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Environmental Risk Factors of TB Infection in Northwest Nigeria

Abubakar Garba Fada
Department of Geography, Usmanu Danfodiyo University, Sokoto, Nigeria

***Corresponding author**
Abubakar Garba Fada

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Abstract: Within the last two decades, tuberculosis (TB) has shown an unprecedented and rather unexpected re-emergence despite achievements in immunization, provision of heath care facilities, discovery of drugs and better understanding of the disease. The Northwest Region of Nigeria is one of those corridors through which the transmission of the disease could be enhanced due to seasonal migration of pastoralists serving as carriers of the disease, going by their mobile lifestyle. This paper tried to examine the prevalence of the disease in this area, with the aim of identifying the environmental risk factors associated with it, among others. Data were collected using a structured questionnaire on 461 patients receiving treatment as sample across the DOTS centres along Fulani route of seasonal migration. Analyses were carried out using descriptive statistics and the logistic regression while significance test was done using ANOVA. Results indicated that 'ever been diagnosed of lung and heart-related diseases' had the highest contribution in the model (B=4.943), followed by 'ever stayed with a TB patient' (B=2.213) and then 'family member ever been infected with TB' (B=1.411). However, the ANOVA test on number of persons sleeping in a room indicated no statistically significant difference in the means of the groups, $F (15, 89) = 1.117$; $p = 0.354$. It was concluded that contact with the index and overcrowding play a role in the prevalence of TB in the study area and therefore recommend further studies on individual risk factors so as to guide disease surveillance and control.

Keywords: Overcrowding; TB infection and transmission; TB prevalence; Contacts

BACKGROUND

Within the last two decades, tuberculosis (TB) has shown an unprecedented and rather unexpected re-emergence despite achievements in immunization, provision of heath care facilities, discovery of drugs and better understanding of the disease. As an infectious disease, TB has social, biological and environmental characteristics which lend it for geographic study. A number of studies have examined the types and variety of factors responsible for getting exposed to or infected from tuberculosis. Among the factors are those that relate to the physical environment in which the individual lives, although infection with tuberculosis has been shown to be a result of complex interactions between the environment, the host and the pathogen [1, 2]. Our concern is the *proximate* factors or determinants that increase exposure to the infectious agent such as crowding and those that impair the host immune system.

Overcrowding is one of the environmental factors that is said to promote infection and transmission of tuberculosis as it is usually associated with poverty and increased susceptibility to the disease [3-5]. It may increase the likelihood of exposure and progression to the disease [5], as well as serve as a risk factor for its transmission [4]. The risk of exposure is particularly increased if there is limited air movement in an enclosed space [4]. Reports by Lienhardt *et al* [6], Hill *et al* [7] and Gustafson *et al* [8] have shown that overcrowding is a major risk factor for the development of tuberculosis. Chigbu *et al* [9] have also observed the influence of dusty environment and contacts due to overcrowding on the transmission of *M. tuberculosis*, arguing that whether one gets infected depends on such factors as" the relative virulence of the disease strain, intensity of exposure to an infectious tuberculosis case and the susceptibility and immune status of the exposed individual". It was for instance observed that an increase of 0.1 persons per room (PPR) increased the risk of two or more cases of TB in a community by 40% [5], showing greater prevalence in crowded spaces [4]. Beggs *et al* [4] also observed that occupancy density, room volume and air change rate are all directly correlated with the number of new TB infections among persons who share airspace.

