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A Study of Clinico-Social Profile and Other Factors Associated with Tuberculosis in Household Contacts of Drug-Resistant Pulmonary Tuberculosis Patients Through Clinical, Microbiological and Radiological Assessment

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ABSTRACT

Background and Aims: Tuberculosis (TB) remains a major global public health concern, with India contributing a substantial proportion of the global burden, particularly of drug-resistant tuberculosis (DR-TB). Household contacts of DR-TB patients are at increased risk of both active TB disease and latent tuberculosis infection (LTBI), yet data on clinico-social determinants in this high-risk group remain limited. This study aimed to detect active TB disease and LTBI among household contacts of DR-TB patients registered under the National Tuberculosis Elimination Programme (NTEP) and to identify associated risk factors, including comparison of drug-susceptibility patterns between index cases and affected contacts.

Methods: A hospital-based cross-sectional descriptive study was conducted from January to December 2021 at a tertiary DR-TB centre in Delhi. A total of 130 DR-TB index cases and 229 adult household contacts were enrolled using total enumeration sampling. Household contacts underwent clinical evaluation, nutritional assessment, sociodemographic profiling, Mantoux testing, chest radiography, and microbiological investigations where indicated. Data were analyzed using SPSS v27.0 and GraphPad Prism v5. Continuous variables were expressed as mean ± standard deviation and categorical variables as frequency (%). Associations were assessed using *t*-test, one-way analysis of variance (ANOVA), chi-square test, or Fisher's exact tests, with $p \leq 0.05$ considered significant.

Results: Among household contacts, active TB disease was detected in 12 individuals (5.2%), while LTBI was present in 112 contacts (48.9%). The mean age of contacts was 38.6 ± 15.4 years, with near-equal gender distribution. Among contacts with active TB, 83.3% were drug-resistant. Active TB disease was significantly associated with prolonged daily exposure (>9 hours), bed sharing, room sharing, absence of BCG scar, and undernutrition, whereas LTBI showed no significant association with demographic, nutritional, or socioeconomic variables.

Conclusion: Household contacts of DR-TB patients bear a substantial burden of TB infection and disease. Exposure-related factors and absence of BCG vaccination play a critical role in progression to active TB, underscoring the need for intensified contact screening, early diagnosis, and targeted preventive strategies.

Keywords: Tuberculosis; Drug-Resistant Tuberculosis; Household Contacts; Latent Tuberculosis; Risk Factors; Contact Tracing

INTRODUCTION

Tuberculosis (TB) is a chronic infectious disease caused by *Mycobacterium tuberculosis* and continues to pose a major global public health challenge despite significant advances in diagnostic methods, treatment strategies, and preventive interventions. The Global Tuberculosis Report published by the World Health Organization (WHO) in 2021 highlights the persistent burden of TB worldwide. In 2020, men aged over 15 years accounted for 56% of newly diagnosed TB cases, women for 33%, and children for 11%, with adults constituting nearly 88% of the total burden. Approximately 8.2% of TB cases occurred among people living with HIV, predominantly in the African region. Notably, two-thirds of the global TB burden was concentrated in eight countries, with India alone contributing 26% of cases, followed by China, Indonesia, the Philippines, Pakistan, Nigeria, Bangladesh, and South Africa [1].

Until the emergence of the coronavirus disease (COVID-19) pandemic, TB remained the leading cause of mortality from a single infectious agent, surpassing HIV/AIDS. However, the pandemic substantially disrupted TB control efforts, reversing years of progress in case detection and treatment coverage. Globally, the number of newly diagnosed TB cases declined sharply from 7.1 million in 2019 to 5.8 million in 2020, largely due to reduced access to healthcare services and interruptions in routine TB programs [1].

India bears the highest TB burden globally, with an estimated 2.5 million prevalent TB cases and approximately 2.2 lakh TB-related deaths annually. Although TB-associated mortality is higher among men, the disease burden among women remains considerable [2]. Of increasing concern is the growing prevalence of drug-resistant TB (DR-TB). In 2020, nearly half a million individuals worldwide developed rifampicin-resistant TB, of whom 71% were diagnosed with multidrug-resistant TB (MDR-TB) [1].

MDR-TB is defined as resistance to at least both isoniazid and rifampicin, with or without resistance to other first-line anti-TB drugs. Additional resistance patterns include pre-XDR-TB, characterized by MDR-TB with fluoroquinolone resistance, and extensively drug-resistant TB (XDR-TB), defined as MDR-TB with additional resistance to at least one fluoroquinolone and one Group A drug such as bedaquiline or linezolid. Treatment regimens for these forms of TB are prolonged, costly, less effective, and associated with a high incidence of adverse drug reactions [2]. Furthermore, patients with MDR-TB may remain infectious for longer durations, thereby sustaining transmission within the community.

The COVID-19 pandemic further exacerbated the DR-TB crisis, with a 15% reduction in the number of patients receiving treatment for drug-resistant TB and a 21% decline in TB preventive therapy between 2019 and 2020 [1]. These setbacks underscore the urgent need to restore and strengthen essential TB services, particularly active case detection and preventive strategies.

Household contacts of TB patients represent a high-risk group for infection and disease progression. While contact investigation is a cornerstone of TB control, especially among vulnerable populations such as children

under five years of age and people living with HIV, the contribution of within-household transmission to the overall burden of MDR-TB remains insufficiently studied [3]. Existing literature provides limited evidence regarding the yield of active TB among household contacts of MDR-TB and XDR-TB patients, particularly those receiving modified regimens due to additional drug resistance in the Indian setting.

There is a paucity of Indian data evaluating the burden of active and latent TB infection among household contacts of patients with MDR-TB and XDR-TB. Systematic screening of these contacts has the potential to interrupt transmission chains, enable early diagnosis, and reduce morbidity and mortality associated with drug-resistant TB. Addressing this knowledge gap is essential for strengthening TB control strategies under the National Tuberculosis Elimination Programme (NTEP).

