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RESEARCH ARTICLE

SPATIO-TEMPORAL DISTRIBUTION OF TUBERCULOSIS REGISTERED CASES AT WUDIL GENERAL HOSPITAL DOTS' CENTRE, KANO STATE

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ABSTRACT

Tuberculosis (TB) is considered one of the world's leading causes of sickness and death, especially in the developing world. This study explored the spatial and temporal variations of TB cases reported to Wudil General Hospital DOTS Centre. Data on TB registered cases from 2015 to 2020 were collected from the Centre. Descriptive statistics were used to analyze the demographic characteristics of patients and trend of the disease, while Choropleth maps were used to analyze the spatial distribution. A two-way analysis of variance (Two-way ANOVA) was employed to show the significant difference in the distribution of reported cases. A total of 960 cases were reported throughout the study period, and cases were highest (62 percent) among males, and among patients (28.3 percent) within the age group of 25-34. Wudil LGA recorded the highest (53 percent), number of cases, followed by Gaya LGA with 11 percent. The annual distribution of cases showed evidence of an upward trend. The result of factorial analysis of variance (Two-way ANOVA) established that there is a significant difference in the number of registered cases between LGAs ($F = 143.673$. $P = 0.000$), the annual reported cases ($F = 4.308$, $P = 0.001$), and interaction effect ($F = 2.449$, $P = 0.000$) between the two variables (LGAs and years). Furthermore, the eta square result indicates that 8.2% and 80.7% of the variations were accounted for by years and LGAs respectively. The study recommends further investigations based on individual-level locations to identify the presence of localized spatial clustering and impact of socioeconomic factors, in order to improve our understanding of the possible causes for unusually high disease rates.

Keywords: DOTS centre, spatial, temporal, Wudil, tuberculosis

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1.0. INTRODUCTION

Tuberculosis (TB) is a bacterial infection caused by the bacillus Mycobacterium tuberculosis. Although it primarily affects the lungs (pulmonary TB), extrapulmonary TB can potentially affect other places (World Health Organization, 2018). When a person with TB coughs, sneezes, talks, or sings, droplet nuclei are formed that are then inhaled by other people, allowing the disease to spread from one person to another (Beza *et al.* 2017). It was found that an individual with untreated pulmonary tuberculosis infects, on average, 10-15 people per year (WHO, 2022). Dusty environments and crowded conditions have been found to favor the transmission of M. tuberculosis. Both close and casual interactions have the potential to contract an infection. The relative virulence of the strain, the degree of exposure to an infectious TB case (closeness and length), and the susceptibility and immune status of the exposed individual all play a role in the likelihood of contracting the disease (Trauer, et al., 2019).

TB was labeled a global emergency by the World Health Organization (WHO) in 1993, and it is still one of the world's leading causes of sickness and death. The aforementioned source also disclosed that 2 billion people, or one-third of the world's population, are TB carriers. Each year, more than nine million of these people get sick with active TB, which can spread to other people. In 2017, an estimated 10 million people, including 5.8 million men, 3.2 million women, and 1.0 million children, were expected to have had tuberculosis (TB) (WHO, 2018).

Comparatively, there were cases in all nations and in all age categories, although overall 90% of cases were adults (over 15 years old), 9% were HIV-positive people (72% in Africa), and two-thirds were in eight nations: India (27%), China (9%), Indonesia (8%), the Philippines (6%), Pakistan (5%), Nigeria (4%), Bangladesh (4%) and South Africa (3%). These nations, together with 22 others on WHO's list of 30 high TB burden countries, accounted for 87% of all cases worldwide (WHO, 2018). The case fatality ratio (CFR) associated with tuberculosis was estimated to be 16% in 2017, lower than 23% in 2000 (WHO, 2018).

Nigeria is ranked sixth among the 30 nations with the highest TB burden in the world as of 2017 (WHO, 2018). In 2017, there was an estimated 418,000 new cases of all kinds of tuberculosis in the country, equivalent to 219 per 100,000 people (WHO, 2018), compared to 210,000 and 133 per 100,000 in 2010 (United States Embassy in Nigeria, 2012). Increased incidence of HIV/AIDS is a major factor in the growing TB pandemic (Okhovat-Isfahani *et al.*, 2019). According to the National HIV Surveillance Report (2024), recent infections from 2020 to January 2024, Lagos, FCT, Rivers, Benue, Nasarawa are leading in the number of HIV recent infections.

The World Health Organization launched the Directly Observed Treatment short course (DOTS) as a global TB control approach. Nigeria adopted the DOTS concept in 2003. The number of TB DOTS service centers increased from 2, 780 in 2008 to 3,931 in 2009, and the number of services provided by TB microscopy laboratories increased from 900 to 1025 in 2010 (United States Embassy in Nigeria, 2012). The Embassy also disclosed that in 2010, there were well-established community TB care programs in more than 179 areas in Nigeria. TB remains a public health problem in Nigeria, despite the deployment of DOTS and the advent of improved diagnostic techniques (Akaninyene, 2013). The issue may, however, be a lack of resources to fully operate the program.

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Numerous TB research studies were conducted in Kano state because it is the most populous state in Nigeria and one of the states with the highest TB cases. Imam and Oyeyi (2008), Abubakar (2015), and Nasir (2008) are a few of the studies. All of these studies were carried out at the Infectious Disease Hospital (IDH), which is situated in the Kano Metropolis and is the largest DOTS facility in the state. Other than Adam and Yakudima's (2019) research in the Madobi local government area, DOTS centers outside of the metropolitan area received little attention. The objective of the current study was to examine how TB cases vary geographically in the Wudil local government region.