To demonstrate the role of crowding and other factors in tuberculosis infection and transmission, Hill *et al* [7] conducted a study in The Gambia using a questionnaire administered on TB patients with history of smoking and index cases in their households. Their data was analyzed using conditional logistic regression, which indicated smoking as a principal factor, as well as crowding and having an infected person in the household. This finding is further buttressed by the work of Kehinde *et al* [10] carried out in Ibadan, Nigeria on health workers and contact with index cases. Using a questionnaire, the authors investigated the relationships between TB infection and its history of contacts with the index and tuberculin skin test. Data were analyzed using Chi-square, which gave 59.0% positivity test among those that spent more than two years in their units, indicating that long duration of contact with index cases poses a great risk to TB infection. On the contrary however, Chigbu *et al's* [9] work on prison inmates in Aba, Nigeria, indicated otherwise. Using tuberculin test on prison inmates 18-63 years old, they focused on lifestyle, history of smoking and contact with index cases, and out of the 155 inmates assessed, 83 (53.5%) indicated positivity to the tuberculin test, and only 14 (16.9%) actually had the TB, an indication also that duration of stay in prison cell or even sharing a cell with an index does not necessarily imply having the infection.

To further buttress the role of other environmental risk factors in the prevalence of tuberculosis, the work of Tornce *et al* [11] could be cited. They conducted a study on 500 household contacts aged less than 15 years in Bangkok, Thailand using a structured questionnaire administered on parents and guardians who accompanied their children to health centres. They found significant associations (47.8%) between household contacts and tuberculosis infection out of which 80% was due to proximity with the index. The skin tuberculin positivity test also showed that longer duration of stay with the index promotes the infection and transmission of the disease. This is similar to the findings by Singh *et al* [12] that contact with a sputum positive patient and exposure to environmental tobacco smoke among others pose high risk factors for transmission of tuberculosis. Their work was based on children under five years of age that also accompany their infected parents to health centres. When the children were tested for positivity using tuberculin skin test, 33.3% of them were discovered to have the infection; out of which nine had contacts with seven infected parents. Also, when data were analyzed using a multiple regression model and both Students-t and Chi-square. All the tests indicated significant relationships of the observed factors, particularly between younger aged children and smokers. This work is also concurs with the work of Nakaoka *et al* [13] in Abuja, Nigeria where contact with index cases was found to be a risk factor for both infection and transmission of tuberculosis. Their work was based on questionnaire administration focused on household characteristics, history of infection and proximity to index. Using the t-test and X^2 to test the relationships, they found significant associations of tuberculosis infection with children having closer contacts with index in the household by 53%. Sobarg *et al*'s [14] work also lends credence to these assertions, where using a logistic regression model, discovered 26.7% of the children in the investigated households with tuberculosis cases having the infection.

Going through the literature, there appears to be few studies on the role of environmental risk Prominent among the studies include the work of Waziri *et al* [15] on factors associated with tuberculosis among patients attending a treatment centre in Zaria, North-west Nigeria and Sagir *et al* [16] on drug-resistant tuberculosis, but other regions had specific studies on tuberculosis. Waziri *et al* [15] used a structured questionnaire to obtain data on transmission of tuberculosis and exposure to some factors from newly diagnosed sputum smear-positive TB patients and non-TB patients attending hospital for other reasons in Zaria, Nigeria. They found significant associations between TB infection and contacts with a tuberculosis index and overcrowding. This study therefore tried to add to that knowledge by considering other environmental risk factors of the disease with a view to explaining its prevalence in the region. It focuses on factors such as 'ever been infected with TB', 'ever suffered other illnesses in the past 12 months' 'limited access to health care' and 'exposure to dust at workplace' as risk factors of tuberculosis infection in the Northwest Region of Nigeria.

THE STUDY AREA

For the purpose of this study, the Northwest Region consists of Udoh's [17] Rima and Middle Niger Valley regions of Nigeria. It covers those sections of the Rima and Middle Niger Valleys within Sokoto, Kebbi and Niger States and lies between longitudes $3^o30'0''$ – $7^o30'0''$ and latitudes $13^o35'$ -$10^o25'0''$ (Figure 1).