Aim and Objectives

Primary Objective:

To detect active TB disease and latent TB infection among household contacts of patients registered with drug-resistant TB under NTEP.

Secondary Objectives:

To identify risk factors among household contacts for the development of TB disease.

To compare the drug susceptibility testing (DST) profiles of index cases and household contacts who develop active TB disease.

MATERIALS AND METHODS

This hospital-based, cross-sectional descriptive study was conducted at the Outpatient Department (OPD) and Inpatient Department (IPD) of Kingsway Chest Centre and the Rajan Babu Institute for Pulmonary Medicine and Tuberculosis (RBIPMT), North Delhi Municipal Corporation, GTB Nagar, Kingsway Camp, Delhi-110009. The study population comprised newly diagnosed sputum-positive drug-resistant pulmonary tuberculosis (DR-TB) patients registered under the National Tuberculosis Elimination Programme (NTEP) at RBIPMT, along with their eligible household contacts.

All newly diagnosed DR-TB patients reporting to the OPD or admitted to the IPD during the study period, who fulfilled the inclusion and exclusion criteria, were enrolled as index cases. Household contacts of these index cases were subsequently recruited. Enrolment was carried out through both OPD and IPD services. The study intake period extended from 1 January 2021 to 31 December 2021.

The DR-TB Centre of RBIPMT caters to an approximate population of 5.9 million annually. Based on institutional records from 2019, among 98 registered patients, 45 had rifampicin-resistant/multidrug-resistant tuberculosis (RR/MDR-TB) with additional resistance to either ofloxacin or kanamycin, and 53 had RR/MDR-TB with resistance to both kanamycin and ofloxacin. Considering all eligible household contacts during the study period and with reference to a previous study reporting a prevalence of 5.29%, the sample size was calculated using the formula $n = 4pq/d^2$, where n represents sample size, p the prevalence, $q = 1 - p$, and d the precision. Assuming a 4% margin of error, 5% level of significance, 80% power, and 0.10 precision, the final calculated sample size was 125, as described by Charan and Biswas et al. [4].

Inclusion criteria comprised adult (>18 years) DR pulmonary tuberculosis patients admitted to RBIPMT who provided written informed consent and were willing to undergo diagnostic evaluation, as well as adult household contacts (>18 years) of DR pulmonary TB patients who consented and agreed to diagnostic assessment. Exclusion criteria included individuals younger than 18 years or older than 75 years, unwilling participants, pregnant women, contacts of extrapulmonary TB patients, contacts of patients on modified treatment regimens due to drug intolerance, and household contacts

with comorbid conditions that could influence nutritional status, such as diabetes mellitus, cardiovascular disease, chronic liver or kidney disease, gastrointestinal disorders, malabsorption syndromes, or malignancy.

Ethical approval for the study was obtained from the Institutional Human Ethics Committee prior to initiation. Written informed consent was obtained from all participants in either English or Hindi. Participation was voluntary, without inducement or misrepresentation, and participants retained the right to withdraw from the study at any time without prejudice.

A total enumeration sampling technique was employed, whereby all eligible index patients and their household contacts meeting inclusion criteria were enrolled until the required sample size was achieved within the stipulated study period. All index patients were registered under NTEP and received DOTS-based treatment for sputum-positive DR pulmonary tuberculosis at RBIPMT.

Data collection was performed using a standardized, pre-tested proforma. Index patients and household contacts were informed about the study objectives, and informed consent was obtained prior to data collection. An index case was defined as a patient diagnosed with MDR-TB or XDR-TB by a public health authority. A household contact was defined as an individual who shared the same enclosed living space with the index case for one or more nights or for frequent or prolonged periods during the day.

Assessment of nutritional status included anthropometric measurements such as height, weight, body mass index (BMI), waist-hip ratio (WHR), mid-upper arm circumference (MUAC), and waist-to-height ratio. BMI was calculated as weight in kilograms divided by height in meters squared and categorized according to Indian standards. WHR was measured using waist and hip circumferences, with WHO-recommended cut-off values used to assess health risk. MUAC was measured at the midpoint between the acromion and olecranon, and sex-specific cut-offs were applied. Waist-to-height ratio was calculated and classified into underweight, healthy, overweight, and obese categories.

Socioeconomic status was assessed using the Modified Kuppuswamy Scale (2019), based on education, occupation, and monthly family income of the head of the household. Scores from these three domains were summed to classify participants into one of five socioeconomic classes ranging from upper to lower class.

Following informed consent, household contacts underwent clinical evaluation, nutritional assessment, and sociodemographic profiling. Diagnostic investigations included Mantoux test and chest radiography for all contacts. Symptomatic individuals underwent sputum smear microscopy for acid-fast bacilli, and those with smear positivity or clinicoradiological suspicion of tuberculosis were further evaluated using cartridge-based nucleic acid amplification testing (CBNAAT) at the Department of Pulmonary Medicine, RBIPMT.

Detailed clinical history, including respiratory and constitutional symptoms, medical comorbidities, addiction history (smoking and alcohol use), and exposure level to the index case, was obtained from all household contacts. Smoking status was classified according to Centers for Disease Control and Prevention (CDC) guidelines. General physical examination included vital parameters, BMI assessment, and lymph node evaluation. Exposure assessment included duration of cohabitation, room sharing, and sleeping arrangements with the index case. For this study classification of smoking as per CDC [5], USA were used –

Never Smoker- Never smoker is someone who has either never smoked or has smoked < 100 cigarettes per lifetime.

Current Smoker- are those who have smoked 100 cigarettes and now smoke

either every day (every day smoker) or someday (some day smoker).