2.0. LITERATURE REVIEW

Tuberculosis (TB) is one of the leading causes of death worldwide (Asemahagn *et al.*, 2021). TB is one of humanity's oldest diseases and remains a significant global health concern (Natarajan, *et al.*, 2020). It is caused by bacteria belonging to the *Mycobacterium tuberculosis* complex. The disease is primarily transmitted through the airborne inhalation of infectious droplet nuclei (ranging from 1 to 5 microns in size) expelled by an untreated pulmonary TB patient during activities like talking, coughing, sneezing, or singing. Once inhaled, these small droplets reach the alveoli of the lungs, potentially causing TB infection, which can progress to active TB disease. Historically, TB or similar illnesses have been documented across various ancient civilizations (Asemahagn *et al.*, 2021).

In the Vedas, TB was referred to as “Yakshma”, meaning "wasting disease." Similar descriptions also appear in Greek, Chinese, and Arabic literature (Cambau and Drancourt, 2014). Additionally, *Mycobacterium* has been present on Earth for approximately 150 million years. The understanding and management of TB have evolved significantly over time, transitioning from being an incurable disease to one that is treatable. However, the emergence of the HIV/AIDS epidemic in 1981 intensified the global burden of TB. The co-infection of HIV and TB, along with the rise of drug-resistant TB strains, has exacerbated the situation to such an extent that the World Health Organization (WHO) declared TB a global emergency in 1993 (Cambau and Drancourt, 2014).

TB occurs in various forms and is broadly classified into pulmonary TB (PTB) and extrapulmonary TB (EPTB) based on clinical manifestations (Sharma *et al.*, 2015). EPTB refers to TB affecting organs outside the lungs, such as the pleura, lymph nodes, abdomen, genitourinary system, skin, joints, bones, or meninges. According to WHO estimates, there were 10.4 million TB cases worldwide in 2017, with two-thirds occurring in eight countries: India (27%), China (9%), Indonesia (8%), the Philippines (6%), Pakistan (5%), Nigeria (4%), Bangladesh (4%), and South Africa (3%). EPTB accounts for approximately 15–20% of all TB cases (Cambau and Drancourt, 2014; MacNeil, 2019). However, in individuals with HIV, EPTB represents over 50% of all TB cases, adding complexity to the diagnosis and management of the disease (Mehta *et al.*, 2012). Due to its diverse clinical presentations, EPTB often poses significant challenges in early diagnosis, with common symptoms including fever, anorexia, weight loss, malaise, and fatigue (Angeby *et al.*, 2003).

3.0. MATERIALS AND METHODS

3.1. The Study Area

This study was carried out at Wudil General Hospital, which is located in Wudil town the headquarters of the Wudil local government area. Wudil Local Government Area is located between

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Latitude $11^{0}37'$ N and $11^{0}56'$ N and Longitude $8^{0}45'$ E to $8^{0}57'$ E. It is boarded by Warawa and Ajingi local governments to the North, Garko local government to the South, Gaya Local Government to the East, Albasu Local Government to the southeast, and Dawakin Kudu Local Government to the West. It has a total land area of approximately 458 km2 (Figure 1). According to Koppen's classification of climates, the area has a tropical wet and dry climate categorized as Aw Koppen.

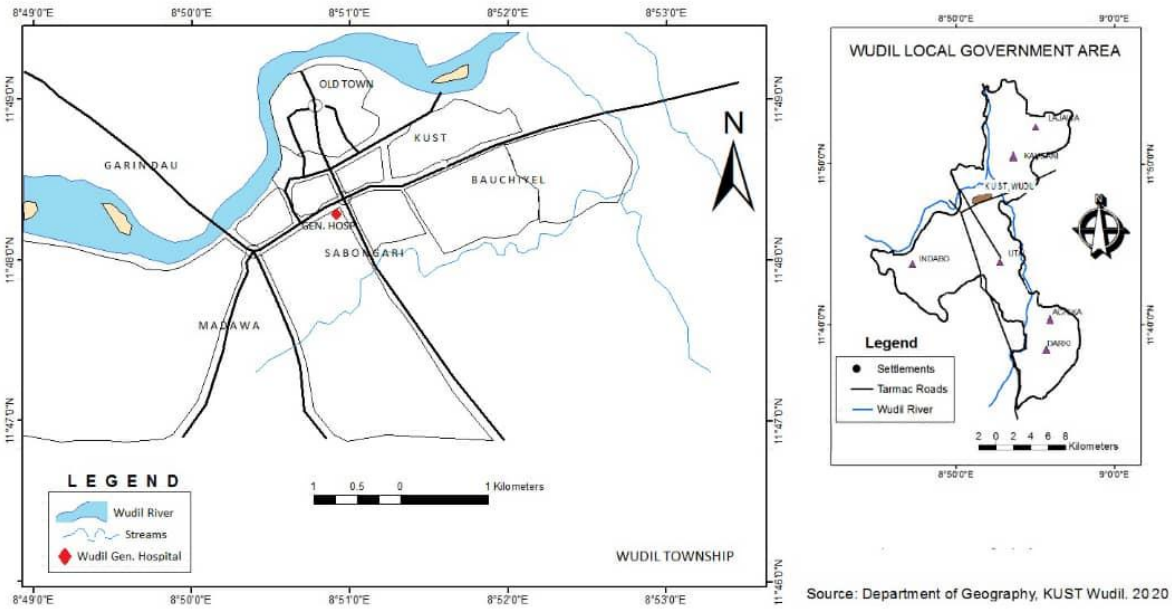

Figure 1: Wudil Town showing the study site (Wudil General Hospital)

The rainy season runs mainly from June to September, with an average annual rainfall of roughly 850mm. The area's temperature varies from 21 °C in the coldest months (December/January) to 31 °C in the hottest months (March/April) (Liman *et al.* 2014). Olofin (2008) identified four distinct seasons, including the dry and cool, dry and hot, wet and warm, and dry and warm seasons, based on local temperature and precipitation regimes. Wudil, like many Hausa communities in northern Nigeria, has both old and new town (Dambazau, 2008).

The old town was poorly planned, with narrow streets that were largely used as footpaths, which made the construction of a modern transportation infrastructure challenging. Houses are compactly constructed and often have one entryway and a fence around them. On the other side, the new town is a carefully planned community with broad streets and functional drainage systems. The area's population is expected to reach 348,534 by 2020. (NPC, 2009). There are 21 public and 7 private healthcare facilities in Wudil LGA. Wudil General Hospital is the only secondary health institution in the area that is owned by the Kano State Government and provides healthcare services in a variety of areas.

