be controlled. However, there are two misconceptions about the case-control study: i.e. matching itself eliminates confounders by the matching variables and that a matched analysis is warranted for a matched case-control study. Pearce argued that matching introduces confounding by matching factors in the case and control, even when it did not exist in the source population. To control such occurrences, he suggested that matching variables should be controlled for during analysis in the matched case-control study. We followed such guidelines in this study and included the matching variables, age, and sex during in analysis.¹⁴

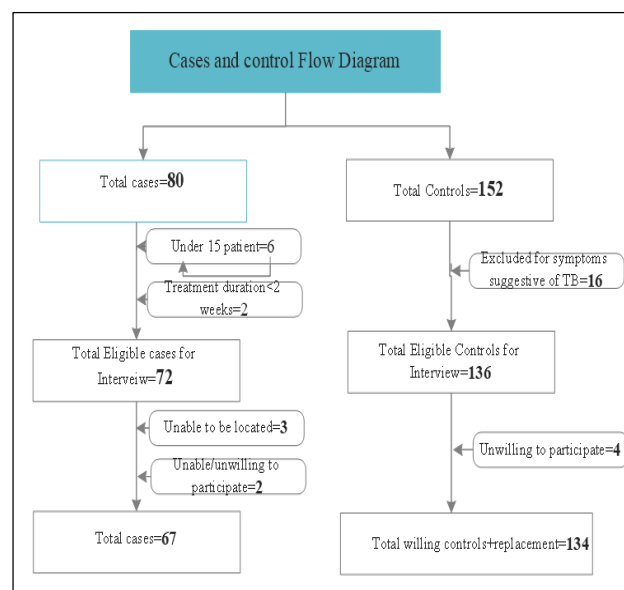


Figure 1: Flow chart of cases and controls.

RESULTS

Of the 80 total TB cases in 7 DOTS treatment centers, 8 were excluded as per the eligibility criteria. A total of 72 patients were eligible for interview of which 3 were unable to be located and 2 were either unwilling or unable to finish the interview yielding a total case count of 67. For the controls, 152 controls were present at the time of the study of which 16 were excluded for having symptoms suggestive of TB; of the 136 eligible controls 4 refused to participate, and as such 2 replacements were made. A total of 134 controls each matched by sex and age to a respective case were included in the study.

Table 1: Socio-demographic characteristics of study participants.

Variables	Cases (n=67)	Controls (n=134)	P value
	N (%)	N (%)	
Sex			0.993
Female	39 (58.2)	78 (58.2)	
Male	28 (41.8)	56 (41.8)	
Age (in years)			0.635
15-25	9 (13.4)	25 (18.7)	
26-45	27 (40.3)	49 (36.6)	
>45	31 (46.3)	60 (44.8)	
Marital status			0.029*
Married	35 (52.2)	91 (67.9)	
Single	19 (28.4)	33 (24.6)	
Widowed	6 (9.0)	7 (5.2)	
Divorced	7 (10.4)	3 (2.2)	
Education			0.269
No education	13 (20.4)	18 (13.4)	
Elementary (1-5)	5 (7.5)	12 (9.0)	
Middle (6-8)	14 (20.9)	17 (12.7)	
Secondary (9-12)	27 (40.3)	66 (49.3)	
Post-secondary	8 (11.9)	21 (15.7)	

Continued.

Variables	Cases (n=67)	Controls (n=134)	P value
Occupation			0.484
Employed	33 (49.2)	73 (54.4)	
Unemployed	34 (50.7)	61 (45.5)	
Wealth quantile index			0.530
Lowest	16 (23.9)	24 (17.9)	
Second	15 (22.4)	25 (18.7)	
Middle	15 (22.4)	26 (19.4)	
High	10 (14.9)	30 (22.4)	
Highest	11 (16.5)	29 (21.6)	

*(P<0.05), **(P<0.01), *** (P<0.001)

Table 2: Living conditions of study participants.

Variables	Cases (n=67)	Controls (n=134)	P value
	N (%)	N (%)	
Family size			0.544
1 to 3	36 (53.7)	58 (43.3)	
4 to 6	19 (28.4)	52 (38.8)	
Above 6	12 (17.9)	24 (17.9)	
Congregated setting			0.750
Yes	21 (31.3)	43 (32.1)	
No	46 (68.7)	91 (67.9)	
History of imprisonment			0.087
Yes	16 (23.9)	12 (9.0)	
No	51 (76.1)	122 (91.0)	
Family history of TB			0.008**
Yes	12 (17.9)	8 (6)	
No	55 (82.1)	126 (94)	

*(P<0.05), **(P<0.01), *** (P<0.001)

Table 3: Personal lifestyle of study participants.