Non-Smoker- Adults who currently do not smoke cigarettes. This includes both never smokers and former smokers.

At the conclusion of the study, household contacts were categorized as either normal or having active tuberculosis disease. Statistical analysis was performed to evaluate associations between nutritional, socioeconomic, and other risk factors with active tuberculosis, as well as to compare drug susceptibility patterns between index cases and affected contacts.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 27.0 and GraphPad Prism version 5. Continuous variables were summarized as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Comparative analyses were conducted using independent and paired *t*-tests, one-way analysis of variance (ANOVA), chi-square test, or Fisher's exact test as appropriate. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

A total of **130 index cases** and **229 household contacts** were included in this study.

Profile of Index Cases

Most index cases were aged 21–40 years (53.8%) and were predominantly male (56.2%). Multidrug-resistant TB (MDR-TB) was the most common drug-resistance pattern (66.9%). Unilateral consolidation was the most frequent chest radiographic finding (47.7%). A prior history of Category-I anti-tubercular treatment was reported in 61.5% of index cases.

Profile of Household Contacts

Among the 229 household contacts, the majority belonged to the 21–40-year age group (42.8%), with nearly equal gender distribution. Nutritional assessment showed a high burden of undernutrition, particularly when assessed by mid-upper arm circumference (71.6% malnourished). Most contacts were asymptomatic, and BCG scar was present in 99.1%. Nearly 40% of contacts spent 6–9 hours daily with the index case, and one-third shared a bed.

TB and LTBI Outcomes

Active TB disease was detected in **12 contacts (5.2%)**, while **LTBI was present in 48.9%**. Among contacts with active TB, **83.3% (10/12)** had drug-resistant TB. Prolonged exposure, bed sharing, room sharing, and absence of BCG scar were significantly associated with active TB disease, whereas no factor showed a statistically significant association with LTBI.

Table 1. Demographic Profile of Index Cases (N = 130)

Variable	Category	No. (%)
Age group (years)	0–20	10 (7.7)
	21–40	70 (53.8)
	41–60	34 (26.2)
	>60	16 (12.3)
Gender	Male	73 (56.2)
	Female	57 (43.8)

Table 2. Drug-Resistance Pattern and Radiological Findings in Index Cases (N = 130)

Variable	Category	No. (%)
DST pattern	MDR-TB	87 (66.9)
	Pre-XDR TB	39 (30.0)
	XDR TB	4 (3.1)
Chest X-ray	Unilateral consolidation	62 (47.7)
	Bilateral consolidation	28 (21.5)
	No abnormality	28 (21.5)
	Cavitary lesions / destroyed lung	12 (9.3)

Table 3. Demographic Profile of Household Contacts (N = 229)

Variable	Category	No. (%)
Age group (years)	0–20	30 (13.1)
	21–40	98 (42.8)
	41–60	66 (28.8)
	>60	35 (15.3)
Gender	Male	114 (49.8)
	Female	115 (50.2)

Table 4 summarizes the association between selected demographic and clinical variables and the presence of active tuberculosis (TB) disease among the study participants.

Active TB disease was observed across all age groups; however, no statistically significant association was found between age and active TB status ($p = 0.46$). Although the proportion of active TB appeared higher in the younger age group (0–20 years: 10.0%) and progressively declined with increasing age, this trend did not reach statistical significance. Similarly, gender was not significantly associated with active TB disease ($p = 0.25$), despite a relatively higher proportion of active TB among males (7.0%) compared with females (3.5%).

Body mass index (BMI) showed a borderline association with active TB disease ($p = 0.08$). Participants with BMI <18.5 kg/m² had a higher prevalence of active TB (17.6%) compared to those with normal or higher BMI, suggesting a possible trend toward increased risk among undernourished individuals, although this did not achieve statistical significance.

A statistically significant association was observed between BCG scar status and active TB disease ($p < 0.01$). All individuals without a BCG scar were found to have active TB, whereas the prevalence of active TB among those with a BCG scar was low (4.4%), indicating a potential protective effect of prior BCG vaccination.

No significant association was found between smoking status and active TB disease ($p = 0.53$). Active TB prevalence was comparable across non-smokers, former smokers, current smokers, and passive smokers. Likewise, socioeconomic status was not significantly associated with active TB disease ($p = 0.22$), although a higher proportion of active TB was noted in participants belonging to the lower socioeconomic group (10.3%) compared to other categories.

Overall, among the variables studied, absence of a BCG scar emerged as the only factor significantly associated with active TB disease, while age, gender, BMI, smoking status, and socioeconomic status did not show statistically significant associations in this cohort.

Table 4: Association of demographic and clinical variables with active TB disease

Variable	Category	Active TB disease Absent n (%)	Active TB disease Present n (%)	p value
Age group (years)	0–20	27 (90.0%)	3 (10.0%)	0.46
	21–40	92 (93.9%)	6 (6.1%)	
	41–60	64 (97.0%)	2 (3.0%)	
	>60	34 (97.1%)	1 (2.9%)	
Gender	Female	111 (96.5%)	4 (3.5%)	0.25
	Male	106 (93.0%)	8 (7.0%)	
BMI (kg/m²)	<18.5	14 (82.4%)	3 (17.6%)	0.08
	18.5–22.99	96 (95.0%)	5 (5.0%)	
	23–24.99	86 (95.6%)	4 (4.4%)	
	≥25	21 (100.0%)	0	
BCG scar	Absent	0	2 (100.0%)	<0.01
	Present	217 (95.6%)	10 (4.4%)	
Smoking status	Non-smoker	94 (96.9%)	3 (3.1%)	0.53
	Former smoker	23 (92.0%)	2 (8.0%)	
	Current smoker	59 (92.2%)	5 (7.8%)	
	Passive smoker	41 (95.3%)	2 (4.7%)	

Socioeconomic status	Upper middle	9 (100.0%)	0	0.22
	Lower middle	83 (96.5%)	3 (3.5%)	
	Upper lower	73 (96.1%)	3 (3.9%)	
	Lower	52 (89.7%)	6 (10.3%)	

The prevalence of active TB disease was higher among those who spent >9 hours (28.6%) with index cases than other time intervals (table 5). This association was found statistically significant (p value <0.01). The prevalence of active TB disease was also higher who shared the bed with index case (10.7%) than who did not (2.6%). There was also significant association between the prevalence of active TB disease and sharing of bed. The prevalence of active TB disease was observed to be higher who shared the same room with index case (9.3%) than who did not (1.6%). There was significant association between the prevalence of active TB disease and sharing of same room as shown in above table (p value =0.01). NO signifcant association was observed between Time since contact living with index case and active TB disease.

