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The Role of Immunity and Living Conditions in the Transmission of Tuberculosis Disease in Abakaliki Ebonyi State, South-East Nigeria

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Abstract
Certain living conditions have been reported to increase the susceptibility, transmission and spread of tuberculosis in certain socioeconomic class. The population of the study consisted of 233 respondents in Abakaliki metropolis. A purposive sampling technique was used for selection of study participants. The reliability of the instrument was determined using Cronbach alpha. Information on Patient's demographic profile, clinical manifestations of TB, laboratory diagnosis of TB disease, sources of TB infection, living conditions of respondents, Risk factors of TB and diets of respondents was collected. The respondents were presented with a questionnaire stating the significance of the study and specific instructions was given on how to fill the questionnaire. Sputum based laboratory test results of suspected TB patients and HIV status of respondents was obtained from the bench book. Results showed that living conditions such as dusty environments (p=0.01), family size <5 (P=0.00), displaced persons (P=0.03), close contacts (P=0.05), life-styles like tobacco snuffing (P=0.00) and HIV infection are important risk factors in the development, transmission and spread of TB disease. Certain lifestyles such as cigarette smoking (P=0.88), consumption of alcohol (P=0.03) and dietary habits showed no significant association with TB disease. Therefore, necessary measures should be put in place by relevant government agencies to combat high prevalence of TB and HIV co-infection and also improve the living conditions of infected respondents in order to negate the increasing transmission rate of TB.

Keywords: Tuberculosis, Immunity, Living Conditions, Transmission of Tuberculosis Disease, Demographic Profile

Introduction
Tuberculosis (TB) is human a disease caused by a rod-shaped, non-spore forming, and aerobic bacteria, *Mycobacterium tuberculosis* (MTB). It is a pandemic disease and the second leading cause of death from an infectious disease with one-third of the world's population infected with the bacteria [1]. Tuberculosis affects mostly adults in the economically productive age groups; around two-thirds of cases are estimated to occur among people aged 15–59 years and it's more common among men

than women [1]. Transmission occurs when a person inhales droplet nuclei containing *M. tuberculosis*, and the droplet nuclei traverse the mouth or nasal passages, upper respiratory tract, and bronchi to reach the alveoli of the lungs [2]. Symptoms of TB include weakness, weight loss, fever, night sweats, loss of appetite, prolonged cough, chest pain, and the coughing up of blood (Hemoptysis).

In 2017, 10 million people were affected with tuberculosis, with a total of 1.6 million deaths (including 0.3 million persons with HIV). Over 95% of deaths occur in low and middle-income countries and seven countries accounts for 64% of the total cases with India leading the count followed by Indonesia, China, Philippines, Pakistan, Nigeria and South Africa. Risk factors include contact with a TB patient, HIV infection, low socioeconomic status, cigarette smoking, alcohol abuse, homelessness, crowded living conditions, immunosuppressive diseases, migration to a countries with a high number of TB cases, and health-care workers [3]. TB is a social disease with medical implications; people with lower socioeconomic status have a higher likelihood of being exposed and has always occurred disproportionately among disadvantaged populations such as the homeless, malnourished [4].

HIV infection is a most important risk factor for development of tuberculosis in persons infected with *M. tuberculosis* because of the immunosuppression associated with HIV infection. Thus, persons with latent tuberculosis as well as newly infected persons may progress rapidly to clinical disease [5]. Smoking impairs the host immune defenses by impairing the clearance of secretions present on tracheobronchial mucosa. This is the first line of defense which aids in clearance of inhaled particles. Thus, by impairing the clearance, it allows the tubercle bacilli to escape the defense and propels it to reach alveoli [6].

Overcrowding and proximity to an infected person plays an important role in the transmission of the disease, along with the absence of ventilation which allows infectious particles released during coughing, wheezing, sneezing or laughing by sick individuals to remain suspended in the ambient air and may become inhaled by persons that are close to them [7]. Malnutrition profoundly affects cell-mediated immunity, and cell mediated immunity is the principal host defense against tuberculosis. This secondary immunodeficiency increases the host's susceptibility to infection and hence increases the risk for developing tuberculosis [8].