Variables	Cases (n=67)	Controls (n=134)	P value
	N (%)	N (%)	
Smoking history			0.435
No	53 (79.1)	112 (83.6)	
Yes	14 (20.9)	22 (16.4)	
Current smokers			0.610
No	65 (97.0)	128 (95.5)	
Yes	2 (3.0)	6 (4.5)	
Smokeless tobacco			0.469
No	63 (94)	129 (96.3)	
Yes	4 (6.0)	5 (3.7)	
Past drinking habit			0.000***
No	43 (64.2)	121 (90.3)	
Yes	24 (35.8)	13 (9.7)	

*(P<0.05), **(P<0.01), *** (P<0.001)

Table 4: Past medical history of study population.

Variables	Cases (n=67)	Controls (n=134)	P value
	N (%)	N (%)	
Previous TB history			0.001***
No	55 (82.1)	129 (96.3)	
Yes	12 (17.9)	5 (3.7)	

Continued.

Variables	Cases (n=67)	Controls (n=134)	P value
Chronic illness comorbidity			0.991
No	54 (80.6)	108 (80.6)	
Yes	13 (19.4)	26 (19.4)	
BCG vaccination scar			0.003**
No	39 (58.2)	48 (35.8)	
Yes	28 (41.8)	86 (64.2)	
History of health facility visit			0.373
No	52 (77.6)	111 (82.8)	
Yes	15 (22.4)	23 (17.2)	
History of hospital admission			0.000***
No	32 (47.8)	106 (79.1)	
Yes	35 (52.2)	28 (20.9)	

*(P<0.05), **(P<0.01), ***(P<0.001)

Table 5: Bivariate and multivariable analysis of risk factors among TB patients and controls, in the Central region of Eritrea.

Variable	Category	cOR (95% CI)	aOR (95% CI)
Age			1.13 (0.88-1.43)
Family history of TB	Yes	3.56 (1.32-9.60) **	5.75 (1.28-25.76)
	No	1	1
Family size	>6	0.53 (0.22-1.25)	
	4-6	0.76 (0.37-1.56)	
	1-3	1	
Congregated setting	Yes	0.89 (0.46-1.73)	
	No	1	
Past drinking habit	Yes	5.23 (2.32-11.78) ***	7.06 (2.4-20.54) **
	No	1	1
History of smoking	Yes	1.50 (0.62-3.63)	
	No	1	
Passive smoking	Yes	2.25 (1.06-4.75) *	3.25 (1.00-9.60)
	No	1	1
Previous TB diseases	Yes	4.80 (1.69-13.62) **	1.88 (0.50-7.02)
	No	1	1
BCG scar	Yes	0.37 (0.19-0.71) *	0.28 (0.11-0.67) **
	No	1	1
History of hospital admission	Yes	3.85 (2.00-7.41) **	4.20 (1.87-9.46) **
	No	1	1
History of imprisonment	Yes	1.89 (0.9-3.96)	
	No	1	
Having chronic illness	Yes	1.00 (0.44-2.20)	
	No	1	
Having visited a health facility	Yes	0.72 (0.35-1.49)	
	No	1	
Educational status	Illiterate	2.73 (0.78-9.49)	
	Literate	1	
Occupation	Unemployed	1.46 (0.66-3.21)	
	Employed	1	
Wealth quantile index	Lowest	1.67 (0.68-4.11)	
	Second	1.58 (0.59-4.25)	
	Middle	1.45 (0.57-3.64)	
	Fourth	0.86 (0.47-3.32)	
	Highest	1	

Note: R²=0.291 and *(P<0.05), **(P<0.01), *** (P<0.001) Results matched for Age and Sex

Socio-demographic characteristics

A total of 67 cases and 134 controls participated in the study. Females were 58.2% of the study participants. Regarding marital status, 52.2% of cases and two third of controls (67.9%) were married, while 28.4% of cases and 24.6% of controls were single. Secondary school education was cited in most of the cases (40.3%) and controls (49.3). Those who were unemployed represented 50.7% of cases and 45.5% of the control. More than two third of the cases (68.7%) were in the middle or below wealth index, while in the control 56% were in the middle or below wealth index quantiles. (Table 1).