3.2. Data Collection

The data used in this research are reported tuberculosis cases collected from the Wudil General Hospital DOTS centre. Although there are seven other Dots centres in the local government, due to

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the lack of completeness of their records, their data were not used for this study. Data collected include monthly diagnosed TB cases, age of patients, sex of patients, location of patients, date of diagnosis, and status of patients on discharge. Six years of records from 2015 to 2020 were collected and used for the study.

3.3. Data Analysis

Annual TB reported cases from 2015 to 2020 were imported into ArcGIS for spatiotemporal data analysis, and choropleth maps were created to visually depict the distribution of cases. Charts and frequency tables were utilized to summarize the findings. To determine the statistical differences in the spatial and temporal distribution of TB cases, a two-way analysis of variance (Two-way ANOVA) was used. Multiple comparison tests with Bonferroni Correction were used to further identify the pairs of variables that differ significantly. ArcGIS version 10.5 was used to map the illness cases, while SPSS version 21 was used for the statistical analysis. Microsoft Excel was used to conduct trend analyses.

4.0. PRESENTATION OF RESULTS AND DISCUSSION

4.0. Presentation of Results

Figure 2 shows that men made up 594 (62%) of the 960 TB patients who were registered during the study period (2015-2020) while women made up 366 (38%). About 28.3% of the patients were between the ages of 25 and 34, 19% were between the ages of 35 and 44, and only 0.1% were between the ages of 0 and 4 (Figure 3). Figure 4 shows the data on the treatment status of patients attending the DOTS center. From the figure, 35.4% of them were fully recovered, (87) 9.1% died, and 55.5% have not completed their doses.

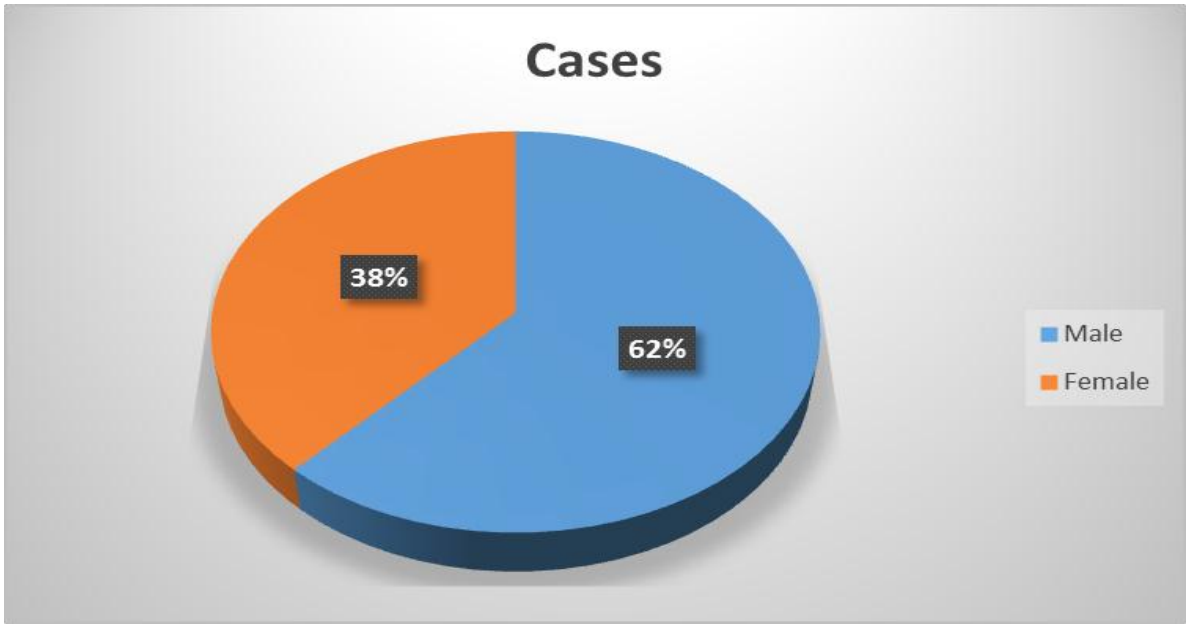

Figure 2: Distribution of TB reported cases by gender

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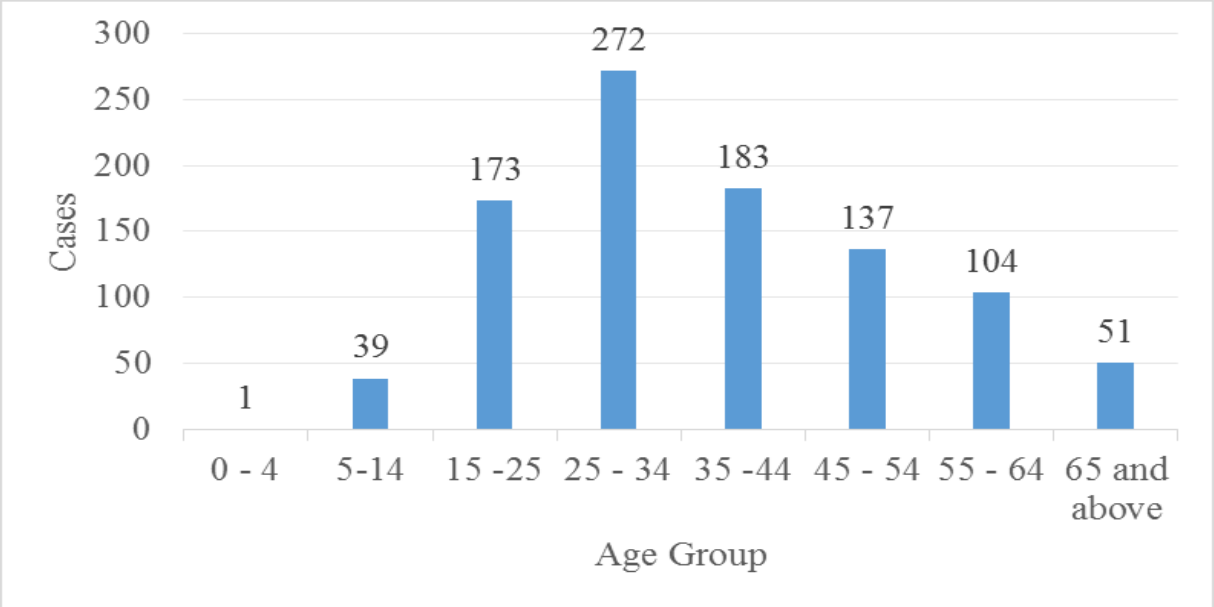

