SPATIAL ANALYSIS OF THE PREVALENCE OF PULMONARY TUBERCULOSIS ALONG FULANI SEASONAL MIGRATION ROUTE IN NORTH-WESTERN NIGERIA

By

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ABSTRACT

The pattern of human mobility affects the spread of infectious diseases, particularly tuberculosis (TB), whose transmission is associated with several factors, including consumption of unpasteurised milk. Studies conducted on the role of seasonal migration on disease transmission, such as TB transmission along Fulani seasonal migration routes in Nigeria, have received inadequate attention. This paper, therefore, analyses the spatial pattern of pulmonary TB along Fulani seasonal migration route in North-western Nigeria using secondary data on TB prevalence collected from case registers of 15 each Directly Observed Therapy Short-course (DOTS) centres along (sample) and off (control) the seasonal migration route. A two-tailed Pearson Rank Correlation Analysis was used to examine the relationships between distance of settlements (along and away from route), and TB prevalence on one hand, and population size of settlements on the other at p≤0.05. Distance away from the route was found to have no effect on TB prevalence but distance along the route had. The role of distance is not clearly defined in affecting TB prevalence in the study area and thus there is no direct link between availability of unpasteurized milk, its consumption and the prevalence of TB tuberculosis. Population size of settlements may simply be acting as a confounder. In this light, it was recommended that further studies on other factors such as climate variability and the culture of the people who actually consume unpasteurized milk as their staple food be carried out in order to ascertain the climatic and socio-economic link between TB the disease and lifestyle within the region.

Keywords: Directly Observed Therapy Short-course, Fulani Seasonal Migration, Pulmonary Tuberculosis, Spatial Variation, Unpasteurized Milk

INTRODUCTION

Cattle-rearing in Nigeria is mainly carried out by the Fulani who keep animals for meat, milk, butter and manure for both subsistence and commercial ventures. Cow milk is consumed fresh, but in most cases it is taken as yoghurt (*nono*) with *fura* (millet balls). A typical nomadic Fulani engages in an extensive transhumance determined mostly by seasonal availability of pasture and water. Movement usually starts in December from the far north where the dry season is well-pronounced during which both pasture and water become increasingly inadequate. For these reasons, movement takes place along the floodplains (*fadama* areas) where pasture and water are available (Ismail Iro, webmaster@gamji.com).

Pulmonary tuberculosis (or simply TB) is a zoonotic disease, transmitted from animals to humans and vice versa (Iseman, 1994). For example, the works of Davies (2006) and Health Protection Agency [HPA] (2009) demonstrate the cross adaptability of *Mycobacterium bovis* in transmitting TB from animals to humans. Ayele *et al* (2004: 924) are also of the view that "an unknown proportion of cases [in Africa] is due to *M. bovis*, which is underreported as a result of the diagnostic limitations of many laboratories in distinguishing *M. bovis* from *M. tuberculosis".* The isolation and identification of *M. bovis* in fresh and sour milk (*nono*) has been reported by Sharubutu (2007), Adebowale (2008), Ofukwu *et al*. (2008) and Abubakar *et al*. (2011). Individuals at risk are those in contact with potentially infected cows such as milkers (Ofukwu, 2006; Yumi and Tooru, 2007) as well as those who consume unpasteurised milk (Thoen, LoBue and De Kantor, 2006). In the view of Abubakar *et al* (2011), even though the prevalence of *M. bovis* infection is low compared with that of *M. tuberculosis*, indications show a high possibility of through consumption of unpasteurized milk (*nono*) among other factors.

Within the last two decades, TB has shown resurgence despite the strides made in the provision of healthcare facilities and services, discovery of drugs and better understanding of the nature of the disease globally. One of the reasons for this is human mobility which has served as an agent for the spread of diseases such as tuberculosis (Carballo 2007). In 2008, the World Health Organization (WHO) ranked Nigeria as the 5th largest country with tuberculosis cases. The United States Embassy in Nigeria (2012) also estimated about 320,000 cases of TB in Nigeria in 2010. Conversely, it has been observed that one of the major health challenges among nomadic people is TB (Chabasse, Roure and Rhaly, 1985; van Cleeff *et al.* 1995; Abubakar *et al*,. 2005) due to "poor health care infrastructure in the areas where nomads live, poor compliance related to the mobile lifestyle of patients that allow the infection to spread" (Sheik-Mohammed and Velema, 1999:698), as well as consumption of unpasteurized milk and its by-products (Sharubutu, 2007), and proximity to infected animals.

Given the pattern of Fulani seasonal migration therefore, it is necessary to understand the risks that the Pastoral Fulani and their animals pose to the larger society in TB transmission. The question is: does the availability of unpasteurized milk or its by-products at the stop-over and destination places of Fulani seasonal migrants have any effect on the prevalence of TB in North western Nigeria? This paper examined the spatial pattern of TB prevalence in relation to proximity to migratory route, and presence of the pastoral Fulani and their livestock in a location. A comparative analysis was made between DOTS centres along the migratory route and those away from it. The assumption is that the former has more access to unpasteurized milk and its by-products, and invariably higher consumption rate than the latter.