Living condition

Living in a family of 4 to 6 people was cited by 28.4% of cases and 38.8% of controls. Similar proportions of cases and controls have lived in congregated settings, i.e. 31.3% of cases versus 32.1% of controls. Almost one-fifth of cases had a history of imprisonment while only 9% of controls stated that they have been imprisoned before. Almost threefold of the cases (17.9%) had a family history of TB as of the controls (6%) (Table 2).

Personal lifestyles

Only 20.9% of the cases and 16.4% of controls replied positively when they were asked if they have ever smoked cigarettes. The proportion of current smokers was 3% in cases and 4.5% in controls. Past alcohol consumption was cited in 35.8% of cases and 9.7% of controls. Smokeless tobacco was consumed by 6% of cases and 3.7% of controls (Table 3).

Past medical history

History of TB diagnosis was almost five folds more among the cases compared to the controls (17.9% versus 3.7%). However, an equal proportion of cases and controls (19.4%) stated that they have a comorbid chronic illness. Two fifth (41.8%) of cases and 64.2% of controls had a BCG vaccination scar on their deltoid. A similar proportion of health facility visits was reported by cases and controls i.e. 77.6% and 82.8% in cases and controls, respectively. More than half of the cases (52.2%) and one-fifth of the controls (20.9%) reported that they had been admitted to the hospital 12 months before the interview (Table 4).

Associated factors of TB

In the bivariate analysis, family history of TB, past alcohol consumption, previous TB disease, absence of BCG vaccination scar, and history of hospital admission were found to be significantly associated with the presence of TB. While history of imprisonment, history of smoking, employment status, educational status, wealth quintile index, having a chronic illness, and having visited a health facility did not show significant

association with TB. Variables that were found to be significant in the bivariate conditional logistic regression were entered into multivariable conditional logistic regression. The matching variables age and sex were also included in the multivariable analysis to control confounding. Past drinking habit was significantly associated with the occurrence of TB (aOR=7.06, CI:2.4-20.54, $p<0.001$). Participants with a history of hospital admission had 4.20 times the odds of being infected with TB compared with those with no history of hospital admission (aOR=4.20, CI:1.87-9.46, $p<0.001$). Having a family history of TB was also an independent risk factor (aOR=5.75, CI:1.28-25.76, $p<0.05$). Having a BCG vaccination scar was identified as a protective factor against TB, as there was 72% less probability of being affected by TB for those who were vaccinated for BCG (aOR=0.28, CI:0.11-0.67, $p<0.05$) (Table 5).

DISCUSSION

There is a high burden of tuberculosis in many countries which may be attributed to demographics and socio-economic profiles like poverty, lack of knowledge, overcrowding, malnutrition, co-morbidity, etc.⁴ Adequate information on factors that contribute to the transmission of tuberculosis helps formulate national TB control policies.⁴ There is a paucity of information on factors contributing to TB in Eritrea. Also, as no single factor is fully attributable to the emergence of TB, this study has tried to assess the factors that are associated with the occurrence of TB in the Central Region of Eritrea. A total of 201 patients participated in this matched case control study.

The result of this study indicates that factors such as a history of alcohol consumption, BCG vaccination, history of hospital admission, previous history of TB, and having a family member infected with TB were found to be associated with the TB. Concurrently, these factors could be attributed to many factors including quality of health system, socio-economic profile, population background characteristics, study setting, sample size, and differences in knowledge, attitude, and practice regarding TB.

Subjects who used to be alcohol consumers had seven times more odds of developing TB when compared to those who were not. A congruent finding was reported by studies in West Africa and Ethiopia in which former alcohol consumers have had an elevated odd of contracting TB.^{4,15} A recent meta-analysis indicated that consuming more than 40 g of alcohol per day results in a nearly three folds increase in the risk of TB.¹⁶ Alcohol significantly hinders anti-mycobacterial defenses by suppressing mobilization, adherence, phagocytosis, and superoxide production of alveolar macrophages. Additionally, alcohol exposure may limit the response of the immune system by inhibiting the activity of macrophages, suppressing the capacity of monocytes to produce cytokines compromising the immune defense, and increasing susceptibility to TB.¹⁷⁻¹⁹ The association

between alcohol and TB is worth exploring as 39.6% of the Eritrean population is classified as heavy drinkers by the Ministry of Health.²⁰

