

A MEASURE OF TRANSMISSION OF TUBERCULOSIS INFECTION AMONG CHILDREN IN HOUSEHOLD CONTACT

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ABSTRACT

Introduction: Tuberculosis (TB) is transmitted through droplets from patients having pulmonary TB, Young children living in the same household are at higher risk Tuberculosis, with great potential to benefit from screening and preventive treatment. This study was conducted with the objectives to estimate the prevalence of TB infection among under five years old children in household contact with pulmonary tuberculosis patients, and assess the factors associated with transmission of TB.

Methods: Pulmonary TB patients receiving treatment from the DOTS Centres in Sunsari District (Index Case-IC) were visited in their household to identify and assess contacts below five years of age. Transverse induration greater than 10 mm was defined as a positive Mantoux test suggestive of tubercular infection.

Results: Among 190 household contacts, Mantoux was positive in 13.7% (95%CI: 11.2-16.2). Higher sputum bacillary load (adjusted OR=3.03; 95% CI 1.01-9.1) and spitting habits of Index Cases (aOR=3.1; 95% CI 1.2-7.7), first-degree relationship (aOR=3.5; 95%CI 1.4-8.7) and longer duration of contact (aOR=6.7; 95% CI 1.4-32.2), were factors significantly associated with positive Mantoux test in the under-five years old household contact.

Conclusion: The prevalence of tuberculosis infection among under-five children in contact with pulmonary tuberculosis patients was 13.7%, which is nearly double than the results of first national tuberculin survey (7%), conducted by National Tuberculosis Centre. This highlights the need for a competent & functioning contact tracing mechanism to halt the chain of transmission of infection. Social and behavioral factors existing in the household were significantly associated with the transmission of Tuberculosis infection.

Key words: Tuberculosis, Contact Tracing, Under Five Children.

INTRODUCTION

An estimated one million children fell ill with Tuberculosis (TB) and 170 000 children died in 2015¹. Children constitute 10% of the Global TB cases.^{2,3} Those infected with TB bacteria have a

10% lifetime risk of developing the disease.¹

Ignorance and stigma among the community, insufficient contact investigation, limited access to diagnostic tests, and a host of other barriers to childhood TB diagnosis was identified by a study in Peru.⁴ While intense scientific and clinical research efforts into novel diagnostic, therapeutic and preventative interventions have focused on TB in adults, childhood TB has been relatively neglected.

However, children are particularly vulnerable to severe disease and death following infection, and those with latent infection become the reservoir of

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infection with reactivation in adulthood, fuelling the future epidemics.⁵ Epidemiology of childhood TB follows that of adult cases, and children constitute nearly 40% of the caseload in high incidence communities.⁶

Transmission of TB to young children usually results from household contact with an infectious case.^{7,8,9} Risk factors for transmission of TB in the household include a wide variety of environmental and host characteristics existing within the household. Intimacy of contact, sleeping arrangements and sputum status of the TB patient have been implicated as risk factors in the transmission of TB, or even Acute Respiratory Infection to Household Contacts, especially under-five year old children who are generally confined to the house.^{10, 11, 12} Limited social contact of very young children reduces their likelihood of becoming infected, unless the caregiver is the source case. However, additional caregivers like grandparents or extended family members taking care of the children during the day are also important.¹³

OBJECTIVES

To study the prevalence of Tuberculosis (TB) infection and factors associated with transmission of infection among children less than five years of age living in the same household with pulmonary TB patients of Sunsari District.

