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Article

Alcohol Consumption of Male Tuberculosis Index Cases and Tuberculosis Transmission Among Social Contacts in Puducherry, India: A Cross-Sectional Analytical Study

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Abstract

We aimed to compare the proportion of tuberculosis infection among social contacts of male tuberculosis Index case with and without alcohol use in the Puducherry district. A cross-sectional study using ego-centric approach was conducted between November 2023 and May 2024. A total of 713 social contacts of 106 male pulmonary tuberculosis index cases were enrolled, stratified by alcohol-use (AUDIT ≥8): 358 contacts from 45 alcohol-using cases and 355 from 61 non-alcohol-use cases. Social contacts were defined based on the frequency and duration of shared indoor exposure with index cases within the past three months. Tuberculosis infection was screened with Cy-Tb skin test (≥5 mm induration) at the third month of index case treatment. Univariate and multivariable analysis were conducted to identify factors associated with tuberculosis transmission. Among the 358 social contacts of alcohol-use index cases,33.8% (n=121; 95% CI, 29.1%–38.8%) tested positive for tuberculosis infection, significantly higher than 21.7% (n=77; 95% CI, 17.7%–26.3%) among 355 contacts of non-alcohol-use cases. Regression analysis revealed that contacts of alcohol-using index cases (aOR=1.6, p<0.05), were significantly associated with tuberculosis infection. Alcohol-use among tuberculosis patients significantly increases the risk of tuberculosis infection in their social networks.

Keywords: latent tuberculosis infection; alcohol drinking; social network; contact tracing

1. Introduction

The National TB Elimination Program of India, aims for tuberculosis (TB) elimination by 2025 which is unmet and remains a substantial challenge [1]. While there is substantial progress in terms of reducing TB incidence by 17.7% since 2015, still the national target of reducing TB incidence by 80% remains elusive [2]. This challenge is underscored by the fact that 5–10% of those with tuberculosis infection (TBI) will develop active TB during their lifetime [3]. To halt the progress of TBI to active disease, it is crucial to screen and treat TB infection, especially among contacts of active TB cases [4]. To lower TB incidence, it is essential to break the chain of transmission [5].

Alcohol plays an important role in TB transmission. However, the mechanisms remain poorly understood. It is a known risk factor for TB, not only in terms of susceptibility but also in facilitating transmission [6]. It weakens immunity, increases infection risk, linked to poor treatment adherence and increased social interaction in crowded, poorly ventilated-spaces like drinking venues [7]. Alcohol use disorders (AUD) are highly prevalent among persons with TB (PTB) in India [8].They often spend more time in social settings, thus increasing the risks of transmission to their social contacts (SC) [9]. Non-household contacts, often neglected, may significantly contribute to

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transmission, particularly in socially active settings like alcohol consumption. Though household transmission matters, studies suggest that a large proportion of transmission occurs in community settings [10,11]. Social interactions, including close contact in neighborhoods, workplaces, and closed settings like alcohol-serving venues, drive TB transmission [12–15]

Contacts of PTBs are at higher risk of infection than the general population. The risk of TBI depends on the individual's immunity, the patient's infectiousness (e.g., sputum smear positivity), proximity, and duration of exposure [16,17]. Systematic screening of high-risk groups and close contacts of patients with TB disease, is one of the cornerstones of the End TB approach [18]. The key to the prevention of TB is tracing and investigating contacts of PTBs. Until recently, India's TB programme focused mainly on household contacts. On the 7th of December 2024, India launched the 100-day TB campaign aiming to provide TB preventive treatment to vulnerable populations, such as smokers, alcohol users, the elderly, those with past TB, the malnourished, and individuals living with HIV in 347 high-burden districts. However, the alcohol users and their contacts remain hard to reach [19]. This probably could be a reason for the lower yield of the screening programmes in India. Less evidence is available on the burden of TB infection (TBI) among the SCs of PTBs with AU as compared to those without in the Indian setting.