THE STUDY AREA

The study area consists of a section of Udo's (1970) Rima and Middle Niger Valley regions of Nigeria (Figure 1). It lies between Longitudes 3^{o}20´E and 7^{o}00´E and between Latitudes 8^{o}13´N and 14^{o}00´N. This includes parts of the present Sokoto, Kebbi and Niger states. The Rima region consists of the Sokoto Basin (about 57936.50 square kilometres) and Rima Basin (about 56327.20 square kilometres) while the Middle Niger valley region starts from Kebbi State in Yauri Emirate down to Ilorin in Kwara State. However, this study covered a corridor only within this region as spelt out by the longitudinal and latitudinal extents.

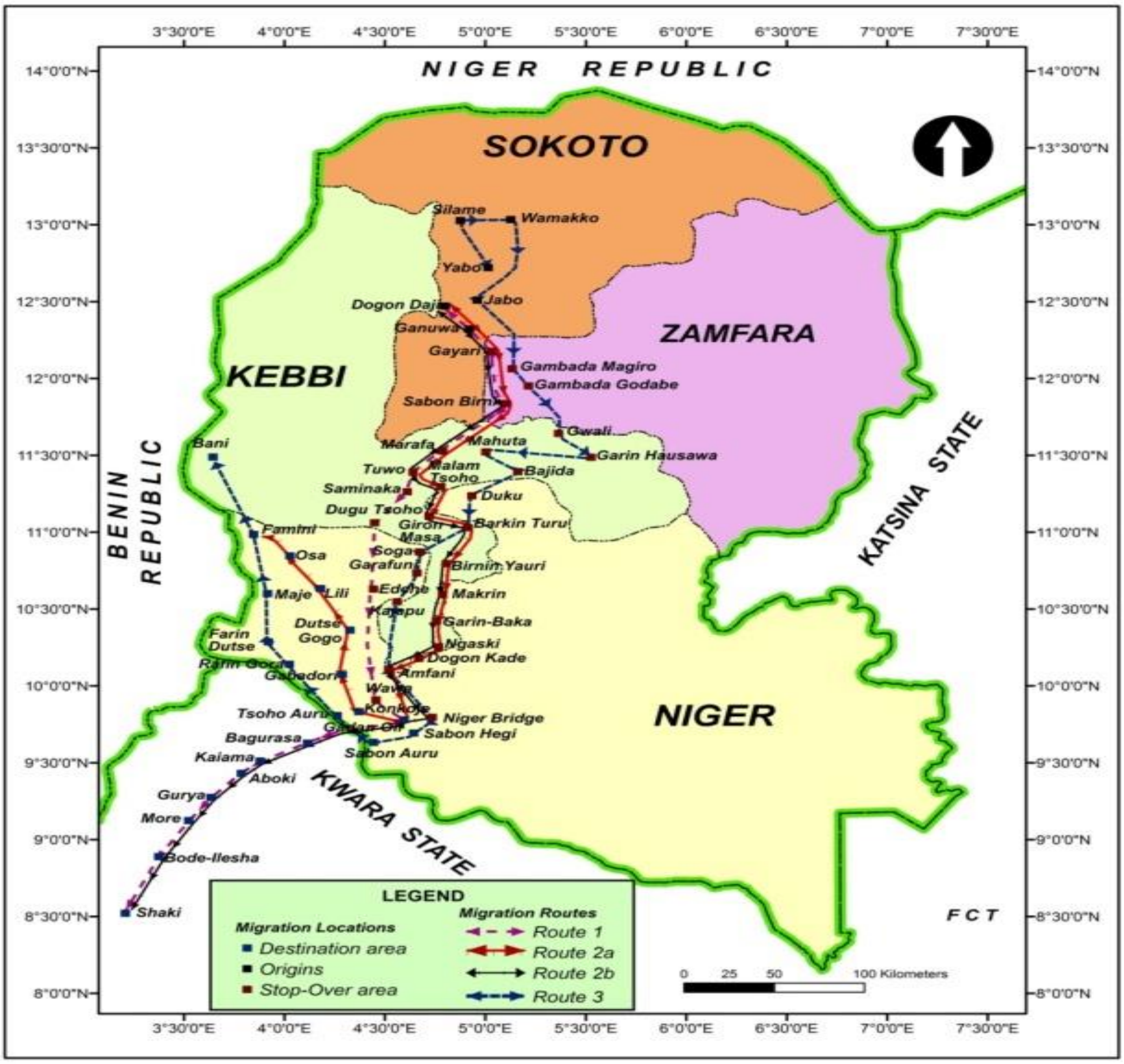

Figure 1: The Study Area and Fulani Migration Routes
Source: Fieldwork, 2010

The study area has a Tropical Continental climate 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 two predominant air masses result in the wet and dry seasons. Thus at the extreme north, we have a long dry season (from October to May) and a short rainy season (from May to September). The two seasons almost equalize as one moves towards the Kainji Lake Reservoir. Mean annual rainfall varies with location (but is usually); 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 (Udo, 1970). The dry-season is the period when the Fulani begin their southward migration. March and April are the hottest months when the Fulani are in their southernmost locations. May to June is the end of the hot season and the beginning of the rainy season in the far north when the northward movement commences. June to September is the peak of the rainy-season. When the Fulani reach their northernmost destinations. These movement schedules could however vary with a particular Fulani group. While some start migrating at the end of the rainy season, others migrate at the peak of the season so as to have continuous pasture for their livestock throughout the year. However, others move only when the situation becomes critical, that is when pasture and water become very scarce (Ismail Iro, webmaster@gamji.com).

