

Prevalence of pulmonary tuberculosis and associated risk factors among people working in two Marble Stone Factories in Tigray Region, Northern Ethiopia

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Abstract

Background: Tuberculosis is a chronic infectious disease caused mainly by *Mycobacterium tubercule* that causes severe public health problem in Ethiopia. Employees working in construction, mines and stone crushing are exposed to silica dust, and hence, are expected to be vulnerable to pulmonary tuberculosis. However, there is little information on the epidemiology of pulmonary tuberculosis in people working in construction and stone crushing marble factories. This study was, therefore, conducted to estimate the prevalence of pulmonary tuberculosis and to assess associated risk factors in employees working in Saba and Semayata Marble Stone factories, Tigray, Northern Ethiopia.

Methods: A cross-sectional study was conducted in people working in Saba and Semayata marble stone factories between February and April 2018. A total of 106 study participants were selected using simple random sampling and then screened for pulmonary tuberculosis based on cardinal signs and symptoms. Sputum samples were collected from participants with symptoms of pulmonary tuberculosis and tested with GeneXpert MTB/RIF for the diagnosis of *M. tuberculosis*. Data were analyzed using SPSS version 20.0. Associations of the potential risk factors with the prevalence were assessed using binary and multivariable logistic regression analyses. Variables which had a P value less than 0.05 were considered statistically significant in the final model.

Result: The prevalence of pulmonary tuberculosis was 1.9% (95% CI, 1.87-1.93). Work experience (AOR=1.48, 95%CI=1.03-8.58), history of contact with chronic coughers (AOR= 4.0, 95% CI=1.19-14.02) and loss of appetite (AOR=8.6, 95% CI=2.0-32.52) were significantly associated with the prevalence of pulmonary TB in people working in Saba and Semayata Marble Stone factories

Conclusion: The prevalence of pulmonary tuberculosis among employees working in Saba and Semayata marble stone factories was relatively higher as compared to the Ethiopian National prevalence of pulmonary tuberculosis, which warrants for strengthening of systematic screening for tuberculosis prevention and control activities in marble stone factories.

Key words: Marble stone factory, prevalence, pulmonary tuberculosis, risk factors, Tigray region, Northern Ethiopia

Background

Tuberculosis (TB), which commonly affects the lungs, is a major public health problem throughout the globe. About one-third of the world's population is infected with *Mycobacterium Tubercule* (MTB), and thus, in danger of developing active TB during their lifetime (FMOH 2016; FMOH 2011; Department of Health, Republic of South Africa 2014). TB has been one of the top ten causes of death and leading cause from a single infectious agent (WHO report 2012; WHO report 2014; WHO report 2016; Global Fund 2018). It spreads from individual to individual by inhaling infected droplet nuclei released from TB cases (Department of Health, 2014; FMOH 2018a; World Vision 2017).

Despite dramatic improvements in better access to high-quality TB care, most people remained undiagnosed or have been lately diagnosed with TB. Latent infection with MTB does not result in signs of disease and is not infectious, but results in persistent

immune response to *M. tuberculosis* antigen. Nevertheless, the occurrence of active TB remains 10–15 percent of lifetime risk (Haileyesus et al. 2015; WHO 2014a; WHO 2013; Kelemework et.al. 2015).

The growth of multidrug resistance TB (MDR-TB), Human Immunodeficiency Virus (HIV) pandemic, malnutrition and smoking worsen the burden of TB in Africa, including Ethiopia. It was estimated that 10 million people suffered from TB in 2017, while an additional 1.3 million people died of it (WHO 2014; WHO 2013; WHO 2018).

Even though efforts are being made to prevent and control TB in Ethiopia (WHO 2020), the country is one of the 30 high TB burden countries, with an estimated annual incidence and death rates of 177 and 25 per 100,000 population, respectively, in 2016 (WHO 2016; FMOH 2018b).