Puducherry, a Union Territory in southern India, has a high TB burden and a higher prevalence of alcohol-use among PTBs than other high TB burden areas within India. Previous study shows that in Puducherry, 59% of PTBs consumed alcohol, and 54% of them had AUD based on the Alcohol Use Disorders Identification Test (AUDIT) [20].AU in this setting is predominantly found in males. In this study, we aim to compare the proportion of TBI among SCs of male PTBs with and without AU in the Puducherry district.

2. Materials and Methods

Study Design, Population and Setting

A community-based, cross-sectional analytical study was undertaken in the Puducherry district between November 2023 and May 2024 to identify TBI among SCs of male pulmonary PTBs, stratified by alcohol consumption. The study population consisted of SCs of men with microbiologically confirmed pulmonary tuberculosis receiving treatment in the district. Women were excluded to ensure homogeneity, as AU is less common among them.

The Government Chest Clinic (GCC) in Puducherry which is the district's central TB registry, provided the list of newly reported male pulmonary TB cases. Patients were contacted through their designated Primary Health Centers (PHCs) and enrolled at a convenient time and place, either at the PHC or their residence, based on their preference.

Data Collection Tools

Following written informed consent, each index case (IC) was interviewed using a semi-structured questionnaire adapted from a similar study conducted in Chennai [21]. It was then piloted to ensure clarity and relevance to the Puducherry context. Alcohol use was assessed using the AUDIT tool [22], with a score ≥8 used to classify participants into alcohol-use and non-alcohol-use groups.

The study used an egocentric approach, relying on each IC to nominate their SCs. ICs reported individuals they had shared enclosed spaces with, such as in neighborhoods, workplaces, public venues, or drinking settings, during the three months before diagnosis. Pregnant women, children under one, and anyone who had recently received the BCG vaccine were excluded.

Information on socio-demographic characteristics, medical history, behavioural risk factors such as alcohol use, tobacco use, TB-related parameters, and anthropometric measurements were collected via face-to-face interviews. Contact and venue-level exposures were captured.

To assure data quality, each participant was allocated a unique ID to maintain confidentiality and facilitate the linkage of index and contact data. To mitigate recall bias, memory cues (including festivals, travel, hospitalisation, social gatherings, and key events such as marriage, funeral etc) were

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employed to aid participants in recollecting timelines and contacts. Key questions were repeated in several to validate responses.

Screening for TBI

Cy-Tb skin test was administered intradermally to the contacts at the 3rd month ICs treatment. An induration of ≥5 mm was considered TBI positive. After evaluation for TBI, the contacts were referred to the nearest hospital or government chest clinic for chest x-ray and sputum testing to rule out active TB (figure S1).

Operational Definition

- ***Persons with pulmonary tuberculosis (PTB) / Index case (IC):*** Persons with confirmed tuberculosis by sputum smear microscopy / CBNAAT / Gene-Xpert.
- ***Alcohol use:*** Defined as study participants who scored ≥8 when screened using the Alcohol Use Disorder Identification Test (AUDIT).
- ***Social contact (SC):*** Individuals who shared an enclosed space (e.g., at social gatherings, workplaces, or other facilities) with the index case for at least three days per week, for two to four hours per day, in the three months preceding the index case's current treatment episode.
- ***Casual and close contact:*** Based on the duration of time spent with the index case, social contacts were categorized as casual or close using a weighted score from three factors:
  i. time spent with the index case (<4 weeks = 1, 4–8 weeks = 2, >8 weeks = 3);
  ii. frequency per week (3 or more times/week = 1, daily = 2);
  iii. hours per week (2–4 hours = 1, 4+ hours = 2, all day = 3).
  - Those with a total score ≥6 were classified as close contacts, and those with a score <6 as casual contacts.
- ***Tuberculosis infection (TBI):*** A person who undergoes Cy-TB testing and develops an induration of 5 mm or more is considered to have TB infection.

Ethics

Ethical approval was obtained from the Institutional Ethics Committee (IEC) of JIPMER, and administrative clearance from the State TB Control Officer, National Tuberculosis Elimination Programme (NTEP), Puducherry.