METHODS

A community-based cross-sectional study was carried out in 3 municipalities and 49 Village Development Committees (VDC) of Sunsari District, situated in south-west of Koshi zone in the eastern development region of Nepal. This district has 1, 62, 407 households with 4.7 members per household and an under five population of 68052.¹⁴ There are 14 Directly Observed Treatment Short Course (DOTS) centres and 52 sub-centres that registered 568 sputum positive and 362 sputum negative cases in this district in 2015.¹⁵

All household contacts under five years of age of newly diagnosed patients with Pulmonary TB (both sputum smear positive and negative) registered in the National Tuberculosis Program (NTP), and attending the DOTS clinics in Sunsari District were included in the study. Household contact (HC) was

defined as a child less than 5 years of age, living in the same house and sharing the same kitchen as the Pulmonary TB patient. The sample size was calculated by the single proportion formula as 188 based on a similar study done in India.¹⁶ Total of 190 eligible children were enrolled in this study covering more than 95% of the total eligible household contacts of TB patients of Sunsari district.

Stratification was done at two levels- firstly all Pulmonary TB cases from the DOTS register of Sunsari district were identified (Index Case-IC), following which, house to house visits were conducted to identify eligible HC's under five years of age. A pretested semi-structured questionnaire was used to extract information from a single respondent (parents/ caretakers of the child) and a general clinical examination of both IC and HC were performed. Children who were already diagnosed with TB were excluded from the study.

After explaining the risks involved in the procedure, the household contacts were tested intra-dermally with 0.1ml of 5TU PPD with Tween 80 (SPAN Divergent Ltd, Surat, India - calibrated against Batch RT 23 manufactured by Statens Serum Institute, Denmark) and followed up in their homes within 48 to 72 hours, where the width of reaction (indurations) in the horizontal plane was noted by the pen method. Mantoux test was considered positive for indurations of 10 mm or more, which was suggestive of Tubercular Infection.

All children were managed according to the standard National Tuberculosis Program guidelines.¹⁷ Children with positive screening result were referred to BP Koirala Institute of Health Sciences (BPKIHS), a tertiary care hospital and evaluated by the Consultant Paediatrician. They underwent chest x-ray, GeneXpert test and other relevant tests for the diagnosis of TB. Those diagnosed as TB Disease were treated under DOTS regimen, and those under-five children with TB infection were provided with Isoniazid Preventive Therapy (IPT) in the local DOTS centres.

Operational definitions:

Relationship with contact: The connection between the HC and the IC, categorized as first degree (father/mother/siblings) or second degree (other than the father/mother/siblings)

Proximity of contact: The closeness or intimacy of contact between the IC and HC; categorized as Solitary (different room sleepers), room sharers (same room/different bed) or same surface co-sleepers (same bed)

Duration of contact:

The infectious period extends from approximate dates start of TB symptoms to the period of effective treatment (demonstrated by negative sputum smears) and diminished symptoms; the duration of contact for HC was determined by the time they spent with the IC during the infectious period. Information from the patient interviews and other documents were assembled to assist in estimating the duration of contact.

Contact ethnicity:

The indigenous nationalities of Nepal classified based on Nepal Demographic and Health Survey 2011.¹⁸

Sputum bacillary count:

The number of TB bacilli present in sputum identified by microscopy and categorized based on American Thoracic Society guidelines into five categories.¹⁹ Generally speaking, the sputum sample must contain 5,000 to 10,000 Acid Fast Bacilli per millilitre of specimen to be detected on Ziehl-Neelsen staining, whereas 10 to 100 organisms are needed for a positive culture.¹⁹

Injudicious spitting habits: The presence of a careless habit of spitting in and around the house in the Index case.

Statistical Analysis:

Odds Ratio (OR) with confidence limit was calculated for inferential statistics. Logistic regression analysis was performed for all independent variables with p-value <0.20 in the bivariate analysis, This was done to identify associated factors for transmission of infection from Index Case to Household Contacts with the probability of significance set at 95% of Confidence Interval (CI).

Ethical approval was obtained from the Institutional Review Committee of BPKIHS at the onset of the study and permission was taken from the DOTS centres of Sunsari district to gather information

on the Pulmonary TB patients. Informed written consents were obtained from the legal guardian of the children after explaining the objectives, and the methods.