Miners, foundry workers, stone crushers and others engaged in related occupations who particularly work

in closed and unsafe area have a higher exposure to silica dust and are vulnerable to TB (Kingsley and Rajen 2016). Research conducted in Iran has shown that the risk of a patient with silicosis to develop pulmonary TB was 2.8-39 times and for extra-pulmonary TB 3.7 times higher than in the healthy population (Aliasghar & Mansooreh 2015). Moreover, an evidence from India indicated that pulmonary tuberculosis prevalence among marble stone factory workers was 6.25%, which is higher than the prevalence in the general population (4.38%) (Shashi et al. 2014).

Ethiopia, one of the fast-growing economies in Africa, is investing in manufacturing industries and the number of workers is increasing. At the same time, the number of factory workers who get exposed to dust particles, chemicals and active waste products is increasing, while disease symptoms occur very late after exposure and workers are not treated properly while seeking care. Moreover, the country is expected to reduce the incidence and mortality rate of all TB forms by 20% and 35%, respectively, in 2020 (FMoH 2015).

Therefore, this study was conducted to assess the prevalence and risk factors among marble stone factory workers as this can support the "END TB" strategy, a recommendation from WHO to systematically screen and investigate undiagnosed TB cases in the community, including marble stone factories.

Methods

Study setting: The study was conducted in Saba and Semayata marble stone factories from February 10 to April 05, 2018. Saba and Semayata marble stone factories are found 239 and 50 kilometres far from the capital of Tigray region, Mekelle, respectively. The total numbers of workers employed in the two marble stone factories were about 800. Tigray Region is the northernmost part of the ten regions of Ethiopia.

Study design and participants: Cross-sectional study design was employed to estimate the prevalence and associated factors of pulmonary TB. All workers of Saba and Semayata marble factories were sources of the study participants while individuals selected through simple random sampling were study participants.

Eligibility criteria: Employees who had working experience of less than 6 months in both factories were excluded in the study.

Sample size and sampling technique: Sample size was calculated using single population proportion formula [$n = (Z \alpha/2)^2 P (1-P) / d^2$] taking prevalence of TB in India marble stone factory 6.2% (Shashi et al. 2014), assuming 95% level of confidence, 5% margin

of error, and non-response rate 10% as there is limited baseline information from Ethiopia. Accordingly, the total sample size calculated was 106. The sample was proportionally allocated to the two factories based on the numbers of employees and then the 106 employees were selected following simple random sampling technique.

Data collection procedures, laboratory investigation and data quality assurance: Two Health officers (HO) and two laboratory technologists were recruited, trained for the basic interviewing techniques and briefed on the objective of the study. The data collectors were assigned to the factories in two groups, with one health officer and one laboratory technologist in each group. The HOs interviewed the study participants using a pre-tested and structured questionnaire, which was adapted from different literature sources to identify pulmonary TB suspects. Clients with persistent cough for two weeks or more and presence of other symptoms such as expectoration, bloody sputum, fever, chest pain, shortness of breath, fatigue, night sweats, loss of appetite, loss of body weight and contact history with active TB patients were considered as suspects for pulmonary TB (Syed 2013; Mucheye et al. 2017).

The laboratory technologists collected spot sputum specimens from each symptomatic study participants using a sterile falcon tube when the team met symptomatic individuals. As per the Standard Operating Procedure (SOP) (GeneXpert Dx System operator manual software version 4), the sputum samples were transported for investigation in an ice box. Sputum samples were kept in the laboratory from 2-8°C in a refrigerator for up to seven days until investigated by GeneXpert MTB/RIF.

Originally, the questionnaire was written in English and then translated to Tigrigna, which is local language in the study areas, then translated back to English. Four data collectors and two supervisors with data collection experience and who can speak the local language (Tigrigna) were recruited. The data collectors and supervisors were trained for two days. Supervision was conducted on daily basis and completeness of data was checked.

The GeneXpert diagnostic system performs internal quality control for each sample automatically. During each test, the system uses Sample-processing control (SPC), which ensures a sample was correctly processed. The sample processing control is included in the cartridge and is processed with the sample and the DNA is detected by a PCR assay. Internal control (IC)—verifies the performance of the PCR reagents and prevents a false negative result. The internal control PCR assay assesses if there is any inhibition, possibly by components, in the test sample. The

internal control is provided in the cartridge and should be positive in a negative sample. Endogenous control (EC)—normalizes targets and ensures sufficient sample is used in the test. The endogenous control is taken from the specimen sample. In addition to the controls, the GeneXpert instrument performs a probe check during the first stage of the test. A probe check verifies the presence and the integrity of the labeled probes. A probe-check status of “Pass” indicates that the probe check results meet the acceptance criteria (Sergey 2021).