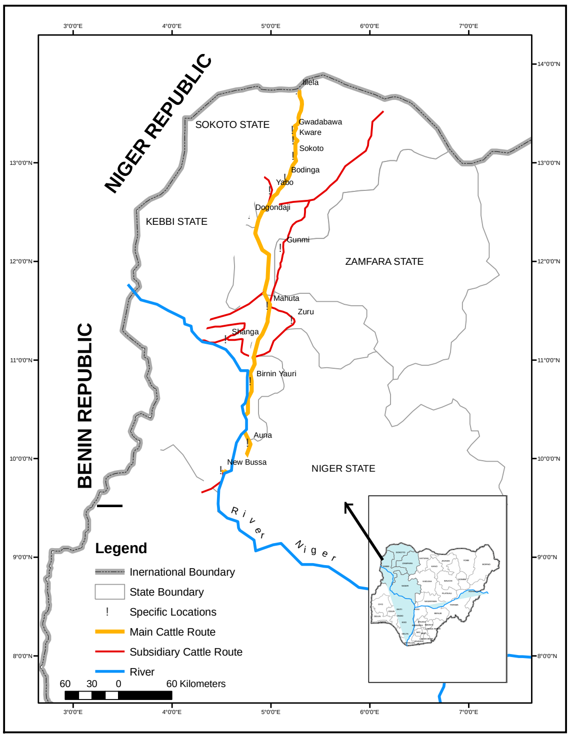

Fig-1: The Study Area

Source: Fieldwork, 2010

The study area is characterized by a Tropical Continental Climate belt dominated by two opposing air masses; the dry Tropical Continental blowing from the Sahara Desert and a moist Tropical Maritime air mass from the Atlantic Ocean. These air masses result in two major seasons, the wet and dry. In between these two major categories, there is the harmattan period with its dry, cold and dusty wind from across the Sahara Desert between November and February. Mean annual rainfall also varies with the location but is usually between 600mm in the far north to 1000mm towards the south, with a peak in August when almost a third of the annual rainfall is received. Temperatures are generally high throughout the year reaching about 45^{o}C in May but may drop to about 20^{o}C in December to February during the *harmattan* period [17].

The 2006 National Population Census [18] showed the population of the LGAs in the Study Area as 3,140,370 people. These were projected for the year 2010 as 13,503,617. Population density is generally low in the study area and population is mostly concentrated in the urban areas and in the closed settled zones around the urban areas. The majority of the people in the region are Muslims but a proportion of those of Christian faith and traditionalist's increases as you move southwards towards Kainji. There are also a number of ethnic groups within the region, but the Hausa-Fulani dominate. In the far north, we have the Hausa-Fulani and Zabarmawa. As you move southwards, the Kambari, Dakakari, Gwagi and Nupe dominate. There are thus people of varied cultures and religious beliefs across the entire region.

STUDY METHODS

Sampling was carried in DOTS centres along Fulani route of seasonal migration (Figure 1). The target population consisted of all patients currently receiving treatment on TB in DOTS centres (Table 1). Since the treatment for tuberculosis is for complete eight (8) months, except for relapses (failures), deaths and absconments, all patients registered for the past seven (7) months in the various DOTS centres (and expected to still be receiving treatment as at the time of the interview) were assessed. From the target population of 1736 patients, a sample was drawn, using a formula adopted from Araoye [19] given by:

$$nf = \frac{n}{1+\frac{(n)}{(N)}}$$

Where nf = the desired sample size when population is less than 10,000

n = desired sample size when population is more than 10,000

N = estimate of the population

This gave us an estimated sample size of 461 for all the DOTS centres for the year 2010, which was proportionately drawn in accordance with the recorded TB prevalence.. The questionnaire was used to obtain data, but the characteristics of the building that indicate occupancy density, room volume and air change rate were not part of the questions asked, because not all respondents could give exact sizes of the rooms as well as the number and sizes of windows, frequency of opening, etc. As patients presented themselves for treatment and advice, questionnaires were administered on them directly in the local languages by the DOTS Officers in the respective DOTS centres. Thus, respondents were captured only when they came to make contact with the physician in the DOTS centres.