Pretesting was done on 10% of the sample size not included in the final study, following which necessary corrections were incorporated. Quality was assured by calibrating the measuring instruments to check for precision during data collection, double checking for errors before entry. During entry, data was checked for completeness, coded and labelled clearly. All the procedures and observations including interviews, clinical examination and Mantoux test were performed by the Principle Investigator.

RESULTS

The study population consisted of 108 Index Cases (IC) and their 190 eligible under five contacts with Household Contact/Index Case (HC/IC) ratio of 1.76. The mean age of the IC were 44.5 years (SD = 18.05) and 68.5% were males. Similarly, 84(77.8%) of the IC's were sputum positive Pulmonary TB patients and 28(25.9%) had a habit of spitting injudiciously in and around the house (Table 1).

Table 1: Index Case distribution by socio-demographic, sputum status and personal habits

Character-istics	Categories	Frequency (n=108)	Percentage (%)
Age	15-29 years	28	25.9
	30-44 years	30	27.8
	45-59 years	22	20.4
	60 years & above	28	25.9
Gender	Male	74	68.5
	Female	34	31.5
Sputum Status	Positive	84	77.8
	Negative	24	22.2
Education	Illiterate	40	37.0
	Primary	22	20.4
	Secondary	31	28.7
	≥ Intermediate	15	13.9
Injudicious Spitting Habit	Absent	80	74.1
	Present	28	25.9

Mantoux test was positive in 13.7% (95%CI: 11.2-16.2) of the household contacts. Among the HC's, 43(22.6%) shared the same bed with IC, while 133 (70%) slept in different rooms. A Total of 189 (99.5%) children gave a history of BCG vaccination, while BCG scar was visible only in 182 (95.8%). Nutritional status assessed by computing with for age and graded based on Indian Academy of Paediatrics (IAP) grading for malnutrition showed 28 (14.7%) children to be undernourished, while severe malnutrition (grade IV) was no observed (Table 2).

Higher sputum bacillary count (2+/3+)and presence of injudicious spitting habits in and around the house in the IC, closer relation and proximity to IC, more than 60 days duration of contact and household contacts of hill janjati ethnicity were found to be significantly associated with a positive TST on bivariate analysis (Table 3).

Goodness of fit: Chi-square = 13.8, df = 7, p = 0.054
aOR- Adjusted Odds Ratio
Variable(s) entered on step 1: Sputum bacillary count, smoking & spitting habit of IC, proximity & relation of IC to contact, duration of exposure and ethnicity of contact.

Presence of injudicious spitting habit of IC [adjusted OR = 3.1; 95%CI(1.2-7.7); p-0.016], first degree relationship between IC and contact [aOR = 3.5; 95%CI(1.4-8.7); p-0.009], higher sputum bacillary load(2+/3+) [aOR = 3.03; 95%CI(1.01-9.1); p-0.048] and duration of contact with IC more than 60 days [aOR = 6.7; 95%CI(1.4-32.2); p-0.018] remained significant in the logistic regression analysis after adjusting for other variables (Table 4).

Table 2: Household contact characteristics

Characteristics	Categories	Frequency (n=190)	Percentage (%)
Age Groups	< 3 years	100	52.6
	3 year – 5 years	90	47.4
Gender	Male	101	53.2
	Female	89	46.8
Proximity to IC	Solitary (Different Room Sleepers)	133	70
	Room Sharers (Same Room/ Diff. bed)	14	7.4
	Same Surface Co-sleepers (Same bed)	43	22.6
Overcrowding	Present	146	76.8
	Absent	44	23.2
Socio-Economic Status	Below poverty line (<1.9\$/day)	182	95.8
	Above poverty line (≥ 1.9\$/day)	8	4.2
BCG Scar	Present	182	95.8
	Absent	8	4.2
IAP classification for Malnutrition	Normal (>80)	162	85.3
	Grade I (71-80)	18	9.5
	Grade II (61-70)	9	4.7
	Grade III (51-60)	1	0.5
Mantoux Test (TST)	Positive (≥10mm)	26	13.7
	Negative (<10mm)	164	86.3