The vegetation of the study area is highly gradational, starting with a typical Sahel Savannah at Illela (Sokoto State) bordering with Niger Republic. It consists of an almost continuous grass cover and thin tree cover, moving southwards to the Guinea Savannah and Savannah woodlands, as well as The Riparian vegetation along the river valleys and the Kainji Lake Reservoir. However, the Middle valley, the vegetation is transitional and consists of open savannah woodlands with a greater density of trees in the south. The floodplains (*fadama*) of the large rivers (e.g. Sokoto and Rima) support open savannah with occasional trees, but the valleys of the smaller and seasonal streams are covered with dense riparian woodlands. The major determinant of vegetation types and the availability of pasture for the livestock are the rainfall regimes. This is the more reason why the Fulani keep on migrating seasonally to catch up with water and pasture (Udo, 1970).

There are a number of ethnic groups within the region, but the Hausa-Fulani is dominant. In the far north, there are the Hausa-Fulani and Zabarmawa. As one moves southwards, the Kambari, Dakakari, Gbagyi and Nupe dominate. There are thus people of varied cultures living in the region. The primary activity of the people is farming with variations depending on the location. Cattle are mostly kept by the Fulani, together with few ruminants that provide medication and for immediate or emergency needs such as during festivities and provide medication. However, the Hausas have nowadays learnt to keep some cattle in their houses for their daily needs of dairy by-products, particularly yoghurt (*nono*) and butter in the absence of the Fulani as well as for the purpose of fattening of the animal prior to sale. In fact, yogurt is consumed with millet balls (*fura*) in almost every household in the northern-most part of the study area, i.e. Sokoto, Kebbi and Zamfara.

MATERIALS AND METHODS

Both primary and secondary data were collected and analyzed for this study. The primary data included geographical coordinates of accessible settlements using the GPS both along the identified Fulani transhumance route and away from it. Conversely, the secondary data included case registry data of TB prevalence from DOTS centres along or proximal to the route of migration (Table 1), as well as those away from it {to serve as control} (Table 2). It also included geographical coordinates of the settlements with poor access and the 1991 locality-based population figures of affected settlements obtained from the National Population Commission. The 1991 population data were projected to 2010 (Table 3) using the exponential population growth rate: $A_f = A_b * (1 + \%/100)^{(f-b)}$, where A is the population, f is the future year, b is the base year and % is the growth rate per year (3.4%).

Table 1: Monthly Prevalence of TB in the Sample DOTS Centres in 2010

DOTS Centre	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
GH Illella	12	7	10	9	5	7	8	2	15	23	8	9	115
PHC Gwadabawa	7	4	12	4	8	10	6	9	11	6	8	8	93
CHC Kware	8	3	1	3	8	7	4	2	9	2	11	21	78
SH Sokoto	38	52	67	29	29	37	48	9	45	54	35	41	484
GH Bodinga	1	1	5	7	8	2	0	7	13	7	5	6	59
GH Yabo	3	3	1	3	2	2	3	3	4	3	4	2	34
GH Dogondaji	1	2	3	2	1	3	1	2	1	5	6	3	30
GH Gummi	5	7	1	4	0	2	2	1	5	2	2	3	34
MBGH Zuru	16	27	10	12	20	18	6	12	18	18	9	16	182
PHC Mahuta	9	4	6	1	3	2	1	5	1	4	1	3	40
GH Shanga	12	6	4	13	6	5	7	3	5	6	4	5	76
GH Yauri	21	26	32	23	22	14	29	18	13	18	18	25	259
GH Warra	7	5	2	3	2	4	4	5	4	6	8	16	66
RH Auna	2	3	0	1	1	1	0	2	1	2	1	3	17
GH New Bussa	8	3	9	8	7	7	9	8	8	10	4	7	88
TOTAL	150	151	143	122	122	121	144	89	153	166	133	168	1655

Source: Fieldwork, 2010

Distances between some DOTS centres and locations of patients were not readily available and were therefore determined from roads and footpaths on the topographical maps of these areas and in some cases, geographical coordinates were used in computing straight line distances between them (Tables 3 and 4). It was thought easier to use the coordinates because of the large number of settlements involved and the fact that the Fulani do not follow well-defined routes that could be measured during the course of seasonal migration. The coordinate data were also used in locating the settlements on the map and in drawing the TB prevalence map to allow for visualization. Population data were used to correlate size of settlements and TB prevalence using a two-tailed Pearson Correlation Analysis. The Microsoft Excel was used to draw graphs that show spatial patterns visually.