Table 5: Association of level of exposure of index cases with active TB disease amongst household contacts

	Active TB infection		**p value**
	Absent	**Present**	
Time spent with index case in same room daily			
<3 hours	56(100.0%)	0	<0.01
3-6 hours	72 (96.0%)	3 (4.0%)	
6-9 hours	84 (92.3%)	7 (7.7%)	
>9 hours	5 (71.4%)	2 (28.6%)	
Sharing of bed with index case			
No	150 (97.4%)	4 (2.6%)	0.02
Yes	67 (89.3%)	8 (10.7%)	
Sharing of same room			
No	120 (98.4%)	2 (1.6%)	0.01
Yes	97 (90.7%)	10 (9.3%)	
Time since contact living with index case			
<6 months	3 (100.0%)	0	0.50
6 months – 2 years	108 (93.1%)	8 (6.9%)	
>2 years	106 (97.4%)	4 (3.6%)	

The association between sociodemographic and clinical characteristics and latent tuberculosis infection (LTBI) among household contacts was analysed (Table 6). LTBI prevalence did not differ significantly across age groups (p = 0.71). Although a higher proportion of LTBI was observed among participants aged 0–20 years (56.7%) compared to those aged >60 years (42.9%), this variation was not statistically significant.

Gender-wise distribution showed comparable proportions of LTBI among males (50.9%) and females (47.0%), with no significant association between gender and LTBI status (p = 0.55). Similarly, body mass index (BMI) categories did not demonstrate a statistically significant association with LTBI (p = 0.10). However, a relatively higher prevalence of LTBI was noted among underweight individuals (<18.5 kg/m²; 52.9%) and those with BMI 23–24.99 kg/m² (53.3%), while participants with BMI ≥25 kg/m² showed a lower prevalence of LTBI (23.8%).

Presence of a BCG scar was not significantly associated with LTBI status (p = 0.49). Nearly half of the participants with a BCG scar had LTBI (49.3%), whereas none of the participants without a BCG scar

had LTBI, though the number in this category was very small.

Smoking status also showed no statistically significant association with LTBI (p = 0.52). Former smokers demonstrated a comparatively higher prevalence of LTBI (60.0%), followed by current smokers (51.6%), passive smokers (48.8%), and non-smokers (44.3%), but these differences were not significant.

With respect to socioeconomic status, LTBI prevalence was highest among participants belonging to the upper-middle socioeconomic class (66.7%), followed by the lower (53.4%) and upper-lower classes (48.7%). However, socioeconomic status was not significantly associated with LTBI (p = 0.49).

Overall, none of the evaluated sociodemographic or clinical variables showed a statistically significant association with latent tuberculosis infection among household contacts in the present study.

Table 6: Association of Sociodemographic and Clinical Factors with Latent Tuberculosis Infection

Variable	Category	Latent TB Infection Absent n (%)	Latent TB Infection Present n (%)	p-value
Age group	0–20 years	13 (43.3)	17 (56.7)	0.71
	21–40 years	49 (50.0)	49 (50.0)	
	41–60 years	35 (53.0)	31 (47.0)	
	>60 years	20 (57.1)	15 (42.9)	
Gender	Female	61 (53.0)	54 (47.0)	0.55
	Male	56 (49.1)	58 (50.9)	
Body Mass Index (kg/m²)	<18.5	8 (47.1)	9 (52.9)	0.10
	18.5–22.99	51 (50.5)	50 (49.5)	
	23–24.99	42 (46.7)	48 (53.3)	
	≥25	16 (76.2)	5 (23.8)	
BCG scar	Absent	2 (100.0)	0 (0.0)	0.49
	Present	115 (50.7)	112 (49.3)	
Smoking status	Non-smoker	54 (55.7)	43 (44.3)	0.52
	Former smoker	10 (40.0)	15 (60.0)	
	Current smoker	31 (48.4)	33 (51.6)	
	Passive smoker	22 (51.2)	21 (48.8)	
Socioeconomic status	Upper middle	3 (33.3)	6 (66.7)	0.49
	Lower middle	48 (55.8)	38 (44.2)	
	Upper lower	39 (51.3)	37 (48.7)	
	Lower	27 (46.6)	31 (53.4)	

LTBI was higher among those who spent 6-9 hours (49.5%) with index cases than other time intervals. This associaoton was found statistically non- significant (p value =0.98). The LTBI was also higher who shared the bed with index case (52%) than who did not (47.4%). There was also no significant association between the LTBI and sharing of bed. LTBI was observed to be higher who shared the same room with index case (50.5%) than who did not (47.5%). There was no significant association between the LTBI and sharing of same room as shown in above table (p value =0.61). No signifcant associaotion was observed between Time since contact living with index case and LTBI (table 7).

