



Investigation of the risk factors for pulmonary tuberculosis: A case–control study among *Saharia* tribe in Gwalior district, Madhya Pradesh, India

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Background & objectives: Prevalence of pulmonary tuberculosis (PTB) is known to be high in the indigenous tribal community *Saharia* in Madhya Pradesh, India. The risk factors for PTB are not well known among them. This study was done to determine various risk factors associated with PTB in the indigenous community *Saharia*.

Methods: A prevalence survey was conducted among *Saharias* of Gwalior district of Madhya Pradesh. The population surveyed was 12,123 which was the source of cases and controls for the present study. All the bacillary-positive cases and controls in the ratio of 1:5 were included in the survey. Data were collected by the trained health workers from the patients and controls using a semi-structured pre-coded and pre-tested questionnaire which included data on risk factors including demographic factors, host-related factors and household factors. The individuals were also screened for diabetes mellitus and HIV.

Results: Malnutrition and history of asthma were associated with an increased risk of PTB. More than 56 per cent cases were attributed to malnutrition and 12 per cent attributed to asthma. Low family income, alcohol consumption and smoking were the other contributors. The risk was higher in males as compared to females.

Interpretation & conclusions: The study emphasized that the main contributors were social factors. Nutrition supplementation, especially in tuberculosis (TB) patients and integrated approach to improve their living conditions are needed to control TB in this community.

Key words Malnutrition - pulmonary tuberculosis - risk factors - *Saharia*

Tuberculosis (TB) remains a major global health problem. The major challenges to TB control today include multidrug-resistant-TB and HIV-TB co-infection. Another important challenge is the growing body of evidence, suggesting coexisting diabetes as a

risk factor for new as well as reactivation of old cases of TB¹. Apart from diabetes and HIV co-infection, there are many risk factors associated with TB infection and disease such as age, sex, malnutrition (biological factors), tobacco smoking, alcoholism (behavioural

factors), poverty, overcrowding and poor housing (socio-economic factors)²⁻⁴.

Many studies have demonstrated a direct relationship between active smoking and TB⁵. India has a high burden of TB with an estimated prevalence of 230/100,000 population. In 2015, there were an estimated 10.4 million new (incident) TB cases worldwide, of which 2.8 million were estimated to have occurred in India⁶. However, there are only a few studies on risk factors for TB from India^{7,8}.

Tribal population constitutes around 8.2 per cent of the total population of the country and one quarter of the total population in the State of Madhya Pradesh⁹. There are 46 ethnic groups in the State, and three among them have been categorized as Particularly Vulnerable Tribal Groups (PVTGs), earlier called as primitive tribal groups. The *Saharia* is one of these three PVTGs in the State. They are mainly located in Gwalior and Chambal divisions of Madhya Pradesh⁹. A high prevalence of pulmonary TB (PTB) (3294/100,000) has been reported among them in our earlier study¹⁰. Smoking and alcohol consumption have been shown to be associated with PTB disease in this population¹¹. There is, however, no information on the role of other risk factors for PTB. Therefore, the present study was undertaken to find an association of various risk factors with PTB in this indigenous community.

Material & Methods

This study was conducted by the ICMR- National Institute for Research in Tribal Health, Jabalpur, India, after taking approval from the institutional ethics

committee. A survey of PTB was carried out in four blocks of Gwalior district of Madhya Pradesh during March to November, 2013.

All individuals aged 15 yr and above were screened for PTB by chest symptoms such as persistent cough for two weeks or more, chest pain for one month or more, fever for one month or more and haemoptysis anytime in the last six months. All symptomatics were investigated by sputum smear and culture examinations. The population surveyed was 12,123 and was the source of cases and controls for the present study as described elsewhere¹⁰. The cases were defined as those who were sputum smear and/or culture positive for PTB and who were screened and declared not to have TB formed the controls (Fig. 1). A list of all the detected cases and controls was prepared, and those willing to participate and gave consent were included in the risk factors study.