Table 2: Monthly Prevalence of TB at Control DOTS Centres in 2010

DOTS Centre	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
GH Jega	13	11	11	14	6	8	6	8	7	7	14	10	**116**
GH Aleiro	14	21	11	4	9	21	8	16	15	10	15	22	**166**
GH Argungu	26	26	38	22	17	15	20	19	15	20	13	9	**240**
GH Gwandu	19	8	15	13	6	9	14	8	13	5	17	5	**132**
GH Kamba	22	37	32	7	13	13	14	8	6	7	5	8	**133**
GH Maiyama	7	3	3	2	2	3	4	5	3	2	3	4	**41**
GH Tureta	6	0	0	0	2	1	3	1	1	1	2	1	**18**
GH Tangaza	0	1	6	4	2	1	3	2	3	3	0	1	**26**
Leprosarium	6	5	14	4	3	6	12	2	13	9	2	15	**91**
GH Wurno	10	10	14	16	17	7	21	11	10	5	11	15	**147**
GH Rabah	18	6	1	2	2	11	8	2	0	6	12	13	**81**
PHC Gande	3	6	2	4	4	5	1	2	3	0	4	2	**35**
GH Goronyo	9	7	5	3	1	4	6	1	2	2	1	5	**46**
GH Binji	1	4	1	1	2	6	5	7	7	1	1	12	**48**
GH Gada	4	0	5	6	1	6	4	7	7	6	4	8	**58**
Total	**158**	**145**	**158**	**102**	**87**	**116**	**129**	**99**	**105**	**84**	**104**	**140**	

Source: Fieldwork, 2010

Table 3: Distances along the Route, TB Prevalence and Projected Population Size of Sample Centres

DOTS Centre	Number of TB Cases	Distance (km) Along Route	Projected 2010 Population	Prevalence/Thousand
GH Illella	115	0.00	29345	3.92
PHC Gwadabawa	93	46.97	22658	4.10
CHC Kware	78	60.29	16336	4.77
SH Sokoto	484	77.77	624569	7.18
GH Bodinga	59	104.48	16085	3.67
GH Yabo	34	127.41	19319	1.76
GH Dogondaji	30	160.67	16084	1.87
GH Gummi	34	200.11	57082	0.60
MBGH Zuru	182	265.17	11440	15.90
PHC Mahuta	40	279.58	3616	11.06
GH Shanga	76	304.93	25629	2.97
GH Yauri	259	352.37	35457	7.30
GH Warra	66	415.56	13516	4.88
RH Auna	17	426.89	40361	0.42
GH New Bussa	88	481.80	11591	7.59

Source: Fieldwork, 2010

Table 4: Distance of Control DOTS Centres to Route of Migration

DOTS Centre	Number of TB Cases	Projected 2010 Population	Distance to Route of Migration (Km)	TB Prevalence/Thousand
GH Jega	116	72891	76.6	1.59
GH Aleiro	166	19934	53.7	8.32
GH Argungu	240	25629	54.7	9.36
GH Gwandu	132	28717	20	4.60
GH Kamba	133	39534	148	3.36
GH Maiyama	41	9119	77.8	4.50
GH Tureta	18	3819	65.3	4.71
GH Tangaza	26	7480	31.2	3.48
Amanawa Leprosarium	91	1119	12.2	81.32
GH Wurno	147	36703	19.5	4.00
GH Rabah	81	12535	28.4	6.46
PHC Gande	35	8513	43.8	4.11
GH Goronyo	46	15776	44.5	2.92
GH Binji	48	12515	37.3	3.84
GH Gada	58	9572	37.8	6.06

Source: Fieldwork, 2010

RESULTS AND DISCUSSION

Four major routes of seasonal migration were identified (Figure 1). At some points, these routes diverge to grazing areas along the *fadama* for pasture and water, or even to the stipulated local grazing reserves. They all converged around major stop-over places like Gayari (Gummi LGA, Zamfara State) and their environs for a stipulated number of days, before proceeding to their destinations. The selected study route was determined during a reconnaissance survey with the highest traffic of migrant Fulani.

Sample DOTS centres

Table 1 shows variations of TB prevalence among the sample stations. The downward trend in the prevalence from Illela at the border with Niger Republic to New Bussa, the southernmost location among the settlements, could be attributed to the decreasing availability of unpasteurized milk and its by-products as one moves southwards. It might also be as a result of the decrease in the consumption of these by-products as one moves southwards. The population of this ethnic group decreases because the Hausa/Fulani population diminishes southwards. Figure 2 shows the spatial variation among individual sample stations. Except for August, there is a slight downward trend among stations as one moves from the north (places of origin) towards the south (stop-over and destination areas). This means that, prevalence is higher in the far north than in the south. Whether this is associated with the higher population of cattle in the area or the number of people who consume the by-products remains a question to be answered. Other reasons could be variations in control programmes among the states in the region as well as socio-economic factors such as literacy and income levels. It can also be seen that some places in the far north (i.e. Kware and Sokoto) and stop-over points (Gumi, Zuru, Shanga and Yauri) have the highest prevalence compared to places of destination. The reason for this could be the higher consumption of unpasteurized milk in almost every household in the far north.