The proportion of the study participants who smoke cigarettes is comparatively few and, therefore, an insignificant association was found between smoking and the risk of TB. However, the association between TB and smoking is well established by several studies.^{21,22} Smoking results in histological changes in the lower respiratory tract that, in turn, lead to alteration in the epithelial function such as reduced ciliary activity, decreased clearance of inhaled substances, and abnormal vascular and epithelial permeability which in effect increases the risk of developing TB.⁴ The association between smoking and TB needs further investigation as data from the MOH indicates that 7.2% of the Eritrean population is categorized to be smokers.²⁰

Being vaccinated for BCG during childhood reduces the risk of contracting TB as found by several studies.^{23,24} In this study, those who were vaccinated were 72% less likely of developing TB when compared with those who were unvaccinated. This result is corroborated by findings in Ethiopia and west Africa where 66% and 33% less probability of TB disease was recorded respectively for those who were vaccinated as compared to those unvaccinated.^{5,15} There was higher protection of BCG in Eritrea compared to those countries and the reason could be the high coverage of the BCG vaccine in Eritrea, which according to WHO report in 2020 stands at 97.1% while the BCG coverage in Ethiopia was only 79% in 2019.^{12,25} BCG coverage in Ethiopia corresponds with one of the highest rates of TB in the world at 151 (107-204) per 100,000.¹¹

More cases than controls stated that they were admitted to a hospital in the 12 months before the diagnosis of the current illness. Those with hospital admission history were found to be 4.2 times higher odds of TB when compared with those with no history of admission. Findings of studies done in Addis Ababa lend impetus to this finding as individuals with a history of admission were found to be 3.39 times more at risk of having TB than those who have never been admitted.⁴

Similarly, a study done in India found that, the incidence rate among health care workers to be 17 per 1000 people.²⁶ Diseases that compelled admission reduce the competency of the immune system, and this along with the higher risk of TB transmission in hospitals could increase the likelihood that admitted patients could contract TB while they stay there.

People with a prior diagnosis of TB have an elevated risk for reinfection with TB compared to those who had no prior TB diagnosis. For instance, a cohort study in Barcelona reported a 13 times higher incidence rate among the population with TB history compared to the general population.²⁷ In the current study, however, no

significant association was found between prior TB disease and the risk of TB.

The risk of TB increased with having a family member with TB.¹⁵ In this research, study subjects who had a history of TB among their family members were 5.75 times more likely to develop TB compared with those with no history of TB among their family members. Similar findings were also reported in Addis Ababa where a family history of TB was associated with the risk of developing TB.⁴ Similarly, in a study done in West Africa, participants with a family history of TB were 3.25 times more likely to develop TB.¹³ In a study done in the Gambia, having a household member with TB carried an odd of 7.55 of being infected by TB (aOR=7.55 (3.43-16.6) <0.0001).²⁸ Having a family member with TB increases the exposure to TB bacilli which in turn predisposes a healthy person to TB. Additionally, factors that may have predisposed the family member with TB can also increment the probability of other family members to be infected with TB.

HIV is the main driver of the TB epidemic in many countries and it is labeled as the most important risk factor in high prevalent countries of Sub-Saharan Africa.²⁹ HIV promotes the progression of latent or recent infections of TB to active disease.³⁰ It is also associated with higher mortality and unfavorable TB treatment outcomes.^{31,32}

A study conducted in three African countries showed that HIV positive were 2.14 times (CI: 1.23-3.73, P value=0.006) more exposed to TB as compared to HIV negative.¹⁵ Similarly, a study done in Gambia found HIV to pose 3.2 times higher risk for contracting TB (aOR=3.2, CI: 1.5-7.2).²⁷ However, in our study, the number of HIV-positive participants was limited yielding a total separation during multivariable analysis. Therefore, HIV was not included in the final model for the determinant of TB in this study. A study with more study participants can help to measure the exact contribution of HIV as a determinant of TB in the Central Region of Eritrea.