The sample size for unmatched case-control study was calculated assuming the prevalence of an exposure of 25 per cent in controls, odds ratio (OR)=1.5, 95 per cent confidence interval (95% CI), 80 per cent power and 1:5 ratio of cases and controls. A minimum sample of 264 cases was calculated with its five time controls. The sample size was estimated using Kelsey's Method with the help of online OpenEpi calculator¹². The controls were selected randomly from the same village from where cases were found¹³. For each TB case, five controls from the same village were randomly selected. The randomization was done by the survey team in the field in such a manner that five controls per case should be interview successfully.

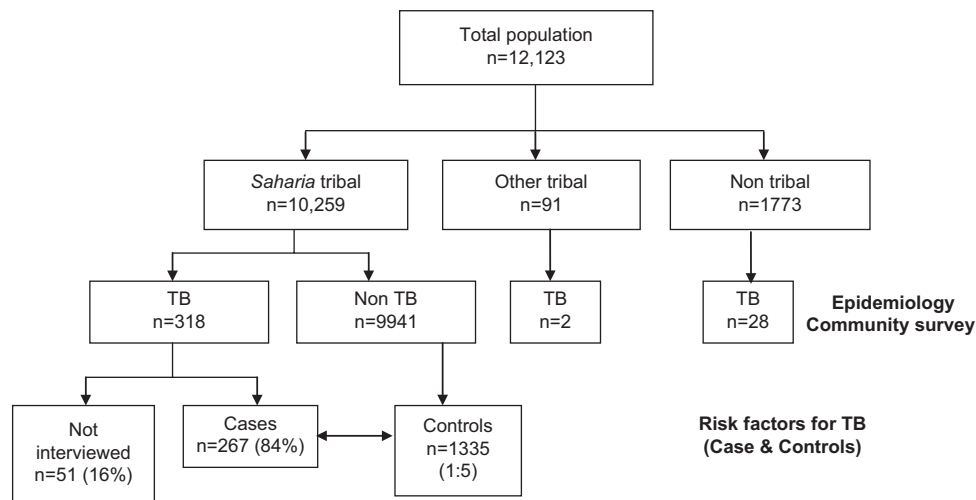


Fig. 1. Flow chart showing intake of cases and controls.

Data collection: Using a semi-structured pre-coded and pre-tested questionnaire, the data on risk factors including demographic (age, sex) data were collected by the trained health workers from all the patients and controls. The interviews were conducted at home in their local language (Hindi). The data on host-related factors *viz.* education, occupation, bacillus Calmette–Guérin (BCG) vaccination, height and weight for computing body mass index (BMI), previous history of TB, smoking and alcohol intake were collected from all individuals. BMI <18.5 kg/m² was considered as undernutrition¹⁴. A history of asthma was also noted. In addition, they were screened for blood glucose levels (to rule out diabetes mellitus) and HIV status. Information on household factors *viz.* household size, type of house, income, overcrowding, biomass fuel use and household member/relative with TB was also collected.

Quality check for data collection was inbuilt in the methodology. A 10 per cent random sample of individuals interviewed by the health worker was selected independently by a supervisor and the extent of agreement was ascertained for any corrective measures.

Blood sugar estimation: Capillary blood glucose using a glucometer (AccuChek Active, Australia) was done after overnight fasting to estimate blood sugar. Samples were collected by finger prick method, and the test was done as per the manufacturer's protocol. In case of abnormal blood sugar values (fasting glucose level >126 mg/dl)¹⁵, the patients were referred to primary health centres/community health centres/district TB centres for further evaluation to rule out diabetes mellitus.

HIV testing: After obtaining informed consent, HIV test was done on whole-blood samples collected by finger prick method. The test was done by rapid test (SD Bioline, Standard Diagnostics Inc., Germany). Reactive individuals were referred to nearest integrated counselling and testing centre for confirmation of HIV status. Pre- and post-test counselling was performed as per the standard guidelines¹⁶.

Data management and analysis: Data entry was done using the Census and Survey Processing System software package version 5.0. Data were analyzed using Statistical Package for the Social Sciences (SPSS/PC version 20.0; SPSS Inc., Chicago, IL, USA) package. The attributable proportion of all modifiable risk factors was calculated using the standard population

attributable fraction formula -

$$PAF = \frac{P(OR - 1)}{P(OR - 1) + 1}$$

where *P* is prevalence of exposure in population and OR is the adjusted OR¹⁷.