Ventilation can reduce the concentration of airborne pathogens by removing or diluting airborne droplet nuclei. It is generally accepted that a higher ventilation rate can dilute the contaminated air inside a space more rapidly than a lower ventilation rate, and presumably also decrease the risk of transmission to individuals in the space [9]. Certain occupations, such as mining, quarrying, foundry, pottery work, health Care workers, especially mycobacteriology laboratory workers and those who work in autopsy room, are at increased risk of tuberculosis [10]. Housing conditions are used as socio-economic indicators of health and well-being. Poor air quality within homes as a result of inadequate ventilation, and the presence of dust particles, contribute to poor respiratory health in general and have been implicated in the spread and/or outcome of tuberculosis (TB) [11].

Tuberculosis particularly affects vulnerable populations; migrants are the most affected population. Migration as a social determinant of health increases Tuberculosis-related morbidity and mortality for migrants and their communities along all migration pathways [12].

Tuberculosis is prevented by better public health measures and social conditions such as reduction in homelessness, smoking, overcrowding, malnutrition and HIV infection. Rapid specific therapy to interrupt spread of infection, retreatment of patients who have multi-drug-resistant tuberculosis carried out in programs with comprehensive microbiological, pharmacokinetic, psychosocial, and nutritional support systems as well as vaccination of infants and children with Bacille Calmette-Guérin (BCG) vaccine to prevent complications.

Increase in tuberculosis case rates in developing countries has been attributed to a group of factors, including the epidemic of human immunodeficiency virus (HIV) infection, diminished public health efforts to control tuberculosis, rising poverty, homelessness, overcrowded conditions, poorly organized tuberculosis control programs with low case finding and cure rates and immigration from countries with a high prevalence of tuberculosis [13].

It has been observed that certain living conditions increase the susceptibility, transmission and spread of tuberculosis in certain socioeconomic class. Tuberculosis is commonly associated with multi-factorial environmental and host related factors; this study will help in understanding the respective effects of environmental and host related factors on the development of the disease and will have significant contributions for prevention and control of tuberculosis. The aim of this research is to study the role of environmental factors in the spread of tuberculosis infection and disease.

Materials and methods

Study design

This is a cross-sectional descriptive study in which data on variables related to the transmission of pulmonary tuberculosis were collected to uncover the relationship existing between the variables and TB infection [14].

Study area

This study was carried out in Abakaliki Ebonyi state, South-East Nigeria. The inhabitants are mainly Igbo ethnic group. The state has a total land area of 5,932 square kilometers and situated between latitude 6° 15′ 18″ and longitude 8° 05′ 55″ (SEED, 2004). The state has a population of about 1.8million people and the state capital has a population of 79,280 people (NPC, 2006). Abakaliki hosts a Federal Teaching Hospital and Mile 4 Missionary Hospital, which has largely contributed to the affordability of public health care delivery in the city and state at large. There have been massive infrastructural developments ongoing in the urban center; these include road construction, shopping malls and market places among others. The state capital has various recreational centers, sports centers, hotels, water fountains, decorative and street lights. The state has several mineral resources including lead with few large-scale commercial mining and quarrying activities. The indigenes of this area are predominantly farmers, skill laborers including brick layers with few public and civil servants as well as traders. The climate of the state is tropical with two seasons; rainy and dry seasons. The area is windy and dusty due to massive road constructions, increased mining and quarrying activities especially during dry season. More of the populace especially those living in slums however, are faced with poor housing quality accompanied by overcrowding.

Study population
The participants for this study were recruited from patients attending TB health care facilities namely Mile 4 hospital and Federal Teaching Hospital II (FETHA II) Abakaliki. A total of 233 TB patients who visited TB health care facilities; Mile 4 hospital (83 patients) and FETHA II (150 patients) completed a questionnaire titled “social factors of TB in Ebonyi state, South-East Nigeria”. Confirmed and suspected TB patients sent to mycobacteriology laboratory of FETHA II and Mile 4 hospital comprised subjects who met the criteria for the study.
Inclusion criteria for recruitment of patients for the study include; Patients with positive AFB result, Patients with HIV/AIDS while exclusion criteria includes Patients with negative AFB result, Paediatrics patients and Patients unable to comply.

Sampling Technique
A purposive sampling technique (non-probability sampling technique) was used for selection of study participants.