Table 3: Bivariate analysis

Characteristic	Category	Mantoux Test		Total (n=190)	OR	95% CI		Significance (p-value)
		Negative	Positive			Lower	Upper	
Sputum Bacillary Count (n=144)	0/1+	93.7	6.3	79	1.0			
	2+/3+	81.1	18.9	111	3.45	1.2	9.6	0.013
IC spitting Habit	No	91.8	8.2	134	1.0			
	Yes	73.2	26.8	56	4.09	1.74	9.6	0.001
Proximity to IC	Diff. Room	90.2	9.8	133	1.0			
	Same Room	77.2	22.8	57	2.7	1.17	6.3	0.017
Duration of Contact	≤ 60 days	95.7	4.3	47	1.0			
	> 60 days	83.2	16.8	143	4.5	1.03	19.9	0.03
Relation with IC	2 nd Degree	91.0	9.0	122	1.0			
	1 st Degree	77.9	22.1	68	2.8	1.22	6.6	0.012
Contact Ethnicity	Others	90.9	9.1	110	1.0			
	Hill Janjati	80.0	20.0	80	2.5	1.07	5.8	0.031

Table 4: Logistic Regression Analysis

Characteristics	Category	Adjusted OR (aOR)	95% CI		Significance (p-value)
			Lower	Upper	
Relation of Contact to IC	Second Degree	1			
	First Degree	3.5	1.4	8.7	0.009
IC Spitting Habit	Absent	1			
	Present	3.1	1.2	7.7	0.016
Sputum Bacillary Count of IC	Low bacillary count (0/1+)	1			
	High Bacillary Count (2+/3+)	3.03	1.01	9.1	0.048
Duration of Contact	≤ 60 days	1			
	> 60 days	6.7	1.4	32.2	0.018

DISCUSSION

Higher risk of infection among household contacts of Pulmonary TB patients than the general population have been reported earlier.^{11,16,21,22} This study reports 13.7% (95%CI:11.2-16.2) transmission of Tuberculosis infection to under five year old HC's of Pulmonary TB patients established by a positive Mantoux Test (≥ 10 mm) and factors associated with it. This is in contrast with the first national survey done in Nepal, which presented a national prevalence of infection of 7.0% (95%CI:4.2–9.7).²⁴ This warrants for a strong contact tracing mechanism in the National Tuberculosis Program (NTP) to curb the transmission of Infection. Although contact tracing has already been introduced in Nepal in recent years, its implementation in the field remains to be seen.

The intimacy of contact with the IC also has bearings on transmission of infection and more the intimacy, greater the chances of infection. Bed sharing has been shown to transmit respiratory infections in a study from The Gambia.¹² Similarly, the intimacy of contact as judged by sleeping in the same room with the Index case increased the chances of contact having a positive Mantoux Test by 2.7 times in this study. [OR=2.7; 95%CI (1.2-6.3); p=0.017]. Similar results have been demonstrated by another study on older HCs in Dharan.²⁵ These findings points to the fact that proper care of young children needs to be highlighted in counselling Pulmonary TB patients at DOTS centres.

Social determinants, habits, traditions and customs increase the risk of infection among certain ethnic population as demonstrated by a study in Greenland.²⁶ Hill Adibasi/Janajati (disadvantaged indigenous nationalities of the hills) are a dominant

ethnic group in Nepal comprising 27.3% of the total population.²⁷ The National Legal Code (Muluki Ain) proclaimed in the period of autocratic Rana rule in 1854 AD categorized them as non-enslavable matwali (liquor drinkers) based on their fondness for alcohol.²⁸ An extended analysis of Nepal Demographic and Health Survey 2006 revealed that 43% of the women of this ethnicity cited lack of money for treatment as a problem in accessing health care.. Only 80% children of this ethnicity received all basic vaccinations compared to 92% for Hill Brahmins.²⁸

According to the findings of this study, Hill Janjati contacts under five years were 2.5 times more likely to have a positive TST [OR=2.5; 95%CI (1.07-5.8); p=0.031] than other ethnicities of Sunsari district. Higher rate of transmission of TB bacilli could be explained on the basis of their social customs and consistently lesser access to and use of a range of health services. Further, little is known about the genetic susceptibility to tuberculosis, but studies have reported that polymorphisms in the genes for the interferon gamma receptor are associated with susceptibility.²⁹ This association of ethnicity of the Household Contacts with a positive Mantoux test could be explained by these findings of genetic and socio-cultural differences. However more research is required to explore this finding.