Table 7: Association of closeness of index cases with Latent TB infection amongst household contacts

	Latent TB infection		p value
	Absent	Present	
Time spent with index case in same room daily			
<3 hours	29 (51.8%)	27 (48.2%)	0.98
3-6 hours	48 (50.7%)	37 (49.3%)	
6-9 hours	46 (50.5%)	45 (49.5%)	
>9 hours	4 (57.1%)	3 (42.9%)	
Sharing of bed with index case			
No	81 (52.6%)	73 (47.4%)	0.51
Yes	36 (48.0%)	39 (52.0%)	
Sharing of same room			
No	64 (52.5%)	58 (47.5%)	0.65
Yes	53 (49.5%)	54 (50.5%)	
Time since contact living with index case			
<6 months	1 (33.3%)	2 (66.7%)	0.40
6 months – 2 years	64 (55.2%)	52 (44.8%)	
>2 years	52 (47.3%)	58 (52.7%)	

DISCUSSION

Active case finding (ACF) among household contacts of tuberculosis (TB) patients, particularly those with drug-resistant TB (DR-TB), has been widely recognized as a crucial strategy for early diagnosis and interruption of transmission. Several earlier studies have evaluated the role of ACF, as well as individual nutritional or socioeconomic risk factors contributing to TB disease among household contacts. However, studies comprehensively integrating nutritional status, socioeconomic parameters, intensity and duration of exposure, BCG vaccination status, addictions, and active case finding among household contacts of DR-TB index cases remain limited in the existing literature. This gap underscores the relevance and importance of the present study.

The current study was conducted with the objective of detecting TB disease and latent TB infection (LTBI) among household contacts of patients registered for multidrug-resistant TB (MDR-TB) treatment under the National Tuberculosis Elimination Programme (NTEP) and Programmatic Management of Drug-Resistant TB (PMDT). A total of 229 household contacts of 130 DR-TB index cases were included. Following informed consent, detailed sociodemographic and nutritional assessments were carried out. All contacts underwent clinical examination and investigations including Mantoux test, chest radiography, and sputum smear microscopy for acid-fast bacilli. Contacts with radiological or microbiological features suggestive of TB disease were further evaluated using Cartridge-Based Nucleic Acid Amplification Test (CBNAAT) at the Department of Pulmonary Medicine, RBIPMT, Delhi.

Among the 130 index cases enrolled, the majority were MDR-TB patients (66.9%), followed by pre-XDR-TB (30.0%) and XDR-TB (3.1%). Most index cases belonged to the economically productive age group of 21–40 years (53.8%), consistent with national epidemiological trends. Males constituted 56.2% of index cases, reflecting the known male predominance in TB notification. A substantial proportion of index cases had a prior history of anti-tubercular therapy, with 61.5% having previously received drug-susceptible TB treatment. Radiologically, unilateral consolidation was the most frequent finding, while cavitary lesions and destroyed lung were less common but indicative of advanced disease and higher infectivity potential.

Among the 229 household contacts studied, nearly equal representation of males and females was observed, and the majority

were aged 21–40 years. The prevalence of LTBI was 48.9%, while 5.2% of contacts were diagnosed with active TB disease. Drug-resistant TB was identified in 4.4% of household contacts. These findings are comparable to the pooled estimates reported in a systematic review and meta-analysis by Shah et al. [6], which documented yields of 47.2% for LTBI and 7.8% for active TB among household contacts. Similarly, studies from low- and middle-income countries have reported active TB prevalence ranging from 4.5% to 6.9% among household contacts [7,8]. Singla N et al. [9] also reported a comparable prevalence of active TB (5.29%) among household contacts of MDR-TB cases in Delhi. These findings support the hypothesis that transmission of drug-resistant strains often occurs through primary transmission rather than acquisition during treatment.

In the present study, both LTBI and active TB disease were more frequently observed among adult males aged 21–40 years. Although TB infection and disease appeared numerically higher among males compared to females, no statistically significant association with age or gender was observed. Similar male predominance among adult household contacts has been reported in previous studies [8,10]. This pattern may be attributed to behavioral and biological factors, including greater occupational exposure, higher prevalence of smoking, and increased healthcare-seeking behavior among males.

Nutritional status emerged as an important determinant of TB disease. Active TB was more prevalent among household contacts with a body mass index (BMI) <18.5 kg/m². Although waist-hip ratio and waist-height ratio did not show significant associations with TB disease or LTBI, a large proportion of contacts had low mid-upper arm circumference (MUAC), reflecting underlying malnutrition. The higher occurrence of TB disease among malnourished contacts underscores the well-established bidirectional relationship between TB and undernutrition. Undernutrition compromise's immune function, increasing susceptibility to infection, while TB further exacerbates nutritional depletion through reduced appetite, malabsorption, and increased metabolic demands.

In this study, the prevalence of TB disease was observed to be higher among BMI<18.5kg/m2 (17.6%) than other BMI groups.

56(24.5%) household contacts had a low waist hip ratio, 137(59.8%) patients had a moderate waist hip ratio and 36(15.7%) patients had a high waist hip ratio. The relationship between waist hip ratio and incidence of TB disease and LTBI was statistically non-significant. But, In a study by Mary Gracy Tungdim et al [11], the values of waist hip ratio of TB patients had significantly lower values of anthropometric variables.

Conflicting evidence exists regarding the impact of malnutrition on tuberculin skin test (TST) and interferon-gamma release assay results [12–16]. While malnutrition may increase susceptibility to Mycobacterium tuberculosis infection, impaired immune responses can also lead to false-negative immunological test results [17]. Conversely, obesity has been consistently shown to confer a protective effect against TB [17–21]. Higher BMI may reflect better nutritional reserves, higher protein intake, and improved immune competence, contributing to reduced risk of TB infection and progression [22]. Similar findings were reported by Maheswaran Umakanth et al. [23], who observed a higher prevalence of sputum-positive pulmonary TB among individuals with low BMI.