In univariate analysis, the Chi-square test was used to compare cases and controls to assess the effect of each risk factors of interest. Multivariate model was constructed, including variables that showed a significant statistical effect in the prediction of TB in univariate analysis.

Results

During the survey, 318 TB cases were identified among 10,259 population from *Saharia* community¹⁵. Fifty one (16%) individuals could not be interviewed, 21 moved temporarily, seven were not available during our three visits, six refused to participate and 17 expired. The remaining 267 (84%) cases were interviewed at their residence (Fig. 1).

Profile of study population: The demographic and socio-economic profile of study population is shown in Table I. Age, education and housing (in terms of type, number of rooms and cooking place) were almost similar in both case and controls. Among 267 cases, 211 (79%) were males; whereas among 1335 controls, 660 (49%) were males. More cases were seen from the stone crushing workers and in low family annual income of ₹ ≤10,000 (85 vs. 78%). The mean age of cases and controls was 39.42±13.5 and 39.46±13.4 yr, respectively.

Investigation of risk factors for pulmonary tuberculosis (PTB): Results from univariate analysis carried out on 267 cases and 1335 controls to investigate the demographic and socio-economic risk factors are displayed in Table II. Male gender (OR=3.85; 95% CI 2.82-5.27; *P*<0.001); stone crushing workers (OR=2.26; 95% CI 1.32-3.88; *P*<0.01) and low income (OR=1.59; 95% CI 1.11-2.27; *P*<0.001) were found to increase the risk of PTB. It was observed that malnutrition (OR=3.81; 95% CI 2.61-5.56; *P*<0.001) and history of asthma (OR=3.46; 95% CI 2.48-4.83; *P*<0.001) were associated with increased risk of PTB. Prevalence of HIV was low among controls with one HIV-positive individual (Table II). Abnormal blood sugar was associated with high risk, but the difference was not found to be significant. The risk of TB was higher in tobacco smokers (OR=1.64; 95% CI

Table I. Distribution of demographic and socio-economic, clinical and lifestyle risk factors for pulmonary tuberculosis

Characteristics	No. of cases	Per cent of cases	No. of controls	Per cent of controls	χ^2	<i>P</i>
Age (yr)						
<35	124	46.4	604	45.2	0.129	0.719
>35	143	53.6	731	54.8		
Sex						
Female	56	21.0	675	50.6	78.515	<0.0001
Male	211	79.0	660	49.4		
Education						
Illiterate	211	79.0	1029	77.1	0.509	0.775
Primary	33	12.4	184	13.8		
Middle and above	23	8.6	122	9.1		
Occupation						
Unemployed	67	25.1	303	22.7	18.25	0.0001
Farmer/labour	174	65.2	980	73.4		
Stone crashing/others	26	9.7	52	3.9		
Annual family income (₹)						
<10,000	226	84.6	1036	77.6	6.598	0.010
10,000+	41	15.4	299	22.4		
Type of housing						
<i>Kuchcha</i>	213	79.8	1074	80.4	0.064	0.800
<i>Pucca</i>	54	20.2	261	19.6		
Members per room						
<3	99	37.1	557	41.7	1.985	0.159
4+	168	62.9	778	58.3		
History of migration						
Yes	24	9.0	149	11.2	1.09	0.298
No	243	91.0	1186	88.8		
BMI*						
Normal	34	13.0	478	36.2	54.018	<0.0001
Malnourished (<18.5kg/m ²)	228	87.0	841	63.8		
Blood sugar**						
Normal	248	95.0	1257	97.3	3.74	0.053
Diabetic	13	5.0	35	2.7		
History of asthma						
No	199	74.5	1215	91.0	58.335	<0.0001
Yes	68	25.5	120	9.0		
HIV[^]						
Yes	0	0.0	1	0.1	NC	
No	255	100.0	1282	99.9		
Chewing tobacco						
No	164	61.4	900	67.4	3.582	0.058
Yes	103	38.6	435	32.6		

Contd...