Sample Size

A sample size of 314 per group was calculated for this study using a 10% difference in the prevalence of TBI, based on an assumed prevalence of 31% among contacts of PTBs with AU and 21% in the other group as per the findings of the National TB Prevalence Survey India 2019-2021 [18], with a 95% significance level and 80% power. Accounting for a potential 10% non-response among contacts, the target sample size was 700 (350/group).

Statistical Analysis

Descriptive statistics summarized the baseline characteristics of the participants, including proportions for categorical variables and means with 95% confidence intervals (CIs) for continuous variables. Chi-square tests were used to compare the proportion of TBI between groups. Univariate analysis was performed to assess the association between each explanatory variable and the TBI in SCs. Explanatory variables with a p-value ≤ 0.2 In the univariate analysis were included in a multivariable logistic regression model to identify the association of AU in IC and TBI in contacts after adjusting for potential confounders. The dependent variable in the regression model was TBI, which was coded as 1 for positive and 0 for negative based on the Cy-Tb test results. A p-value of <0.05 was considered statistically significant in the multivariable model. Data were analyzed using STATA version 17.

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3. Results

Of 324 PTBs screened, 159 were excluded for being female or having extrapulmonary TB. Among the remaining 165, 48 declined participation or did not respond. A total of 106 ICs were enrolled: 45 with AU and 61 with NAU. These ICs reported 994 SCs, of whom 713 participated: 358 (50.3%) were contacts of AU TB cases and 355 (49.7%) NAU cases. The mean (SD) age of contacts was 42 [16] years, i.e., 40 [16] years for the AU group and 44 [17] years for the NAU group.

IC with AU were mostly aged 45-60 years, engaged in unskilled occupations and from lower socioeconomic strata compared to non-alcohol-users. Smoking was predominantly higher among AU group, while diabetes and hypertension were more common in the NAU group. Underweight was more frequent among IC with AU (Table 1).

Table 1. Sociodemographic characteristics of Index case.

Characteristics	IC with AU (N1= 45)		IC without AU (N2= 61)		Total IC (N=106)	
	n	%	n	%	n	%
Age groups (years)						
19-30	3	6.7	5	8.2	8	7.6
31-45	12	26.7	10	16.4	22	20.8
46-60	27	60	21	34.4	48	45.2
> 60	3	6.7	25	41	28	26.4
Area of residence						
Rural	5	11.1	9	14.8	14	13.2
Urban	40	88.9	52	85.2	92	86.8
Religion						
Hindu	41	91.1	55	90.2	96	90.6
Christian	3	6.7	2	3.3	5	4.7
Muslim	1	2.2	4	6.6	5	4.7
Education						
Illiterate	4	8.9	4	6.6	8	7.5
Primary	14	31.1	13	21.3	27	25.5
Secondary	17	37.8	30	49.2	47	44.4
Higher secondary	3	6.7	3	4.9	6	5.7
Graduate	7	15.6	11	18	18	16.9
Occupation						
Unskilled	29	64.4	25	41	54	50.9
Unemployed	0	0	3	4.9	3	2.8
Skilled	11	24.4	23	37.7	34	32.2
Student	0	0	1	1.6	1	0.9
Professional	5	11.1	9	14.8	14	13.2
SES						
APL	5	11.1	18	29.5	23	21.7
BPL	40	88.9	43	70.5	83	78.3
Marital status						
Married	39	86.7	52	85.2	91	85.8
Unmarried	5	11.1	9	14.8	14	13.2
Separated / Widow	1	2.2	0	0	1	0.94
Type of TB						
New	40	88.9	55	90.2	95	89.6
Recurrent	5	11.1	6	9.8	11	10.4
BCG Scar						
Yes	43	95.6	54	88.5	97	91.5