Socioeconomic status also played a critical role in TB risk. Although LTBI did not show a significant association with socioeconomic class, active TB disease was more prevalent among contacts belonging to lower socioeconomic strata, consistent with findings by Benhur Joel Shadrach [10]. Poverty-related factors such as

overcrowding, poor ventilation, indoor air pollution, malnutrition, and limited access to healthcare contribute to increased TB transmission and disease progression [24–30]. Lower socioeconomic groups are often exposed to high-risk living environments and face barriers to timely diagnosis and treatment.

Exposure-related factors were among the strongest predictors of TB disease. Sharing a room or bed with the index case was significantly associated with active TB disease. Contacts who spent more than nine hours per day with the index case had the highest prevalence of TB disease. These findings highlight the importance of prolonged and close exposure in TB transmission dynamics. Similar associations have been reported in other studies, including the role of caregiving as a risk factor among household contacts [31]. Poor ventilation and reduced ultraviolet exposure in indoor settings further amplify transmission risk.

BCG vaccination status did not significantly influence LTBI or TB disease in the present study, as 99.1% of household contacts had a visible BCG scar. This finding aligns with previous evidence indicating that BCG-induced tuberculin reactivity wanes over time and does not reliably predict protection against TB disease [32–44]. However, lack of BCG vaccination has been identified as a risk factor in some studies [10], suggesting that its protective effect may vary by age, exposure intensity, and epidemiological setting.

Smoking emerged as an important modifiable risk factor. Active TB disease was more common among former and current smokers compared to non-smokers, and LTBI prevalence was also higher among smokers. These findings are supported by extensive evidence demonstrating the role of tobacco smoke in increasing susceptibility to TB infection, disease progression, and mortality [45–51]. Smoking impairs mucociliary clearance, disrupts alveolar macrophage function, and alters pulmonary immune responses, facilitating M. tuberculosis infection.

Most household contacts identified through ACF were asymptomatic, emphasizing the silent nature of TB transmission. Among symptomatic contacts, cough and fever were the most common symptoms, consistent with previous reports [2]. Radiological abnormalities were present in only 4.7% of contacts, all of whom had active TB disease, reinforcing the utility of chest radiography as a screening tool in contact investigations. Microbiologically, the majority of TB cases were sputum smear-positive pulmonary TB, with a high proportion exhibiting rifampicin resistance, similar to findings from other studies [52,53].

Overall, the findings of this study reinforce the importance of systematic contact investigation as an integral component of TB control, particularly in the context of DR-TB. Although the yield of TB infection and disease was comparable to that reported in studies involving drug-susceptible TB contacts [54], the high proportion of drug-resistant cases among contacts highlights the need for early detection and targeted interventions. Future large-scale studies incorporating molecular epidemiology and genotyping are required to better understand transmission dynamics, virulence, and transmissibility of drug-resistant strains. Strengthening nutritional support, improving living conditions, reducing tobacco exposure, and enhancing socioeconomic status remain critical strategies for preventing TB transmission and improving outcomes among household contacts.

Recommendations

Household contacts of drug-resistant tuberculosis (DR-TB) patients should be systematically screened for tuberculosis infection and disease, irrespective of age, gender, body mass index, socioeconomic status, or BCG vaccination status, as all contacts remain susceptible. Smoking cessation should be strongly encouraged

among household contacts to reduce the risk of TB infection and disease progression. Patients with DR-TB should be considered for appropriate isolation until they achieve culture negativity in order to minimize household transmission. Strict reinforcement of cough hygiene practices and airborne infection control measures within the household setting is essential to reduce exposure. Nutritional assessment should be routinely undertaken, and supplemental nutritional support should be considered for household contacts with low BMI to improve immune resilience. Overall, contact investigation among household contacts of DR-TB patients should be accorded the same priority and rigor as that undertaken for drug-susceptible TB, as it remains a critical component of tuberculosis control and prevention strategies.

Limitations

This study has certain limitations. The relatively small sample size may restrict the generalizability of the findings, and larger multicentric studies are required for validation. The cross-sectional design limits assessment of disease progression and causal relationships. Interferon-gamma release assay (IGRA) could not be performed due to resource constraints. Additionally, detailed anthropometric measures such as mid-thigh circumference and triceps skinfold thickness, as well as body composition parameters including fat mass, fat-free mass, and total body water, were not assessed, which may have limited comprehensive nutritional evaluation.

CONCLUSION

This study demonstrates a high burden of tuberculosis infection and disease among household contacts of drug-resistant tuberculosis (DR-TB) patients. Nearly half of the contacts (48.9%) had latent tuberculosis infection (LTBI), while 5.2% were diagnosed with active TB disease, of whom 83.3% were rifampicin resistant. LTBI was not associated with age, gender, body mass index (BMI), socioeconomic status, or tobacco smoke exposure; however, it was strongly linked to exposure-related factors such as sharing a room or bed and any duration of close contact with the index case. In contrast, development of active TB disease was significantly associated with lower BMI, lower socioeconomic class, absence of a BCG scar, prolonged daily exposure, and sharing living or sleeping spaces with the index case, while age, gender, and tobacco smoke exposure showed no significant association. Notably, overweight household contacts (BMI >23 kg/m²) appeared to be protected against progression to active TB disease. The presence of chest symptoms of any duration among household contacts should prompt immediate evaluation to exclude active tuberculosis.

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REFERENCES

1. WHO | Global tuberculosis report 2021 [Internet]. WHO Available from: http://www.who.int/tb/publications/global_report/en/
2. Guidelines for PMDT in India 2021
3. Grandjean L, Crossa A, Gilman RH, Herrera C, Bonilla C, Jave O et al. Tuberculosis in household contacts of multidrug-resistant tuberculosis patients. Int J Tuberc Lung Dis. 2011 Sep;15(9):1164-9, i. doi:10.5588/ijtld.11.0030.
4. Charan Jaykaran and Biswas Tamoghna: How to Calculate Sample Size for Different Study Designs in Medical Research? Indian J Psychol Med. 2013 Apr-Jun; 35(2): 121–126.
5. Dogra S, Narang P, Mendiratta DK, et al. Comparison of a whole blood interferon-gamma assay with tuberculin skin testing for the detection of tuberculosis infection in hospitalized children in rural India. J Infect. 2007; 54:267–276.