Data management and analysis: Data was entered to Epi-Info software and then cleaned, edited and transferred to SPSS version 20 for analysis. Findings were analysed using descriptive statistics including frequency and percentage, and summarized. Bivariate analysis was carried out to identify the association between each independent variable with the respective outcome variable. Multivariate analysis was employed to identify possible risk factors associated with the outcome variable. In the multivariate analysis, adjusted odds ratio (AOR) and corresponding 95% confidence interval was retrieved. Those variables with *p*-value of less than 0.05 were considered statistically significant.

Ethical Considerations: The study was conducted after ethical clearance with reference number ERC1224/2018 was issued by Institutional Review Board (IRB) of College of Health Sciences, Mekelle University. Only those individuals who provided verbal informed consent were involved in the study. Privacy of each study participant was maintained by using code number on collected sample and personal information, and locking in a cupboard. All the collected sample sputum was only used for the intended purpose. All confirmed TB cases were connected to the nearby health facilities for further diagnosis and follow up.

Results

Socio demographic characteristics of study participants: On the basis of the four cardinal signs and symptoms of TB, a total of 106 participants were screened. Of the study participants, 32(30.2%) were TB screening positive and 95(89.6%) were males and 11(10.4%) were females. The study participants' median age was 29 years. Fifty six (52.8%) of the study participants were married; 57(53.8%) were rural residents; and 46(43.4%) had greater than five family members per household (Table 1).

Table1: Socio demographic characteristics of Semayata and Saba marble stone factory workers, Tigray, Northern Ethiopia, 2018 (N=106)

Variable		Frequency	Percent
Age	19-35	85	80.2
	≥36	21	19.8
Sex	Male	95	89.6
	Female	11	10.4
Marital status	Single	49	46.2
	Married	57	53.8
Educational status	1-12 th grade	56	52.8
	>12 th grade	50	47.2
Residence	Rural	57	53.8
	Urban	49	46.2
Working experience	≤ 10 years	79	74.5
	>10 years	27	25.5
Mask use	Yes	6	5.7
	No	100	94.3
Total family size	1-5	60	56.6
	>5	46	43.4
Monthly family income	≤2000 ETB	56	52.8
	>2001 ETB	50	47.2
Working area	Administrative	6	5.7
	Technical	91	85.8
	Cleaner	9	8.5

ETB= Ethiopian birr

Prevalence of tuberculosis: The prevalence of PTB in the two marble stone factories was found to be 1.9% (95% CI, 1.87-1.93) based on the investigation with GeneXpert MTB/RIF. Both of the PTB positive cases were in the range of 1-12th grade by educational status. Both of the PTB cases were married, dwell in rural

area and had greater than five family members per household. In their working hours, these PTB cases did not use mask and had work experience of more than 10 years [Table 2]. Nevertheless, none of the PTB cases were detected for Rifampicin resistance.

Table 2: Proportion of pulmonary TB with socio-demographic characteristics of study participants in Saba and Semayata marble stone factory workers, Tigray, Northern Ethiopia, 2018 (N=106)