Characteristics	No. of cases	Per cent of cases	No. of controls	Per cent of controls	χ^2	<i>P</i>
Smoking tobacco						
No	142	53.2	868	65.0	13.377	<0.0013
Yes	125	46.8	467	35.0		
Alcohol consumption						
No	183	68.5	1020	76.4	7.359	0.007
Yes	84	31.5	315	23.6		
n	267		1335			

*21 cases/controls missing, **49 cases/controls missing, ^ 64 cases/controls missing. BMI, body mass index; NC, not computed

Table II. Results of univariate and multivariate analysis of all risk factors for pulmonary tuberculosis (n=1602)

Characteristics	Univariate		Multivariate	
	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>
Age (yr)				
<35	1		1	
>35	0.95 (0.73-1.24)	0.720	1.02 (0.76-1.36)	0.914
Sex				
Female	1		1	
Male	3.85 (2.82-5.27)	0.001	4.19 (2.79-6.29)	0.001
Education				
Illiterate	1.09 (0.68-1.74)	0.725		
Primary	0.95 (0.53-1.70)	0.866		
Middle and above	1			
Occupation				
Unemployed	1		1	
Farmer/labour	0.80 (0.59-1.09)	0.165	0.52 (0.36-0.76)	0.001
Stone crushing/others	2.26 (1.32-3.88)	0.003	1.22 (0.65-2.27)	0.536
Annual family income (₹)				
<10,000	1.59 (1.11-2.27)	0.01	1.32 (0.89-1.93)	0.169
10,000+	1		1	
Type of housing				
<i>Kuchcha</i>	0.96 (0.69-1.33)	0.800		
<i>Pucca</i>	1			
Members per room				
<3	1			
4+	1.22 (0.93-1.59)	0.159		
History of migration				
Yes	0.79 (0.50-1.24)	0.297		
No	1			
BMI*				
Normal	1		1	
Malnourished (<18.5 kg/m ²)	3.81 (2.61-5.56)	0.001	3.03 (2.05-4.48)	0.001

Contd...

Characteristics	Univariate		Multivariate	
	OR (95% CI)	P	OR (95% CI)	P
Blood sugar**				
Normal	1		1	
Diabetic	1.88 (0.98-3.61)	0.057	1.53 (0.75-3.10)	0.240
History of asthma				
No	1		1	
Yes	3.46 (2.48-4.83)	0.001	2.53 (1.76-3.66)	0.001
HIV[^]				
Yes	Not done			
No				
Chewing tobacco				
No	1		1	
Yes	1.29 (0.99-1.70)	0.059	1.08 (0.79-1.47)	0.639
Smoking tobacco				
No	1		1	
Yes	1.64 (1.25-2.13)	0.001	1.03 (0.72-1.48)	0.878
Alcohol consumption				
No	1		1	
Yes	1.49 (1.12-1.98)	0.007	0.85 (0.60-1.22)	0.377

*21 cases/controls missing, **49 cases/controls missing, ^64 cases/controls missing. BMI, body mass index; OR, odds ratio; CI, confidence interval

1.25-2.13; $P < 0.001$) and alcohol consumers (OR=1.49; 95% CI 1.11-1.98; $P < 0.01$) (Table II). Alcohol consumption and smoking were meagre in women.

A multivariate model (binary logistic regression) was constructed, including variables of interest that univariate analysis showed a significant association with TB. The risk of TB was found to be associated with male sex, malnutrition and asthma. In multivariate analysis, the risk factors that stood out were malnutrition and history of asthma (Table II). Stone crushing workers were not a risk factor in multivariate analysis as the number was small.

Fig. 2 shows the unadjusted (based on OR) and adjusted [based on adjusted OR (AOR)] attributable proportions for the modifiable risk factors for TB such as nutritional status, annual family income, occupation, smoking tobacco, history of asthma, alcohol consumption and blood sugar level. It showed that 64 per cent cases were attributed to malnutrition, 31 per cent attributed to low annual family income, 18 per cent attributed to tobacco smoking, 18 per cent attributed to asthma, 10 per cent attributed to alcohol consumption, about five per cent attributed to stone crushing work and two per cent attributed to abnormal blood sugar