6. Shah NS, Yuen CM, Heo M, Tolman AW, Becerra MC. Yield of contact investigations in households of patients with drug-resistant tuberculosis: systematic review and meta-analysis. Clin Infect Dis. 2014 Feb;58(3):381-91. doi: 10.1093/cid/cit64
7. Morrison J, Pai M, Hopewell PC. Tuberculosis and latent tuberculosis infection in close contacts of people with pulmonary tuberculosis in lowincome and middle-income countries: a systematic review and meta- analysis. Lancet Infect Dis. 2008 Jun;8(6):359-68. doi: 10.1016/S1473- 3099(08)70071-9.
8. Singh J, Sankar MM, Kumar S, Gopinath K, Singh N, Mani K et al. Incidence and prevalence of tuberculosis among household contacts of pulmonary tuberculosis patients in a peri-urban population of South Delhi, India. PLoS One. 2013 Jul 26;8(7): e69730. doi: 10.1371/journal.pone.0069730.
9. Singla N, Singla R, Jain G, Habib L, Behera D. Tuberculosis among household contacts of multidrug-resistant tuberculosis patients in Delhi, India. Int J Tuberc Lung Dis. 2011 Oct;15(10):1326-30. doi: 10.5588/ijtld.10.0564
10. Shadrach BJ, Kumar S, Deokar K, Singh GV, Hariharan, Goel R. A study of multidrug resistant tuberculosis among symptomatic household contacts of MDR-TB patients. Indian J Tuberc. 2021 Jan;68(1):25-31. doi: 10.1016/j.ijtb.2020.09.030.
11. Mary Grace Tungdim, Heemanshu Aurora, Satwanti Kapoor. Outcome of Tuberculosis Treatment on Measures of Obesity and Adiposity Indices Among the Tribals of Northeast India. Mycobacterial Diseases. 2015;5(3).
12. Gofama MM, Garba AM, Mohammed AA. Mantoux test reactions among children managed for tuberculosis in Maiduguri, Nigeria. Scand J Infect Dis. 2011; 43:15–18.
13. Piñeiro R, Cilleruelo MJ, García-Hortelano M, et al. Effect of nutritional status on Tuberculin skin testing. Indian J Pediatr. 2013; 80:271–275. 97.
14. Rose MV, Kimaro G, Nissen TN, et al. QuantiFERON®-TB gold in-tube performance for diagnosing active tuberculosis in children and adults in a high burden setting. PLoS One. 2012;7: e37851
15. Cunningham-Rundles S, McNeeley DF, Moon A. Mechanisms of nutrient modulation of the immune response. J Allergy Clin Immunol. 2005; 115:1119–28; quiz 1129.
16. Leung CC, Lam TH, Chan WM, Yew WW, Ho KS et al. (2007) Lower Risk of Tuberculosis in Obesity. Arch Intern Med 167: 1297- 1304.10.1001/archinte.167.12. 1297
17. Hanrahan CF, Golub JE, Mohapi L, Tshabangu N, Modisenyane T et al. (2010) Body mass index and risk of tuberculosis and death. AIDS 24: 1501-1508.10.1097/QAD.0b013e32833a2a4a
18. Cegielski JP, Arab L, Cornoni-Huntley J (2012) Nutritional risk factors for tuberculosis among adults in the United States, 1971-1992. Am J Epidemiol 176: 409-422.10.1093/aje/kws007
19. Tverdal A. Body mass index and incidence of tuberculosis. Eur J Respir Dis. 1986; 5:355–362.
20. Edwards LB, Livesay VT, Acquaviva FA, Palmer CE. Height, weight, tuberculosis infection and tuberculosis disease. Ach Environ Health. 1971; 22:106–112.
21. Pednekar MS, Hakama M, Hebert JR, Gupta PC. Association of body mass index with all-cause and cause-specific mortality: findings from a prospective 98 cohort study in Mumbai (Bombay), India. Int J Epidemiol. 2008; 37:524–535.
22. Abba K, Sudarsanam TD, Grobler L, Volmink J. Nutritional supplements for people being treated for active tuberculosis. Cochrane Database Sys Rev. 2008;4:CD00608
23. Underweight among Tuberculosis Patient in Batticaloa District, Sri Lanka by Maheswaran Umakanth et, published in Researchgate in September 2017
24. Hargreaves JR, Boccia D, Evans CA, Adato M, Petticrew M, Porter JD. The social determinants of tuberculosis: from evidence to action. Am J Public Health 2011; 101:654-62.
25. Oxlade O, Murray M. Tuberculosis and poverty: why are the poor at greater risk in India? PLoS One 2012;7: e47533.
26. Krieger N, Waterman PD, Chen JT, Soobader M-J, Subramanian S. Monitoring socioeconomic inequalities in sexually transmitted infections, tuberculosis, and