Figure 3: Distribution of TB reported cases by age group

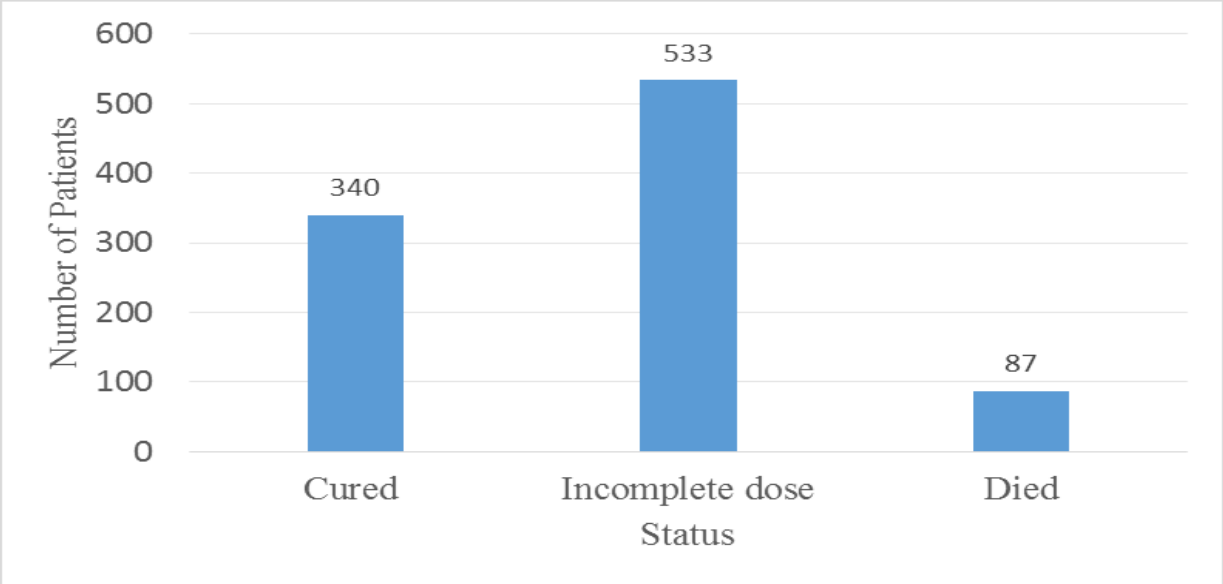

Figure 4: Treatment outcome of TB reported cases

Figures 5A–5F depict a spatio-temporal analysis of registered tuberculosis cases in the research area from 2015 to 2020. According to our findings, TB patients attending the facility come from eight LGAs, with variation among the LGAs. The annual distribution of patients revealed that Wudil LGA consistently had a high number of reported cases, whereas Sumaila and Albasu LGAs reported the lowest numbers of patients over the course of five years (2015–2019) and one year (2020), respectively.

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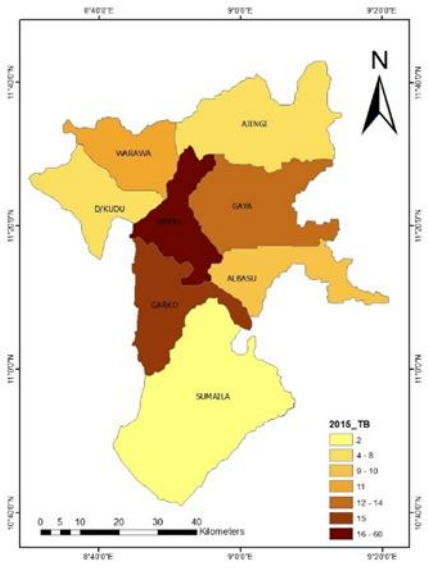
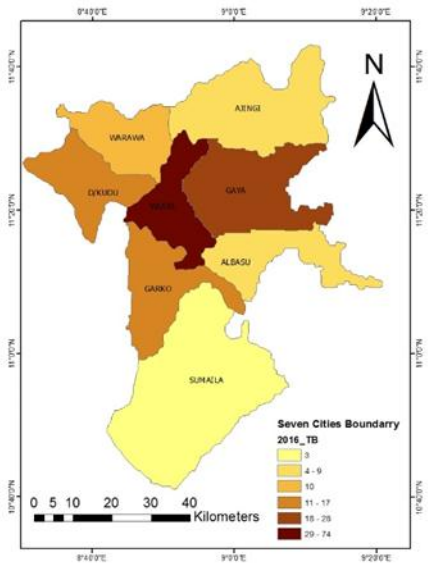
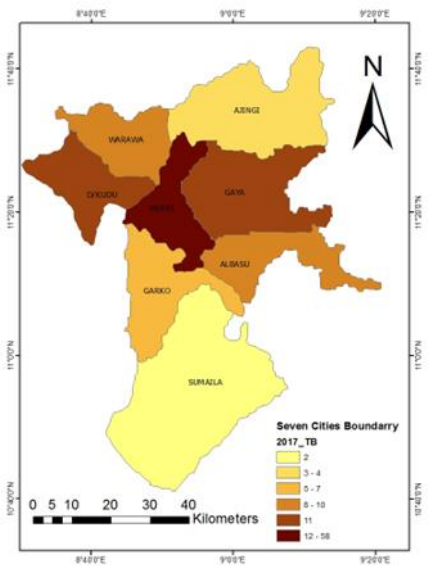