Variable		TB screening		GeneXpert result	
		Positive (%)	Negative (%)	Positive (%)	Negative (%)
Age	19-35	20(18.9)	65(61.3)	1(0.9)	19(17.9)
	≥36	12(11.3)	9(8.5)	1(0.9)	11(10.4)
Sex	Male	30(28.3)	65(61.3)	2(1.9)	28(26.4)
	Female	2(1.9)	9(8.5)	0(0)	2(1.9)
Marital status	Single	7(6.6)	42(39.6)	0(0)	7(6.6)
	Married	25(23.6)	32(30.2)	2(1.9)	23 (21.7)
Educational status	1-12 th grade	18(17.0)	38(35.8)	2(1.9)	16 (15.1)
	>12 th grade	14(13.2)	36(34.0)	0(0)	14 (13.2)
Residence	Rural	18(17.0)	39(36.8)	2(1.9)	16(15.1)
	Urban	14(13.2)	35(33.0)	0(0)	14 (13.2)
Working area	Administrative	1(0.9)	5(4.7)	0(0)	1(0.9)
	Technical	30(28.3)	61(57.5)	2(1.9)	28 (26.4)
	Cleaner	1(0.9)	8(7.5)	0(0)	1(0.9)
Working experience	≤10years	15(14.2)	64(60.4)	0(0)	15(14.2)
	>10years	17(16.0)	10(9.4)	2(1.9)	15(14.2)
Mask use	Yes	2(1.9)	4(3.8)	0(0)	2(1.9)
	No	30(28.3)	70(66.0)	2(1.9)	28 (26.4)
Family size	1-5	17(16.0)	29(27.4)	0(0)	17 (16.0)
	>5	15(14.2)	45(42.4)	2(1.9)	13 (12.3)
Monthly income	≤2000 ETB	20(18.9)	36(34.0)	2(1.9)	18(16.9)
	>2001 ETB	12(11.3)	38(35.8)	0(0)	12(11.3)
Total		32(30.2)	74(69.8)	2(1.9)	30(28.3)

Factors associated with tuberculosis at Saba and Semayata marble stone factories: Work experience (AOR=1.48, 95%CI=1.03-8.58), history of contact with chronic coughers (AOR=4.0, 95% CI=1.19-

14.02) and loss of appetite (AOR=8.6, 95% CI=2.0-32.52) were significantly associated with PTB in multivariable logistic regression analysis as shown in Table 3.

Table 3: Bivariate and multivariable analyses of associated factors versus Pulmonary Tuberculosis among marble stone factory workers of Saba and Semayata, Tigray, Northern Ethiopia, 2018 (N=106)

Variable		TB status		COR (95 % CI)	AOR (95% CI)	P value
		Positi ve (n=2)	Negative (n=104)			
Age	19-35	1(0.9)	84(80.8)	1	1	0.545
	≥36	1(0.9)	20(19.2)	0.23[0.085-0.627]	1.6[0.348-7.395]	
Marital status	Single	0(0)	49(47.1)	1	1	0.237
	Married	2(1.9)	55(52.9)	0.254[0.101-0.639]	0.469[0.134-1.644]	
Education	1-12 th grade	2(1.9)	54(50.9)	1	1	0.839
	>12 th grade	0(0)	50(47.2)	1.218[0.643-1.218]	0.908[0.355-2.320]	
Experience	≤10 years	0(0)	79(76.0)	1	1	0.006*
	>10 years	2(1.9)	25(24.0)	1.38[0.053-0.361]	1.48[1.03-8.58]	
Family size	1-5	0(0)	44(41.5)	1.759[0.762-4.060]	1.639[0.561-4.791]	0.366
	>5	2(1.9)	60(56.6)	1	1	
Opening window	Yes	1(0.9)	49(46.2)	1.759[0.753-4.110]	2.225[0.698-7.093]	0.176
	No	1(0.9)	55(52.0)	1	1	
Knowledge causative agent of TB	Yes	2(1.9)	43(40.6)	1.759[0.753-4.110]	2.225[0.698-7.093]	0.176
	No	0(0)	61(57.5)	1	1	
contact with chronic coughers	Yes	1(0.9)	23(21.7)	1	1	0.026*
	No	1(0.9)	81(76.4)	2.458[0.957-6.316]	4.0 [1.19-14.02]	
Contact with TB pt	Yes	1(0.9)	31(29.2)	1	1	0.735
	No	1(0.9)	73(68.9)	1.074[0.437-2.639]	0.820[0.260-2.585]	
TB disease before	Yes	1(0.9)	11(10.4)	1	1	0.811
	No	1(0.9)	93(87.7)	2.615[0.773-8.845]	1.242[0.209-7.366]	
Know TB is Transmittable	Yes	2(1.9)	62(58.5)	1.062[0.456-2.474]	1.044[0.332-3.284]	0.941
	No	0(0)	42(39.6)	1	1	
Loss of appetite	Yes	1(0.9)	22(20.8)	1	1	0.001*
	No	1(0.9)	82(77.4)	7.279[2.651-19.990]	8.6 [2.0-32.52]	