Sample Size Determination
The sample size was statistically determined using the formula below.

$$n = \frac{z^2 P.q.N}{e^2(N-1)+z^2 P.q}$$

$N = 591$, $e = 0.05$, $z = 1.96$, $P = 0.5$

Therefore $q = 1 - P = 1 - 0.5 = 0.5$

$$n = \frac{(1.96)^2 \times 0.5 \times 0.5 \times 591}{(0.05)^2 \times (591 - 1) + (1.96)^2 \times 0.5 \times 0.5}$$

$$= \frac{3.8416 \times 0.25 \times 591}{0.0025 \times 590 + 3.8416 \times 0.25}$$

$$= \frac{567.5964}{1.475 + 0.9604}$$

$$= \frac{567.5964}{2.4354} = 233.061$$

$n = 233$

Where, N = size of population, n = minimum sample size, Z = standard deviation, P = population proportion, Q = (1.0-p), e = acceptable error set at 0.05
Note: P is assumed to be 50% = 0.5

Methods of Data Collection
The reliability of the instrument was determined using Cronbach alpha. The instrument was designed to fulfill the objectives of the study and research questions. The instrument comprised of nine sections; demographic information of respondents, clinical manifestations, laboratory diagnosis, sources of TB infection, living conditions of respondents, Risk factors of TB, diets of respondents, respondents under treatment and HIV co-infection with TB.

Ethical consideration
In the course of the study, the right of confidentiality of the respondents was respected. Participation was voluntary, hospital permission and ethical approval was gotten from the faculty ethical committee.
Administration of Questionnaire
A questionnaire titled “Social Factors of TB in Ebonyi State, South-East Nigeria” was administered to patients to provide relevant information relating to development, transmission and spread of tuberculosis in the study area. The questionnaire is written in a simple language with dichotomous questions in a closed ended format. The questionnaire comprised of Patients demographic profile (age, gender, marital status, L.G.A and occupation), clinical manifestations of TB, laboratory diagnosis of TB disease, sources of TB infection, living conditions of respondents, Risk factors of TB, diets of respondents as well as therapeutic treatment.
Each patient was presented with a questionnaire stating the significance of the study; specific instructions was given to each respondents on how to fill the questionnaire, respondents who could not read nor comprehend the information in the questionnaire was assisted by reading each question in the questionnaire and explaining the information in a local dialect and their response taken. Sputum based laboratory test results of suspected TB patients and HIV status of respondents was obtained from the bench book.
Statistical method
Descriptive statistical analysis was used for the study. SPSS (version 20.0) was used for all statistical analyses. One sample t-test was used to compare the means with a criterion (cut-off) mean for significance. Means greater than the cut off of 2.50 was regarded as positive response and vice versa. Continuous variables were expressed as mean ± standard deviation. Categorical variables were expressed as number (percentage, %). Using previously described methods, 95% confidence intervals for prevalence estimates were determined [15]. All reported *P* values are two tailed, and statistical significance was set at 0.05 levels. Results were presented in tables and charts.

Results
Association between HIV status and TB disease
The association between HIV status and TB disease is presented in Table 1.
10.3% of the study respondents (TB positive respondents) were shown to be significantly co-infected with HIV ($X^2 = 4.83$, $p = 0.03$). The study consisted of 233 respondents. Out of 233 respondents, 83 (35.6%) were confirmed to be infected with TB while the rest were suspected (150, 64.4).
Association between clinical manifestations and TB status of the patients
The association between clinical manifestation and TB status of the patients is presented in Table 2.
All clinical manifestations presented by TB infected respondents and those still suspected of TB were observed to be associated with the occurrence of TB infections. All confirmed cases presented with prolonged cough >1 month (35.6%, $X^2 = 24.12$ $p = 0.00$).

Comparative evaluation of tuberculin (skin) and sputum based laboratory test.

The comparative evaluation of tuberculin (skin) and sputum based laboratory test is presented in Table 3.

GeneXpert was used as a confirmatory test for the determination of TB status. All study respondents were subjected to this sputum based laboratory assay after testing positive for the tuberculin test (58.8%, X^2 =90.34 p = 0.00) and their TB status confirmed (35.6%, X^2 =212.44 p = 0.00).