violence: geocoding and choice of area-based socioeconomic measures-- the public health disparities geocoding project (US) Public Health Rep.2003;118(3):240.
27. Olson NA, Davidow AL, Winston CA, Chen MP, Gazmararian JA, Katz DJ. A national study of socioeconomic status and tuberculosis rates by country of birth, United States, 1996–2005. BMC Public Health. 2012;12(1):365. doi: 10.1186/1471-2458-12-365.
28. Thorpe LE, Frieden TR, Laserson KF, Wells C, Khatri GR. Seasonality of tuberculosis in India: is it real and what does it tell us? The Lancet. 2004;364(9445):1613–1614. doi: 10.1016/S0140-6736(04)17316-9
29. Lönnroth K, Jaramillo E, Williams BG, Dye C, Raviglione M. Drivers of tuberculosis epidemics: the role of risk factors and social determinants. Social Science and Medicine. 2009;68(12):2240–2246.
30. Muniyandi M, Ramachandran R, Gopi PG, et al. The prevalence of tuberculosis in different economic strata: a community survey from South India. International Journal of Tuberculosis and Lung Disease.2007;11(9):1042–1045.
31. Kyaw Ko Ho Htet et al. BMC Infect Dis. 2018. Improving detection of TB among household contacts of index TB patients by an integrated approach in Myanmar.
32. Karalliedde S, Katugaha LP, Uragoda CG. Tuberculin response of Sri Lankan children after BCG vaccination at birth. Tubercle 1987; 68:33-8.
33. Bahr GM, Stanford JL, Rook GAW, Rees RJW, Abdelnoor AM, Frayha GJ. Two potential improvements to BCG and their effect on skin test reactivity in the Lebanon. Tubercle 1986; 67:205-18.
34. Heyworth B. Delayed hypersensitivity to PPD-S following BCG vaccination in African children -- an 18-month field study. Trans R Soc Trop Med Hyg 1977; 71:251-3.
35. Baily GVJ, Narain R, Mayurnath S, Vallishayee RS, Guld J. Trial of BCG vaccines in South India for tuberculosis prevention: tuberculosis prevention trial, Madras. Indian J Med Res 1980;72(suppl):1-74.
36. Abrahams EW. Tuberculin hypersensitivity following BCG vaccination in Brisbane school children. Tubercle 1979; 60:109-13.
37. Comstock GW, Edwards LB, Nabangxang H. Tuberculin sensitivity eight to fifteen years after BCG vaccination. Am Rev Respir Dis 1971; 103:572-5.
38. Stewart CJ. Skin sensitivity to human, avian and BCG PPDs after BCG vaccination. Tubercle 1968; 49:84-91.
39. Guld J, Waaler H, Sundaresan TK, Kaufmann PC, ten Dam HG. The duration of BCGinduced tuberculin sensitivity in children, and its irrelevance for revaccination: results of two 5-year prospective studies. Bull World Health Organ 1968; 39:829-36.
40. Horwitz O, Bunch-Christensen K. Correlation between tuberculin sensitivity after 2 months and 5 years among BCG vaccinated subjects. Bull World Health Organ 1972; 47:49-58.
41. Orefici G, Scopetti F, Grandolfo ME, Annesi I, Kissopoulos A. Study of a BCG vaccine: influence of dose and time. Boll Ist Sieroter Milan 1982; 61:24-8.
42. Fine PEM, Ponnighaus JM, Maine NP. The relationship between delayed type hypersensitivity and protective immunity induced by mycobacterial vaccines in man. 100 Lepr Rev 1986;57 (suppl 2):275-83.
43. Fine PEM, Sterne JAC, Ponnighaus JM, Rees RJW. Delayed-type hypersensitivity, mycobacterial vaccines and protective immunity. Lancet 1994; 344:1245-9.
44. Chan P C, Chang L Y, Wu Y C, et al. Age-specifi c cut-offs for the tuberculin skin test to detect latent tuberculosis in BCG vaccinated children. Int J Tuberc Lung Dis 2008; 12: 1401–1406
45. Lin HH, Ezzati M, Murray M. Tobacco smoke, indoor air pollution and tuberculosis: a systematic review and meta-analysis. PLoS Medicine. 2007;4(1, article e20)
46. Altet MN, Alcaide J, Plans P et al. Passive smoking and risk of pulmonary tuberculosis in children immediately following infection. A case control study. Tubercle Lung Dis 1996; 77: 537–544.
47. Slama K, Chiang CY, Enarson DA et al. Tobacco and tuberculosis: a qualitative systematic review and meta- analysis. Int J Tuberc Lung Dis 2007; 11: 1049–1061.
48. Maurya V, Vijayan VK, Shah A. Smoking and tuberculosis: an association overlooked. Int J Tuberc Lung Dis 2002; 6: 942–951.

49. Chan ED, Kinney WH, Honda JR et al. Tobacco exposure and susceptibility to tuberculosis: is there a smoking gun? Tuberculosis 2014; 94: 544–550.
50. Houtmeyers E, Gosselink R, Gayan-Ramirez G, Decramer M (1999), Regulation of mucociliary clearance in health and disease. Eur Respir J 13: 1177–1188.
51. Sopori M (2002) Effects of cigarette smoke on the immune system. Nat Rev Immunol 2:372–37
52. Qadeer, E, Fatima, R, Haq, M.U., Yaqoob, A, Kyaw, N.T.T., Shah, S, Das, M, Isaakidis, P. yield of verbal screening amongst household contacts of MDR TB patients in Pakistan. Department for international development, 26 March, 2017
53. Phyo AM, Kumar AMV, Soe KT, Kyaw KWY, Thu AS, Wai PP, Aye S, Saw S, Win Maung HM, Aung ST. Contact Investigation of Multidrug-Resistant Tuberculosis Patients: A Mixed-Methods Study from Myanmar. Trop Med Infect Dis. 2019 Dec 26;5(1):3. doi: 10.3390/tropicalmed5010003.
54. Gounder PP, Harris TG, Anger H, Trieu L, Meissner JS, Cadwell BL at al. Risk for Tuberculosis Disease Among Contacts with Prior Positive Tuberculin Skin Test: A retrospective Cohort Study, New York City. J Gen Intern Med. 2015 Jun;30(6):742-8. doi: 10.1007/s11606-015-3180-2.

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