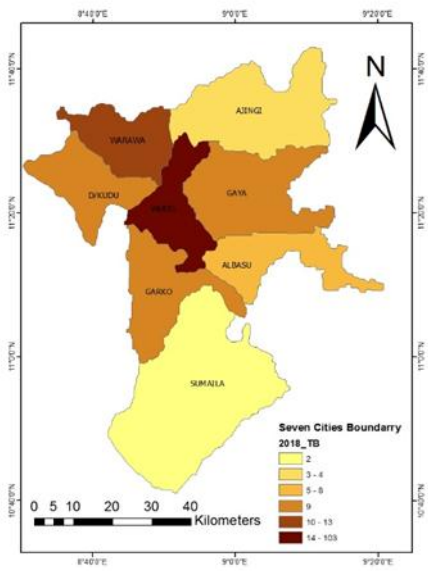
A (2015)



B (2016)



C (2017)



D (2018)

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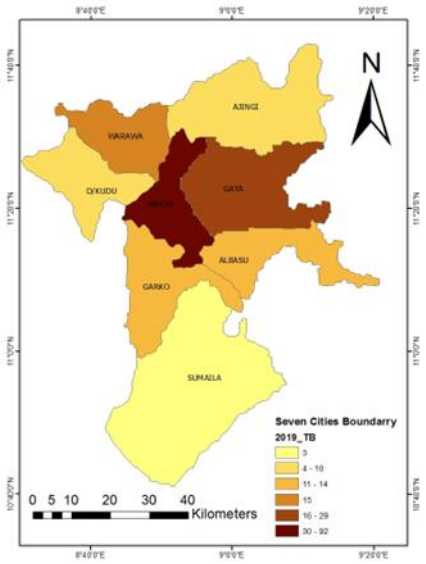
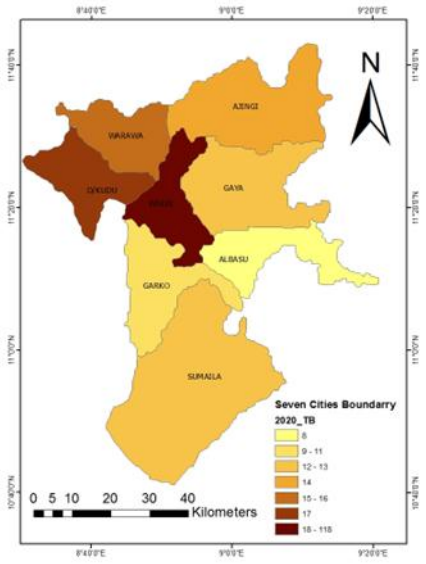
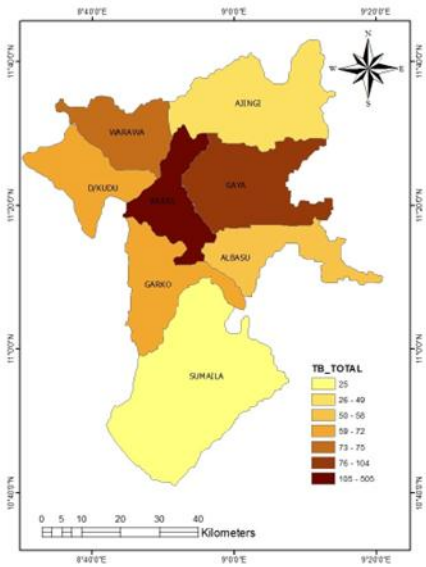


E (2019)



F (2020)



G (2015-2020)

Figure 5: Yearly and Cumulative TB Reported Cases
Source: Authors' Analysis (2026).

Figures 5G and 5H display the total number of TB cases recorded in the region over the research period (2015 – 2020). The results of the finding show that Wudil LGA reported the highest number of cases (505) representing 53%, followed by Gaya 104 cases (11%), and Sumaila LGA recorded the lowest number of cases (25 or 3%).

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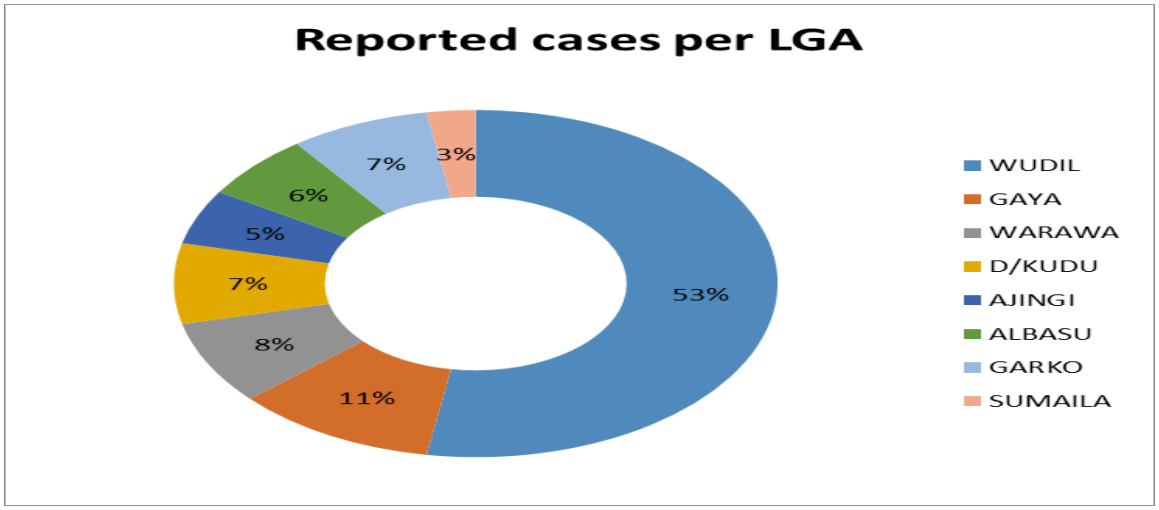

Figure 5H: Proportion of TB reported cases by LGAs

The reported TB cases over time, from 2015 to 2020, are displayed in Figure 6. A clear temporal increasing trend of annual TB reported cases was observed. According to the findings, the year 2020 had the largest number of registered cases (210 or 22%), followed by 2019 (187 cases or 19%), while the year 2017 had the lowest number of instances (112 or 12%).