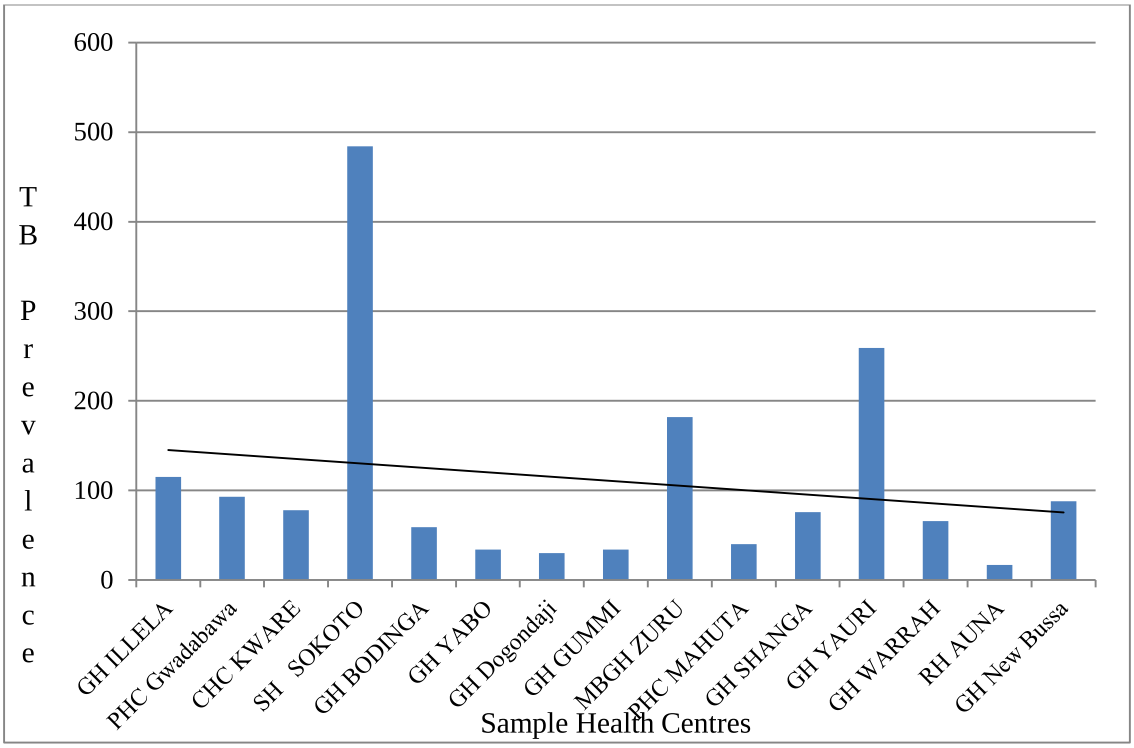

Figure 2: Spatial Variation of TB Prevalence at all the Sample DOTS Centres in 2010
Source: Fieldwork, 2010

Consistently, Yabo, Dogondaji and Auna have very low prevalence. Perhaps due to low turnout of patients to DOTS centres for a number of reasons such as the availability of resources to access the facilities, awareness of the availability of the service, availability of diagnostic facilities, attitude of personnel, proximity to other more urbanized DOTS centres with better facilities such as Sokoto, Yauri and Warra, etc. Thus, except in August, prevalence generally declines from Illela to New-Bussa, though very gently as shown by the trend line.

In Table 1, the Specialist Hospital in Sokoto has the highest TB, followed by Yauri, Zuru and Illela. All other locations have prevalence of less than 100. This shows that population size of settlements (Table 3) where the DOTS centres are located may be the determinant for the prevalence in those areas (Figure 6). This variation can also be attributed to their degree of urbanization. Generally, higher prevalence is reported in settlements with larger population sizes. In other words, the larger the population size of a settlement, the higher the prevalence of tuberculosis. This applies to all the sample DOTS centres where their population size correlates positively with the prevalence of TB However, there are variations among settlements with comparable population sizes. Auna for instance, with a population of 40,361 has a much lower TB than Zuru with a population of 11,440. The higher prevalence among settlements where DOTS centres are located could be an indication of better access to and utilization of the service or the characteristics of the population in these settlements (that are more urbanized and literate). Not only does this population earn better income because of its relatively high literacy level, it is also more aware of available services, in contrast to the more rural populace. Added to this is the possibility of more prevalence due to greater contacts consequent upon greater population size. However, it is possible that there could be falsely low prevalence in some areas due to problems of access to health care by TB patients.