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Smoking						
Yes	7	15.6	2	3.3	9	8.5
Comorbidity						
Yes	18	40	40	65.6	58	54.7
Diabetes						
Yes	15	33.3	34	55.7	49	46.2
Hypertension						
Yes	4	8.9	16	26.2	20	18.8
Body mass index (kg/m2)						
Underweight (<18.5)	25	55.6	25	41	50	47.2
Normal (18.5-22.9)	15	33.3	29	47.5	44	41.5
Overweight (23-24.9)	4	8.9	6	9.8	10	9.4
Obese (>25)	1	2.2	1	1.6	2	1.9
Contact History of TB						
Yes	17	37.8	16	26.2	33	31.1
Smear grade						
Scanty	4	8.9	14	23	18	16.9
1+	21	46.7	29	47.5	50	47.2
2+	13	28.9	10	16.4	23	21.7
3+	7	15.6	8	13.1	15	14.2

*IC= Index case
*AU= Alcohol Use
*APL= Above Poverty Line
*BPL= Below Poverty Line
*Skilled worker= Driver, cook, electrician, barber, carpenter
*Unskilled worker= labour, construction worker, painter, shopkeeper, street vendor, scrap picker, security
*Comorbidities=CVD, Hypothyroidism, hyperthyroidism, CKD, Epilepsy, Stroke

Among the 358 contacts of ICs with AU, 121 (33.8%; 95% CI, 29.1%–38.8%) had TBI, and one (0.28%) had TB disease at baseline. Among the 355 contacts of ICs without AU, 77 (21.7%; 95% CI, 17.7%–26.3%) had TBI, and none had TB disease. The proportion of TBI was significantly higher among contacts of AU ICs (61.1%) than NAU (38.9%). Compared to contacts of NAU ICs, those in the AU group were predominantly males, from lower SES, engaged in unskilled labor and were unmarried. Smoking and AU were more common among contacts in the AU group. They also had more night-time exposure to the IC and had a higher proportion of friends as SCs (Table 2).

Table 2. Sociodemographic characteristics of Social Contacts of Index Case.

Characteristics	Social Contacts of IC with AU (N= 358)		Social Contacts of IC without AU (N= 355)		Total social contacts (N=713)	
	n	%	n	%	n	%
Age						
≤18	27	7.5	20	5.6	47	6.6
19-30	79	22.1	58	16.3	137	19.2
31-45	103	28.8	121	34.2	224	31.4
46-60	117	32.7	92	25.9	209	29.3
> 60	32	8.9	64	18	96	13.5
Area of residence						
Rural	60	16.8	61	17.2	121	16.9
Urban	298	83.2	294	82.8	592	83.1
Gender						
Female	156	43.6	170	47.9	326	45.7

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Male	202	56.4	185	52.1	387	54.3
Religion						
Hindu	316	88.3	316	89	632	88.6
Christian	38	10.6	21	5.9	59	8.3
Muslim	4	1.1	18	5.1	22	3.1
Education						
No formal education	48	13.4	55	15.5	103	14.4
Primary	82	22.9	67	18.9	149	20.9
Secondary	134	37.4	115	32.4	249	34.9
Higher secondary	35	9.8	48	13.5	83	11.6
Graduate	59	16.5	70	19.7	129	18.2
Occupation						
Unskilled	153	42.7	125	35.2	278	38.9
Unemployed	81	22.6	93	26.2	174	24.4
Skilled	75	20.9	76	21.4	151	21.2
Student	28	7.8	29	8.2	57	7.9
Professional	20	5.7	23	6.5	43	6
Retired	1	0.3	9	2.5	10	1.6
Socioeconomic Status						
APL	65	18.2	148	41.7	213	29.8
BPL	293	81.8	207	58.3	500	70.2
Marital status						
Married	278	77.6	288	81.1	566	79.4
Unmarried	79	22.1	60	16.9	139	19.5
Separated / Widow	1	0.3	7	2	8	1.1
BCG Scar						
Yes	320	89.4	318	89.6	638	89.5
Smoking Status						
Yes	75	20.9	31	8.7	106	14.9
Alcohol use						
Yes	138	38.5	58	16.3	196	27.5
Spent night with index case						
Yes	110	30.8	76	21.4	186	26.1
Share food						
Yes	147	41.2	154	43.4	301	42.2
Presence of Chronic Diseases						
Yes	122	34.1	103	29	225	31.6
Diabetes						
Yes	83	23.2	54	15.2	137	19.2
Hypertension						
Yes	82	22.9	77	21.7	159	22.3
Body Mass Index						
Underweight (<18.5)	50	14	34	9.6	84	11.8
Normal (18.5-22.9)	131	36.6	128	36.1	259	36.3
Overweight (23-24.9)	44	12.2	45	12.6	89	12.4
Obese (>25)	133	37.2	148	41.7	281	39.5