Table 1: Association between HIV status and TB

	TB Status (n=233)		X^2	p-value
	Confirmed	Unconfirmed		
	Frequency (%)	Frequency (%)		
HIV status	24 (28.9)	25 (16.7)	4.83	0.03
	59 (71.1)	125 (83.3)		
Total	83 (35.6)	150 (64.4)		

Table 2: Association between clinical manifestations and TB status of the patients

	TB Status (n=233)		X^2	p-value
	Confirmed	Suspected		
	Frequency (%)	Frequency (%)		
Prolonged cough > 1 month	83 (100.0)	112 (72.7)	24.12	0.00
	0 (0.00)	38 (25.3)		
Productive cough	79 (95.2)	128 (85.3)	5.23	0.02
	4 (4.8)	22 (14.7)		
Blood in sputum	52 (62.7)	40 (26.7)	28.96	0.00
	31 (37.3)	110 (73.3)		
Fever	82 (98.1)	118 (78.7)	17.81	0.00
	1 (1.2)	32 (21.3)		
Night sweating	77 (92.8)	92 (61.3)	26.51	0.00
	6 (7.2)	58 (38.7)		
Weight loss	78 (94.0)	106 (70.7)	17.48	0.00
	5 (6.0)	44 (29.3)		
Excessive Fatigue	82 (98.8)	121 (80.7)	15.65	0.00
	1 (1.2)	29 (19.3)		
Total	83 (35.6)	150 (64.4)		

Table 3: Comparative evaluation of tuberculin (skin) and sputum based laboratory test

	TB Status (n=233)		X^2	p-value
	Confirmed	Suspected		
	Frequency (%)	Frequency (%)		
Skin test (Tuberculin)	83 (100)	54 (36.0)	90.34	0.00
Test Outcome	76 (91.6)	32 (21.3)	105.99	0.00
	7 (8.4)	118 (78.7)		
Sputum based Laboratory test	83 (100)	12 (8.0)	187.28	0.00
Test outcome	83 (100)	5 (3.3)	212.44	0.00
	0 (0.0)	145 (96.7)		
Total	83 (35.6)	150 (64.4)		

Association between close contacts of TB patients and TB infections

The association between close contacts of TB patients and TB infections is presented in Table 4.

Close contacts with persons known or suspected to have active TB disease (X^2 =3.81 p = 0.05), and infected family members (X^2 =3.99 p = 0.05) were observed to be associated with the occurrence of TB disease.

Association between living conditions and TB infection

The association between living conditions and TB infection is presented in Table 5.

Majority of the study respondents lived in two rooms apartments (45.9%), followed by those living in one room (33.5%) and flat (20.6%). No association was observed (X^2 =0.14 p = 0.93). However, an association was observed between the occurrence of TB and the following living conditions. Those living in dusty environment (28.8%, X^2 =7.11, p= 0.01), displaced respondents (0.43%, X^2 =4.68p = 0.03) and family size(X^2 =4.68 p = 0.00).

Association between lifestyle of participants and TB disease occurrence

The association between lifestyle of participants and TB disease occurrence is presented in Table 6. Majority of the respondents do not smoke (79%, X^2=0.23, p=0.88) neither do they consume alcoholic drinks regular basis (71.2%, $X2$ =0.90, p = 0.34). Tobacco snuffing was observed to be associated with the occurrence of TB (X^2 =18.01 p = 0.00).

Table 4: Association between close contacts of TB patients and TB infection

	TB Status (n=233)		X^2	*p*-value
	Confirmed	Suspected		
	Frequency (%)	Frequency (%)		
Close Contact With Persons Known Or Suspected To Have Active Tb Disease	33 (39.8)	41 (27.3)	3.81	0.05
	50 (60.2)	109 (72.7)		
Member of the same family?	25 (30.1)	28 (18.7)	3.99	0.05
	58 (69.9)	122 (81.3)		
Volunteer or health-care worker	0 (0.0)	3 (2.0)	1.68	0.20
	83 (100)	147 (98.0)		
Resident and/or employee of high-risk congregate settings	4 (4.8)	9 (6.0)	0.14	0.71
	79 (95.2)	141 (94.0)		
Immunosuppressive therapy	0 (0.0)	4 (2.7)	2.25	0.13
	83 (100.0)	146 (97.3)		
Total	83 (35.6)	150 (64.4)		