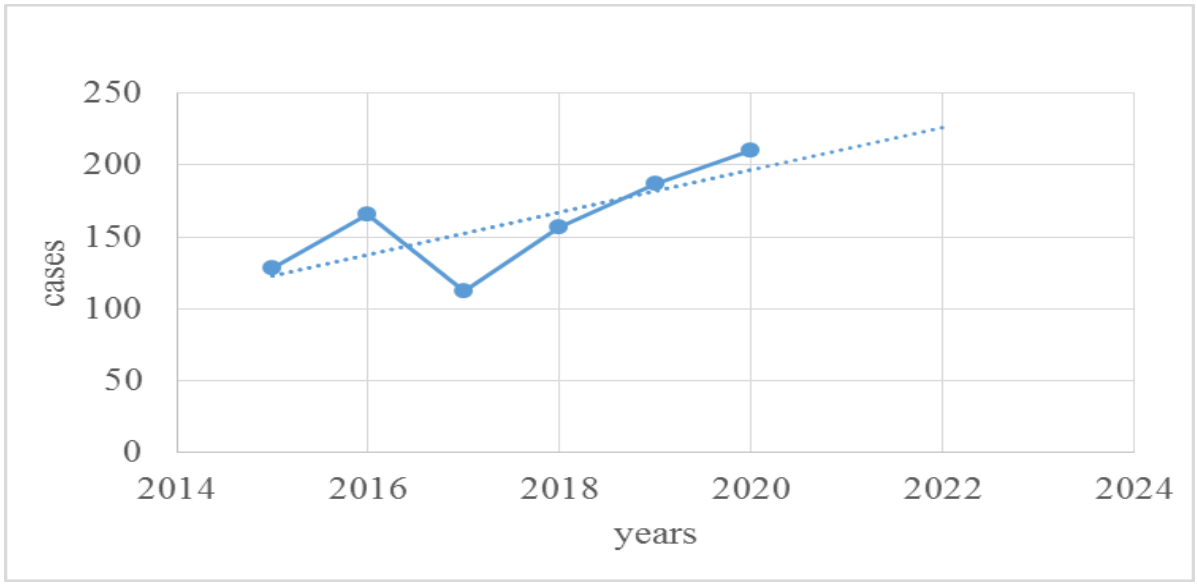

Figure 6: Annual trend of TB reported cases.
Source: Authors' Analysis (2026).

Determination of Significance Difference of TB Reported Cases

In order to determine the existence of significant differences in the TB reported cases between the local government areas attending the DOTS centre, and between the years under study, Two-way factorial design ANOVA (Two-way ANOVA) was applied to the raw data. Table 1 presents the result

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of the ANOVA test. As shown in the table, there was a statistical significance in the number of TB reported cases between the eight LGAs (P = 0.000), there was a statistically significant difference between the years under study (P = 0.001), there was a strong interaction effect between LGAs and years of study (P = 0.000). Results of the Eta Square further indicate that the difference between years of study is very small which accounts for only 8.2% of the variation. However, the variation between LGAs was said to be huge reaching 80.7%.

Table 1: Univariate ANOVA Test Result of TB Reported Cases

Dependent Variable: TBCASE Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5427.167a	47	115.472	23.68	0.000	0.823
Intercept	3444.5	1	3444.5	706.4	0.000	0.746
YEAR	105.042	5	21.008	4.308	0.001	0.082
LGA	4904.222	7	700.603	143.7	0.000	0.807
YEAR * LGA	417.903	35	11.94	2.449	0.000	0.263
Error	1170.333	240	4.876			
Total	10042	288				
Corrected Total	6597.5	287				

a R Squared = .823 (Adjusted R Squared = .788)

Source: Authors' Analysis (2026).

The study go further in the analysis with Post Hoc Test using Tukey HSD to investigate which pairs of LGAs and which pairs of years differ significantly. From the results (Table 2), the mean cases of the year 2019 differ significantly from those of 2015 and 2017 while 2020 differs from 2015, 2017, and 2018 in their registered cases. All other years have similar reported cases.

Table 2: Post Hoc Multiple Comparison Test Result between Years

Year	N	Subset	
		1	2
2017	48	2.6667	
2015	48	2.7917	
2018	48	3.4167	3.4167
2016	48	3.5417	3.5417
2019	48	3.9375	3.9375
2020	48		4.3958
Sig.		0.058	0.255

Source: Authors' Analysis (2026).

With regard to LGAs, mean cases of Wudil significantly differ from cases of the remaining seven LGAs, while cases of Gaya differ significantly from those reported from Wudil, Ajingi, Albasu, and Sumaila LGAs (Table 3).

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Table 3: Post Hoc Multiple Comparison Test Result between LGAs

LGA	N	Subset		
		1	2	3
Sumaila	36	1.1944		
Ajingi	36	1.4722	1.4722	
Albasu	36	1.6944	1.6944	
Dawakin Kudu	36	2.0278	2.0278	
Garko	36	2.0278	2.0278	
Warawa	36	2.0556	2.0556	
Gaya	36		2.8889	
Wudil	36			14.3056
Sig.		0.716	0.121	1

Source: Authors' Analysis (2026).

4.2. Discussions

In this study, the geographic distribution of TB cases reported at the Wudil General Hospital DOTS center between 2015 and 2020 was examined. For TB control programs to work, policymakers need to know where TB patients live and how the number of cases has changed over time. Because of this, it is very important to give policymakers information on the spatial and temporal distribution of TB cases in Wudil LGA. This will help them set up, plan, and improve programs to control TB.