*IC= Index case

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*AU= Alcohol Use
*APL= Above Poverty Line
*BPL= Below Poverty Line
*Skilled worker= Driver, cook, electrician, barber, carpenter
*Unskilled worker= labour, construction worker, painter, shopkeeper, street vendor, scrap picker
*Chronic diseases=Hypertension, Diabetes Mellitus, CVD, Hypothyroidism, hyperthyroidism, CKD, Epilepsy, Arthritis, Asthma, Pancreatitis.

The AU group had more contacts with diabetes mellitus (23.2% vs.15.2%). While overall AU was higher among the contacts of the patients with AU, harmful use was more common among the contacts of NAU group (31% vs. 23.9%) (Table 4). Contacts of AU patients spent more time with the IC, over eight weeks together (40.8% vs. 27.8%) and all day (9.2% vs. 6.2%). Also, a higher proportion of close contacts were in the AU group (37.4%) than in the NAU group (30.1%) (Table 3).

Table 3. Epidemiological and social relationship between index case and social contacts.

Characteristics	Social Contacts of IC with AU (N= 358)		Social Contacts of IC without AU (N= 355)		Total social contacts (N=713)	
	n	%	n	%	n	%
Relation						
Extended family	37	10.3	71	20	108	15.1
Friend	63	17.6	47	13.2	110	15.4
Neighbour	48	13.4	23	6.5	71	9.9
Relative	109	30.4	109	30.7	218	30.6
Workplace contact	101	28.3	105	29.6	206	29
Past TB history						
Yes	2	0.6	3	0.8	5	0.7
Knows TB patient other than index case						
Yes	38	10.6	39	11	77	10.8
Family history of TB						
Yes	25	7	24	6.8	49	6.8
Family history of death due to TB						
Yes	3	0.8	7	2	10	1.4
Type of contact						
Casual contact	224	62.6	248	69.9	472	66.2
Close contact	134	37.4	107	30.1	241	33.8
Duration of knowing index case						
<12 years	199	55.6	155	43.7	354	49.6
>=12 years	159	44.4	200	56.3	359	50.3
Weeks spend with index case						
<4 weeks	75	20.9	92	25.9	167	23.4
4-8 weeks	137	38.3	164	46.2	301	42.2
>8 weeks	146	40.8	99	27.9	245	34.4
Times in a week						
3+times/week	219	61.2	224	63.1	443	62.1
Everyday/week	139	38.8	131	36.9	270	37.9
Hours in a week						

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2-4 hours/week	172	48	201	56.6	373	52.3
4+hours/week	153	42.8	132	37.2	285	39.9
All day	33	9.2	22	6.2	55	7.8
Spend night with index case Yes	110	30.8	76	21.4	186	26.1
Share food						
Yes	147	41.2	154	43.4	301	42.2

Table 4. Alcohol use among social contacts of index case.

Variables	Social Contacts of IC with AU(N=138)		Social Contacts of IC without AU (N= 58)	
	n	%	n	%
AUDIT score				
Low risk (0-3)	3	2.1	1	1.7
Risky (4-9)	47	34.1	16	27.6
Harmful (10-13)	33	23.9	18	31
Severe (14+)	55	39.9	23	39.7
Drink in arrack shop				
Yes	106	76.8	41	70.6
No	32	23.2	17	29.4
Share alcohol with IC				
Yes	75	54.3		-
Frequency of drink with IC				
1-2 times/week	26	34.6		
3+times/week	23	30.6		
Everyday	22	29.4		-
Less than once/week	4	5.4		
Share glass				
Yes	3	4		-
No	72	96		

In univariate analysis, contact type, age group, education level, socioeconomic status, body mass index (BMI), chronic disease, diabetes, hypertension, knowing PTB other than IC, family history of TB, tobacco use, smoking, AU, type of contact based on the frequency of meeting and sharing food with IC had a significant association with TBI (Table 5) were considered for multivariable analysis based on their epidemiological relevance.