Discussion

The study found that pulmonary tuberculosis (PTB) prevalence among marble stone factory workers was 1.9%, which means a prevalence of 1887/100,000. The finding was higher than the prevalence of smear positive TB cases (108/100,000) in the general population of Ethiopia (Kebede et al. 2014). The difference might be due to overcrowding, close contact and poorly ventilated conditions in the marble factory and a high marble dust exposure containing silica favoring higher rates of transmission of the bacteria. However, it is lower than studies conducted in Zambia (9.5%) (Kingsley and Rajen 2016), India (6.2%) (Shashi et al. 2012) and Ethiopia (14.2%) (Kebede et al. 2014). This could be explained due to the difference in the study population; the study participants from Metehara of Ethiopia were clients who came to the hospital with signs and symptoms of TB and the diagnostic tools used in our study was only GeneXpert while the other studies employed bacteriological and radiological examinations.

Different researches and documents highlight transmission of pulmonary TB increases with deprivation, malnutrition and crowded living conditions (FMoH 2011; Yohanes et al. 2012).

Consistently, this study indicated that people who have greater than five family sizes were highly affected. Evidences show that TB disease affects men more than women (WHO 2018; Gebretsadik et.al 2013; Japheth 2014). Likewise, this study found higher number of PTB cases among males compared to females.

The study also revealed that the length of years of service (working experience), contact history with chronic coughers and loss of appetite were determinant factors for the development of pulmonary TB among marble stone factories in the study area. Workers having work experience of greater than ten years were more likely to develop pulmonary TB compared to employees who had working experience of less than 10 years, which could be derived from increased intensity of dust and silica accumulation associated with prolonged exposure.

TB is one of the major public health problems in the 21st century (Laaser and Brand 2014). Despite efforts made to prevent and control it, TB programs have not been successful in achieving their plans related to morbidity and mortality for various reasons. Globally, around four million TB patients are not detected by health systems each year (Global Fund

2018; WHO 2017). Missing of TB patients can be due to lack of access to health facilities, under diagnosing, under reporting or else. Many of the missed cases can be those vulnerable, hard to reach and employees working in marble stone factories. Nonetheless, identifying these cases requires a strong health care system, public-private partnership and active case detection to diagnose and treat early (Enos et al. 2018).

Having history of contact with chronic coughers in the work place was more likely to develop pulmonary TB than those who had no contact with chronic coughers. PTB transmission occurs predominantly through airborne droplets during coughing, sneezing, speaking or singing and close contact with people who have active PTB. A person who has stayed with untreated and active tuberculosis may be able to infect 10 to 15 people per year (FMoH 2016; Department of Health 2014). The study has found two PTB positive cases; denoting 20 to 30 individuals can be infected annually that can aggravate transmission of the disease, which calls active case detection, prompt treatment and strengthening of the health system. Moreover, it was noted that workers with poor appetite were more likely to develop pulmonary tuberculosis compared to their counterparts, which requires further evaluation.

The findings in this study should be interpreted cautiously as there were some limitations. Screening of suspected individuals to TB had been undertaken based on the cardinal signs and symptoms only and diagnostic technique used was GeneXpert; which may underestimate the magnitude of PTB. The study didn't use advanced laboratory diagnostic techniques like culture and molecular assays which could provide better prevalence estimate of PTB. Moreover, the sample size of this study was relatively small, which could affect the statistical inferences of the modeling and should be interpreted carefully.

Conclusion and recommendation

The study found relatively higher prevalence of pulmonary TB compared to the Ethiopian National prevalence of pulmonary TB, which warrants for strengthening of systematic screening for TB and contextualize other TB prevention and control activities like awareness creation, prompt TB diagnosis and treatment in marble stone factories. Moreover, for better evaluation further studies with multiple case detection mechanisms and sophisticated laboratory investigations are recommended.

Competing interests: The authors declare that they have no competing interests.

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