Table 5: Distribution of respondents by living conditions

		TB Status (n=233)		X^2	*p*-value
		Confirmed	Suspected		
		Frequency (%)	Frequency (%)		
Apartment type	One room	28 (33.7)	50 (33.3)	0.14	0.93
	Two room	39 (47.0)	68 (45.3)		
	Flat	16 (19.3)	32 (21.3)		
Living in a fully completed apartment	Completed	76 (91.6)	140 (93.3)	0.25	0.62
		7 (8.4)	10 (6.7)		
Living in apartment with tiled Floor	Tiled	20 (24.1)	19 (12.7)	5.01	0.03
		63 (75.9)	131 (87.3)		
Living in a dusty environment		67 (80.7)	96 (64.0)	7.11	0.01
		16 (19.3)	54 (36.0)		
Living in a well ventilated house		70 (84.3)	119 (79.3)	0.87	0.35
		13 (15.7	31 (20.7)		
Number of people living in the respondents apartment	<2	20 (24.1)	20 (13.3)	5.48	0.07
	3-5	41 (49.4)	74 (49.3)		
	6-11	22 (26.5)	56 (37.3)		
Displaced		1 (1.2)	12 (8)	4.68	0.03
		82 (98.8)	138 (92)		
Living with displaced persons or putting up with other relatives in a crowded setting?		6 (7.2)	17 (11.3)	1.01	0.31
		77 (92.8)	133 (88.7)		
Family size	< 5	43 (51.8)	44 (29.3)	11.93	0.00
	5-10	37 (44.6)	94 (62.7)		
	> 10	3 (3.6)	12 (8.0)		
Total		83 (35.6)	150 (64.4)		

Table 6: Association between life style of participants and TB disease occurrence

	TB Status (n=233)		X^2	*p*-value
	Confirmed	Suspected		
	Frequency (%)	Frequency (%)		
Cigarette smoking	17 (20.5)	32 (21.3)	0.23	0.88
	66 (79.5)	118 (18.7)		
Consumption of alcoholic drinks on regular basis	27 (32.5)	40 (26.7)	0.90	0.34
	56 (67.5)	110 (73.3)		
Snuffing tobacco	25 (30.1)	13 (8.7)	18.01	0.00
	58 (69.9)	137 (91.1)		
Total	83 (35.6)	150 (64.4)		

Distributions of TB patients according to dietary habits

The distribution of TB patients according to dietary habits is presented in Table 7.

Majority of the respondents were guaranteed of 3 square meals (77.7%, X^2 =0.03,p = 0.86), ate thrice daily (67.4%, X^2 =5.51 p = 0.06) and choose their meals themselves (72.5%, X^2 =0.06 p = 0.81) and no association was observed between these dietary habits and the occurrence of TB.

Table 7: Distributions of TB patients according to dietary habits

		TB Status (n=233)		X^2	*p*-value
		Confirmed	**Suspected**		
		Frequency (%)	**Frequency (%)**		
Guarantee of 3 square meals		65 (78.3)	116 (77.3)	0.03	0.86
		18 (21.7)	34 (22.7)		
How many times do you eat daily?	Once	1 (1.2)	4 (2.7)	5.51	0.06
	Twice	33 (39.8)	38 (25.3)		
	Thrice	49 (59.0)	108 (72.0)		
What kind of meals do you eat daily?		61 (73.5)	108 (72.0)	0.06	0.81
		22 (26.5)	42 (28.0)		
Does meat or milk form part of your meals daily?		64 (77.1)	116 (77.3)	0.02	0.97
		19 (22.9)	34 (22.7)		
Do you choose your meals?		61 (73.5)	115 (76.7)	0.29	0.59
		22 (26.5)	35 (23.3)		
Is feeding well challenging in your family?		31 (37.3)	43 (28.7)	1.86	0.17
		52 (62.7)	107 (71.3)		
Total		83 (35.6)	150 (64.4)		

Discussions

It is known that dusty environments are hospitable to infectious particles which cause respiratory disease. Crowding, poor air quality within homes as a result of inadequate ventilation, and the presence of dust particles contribute to poor respiratory health in general [16]. In this study, association between the living conditions and TB infection showed that family size <5 (p=0.00), living in dusty environment (p=0.01) and displaced persons (p=0.03) were significantly related to TB disease. Hawker reported that dusts harbor infectious particles which cause respiratory disease and also that overcrowding and poor air quality contribute to poor respiratory health in general [16].