Table 5. Independent factors associated with TBI among Social Contacts of Index case.

Variables	Total	TBI positive		TBI Negative		Unadjusted odds ratio (95%CI)	Adjusted odds ratio (95%CI)	Adjusted p value
	N	n	%	n	%			
Contact Type								
Index case with AU	357	121	61.6	236	45.9	1.9(1.3-2.5)	1.6* (1.03-2.5)	0.037
Index case without AU	355	77	38.9	278	54.1	(ref)	(ref)	
Age								
≤18	47	8	4	39	7.6	(ref)	(ref)	
19-30	137	33	16.6	104	20.2	1.6 (0.6-3.6)	1.3(0.5-4)	0.5
31-45	224	61	30.8	163	31.7	1.8 (0.8-4.1)	1 (0.4-3)	0.8
46-60	208	64	32.4	144	28	2.2 (0.9-4.8)	0.5 (0.2-1.5)	0.4
>60	96	32	16.2	64	12.5	2.4 (1.02-5.8)	0.5 (0.1-1.5)	0.3

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Education								
No formal	103	41	20.7	62	12	4(2.2-7.7)	3.1(1.3-7.7)	0.012
education	480	139	70.2	341	66.4	2.5(1.4-4.3)	1.7(0.8-3.3)	0.113
School level	129	18	9.1	111	21.6	(ref)	(ref)	
Graduate level								
Occupation								
Unskilled	278	93	47	185	36	1.9(0.8-4.1)		
Unemployed	173	48	24.2	125	24.3	1.5(0.6-3.2)		
Skilled	151	42	21.2	109	21.2	1.5(0.6-3.3)		
Student	57	5	2.5	52	10.1	0.4(0.1-1.2)	*Not included in model*	
Professional	43	9	4.6	34	6.6	(ref)		
Retired	10	1	0.5	9	1.8	0.4(0.05-3.8)		
Area of residence								
Rural	120	39	19.7	81	15.8	1.3(0.8-2)	*Not included in model*	
Urban	592	159	80.3	433	84.2	(ref)		
Gender								
Female	325	84	42.4	241	46.9	0.8(0.6-1.2)	*Not included in model*	
Male	387	114	57.6	273	53.1	(ref)		
Religion								
Hindu	631	172	86.8	459	89.3	(ref)		
Christian	59	19	9.6	40	7.8	1.3(0.7-2.2)	*Not included in model*	
Muslim	22	7	3.6	15	2.9	1.2(0.5-3)		
Socioeconomic Status								
APL	213	37	18.7	176	34.2	(ref)		
BPL	499	161	81.3	338	65.8	2.3(1.5-3.4)	*Not included in model*	
BMI								
Underweight	84	39	19.7	45	8.8	(ref)	(ref)	
Normal	258	68	34.3	190	36.9	0.4 (0.3-0.7)	0.5 (0.2-1.1)	0.1
Overweight	89	30	15.2	59	11.5	0.6 (0.3-1.1)	1 (0.4-2)	0.8
Obese	281	61	30.8	220	42.8	0.3 (0.2-0.5)	0.4*(0.2-0.96)	0.035
Presence of any chronic disease								
Yes	224	97	49	127	24.7	2.9(2.1-4.1)	0.3(0.1-1)	0.063
No	488	101	51	387	75.3	(ref)	(ref)	
Diabetes								
Yes	137	72	36.4	65	12.6	3.9 (2.7-5.8)	5* (2.3-11.5)	<0.001
No	575	126	63.6	449	87.4	(ref)	(ref)	
Hypertension								
Yes	159	81	40.9	77	15	3.9 (2.7-5.7)	7.6*(3.2-18)	<0.001
No	553	117	59.1	437	85	(ref)	(ref)	
Knowing person with TB other than index case								
Yes	77	41	20.7	36	7	3.5(2.1-5.6)	2.2(0.9-4.9)	0.06
No	635	157	79.3	478	93	(ref)	(ref)	
Family history of TB								
Yes	49	27	13.6	22	4.3	3.5 (1.9-6.4)	3.2*(1.2-8.4)	0.017
No	663	171	86.4	492	95.7	(ref)	(ref)	
Smoking								
Yes	106	59	29.8	47	9.1	4.2 (2.7-6.5)	1.8 (0.9-3.6)	0.1