The regression model was used to assess the contributions of the variables in determining the incidence of tuberculosis, and to test the significance of the relationships, the analysis of variance (ANOVA) was used.

RESULTS AND DISCUSSION

Table 1 shows the environmental risk factors identified during the interview and Table 2 shows the number of persons sleeping in a room, without taking into cognizance the size of the room, which could differ not only between rural and urban settlements, but also between locations due to cultural settings. From the table, the highest number of responses is in the group of two to three persons per room in all locations. The least is in the group of six persons per room. What this means is that either the family sizes are small or the culture does not allow parents to sleep in the same room with children older than 3 years. This is particularly true with Muslims who form the majority of the population in the study area. The table shows that even where the number of persons sleeping in a room reaches up to four, there is seems to be no evidence of overcrowding.

Table 1: The Identified Environmental Risk Factors

Health Facility	Ever been infected with TB		Ever Been Diagnosed of lung- or heart related disease		Ever Suffered other illnesses in the last 12 months		Ever stayed with TB patient		Ever smoked Cigarettes		Animal grazing on Fields		Sleeping in midst of Animals		Consumption of Fresh Milk		Exposure of Job to Dust	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
PHC Gw	32	30	7	30	14	22	4	31	12	24	1	35	0	36	18	13	11	34
GH Illela	26	26	1	26	1	26	3	24	9	18	1	24	0	26	9	17	1	22
CHC Kwa	19	17	2	17	8	11	2	17	8	11	3	16	0	18	0	1	5	13
S/H.Soko	57	62	7	62	17	52	7	62	8	42	1	51	0	53	2	50	5	47
GH Bodin	10	9	1	9	3	7	3	7	4	6	4	4	0	10	5	2	2	4
GH Yabo	2	17	3	11	1	9	2	11	4	11	2	7	0	11	3	8	3	7
GH DDaji	8	10	0	10	0	5	2	8	2	7	1	3	0	3	6	0	0	6
GH Gum	0	8	2	8	2	8	1	9	2	8	1	9	0	9	1	9	1	9
GH Zuru	5	14	4	14	13	5	1	17	0	15	2	9	0	8	2	0	0	11
PHC Mah	8	8	2	8	3	7	2	8	2	8	4	3	0	6	5	5	8	0
GH Yauri	18	20	0	20	3	17	1	19	6	13	2	16	0	19	7	13	4	13
GH Warra	4	5	0	5	0	4	1	4	1	1	0	2	1	3	3	6	2	7
GH Auna	1	11	2	13	4	8	1	13	3	9	1	12	0	14	3	7	1	13
GH N/Bu	12	19	1	19	8	12	7	13	7	13	13	7	3	15	18	2	5	5
GH Shang	0	1	0	1	0	0	2	5	1	4	1	5	1	6	1	4	2	2
Total	202	248	32	253	77													

Source: Fieldwork 2011

Table 2: Number of Persons Sleeping in a Room in Sample Areas

Location	Number of Persons sleeping in a room							Sample Size
	1	2	3	4	5	6	>6	
Illela	3	17	6	4	1	0	1	32
Gwadabawa	1	7	13	3	1	1	0	26
Kware	0	4	4	10	4	0	0	22
Sokoto	9	50	20	32	13	5	5	134
Bodinga	0	3	5	4	3	1	0	16
Yabo	0	4	3	2	1	0	0	10
Dogondaji	0	1	2	2	1	2	0	8
Gummi	1	1	3	2	1	0	0	10
Zuru	5	17	6	20	2	1	0	51
Mahuta	0	4	5	0	2	0	0	11
Shanga	0	3	3	0	1	0	0	21
Yauri	3	10	28	17	6	6	2	72
Warra	0	5	2	5	3	3	0	18
Auna	0	1	1	2	1	0	0	5
New Bussa	0	7	4	5	2	2	0	25

Source: Fieldwork, January 2011

Results of the ANOVA test on variation in the number of persons that sleep in a room (Table 3) indicate no statistically significant difference in the means of the groups, F (15, 89) = 1.117; p = 0.354, since the calculated value is greater than the alpha value of 0.05. This means, crowding is not a risk factor in the prevalence of TB in the study area. Therefore, this study does not lend credence to Clark *et al* [5] work which found an increased risk of two or more cases of TB in a community by 40% with an increase of 0.1 persons per room. It also disagrees with the work of Hill *et al* [7] that found overcrowding as one of the risk factors of TB but agrees with the work of Chigbu *et al* [9] who believe that the duration of exposure is more important than the occupancy density.