Limitations of the study

This study has assessed potential determinants of TB in the Central region of Eritrea using matched case-control study. This study is the first of its kind and it will help identify risk factors that are driving the dynamics of TB in Eritrea. However, due to the limited number of TB cases during the study period, the confidence interval for some variables was wide. Hence the results, even though they may elucidate the current conditions in the study area, studies with more participants are needed to unquestionably establish the risk factors identified in this study. Therefore, generalization of the study results to the whole of Eritrea should be done with caution as the factors that drive the TB epidemic in other regions could be various and disparate in each region of Eritrea.

CONCLUSION

The factors identified as the predictors of TB in the Central Region of Eritrea by this study were past alcohol consumption, family history of TB, absence of BCG scar, and history of hospital admission. Programs targeting alcohol consumption could help in reducing the occurrence of TB in the study area. Instituting strict guidelines to prevent TB infection in a health care facility would also help reduce the burden of TB in the Central Region. BCG vaccination was proven to present a protective effect against TB and as such the current coverage of the BCG vaccination program under the expanded program of immunization (EPI) should be maintained. Finally, as this study was limited in scope and design, larger studies with longitudinal research designs are needed to exactly ascertain the factors that are driving the TB in the Central Region of Eritrea.

ACKNOWLEDGEMENTS

The authors would like to thank all the study participants and health staff of the DOTS treatment centers for their invaluable contribution to this study. The authors also thank Mr. Zenawi Zeramariam Araya, Mr. Nahom Kiros, and Dr. Eyob Azaria for their support during the preparation of this manuscript.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

- World Health Organization. (2020). Global tuberculosis report 2021. Geneva: World Health Organization; 2021. License: CC BY-NC-SA 3.0 IGO; 2021.
- Houben RM, Dodd PJ. The global burden of latent tuberculosis infection: a re-estimation using mathematical modelling. *PLoS Medicine*. 2016;13(10):e1002152.
- World Health Organization. Latent tuberculosis infection: updated and consolidated guidelines for programmatic management (No. WHO/CDS/TB/2018.4). World Health Organization; 2018.
- Shimeles E, Enquselassie F, Aseffa A, Tilahun M, Mekonen A, Wondimagegn G, et al. Risk factors for tuberculosis: a case-control study in Addis Ababa, Ethiopia. *PloS One*. 2019;14(4):e0214235.
- Duarte R, Lönnroth K, Carvalho C, Lima F, Carvalho ACC, Muñoz-Torrico M, et al. Tuberculosis, social determinants and comorbidities (including HIV). *Pulmonology*. 2018;24(2):115-9.
- Jurcev-Savicevic A, Mulic R, Ban B, Kozul K, Bacun-Ivcek L, Valic J, et al. Risk factors for pulmonary tuberculosis in Croatia: a matched case-control study. *BMC Public Health*. 2013;13(1):1-8.
- Blas E, Kurup AS. (Eds.). Equity, social determinants and public health programmes. World Health Organization; 2010.
- Hargreaves JR, Boccia D, Evans CA, Adato M, Petticrew M, Porter JD. The social determinants of tuberculosis: from evidence to action. *American Journal of Public Health*. 2011;101(4):654-62.
- Lönnroth K, Castro KG, Chakaya JM, Chauhan LS, Floyd K, Glaziou P, et al. Tuberculosis control and elimination 2010-50: cure, care, and social development. *The Lancet*. 2010;375(9728):1814-29.
- Lönnroth K, Jaramillo E, Williams BG, Dye C, Raviglione M. Drivers of tuberculosis epidemics: the role of risk factors and social determinants. *Social Sci Med*. 2009;68(12):2240-6.
- World Health Organization. Global tuberculosis report 2013. World Health Organization; 2013.
- Annual Report 2020: Journey towards GPW13 Goals through achievement of UHC in Eritrea. Asmara, Eritrea: World Health Organization; 2020.
- Rothman KJ, Greenland S, Lash TL. Modern epidemiology (Vol. 3). Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins; 2008.
- Pearce N.. Analysis of matched case-control studies. *BMJ*. 2016:352.
- Lienhardt C, Fielding K, Sillah JS, Bah B, Gustafson P, Warndorff D. Investigation of the risk factors for tuberculosis: a case-control study in three countries in West Africa. *Int J Epidemiol*. 2005;34(4):914-923.
- Imtiaz S, Shield KD, Roerecke M, Samokhvalov AV, Lönnroth K, Rehm J. Alcohol consumption as a risk factor for tuberculosis: meta-analyses and burden of disease. *European Resp J*. 2017;50(1).
- Pokhrel AK, Bates MN, Verma SC, Joshi HS, Sreeramareddy CT, Smith KR. Tuberculosis and indoor biomass and kerosene use in Nepal: a case-control study. *Environmental Health Perspectives*. 2010;118(4):558-64.
- Souza de Lima D, Morishi Ogusku M, Porto dos Santos M, de Melo Silva C., Alves de Almeida V, Assumpção Antunes I. Alleles of HLA-DRB1* 04 associated with pulmonary tuberculosis in Amazon Brazilian population. *PloS One*. 2016;11(2):e0147543.
- Hsu WH, Kuo CH, Wang SS, Lu CY, Liu CJ, Chuah SK, et al. Acid suppressive agents and risk of Mycobacterium tuberculosis: case-control study. *BMC Gastroenterology*. 2014;14(1):1-7.
- Mufunda J, Ghebrat Y, Usman A, Mebrahtu G, Gebreslassie A. Underestimation of prevalence of raised blood sugar from history compared to biochemical estimation: support for the WHO rule of halves in a population based survey in Eritrea of 2009. *Springerplus*. 2015;4(1):1-5.
- Gambhir HS, Kaushik RM, Kaushik R, Sindhwani, G. Tobacco smoking-associated risk for