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No	606	139	70.2	467	90.9	(ref)	(ref)	
Alcohol use								
Yes	196	91	46	105	20.4	3.3 (2.3-4.7)	1.3 (0.7-2.3)	0.4
No	516	107	54	409	79.6	(ref)	(ref)	
Sharing food								
Yes	301	131	66.2	170	33.1	3.9(2.8-5.6)	3.2* (2-5)	<0.001
No	412	67	33.8	344	66.9		(ref)	
Type of contact based on frequency of meeting								
Casual contact	472	70	35.4	401	78	(ref)	(ref)	
Close contact	241	128	64.6	113	22	6.5(4.5-9.3)	5.8*(3.7-9)	<0.001

**The variables such as occupation, area of residence, religion, gender, and socioeconomic status were excluded from the multivariable model due to either a lack of statistical significance in univariate analysis (p > 0.20) or concerns related to multicollinearity (mean VIF=2.6).*

In the multivariable regression analysis (Table 5), numerous characteristics were identified as strongly associated with a higher likelihood of TBI among contacts. Contact with an IC reporting AU was significantly associated with an increased risk of TBI (aOR 1.6, 95% CI 1.03-2.5, p=0.05). Close contacts (aOR:5.8,95% CI: 3.7-9, p<0.001) were significantly more likely to acquire TBI than casual contacts and sharing food with the IC was found to be a significant predictor for TBI (aOR: 3.2, 95% CI: 2-5, p<0.001). Furthermore, diabetes was identified as a significant risk factor, with patients diagnosed with diabetes having a fivefold risk for TBI (aOR: 5, 95% CI: 2.3-11.5, p<0.001). Similarly, hypertension was strongly associated with an increased risk of TBI (aOR:5,95% CI: 2.3-11.5, p<0.001). Participants with a familial history of tuberculosis significantly increased the probability of TBI by nearly threefold (aOR: 3.2, 95% CI: 1.2-8.4, p=0.017). Contacts with no formal education had a much higher chance of TBI (aOR:3.1, 95% CI: 1.3–7.7, p=0.012) than those with at least a graduate degree. Additionally, obese people had a much lower chance of getting TBI (aOR: 0.4, 95% CI: 0.2-0.96, p= 0.035), suggesting that a higher BMI may be a protective factor. The mean variation inflation factor (VIF) was found to be 2.6, indicating no significant multicollinearity among the included independent variables.

4. Discussion

The current study assessed TBI among 713 contacts;358 from AU and 358 from NAU index cases. TBI was higher among contacts in the AU group (33.8% vs.21.7%) compared to NAU, a finding likely generalizable in Indian context. The National TB Prevalence Survey India 2019-2021 reported a 21% TBI in the general population [23], while a prior Puducherry study reported 29.6% TBI among household contacts when using a ≥10 mm Mantoux test cut-off(unpublished) [24]. These findings indicate that extra-household transmission contributes substantially to the overall TB burden, much like household transmission.

TBI was more common among friends of PTBs, with 25% of alcohol-sharing contacts infected and 52% being friends, aligning with K Nagarajan's findings that extra-household contacts have higher TB risk, thus highlighting the potential for transmission within social networks [21].