In this study, 960 TB patients were registered in the Wudil General Hospital DOTs Centre between 2015 and 2020. The findings of this study indicate that men have higher case notification rates than women. The findings of the present study supported previous research (Aliyu, 2015; Tabatabaee *et al.* 2015; Brahmapurker *et al.* 2016; Audu *et al.* 2017; Huang *et al.* 2017; Omote *et al.* 2018) that also found a higher rate (more than 60%) of notified cases among males. Other studies (Hamusse *et al.* (2014); Dandisso *et al.*, 2015; Effiong and Nwakaego, 2015; Ogbudebe *et al.*, 2015; Ojiezeh *et al.*, 2015; Horton *et al.* (2016); Shaweno *et al.* 2017; Tadesse *et al.* 2018; Adam and Yakudima, 2019; Gilaw *et al.* 2019; Asemahagn *et al.* 2021; Ugwu *et al.* 2021; Moyo *et al.* 2022) found a slightly higher case notification rate among male patients.

The greater notification rates among males compared to females have been related to a higher prevalence of infection among males beginning in early adulthood, which has been linked to higher risks of exposure, alcohol consumption, smoking and high mobility that exposed them to high chance of acquiring the infection (Asemahagn *et al.* 2021). While they may have fewer social interactions than men, many women in the typical Hausa/Fulani community spend extended periods of time indoors in homes with poor ventilation and lighting (i.e., away from sunlight, which kills tubercle bacilli quickly), whereas many men spend comparatively more time outdoors with friends, attending religious gatherings, doing business in the market, or doing agricultural work.

Thus, it is anticipated that men will be more likely than women to get a TB infection. In a similar study, Effiong and Nwakaego (2015) associated higher case notification rates among males to the stigma attached to the condition, which tends to have more impact on females than males. A lower-

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case notification rate among women may also be attributed to their poorer socioeconomic level, higher rates of unemployment, less access to health care, and a less proactive approach to preventive care (Nigeria National HIV Sero-prevalence Survey, 2010; cited in Effiong and Nwakaego, 2015).

Nonetheless, our findings contradict the findings of Gyar *et al.* (2014), Miandad *et al.* (2014), Iroezindu *et al.* (2016), and Xia *et al.* (2020) who discovered that female patients outnumbered males in their respective fields of research. Most of these studies have concluded that the high incidence of tuberculosis in females is caused by co-infection with HIV, which is more prevalent in females than in males.

Our findings on the age group of TB patients revealed that the majority of TB cases (47%) were among those aged 25 to 44, which is comparable with the findings of studies by Gyar *et al.* (2014), Audu *et al.* (2017), and Omete *et al.* (2018), who showed high incidence among those aged 31–40 years, 27–39 years, and 21–40 years, respectively. The reasons for the high rate of case notification among these age groups were not adequately documented in this part of the country. Nevertheless, it is highly likely that their involvement in a variety of economic and social activities may play a role in the outcome.

Our study found a treatment success rate of 35.4%, an incomplete dosage rate of 55.5%, and a failure rate of 9.1%. The achieved success rate falls considerably short of the national success rate of 85.0% (Federal Ministry of Health, 2009). This result was also lower than the success rate rate reported in Kano and Cross Rivers (Kingsley, 2014) and Madobi (Adam and Yakudima, 2019). It's possible that a very high rate of incomplete doses is to blame for the extremely low success rate that was found in this study. In our analysis, the percentage of defaulted patients was lower than that reported by Tefera *et al.* (2014), Karanjekar *et al.* (2014), and Brahmapurkar *et al.* (2016), respectively. The causes of the high default rate in this study are unknown, so there is a need to properly study them to achieve global TB management programs.

In terms of the spatial distribution of TB cases that have been reported, the overall findings indicated Wudil as the local government area (LGA) with the greatest percentage of registered cases; more than half of the people who have TB are from that area. This area is the most urbanized of the eight LGAs attending the DOTS facility, and it has a large periodic cattle market, the Aliko Dangote University of Science and Technology (ADUSTECH), better road and public transportation access, and a higher population concentration than the other LGAs, which may contribute to a higher number of registered TB patients. This finding is consistent with the findings of the study that was conducted by Huang *et al.* (2017), which discovered a high prevalence of TB infection transmission in commercial and heavily inhabited areas. The study discovered significant variation in the distribution of TB reported cases among the local government areas under study. The finding is similar with studies by Sikalengo *et al.* (2018), Sarker *et al.* (2019), Xia *et al.* (2020) and Wang *et al.* (2021) who also found spatial variation in the distribution of TB cases.

The findings of this study demonstrate that the annual distribution of TB registered cases increased during the study years. This could be due to an intense case-finding campaign launched in the state by the government and other international organizations, which could contribute to the observed

variation in the disease's annual distribution pattern. Such encouraging actions assist patients to overcome their shyness and register at TB Control Centers. Additionally, an increase in access to and utilization of TB control services may contribute to an increase in the number of TB cases that are reported. This finding is consistent with the findings of the investigation conducted by Dangisso *et al.* (2015), Shaweno *et al.* (2017), Tadessa *et al.* (2018) and Adam and Yakudima (2019) who also discovered an annual growth trend in TB reported cases. Contrary findings were however reported by Cui *et al.* (2019), Xia *et al.* (2020) and Wang *et al.* (2021) who showed a declining annual trend of TB reported cases. This might be linked to variation in the area of study and periods.

5.0. CONCLUSION

The study investigates spatio-temporal distribution of tuberculosis cases reported to Wudil General Hospital DOTs Center from 2015 to 2020. Results of the study revealed that cases significantly differed in both space and time. Most of the cases were reported from Wudil local government area. The cases generally showed an upward trend. The study further identified that male and youth are most significantly affected populated population group. Targeting the most affected local government area in TB prevention and control activities is crucial to reduce transmission of the disease in the area. Conducting further study is required to investigate for the high rate of defaulters among the patients that led to low treatment success rate.