Table 3: The Results of the ANOVA for Number of Persons Sleeping in a Room

M		Sum of Squares	df	Mean Square	F	Sig.
one	Between Groups	66.059	15	4.404	1.117	.354
	Within Groups	350.932	89	3.943		
	Total	416.990	104			

On other environmental risk factors, Table 4 shows many positive responses to questions on 'ever been infected with TB', 'ever suffered other illnesses in the past 12 months' and 'exposure to dust at workplace' among other environmental factors.

Table 4: Other Environmental Factors

Health Facility	Ever been infected with TB	Ever Been Diagnosed of lung- or heart r elated disease	Ever Suffered other illnesses in the last 12 months	Family member ever been infected	Ever stayed with TB patient	Exposure of Job to Dust
GH Illela	32	7	14	3	4	11
PHC Gwadabawa	26	1	1	4	3	1
CHC Kware	19	2	8	3	2	5
S/H.Sokoto	57	7	17	9	7	5
GH Bodinga	10	1	3	1	3	2
GH Yabo	1	0	1	0	0	1
GH Dogondaji	8	0	0	1	2	0
GH Gummi	0	2	2	1	1	1
GH Zuru	5	4	13	1	1	0
PHC Mahuta	8	2	3	0	2	8
GH Shanga	18	0	3	2	1	4
GH Yauri	4	0	0	1	1	1
GH Warra	1	0	1	0	0	0
RHC Auna	12	1	8	11	7	5
GH New Bussa	0	0	0	2	2	2
Total	201(47.74%)	27 (6.41%)	74 (17.58%)	39 (9.26%)	36 (8.55%)	44(10.45%)

Source: Fieldwork, 2011

The risk of 'ever been infected' had the highest record (47.74%), followed by 'ever suffered other illnesses in the past 12 months' (17.58%) The least effect is found with 'ever been diagnosed of lung or heart-related disease' (6.14%) 'Family member ever been infected', 'ever stayed with a TB patient' and 'exposure of job to dust' showed fairly similar values. This is rather surprising since a person that ever got infected is supposed to have developed some immunity that will prevent re-infection. It is possible that the disease could have developed drug-resistance or the reinfection could have been due to treatment failure due to abscondments. As for the 'ever suffered other illnesses in the past 12 months', such illnesses could have lowered patients' immunity and therefore made them more vulnerable to infection. 'Ever been diagnosed of lung or heart-related diseases poses lower risk perhaps because the diseases were not directly related to tuberculosis.

The finding of the study is therefore in agreement with Sigh *et al* [12] who reported that contact with infected cases could bring about infection, as well as the work of Hill *et al* [7] that 'contact with a family member that had history of infection is a risk factor'. It also agrees with the work of Kehinde *et al* [10] that long exposure to tuberculosis could be a risk factor in its infection and that of Waziri *et al* [15] who found significant associations of TB infection with contacts with a tuberculosis index and overcrowding.

Table 4 also shows variations among stations where sampling was carried out. Generally, stations with the highest prevalence (such as Illela, Sokoto and Yauri) also had higher risks of 'ever been infected', perhaps by virtue of their population sizes, except for Zuru and Yauri. Conversely, places with lower prevalence also had lower risks, except for Auna. Thus, it is probable that this variable may be acting as a confounder due to population size of the settlement where the DOTS centre is located.