A two-tailed Pearson Correlation Analysis carried out to determine the degree of relationship between population size of settlements and TB prevalence (Table 5) indicate a high positive TB relationship (r = 0.765) at *p*-value of 0.000. The coefficient of determination (r^2) being 0.765^2 x 100 = 58.52. This indicates that there is nearly a 60% relationship between the variables correlated and only 40% may be due to chance factors. Therefore, even though population size may be a determinant of TB prevalence, some other factors may be at play at some stations. However, disease transmission processes do not always generally follow the rule of distance since hierarchical effects can sometimes occur when diseases spread first to major cities, then to intermediate-size places, and later to small towns for the simple reason that larger places have a greater potential for interaction. With more carriers of a disease coming to a place, large cities have more interactions with other people and places. It signifies the role of population size acting as a confounder interfering with the distance decay process.

Table 5: Results of Correlation between Population Size of Settlements and TB Prevalence

		Prevalence	Population
Prevalence	Pearson Correlation	1	0.765**
	Sig. (2-tailed)		0.000
	N	33	33
Population	Pearson Correlation	0.765**	1
	Sig. (2-tailed)	0.000	
	N	33	33

**. Correlation is significant at the 0.01 level (2-tailed)

As earlier observed in Table 3, there is an increase in distance along the route southwards which is associated with decrease in the prevalence of TB in the region which is in consonance with the distance decay theory. In fact, Illela which is the starting point of seasonal migration recorded higher prevalence than Auna which is almost 427 kilometres away. However, the same table (Table 3) shows the influence of distance more clearly when TB prevalence was computed per thousand population. MGH Zuru with the distance of 265.17 Km from the origin of migration along the route has the highest prevalence (15.90) while RH Auna, with even much greater distance, has the least (0.42) prevalence. This indicates that distance along the route of migration is not necessarily a determinant of TB prevalence.. A two-tailed Pearson Correlation Analysis was equally carried out (using data in Table 5) to examine the role of distance in the prevalence. The correlation coefficient (r) of -0.172 (Table 6) obtained indicated a negative or an inverse correlation between distance and TB prevalence. With the coefficient of determination (R^2) of 2.95%, the association between the variables is weak. This is in line with the earlier finding that there is a slight decrease in the prevalence of TB with increase in distance within the region.

Table 6: Correlations between TB Prevalence and Distance along the Migration Route

		Prevalence	Distance
Prevalence	Pearson Correlation	1	-0.172
	Sig. (2-tailed)		0.541
	N	15	15
Distance	Pearson Correlation	-0.172	1
	Sig. (2-tailed)	0.541	
	N	15	15

The weak negative correlation is however an indication that TB prevalence decreases with distance. This concurs with Dye *et al* (2009:689), who assert that tuberculosis incidence trends may result from numerous biological, social and economic variables, and therefore "strong correlation does not necessarily reflect a causal link and the absence of a correlation does not exclude causality".

Control DOTS centres

Figure 3 shows the spatial variation of TB prevalence among control DOTS centres. The highest prevalence was found in Argungu, Aleiro and Wurno DOTS centres. Tureta DOTS Centre has the lowest prevalence, followed by Tangaza and Gande. This disparity could be explained first by their population size which could in any case serve as a confounder. Secondly, stations with the lowest prevalence are the farthest away from the Fulani migration route, thus limiting the availability of unpasteurized milk and its by-products.