In present study, contacts of AU index-case were mostly with lower education, unskilled workers, and below the poverty line; they had higher TBI positivity, reflecting structural vulnerability due to poor living conditions, limited health-seeking behavior, and increased infection risk, consistent with prior research linking socioeconomic disadvantage to TB [25]. AU weakens immunity and promotes gatherings in high-risk settings like liquor shops, and combined with poor socioeconomic factors, increases TB infection susceptibility [26].

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An earlier study found an inverse-relationship between AU and TBI among household contacts, likely due to less time spent at home by PTB with AU [9,24]. In South Africa, household contacts infected with the same strain as that of the PTB, may have acquired TB outside the household, since the same strain was also the most prevalent strain in the community [11], suggesting that over 75% of transmission may occur outside the household due to extensive social mixing. While household screening is economical, it has limited impact, highlighting the need for community-level screening [10,11].

This study shows that contacts of AU ICs are more vulnerable to TBI (aOR= 1.6) due to closer interactions, including prolonged time together, drinking, and food sharing. A higher proportion of contacts in the AU group were close contacts (37.4% vs. 30.1%), had contact >8 weeks (40.8% vs. 27.9%), spent nights (30.8% vs. 21.4%), and shared food (41.2% vs. 43.4%), indicating greater exposure within AU networks. TBI was 61.1% in contacts of AU group vs. 38.9% in the other, despite more harmful AU among the SCs of NAU group. This substantial variation in infection rates strongly suggests the IC's alcohol drinking status coupled with food sharing could have significant impacts on the transmission dynamics of TBI rather than the drinking status of the contacts. Alcohol is an immunosuppressant [27], increasing bacterial load and prolong infectiousness in people with AU, raising the risk of TB transmission. Thus, leading to poor treatment adherence and more frequent close interactions in settings like bars[14,28,29]. Food sharing, often in poorly-ventilated settings [24], may increase the transmission risk and often coincide with alcohol consumption. The findings suggest AU as a key modifiable risk factor in TB transmission.

Close contact was the strongest predictor of TBI (aOR=5.8), reinforcing that duration and proximity drive transmission, particularly in AU networks. A recent study also proposed scoring contact duration and frequency to improve extra-household TB screening efforts [16].

These findings show that diabetes and hypertension were associated with a higher risk of TBI. Other studies show that, these comorbidities were more common in the AU group, suggesting alcohol may worsen or contribute to these conditions, further increasing TBI risk [30,31]. Targeted screening and TB preventive treatment in groups with chronic diseases and heavy AU may aid TB control.

TBI was also more likely among individuals with no formal education. Low literacy is often linked to unskilled, low-paying jobs in informal sectors where AU is common, increasing transmission risk. Public health interventions in low-literacy communities could reduce TB spread [32].

Obesity was linked to lower TBI odds (aOR 0.4; 95% CI: 0.2–0.96), in line with studies showing an inverse relationship between BMI and TB risk. Various studies have shown that higher BMI reduces both the likelihood of TB and progression to active disease, with each unit increase in BMI linked to a 2% decline in TB incidence [33–36].

5. Conclusions

This study underscores the role of AU in TB transmission and the need to expand contact tracing beyond households. Risk-based screening under the National TB Program could be more effective. Relying on patient-reported contacts may have introduced recall and social desirability biases, leading to underreporting or misclassification bias.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org. Figure S1: title; Table S1: title; Video S1: title.

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Informed Consent Statement: Written informed consent was obtained from all subjects involved in the study. The consent covered participation in the study, sharing of social contact details by index cases, details of alcohol use and administration of the Cy-Tb skin test to eligible social contacts.

Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Abbreviations

The following abbreviations are used in this manuscript:

TB	Tuberculosis
TBI	Tuberculosis infection
PTB	Persons with Tuberculosis
IC	Index case
SC	Social contact
AU	Alcohol use
NAU	Non-alcohol use
AUD	Alcohol use disorder
BMI	Body Mass Index
aOR	Adjusted Odds Ratio

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