The contributions of individual environmental risk factors were further assessed using a multiple regression analysis (Table 5) given by Y (Prevalence) = $a_0+X_1a_1+X_2a_2+\ldots\ldots\ldots X_nb_n$), where a_0 is a constant, X_1 is 'ever been infected', X_2 is 'ever been diagnosed of lung-related disease, X_3 is 'ever suffered illness in the last 12 months', X_4 is 'family member ever been infected', X_5 is ever stayed with a TB patient', and X_6 is exposure of job to dust'.

Table 5: The Results of the Regression Analysis for Environmental Risk Factors

Model		Unstandardized Coefficients		Stand. Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	66.551	44.037		1.511	0.169
	Everinfect[1]	4.943	3.053	0.630	1.619	0.144
	Everdiagn[2]	20.237	38.454	0.400	0.526	0.613
	Eversuffer[3]	1.411	14.815	0.066	0.095	0.926
	Familyme[4]	2.213	27.568	0.059	0.080	0.938
	Everstyed[5]	-6.616	40.719	-0.118	0-.162	0.875
	Exposudu[6]	-18.168	10.655	-0.485	-1.705	0.127
a. Dependent Variable: Prevalence						

[1]Ever been infected with TB; [2]Ever been diagnosed of lung and heart-related diseases; [3]Ever suffered illness in the last 12 months; [4]Family member ever been infected; [5]Ever stayed with a TB patient; 'Exposure of job to dust'

The results indicate that 'ever been diagnosed of lung and heart-related diseases' seems to have the highest contribution in the model (B=4.943), followed by 'ever stayed with a TB patient' (B=2.213) and then 'family member ever been infected with TB' (B=1.411). In this analysis, the role of 'ever been diagnosed of lung or heart-related diseases that was hitherto not clearly spelt out in the raw data now becomes evident.

Thus, the finding agrees with many of the studies carried out on TB risk factors. Notably, the works of Lienhardt *et al* [6] who assert that a high risk of TB infection exists among contacts of TB cases, which increases with the intimacy of contact with the case; Tornce *et al* [11] who argue that persons living in the household of a TB patient are at high risk of becoming infected and developing the disease; Singh *et al* [12] who believe that contact with a sputum-smear positive patient and the occurrence of positive tuberculin test are correlated; Nakaoka *et al* [13] who said exposure to adults by children of smear-positive TB is the most important risk factor for transmission within the household; Hill *et al* [7] who stress that overcrowding and a history of household exposure to a known TB case are risk factors; Sororg, *et al* [14] who believe that increased risk of TB infection might be as a result of closer contact between infected family; and Kehinde *et al* [10] who believe that longer exposure to TB index case is responsible for greater infection as well as that of Waziri *et al* [15] who found significant associations of TB infection with contacts with a tuberculosis index and overcrowding.

The results of the ANOVA, presented in Table 6 however, indicate no statistically significant difference between the variables considered, $F(19, 70) = 1.245$, $p=0.249$ at 0.05 significance level since the p-value is greater than the alpha value of 0.05,.thus, contradicting the works of Lienhardt *et al* [6], Tornce *et al* [11], Singh *et al* [12], Nakaoka *et al* [13], Hill *et al* [7], Sororg, *et al* [14] and Kehinde *et al* [10].

Table 6: The Results of the Analysis of Variance on Environmental Factors

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	66.299	19	3.489	1.245	0.249
Within Groups	196.201	70	2.803		
Total	262.500	89			

CONCLUSION AND RECOMMENDATION

Environmental risk factors, particularly history of infection such as contacts with index patients, play significant role in the prevalence of tuberculosis in the study area, although there is no statistically significant difference between the identified factors in the prevalence, $(F=19.70) = 1.245$, $p=0.249$. The study concludes that environmental risk factors play a vital role in determining both the infection, as well as the transmission of tuberculosis in the study area and therefore recommends more detailed studies on specific risk factors so as to shed more light on the appropriate measures to take in surveillance and control of the disease.

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