- tuberculosis: a case-control study. *Int Health*. 2010;2(3):216-22.
22. Basu S, Stuckler D, Bitton A, Glantz SA. Projected effects of tobacco smoking on worldwide tuberculosis control: mathematical modelling analysis. *BMJ*. 2011;343.
23. Adesokan HK, Cadmus EO, Adeyemi WB, Lawal O, Ogunlade CO, Osman E, et al. Prevalence of previously undetected tuberculosis and underlying risk factors for transmission in a prison setting in Ibadan, south-western Nigeria. *Afr J Med Med Sci*. 2014;43(Suppl 1):45.
24. Kehinde AO, Baba A, Bakare RA, Ige MO, Gbadeyanka CF, Salako AO. Risk factors for pulmonary tuberculosis among health-care workers in Ibadan, Nigeria. *Afr J Med Med Sci*. 2010;39(2):105-12.
25. Atalell KA, Alemayehu MA, Teshager NW, Belay GM, Alemu TG, Anlay DZ, et al. Mapping BCG vaccination coverage in Ethiopia between 2000 and 2019. *BMC Infect Dis*. 2022;22(1):1-9.
26. Millet JP, Shaw E, Orcau À, Casals M, Miró JM, Caylà JA. Barcelona Tuberculosis Recurrence Working Group. Tuberculosis recurrence after completion treatment in a European city: reinfection or relapse?. *PloS One*. 2013;8(6):e64898.
27. Hill PC, Jackson-Sillah D, Donkor SA, Otu J, Adegbola RA, Lienhardt C. Risk factors for pulmonary tuberculosis: a clinic-based case control study in The Gambia. *BMC Public Health*. 2006;6(1):1-7.
28. Iliyasu Z, Babashani M. Prevalence and predictors of tuberculosis coinfection among HIV-seropositive patients attending the Aminu Kano Teaching Hospital, northern Nigeria. *J Epidemiol*. 0903030070-0903030070.
29. Lönnroth K, Raviglione M. Global epidemiology of tuberculosis: prospects for control. In *Seminars in Respiratory Critical Care Medicine* 2008;29(5):481-91.
30. Malkin JE, Prazuck T, Simonnet F, Yameogo M, Rochereau A, Ayeroue J, et al. Tuberculosis and human immunodeficiency virus infection in west Burkina Faso: clinical presentation and clinical evolution. *Int J Tubercul Lung Dis*. 1997;1(1):68-74.
31. Rao KG, Aggarwal AN, Behera D. Tuberculosis among physicians in training. *Int J Tubercul Lung Dis*. 2004;8(11):1392-4.
32. Banerjee A, Moyo S, Salaniponi F, Harries A. HIV testing and tuberculosis treatment outcome in a rural district in Malawi. *Transactions Royal Society Trop Med Hygiene*. 1997;91(6):707-8.

Cite this article as: Mebrahtu FG, Ghezae MM, Belew EH, Berhe DN, Tesfariam EH, Berhane TN, et al. Determinants of tuberculosis in central region of Eritrea: a matched case-control study. *Int J Community Med Public Health* 2023;10:2001-9.