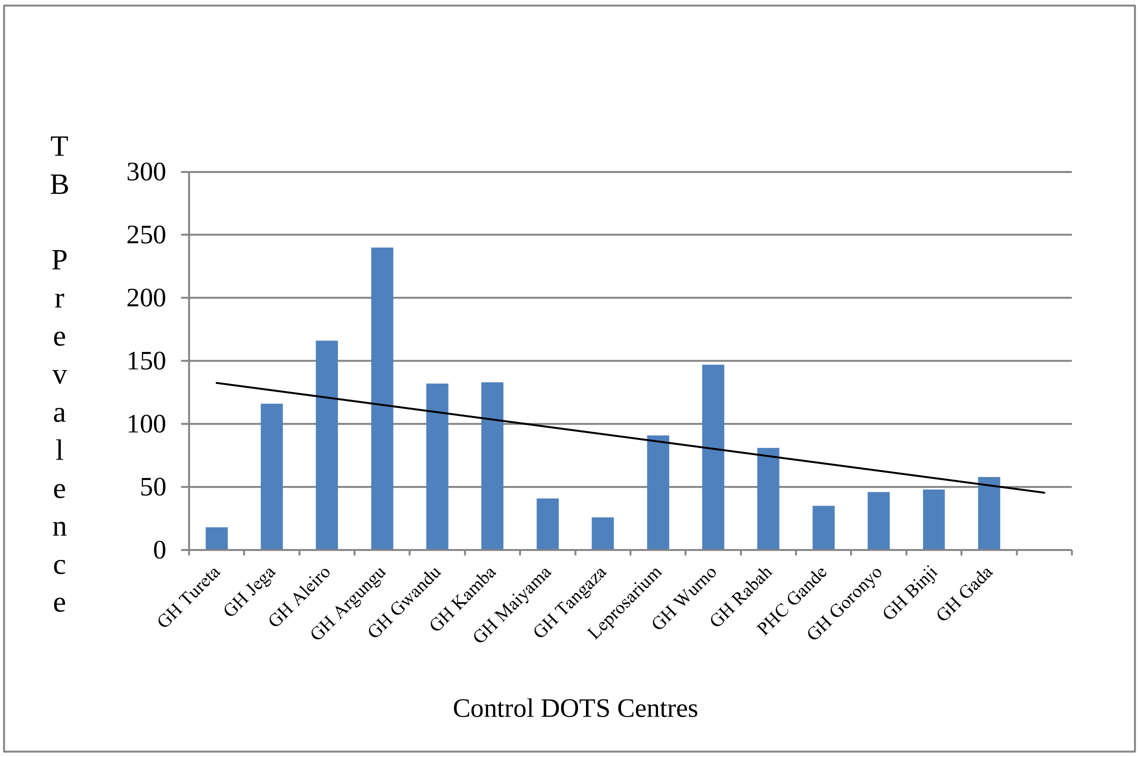

Figure 3: Spatial Variation of TB Prevalence at all Control DOTS Centres in 2010
Source: Fieldwork, 2010

Distances of control DOTS centres to the Fulani route of seasonal migration were computed to determine whether distance away from this route plays any role in the prevalence of TB in those places (Table 7). This does not indicate clear relationship between TB prevalence and distance away from the route. However, when prevalence was computed per thousand population, Amanawa Leprosarium with the least distance (12.2 km) had the highest prevalence (81.32), while Jega (one of the most distant – 76.6 km) had the lowest (1.59). It is therefore probable that distance could play a role in the prevalence. This relationship between distance from the route and TB prevalence was further determined using a two-tailed Pearson Correlation Analysis and the results in Table 8 indicated a very weak positive relationship (*r* = 0.111) and a coefficient of determination of 1.23%, with no statistical significance (p = 0.693) at 0.05 alpha level. In other words, there is no relationship between proximity to the route and the prevalence of TB in the areas. Put another way, distance to the route does not determine the prevalence of TB

Table 7: Distance of Control DOTS Centres to Route of Migration

DOTS Centre	Number of TB Cases	Distance to Route of Migration (Km)	Projected 2010 Population	TB Prevalence/Thousand
GH Kamba	133	148	39534	3.36
GH Argungu	240	54.7	25629	9.36
GH Aliero	166	53.7	19934	8.33
GH Jega	116	76.6	72891	1.59
GH Gwandu	132	20.0	28717	4.60
GH Maiyama	41	77.8	9119	4.50
PHC Gande	35	43.8	8513	4.11
GH Tangaza	26	31.2	7480	3.48
GH Binji	48	37.3	12515	3.84
GH Goronyo	46	44.5	15776	2.92
GH Gada	58	37.8	9572	6.06
GH Tureta	18	65.3	3819	4.71
Amanawa Lepros.	91	12.2	1119	81.32
GH Rabah	81	28.4	12535	6.46
GH Wurno	147	19.5	36703	4.00

Source: Fieldwork, 2010

Table 8: Results of Correlation Analysis between Distance of Control DOTS Centres to Route of Migration and TB Prevalence

		Prevalence	Distance to route
Prevalence	Pearson Correlation	1	0.111
	Sig. (2-tailed)		0.693
	N	15	15
Distance to route	Pearson Correlation	0.111	1
	Sig. (2-tailed)	0.693	
	N	15	15

Sample versus Control DOTS centres

The visual relationship of the sample and control stations is shown in Figure 4. The data were ranked since all settlements and their prevalence records could not be shown. In all cases, the size of settlements appears to determine the prevalence, but the highest density of tuberculosis prevalence among all settlements was found closer to the DOTS centres.