Surprisingly, in this study, a number of participants living in a completed and well-equipped apartment (p=0.03) had significant association with TB disease. These set of persons could have been infected as a result of close contacts with relatives already confirmed TB positive or volunteer health care worker who have been in close contacts with TB patients.

Environmental factors such as inadequate ventilation in a relatively small and enclosed space results in insufficient dilution or removal of infectious droplet nuclei, recirculation of air containing infectious droplet nuclei and duration of exposure enhance the likelihood of TB transmission [11]. Overcrowding and proximity to an infected person plays an important role in the transmission of TB disease [7]. In this study, an association between close contacts of TB patients and TB was not statistically significant (p=0.05). This finding contrasts with the study of Beggs where it was observed that proximity, inadequate ventilation and relatively small and enclosed space enhanced the likelihood of TB transmission [11]. Close contacts allows infectious particles released during coughing, wheezing, sneezing or laughing by sick individuals to remain suspended in the ambient air and may become inhaled by persons that are close to them [7].

Clinical Manifestations often include prolonged productive cough, progressive fatigue, weight loss, and a low-grade fever accompanied by chills and night sweats [17]. In this study, clinical manifestations; prolonged cough >1 month (p= 0.00), productive cough ((p= 0.02), hemoptysis (p= 0.00), fever (p= 0.00), night sweating (p= 0.00), weight loss (p= 0.00) and fatigue (p= 0.00) were significantly associated with the occurrence of TB infections. This finding is in concordant with previous study [17]. Cough may initially be nonproductive, it advances to a productive cough of purulent sputum. Hemoptysis is due to destruction of a patient's blood vessel located in the wall of the cavity or the rupture of a dilated vessel in a cavity. Hematologic studies might reveal anemia, which is the cause of the weakness and fatigue [18].

Smoking impairs the host immune defense mechanism; it impairs the clearance of secretions present on tracheobronchial mucosa, the first line of defense which aids in clearance of inhaled particles. Thus, by impairing the clearance, the tubercle bacilli escape the host's defense and propel it to reach alveoli [6]. In this study, Majority of the respondents do not smoke (p=0.88) neither do they consume alcoholic drinks on regular basis (p= 0.34). However, a significant association was found between tobacco snuffing (p= 0.00) and occurrence of TB disease. This finding is in concordant with previous study Louwagie who found that tobacco snuffing increased the development, transmission and spread of TB disease [19]. The nicotine in tobacco acts on the cholinergic receptors of the alveolar macrophages and decrease the phagocytic activities of the macrophages [20].

The prevalence of TB and HIV co-infection among the study participants was found to be an important risk factor (p=0.03). This finding is in concordant with previous studies where it was observed TB and HIV co-infection enhanced the risk of TB contraction. This is attributed to the fact that the ability of the host to respond to the organism may be reduced by the presence of HIV infection which weakens the host immune system. In these circumstances, the likelihood of developing tuberculosis disease is greater, especially those with low CD4 cell counts [21].

TB is a social disease with medical implications; people with lower socioeconomic status have a higher likelihood of being exposed and has always occurred disproportionately among disadvantaged populations such as the homeless and malnourished [4]. In this study however, majority of the respondents was guaranteed of three square meals, ate thrice daily and choose their meals themselves contrasting the findings of Lopez [4]. However, no significant association was observed between the dietary habits and occurrence of TB disease in this study.

However, this finding contrasts sharply with previous study that reported significant occurrence of TB among volunteer health workers [22]. Surprisingly, most volunteer health workers was found among the study participants who do not show significant association. This could be as a result of improved safety techniques used in diagnosis of TB and strict adherence to protective measures.

Conclusion

In conclusion, this study has established that some living conditions such as living in dusty environments (p=0.01, 80.7%), family size (p=0.00, 51.8%) and displacement from place of residence (*p=0.03, 1.2%*) were shown to be associated with the occurrence of TB disease. Furthermore life-styles like, tobacco snuffing (*p=0.00, 30.1%*) was also implicated in the development, transmission and spread of TB disease.

In this study also, there was a clear association of HIV infection (*p=0.03, 28.9%*) with TB disease occurrence. Therefore, necessary measures should be put in place by relevant government agencies to combat high prevalence of TB and HIV co-infection and also improve the living conditions of TB infected respondents in order to negate increasing transmission rate of TB.

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