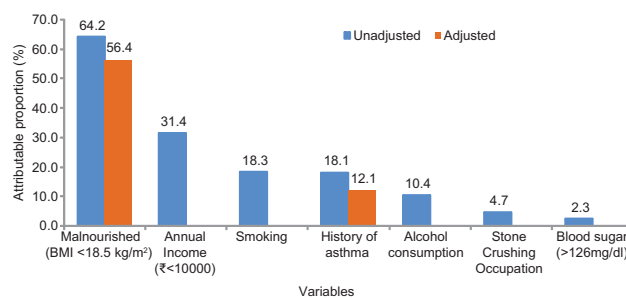


Fig. 2. Attributable proportions for the modifiable risk factors of tuberculosis.

(diabetics). After adjusting (based on AOR), it was found that 56 per cent of the cases were attributed to malnutrition and 12 per cent attributed to asthma.

Discussion

In our study, males had significantly higher prevalence of TB than females. This difference was not attributed to gender bias because the coverage for screening examinations in this active case detection survey was uniformly high for both males and females. The immune response is known to be different in the two sexes, indicating sexual dimorphism. Evidence suggests that at physiological levels, oestrogen is

beneficial to the immune system, whereas the male sex hormone, testosterone, is immunosuppressive¹⁸. Habits such as smoking and alcoholism might have also contributed to TB in men as these habits were found to be negligible among women.

TB has been found more in stone crushing workers in earlier study¹⁹. Indoor air pollution has been considered as an important risk factor for TB in India by other authors²⁰. Although these factors were observed in many cases in our study, these were not found to be significant. Majority of people in these areas were exposed to these factors. Underlying silicosis in these stone crushing workers cannot be denied; however, we could not evaluate the same as this was a field-based study and X-ray facility was not available.

In a study by Lienhardt *et al*²¹, TB was shown to be associated with male sex, family history of TB, absence of a BCG scar, smoking, alcohol, anaemia, HIV infection and history and treatment of worm infection. In another study in a tertiary care hospital from south India, diabetes was found to be a predominant risk factor²². Kolappan *et al*² found that risk factors such as age, male sex, smoking and alcoholism were independently associated with pulmonary TB. In our study, age did not have an effect on TB. In another study from south India, TB was associated with low education level, kitchen type and diabetes, reflecting the complex interaction between non-communicable disease, urbanization and a changing economic climate²³. Smoking increases mortality from TB by increasing the incidence of the disease²⁴. Both smoking and alcoholism were important risk factors for TB in our study; however, these did not turn out to be significant in multivariate analysis.

HIV co-infection is a known risk factor for progression of *Mycobacterium tuberculosis* infection to active disease, increasing the risk of latent TB reactivation 20-fold²⁵. HIV was not found to be a risk factor in the present study as the prevalence of HIV was found to be very low among this community. Diabetes prevalence was also found to be low in the study population and it was not significant in TB cases.

In this study majority of cases of TB were attributed to malnutrition, followed by low annual family income, tobacco smoking, asthma and alcohol consumption. This is a marginalized community with no sustainable income and poor knowledge about the disease. Modelling study data based on National Family Health Survey (NFHS) showed that about 50 per cent of TB cases could be

attributed to undernutrition, thereby implying that improving nutritional status could have a dramatic impact on TB incidence²⁶. A study from Chhattisgarh, Central India, also found undernutrition in a large number of TB cases and that undernourished patients had more severe disease²⁷. Padmapriyadarsini *et al*²⁸ have recommended nutrition supplementation for TB patients. An integrated approach to improve their living conditions is also needed to control TB in this community. The Revised National Tuberculosis Control Programme has special provisions for tribal areas under its tribal plan such as additional facilities, incentives for workers and patients²⁹ which needs to be effectively implemented.

The limitation of this study was that the individuals with abnormal blood sugar level were not confirmed as diabetics though they were referred to health centre for further testing. In addition, the exposure levels of indoor air pollution could not be measured.

In conclusion, the present survey showed that the *Saharia*, one of the PVTGs residing in Central India, had PTB due to the major risk factors of malnutrition, history of asthma and their living conditions. Appropriate interventions need to be developed for nutritional supplementation for effective management of TB in this vulnerable population.

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Conflicts of Interest: None.

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