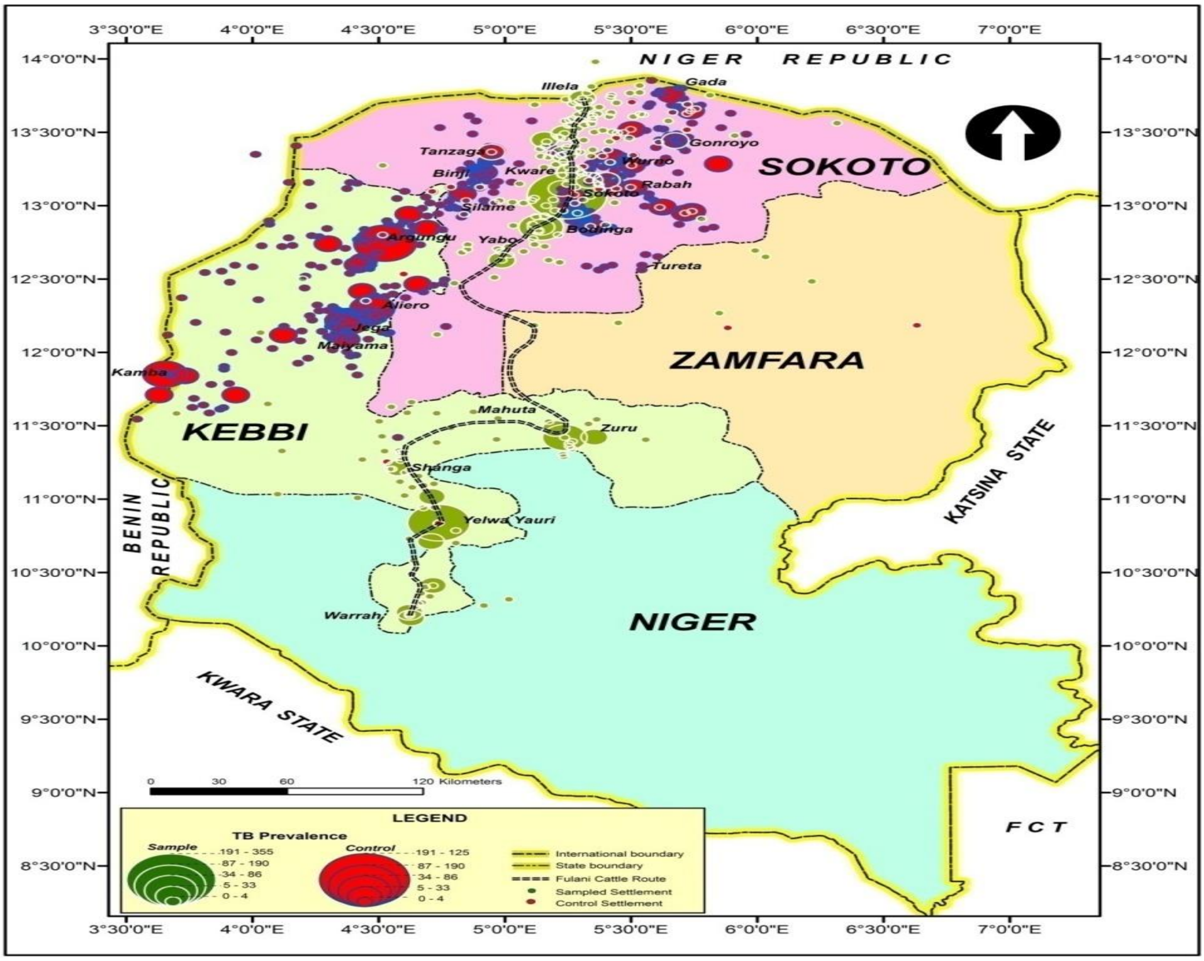

Figure 4: Spatial Pattern of TB Prevalence in 2010

Source: Fieldwork, 2010

The finding does not entirely agree with Ayele *et al* (2004), Thoen *et al* (2006), Abubakar *et al* (2010) and Sharubutu (2007) who attributed TB prevalence to consumption of unpasteurized milk and its by-products as a risk in view of the possible role of climate. It rather dispels the misconception that all types of unpasteurized milk and its by-products can cause TB. Even if unpasteurized milk does, the attribution could be very minimal, just like any other infectious agent. Distance away from the route of migration (only) seems to play some role in the prevalence as indicated by the statistically significant variations among control stations, which could probably mean that either the Fulani or their livestock are carriers of the disease, or the availability of unpasteurized milk. Certainly, the month of the year or the season play a significant role in the prevalence, as well as population size of settlement. Whether this is a coincidence with the Fulani seasonal migration or simply a climatic role, remains to be determined and is beyond the scope of this paper.

CONCLUSION

This study concludes that the consumption of unpasteurized milk and its by-products does not completely explain the prevalence of pulmonary tuberculosis in the North-western region of Nigeria. Rather, some factors, such as climatic, socio-cultural, environmental, proximity to carriers, might be responsible. In this light, the following recommendations are made:

1) There is the need to carry out more research on the influence of climate on tuberculosis prevalence in the study area so as to understand the synergy between climate and lifestyle in TB transmission.
2) There is the need to carry out a study on the people who actually consume unpasteurized milk and its by-products so as to ascertain the dangers posed by these products.
3) It is necessary to conduct empirical studies on zoonotic infection of tuberculosis, because societies who have been taking unpasteurized milk or its by-products as their staple food for ages might not accept the fact that these products pose any risk to their health, unless it is proven scientifically.
4) Research laboratories should be established to determine the different types of tuberculosis and the causative agents so as to clinically ascribe TB type.

ACKNOWLEDGEMENTS

This work was part of a PhD thesis on "The Prevalence of Pulmonary Tuberculosis in the North-western region of Nigeria" in the Department of Geography, University of Ibadan. Nigeria, in 2015. It was sponsored by the Usmanu Danfodiyo University, Sokoto, as a study leave grant. I therefore wish to express my gratitude to the University for the sponsorship and the Supervisor of the Thesis, Professor S. I. Okafor, as well as the DOTS officers for releasing the necessary case registry data. My gratitude also goes to Dr Nathaniel Eniolorunda of the Department of Geography, Usmanu Danfodiyo University Sokoto, for helping to analyse the data and draw the maps.

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