Grading of sputum smear, a quantitative measure of TB bacilli in the sputum samples, has been suggested as a parameter that can represent the severity and the infectiousness of the disease. Dissemination of increasing number of tubercle bacilli from an infectious case results in higher risk of infection in under-five contacts. Presence of TB bacilli in the sputum of the Index case and the bacillary load in the sputum have been implicated in the transmission of tuberculosis infection in

various studies.^{11,16, 21, 22, 30} This study similarly demonstrated this fact, where higher the load of sputum bacilli (2+/3+) of the IC, more likely the transmission to household contacts. [aOR=3.03; 95%CI (1.01-9.1): p=0.048]

The presence of injudicious spitting habits in and around the house by IC showed a 3.1 times greater chance of the HC acquiring the infection [aOR=3.1; 95%CI (1.2-7.7): p=0.016] This calls for stringent legal and regulatory measures to outlaw spitting at public places to prevent the spread of Tuberculosis and other air borne pathogens. Notices declaring spitting as illegal and the cause for spread of Tuberculosis were publicized as early as 1900 AD.³¹ Many experts at that time believed that spitting was the sole cause for spread of disease among mankind and New York Department of Health began to conduct anti-spitting campaigns to transform this traditional habit from annoyance into a public health threat.³² Recent study from India has shown quite a large proportion (49.2%) of the study population practicing injudicious spitting.³³ This plays a role in the spread of TB, as the organism can survive for prolonged periods outside the human body. Patients with correct knowledge regarding hazards of indiscriminate sputum disposal had significantly better practice of appropriate sputum disposal as compared to patients with incorrect knowledge (p=0.0001) in a study from India.³⁴ This calls for Behavior Change Communication activities to curb this practice common in Nepal.

The closeness of relation of contact to the Index case has been implicated in transmission of infection in some studies.^{10,11,22, 30} First degree relationships (spouse/son/daughter of the Index case) provide closer contact between IC and HC, increasing the chances of transmission of infection. First degree relations also tend to live together within the same household in closed spaces, resulting in higher chances of infection. Closer relationship of the contact to IC (first degree) [aOR=3.5; 95%CI(1.4-8.7): p=0.009] was found to be associated with transmission of TB infection to HC's. Similar results have been observed in studies conducted in Indonesia³⁰ and Nepal.²⁵

Greater duration of contact (>60 days) between the IC and HC was found to be 6.18 times more likely to result in a positive TST in this study [aOR=6.7; 95%CI (1.4-32.2); p=0.018]. This follows the

fact that longer duration of exposure results in more chances of transmission due to prolonged exposure. This fact has also been highlighted by some studies.^{35, 36}

CONCLUSION

The findings of this study emphasize the importance of integrating behaviour change communication activities during counselling of Pulmonary TB patients at DOTS centres on infection prevention measures (proper sputum disposal) and good care of young children in the household. This will serve as a cost-effective means to curb the transmission of TB infection to young children in those households.

LIMITATION OF THE STUDY

The sampling frame included only TB patients registered in national DOTS Registers, which could have excluded pulmonary TB patients and their contacts managed solely in private sectors. Although a negative history of HIV was obtained in all subjects, HIV testing was not feasible due to time and resource constraints. Toddlers (<3 years) are usually confined to the household, however, older children (4-5 years) could have been exposed to TB case while playing outside of the house, although a negative history of exposure outside the household was obtained in all subjects.

CONFLICT OF INTEREST

None

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