Conflict of Interest

The authors declare that no conflict of interest exist in this manuscript.

REFERENCES

Abubakar A.Y. (2015) Spatial Distribution of Tuberculosis in Kano Metropolis. An Unpublished BSc Pproject, Department of Geography, Bayero University, Kano

Adam, A.I. and Yakudima, I.I. (2019) Spatio-temporal trends of Tuberculosis in Madobi local government area, Kano State. *Bayero Journal of Pure and Applied Sciences,* 12(1):166-175

Akaninyene, A.O. (2013) A Review of the National Tuberculosis and Leprosy Control Programme (ntblcp) of Nigeria: Challenges and Prospects. *Annals of Tropical Medicine and Public Health*, 6, 491-500.

Aliyu, M.S. (2015) Prevalence of Multi- Drug Resistant Mycobacterium Tuberculosis (MDR-TB) in Kaduna State, Nigeria. Ph D thesis, Department of Microbiology, Ahmadu Bello University, Zaria, Nigeria

Ängeby, K. A. K., Werngren, J., Toro, J. C., Hedström, G., Petrini, B., & Hoffner, S. E. (2003). Evaluation of the BacT/ALERT 3D system for recovery and drug susceptibility testing of Mycobacterium tuberculosis. *Clinical microbiology and infection*, *9*(11), 1148-1152.

Asemahagn, M.A., Alene, G.D., Yimer, S.A (2021). Spatial-temporal Clustering of Notofied Pulmonary Tuberculosis and its Predictorsin East Gojjam Zone, North West, Ethiopia. *PLoS One*, 16(1): e0245378

Audu., O., Agelalgbabuls, S., Anejo-Okopi, J., Joshua, I.A., Anefu, G.O., and Isa, S.E. (2017) Late Commencement of AntiTuberculosis Drugs in Three Directly Observed Treatment Short Course Centres in Benue State Nigeria: A Neglected Correlate of Tuberculosis Management. *Journal of Tuberculosis Research*, 5: 95-105

Beza, M.G., Hunegnaw, E., and Tiruneh, M. (2017) Prevalence and Associated Factors of Tuberculosis in Prisons Settings of East Gojjam Zone, Northwest Ethiopia. *International Journal of Bacteriology*, Volume 2017, Article ID 3826980, 7 pages

Brahmapurkar K.P, Khan Q.H, Zodpey S, Ruikar M.M, Brahmapurkar V.K (2016). Death and Defaulted Trends among Registered TB Cases at Jagdalpur TU in Bastar district of Chattisgarh, India. *Int J Med Sci Public Health*, 5:2361-2365

Cambau, E., & Drancourt, M. (2014). Steps towards the discovery of Mycobacterium tuberculosis by Robert Koch, 1882. *Clinical Microbiology and Infection*, *20*(3), 196-201.

Cui, Z., Lin, D., Virasakdi, C., Zhao, J. Lin, M., Ou, J,, Jinghua, Z, (2019). Spatio-temporal Patterns and Ecological Factors of Tuberculosis Notification: A Spatial Panel Data Analysis in Guangxi, China, *PLoS One*, 14(5): e212051

Dambazau, A.M. (2008) A Summary of the Geography of Wudil Local Government Area. In Olofin, E.A., Nabegu, A.B. and Dambazau, A.M. (eds). *Wudil within Kano region: a geographical synthesis.* A publication of the department of Geography, Kano University of Science and Technology Wudil. Revised Edition. Adamu Joji Publishers Kano City. Pp 149-177

Dangisso, M.H., Datiko, D.G. and Lindtjorn, B. (2015) Spatio-Temporal Analysis of Smear-Positive of Tuberculosis in the Sidama Zone, Southern Ethiopia. PLoS ONE, 10(6): e0126369

Effiong, J.O. and Nwakaego, I.F. (2015) Gender Differences among Clients Attending Tuberculosis Unit of a Teaching Hospital in Southern Nigeria. *Scholars Journal of Applied Medical Sciences*, 3: 228-233

Federal Ministry of Health (FMoH) (2009) National Tuberculosis and Leprosy Control Programme: Annual Report Abuja, Nigeria.

Gelaw Y.A., Williams, G., Assefa, Y., Asressie, M., Soares, Magalhaes, R.J (2019). Sociodemographic profiling of tuberculosis hotspots in Ethiopia, 2014–2017 *Trans R Soc Trop Med Hyg*, 113(7):379–391.

Gyar, S.D., Dauda, E. and Reuben, C.R. (2014) Prevalence of Tuberculosis in HIV/AIDS Patients in Lafia, Central Nigeria. *International Journal of Current Microbiology and Applied Sciences*, 3(6): 831-838

Hamusse, S.D., Demissie, M., Lindtjørn, B (2014). Trends in TB case notification over fifteen years: the case notification of 25 Districts of Arsi Zone of Oromia Regional State, Central Ethiopia. *BMC Public Health*, 14(1):304

Horton, K.C., MacPHERSON, P., Houbern, R.M., White, R.G., Corbett, E.L (2016). Sex Differences in Tuberculosis Burden and Notifications in Low- and Middle- income Countries: a Systematic Review and Meta-analysis. *PLoS Med*, 13: e1002119

Huang, L., Li, X., Abe, E.M., Xu, L., Ruan, Y., Cao, C. and Li, S. (2017) SpatioTemporal Analysis of Pulmonary Tuberculosis in the Northeast of the Yunnan Province, People's Republic of China. *Infectious Diseases of Poverty*, 6:53

Imam, T.S. and Oyeyi, T.I. (2008) A Retrospective Study of Pulmonary Tuberculosis (PTB) Prevalence among Patients Attending Infectious Diseases Hospital (IDH) in Kano, Nigeria. *Bayero Journal of Pure and Applied Sciences*, 1(1): 10-15

Iroezindu, M.O., Ofondu, E.O., Mbata, G.C., van Wyk, B., Hausler, H.P., Au, D.H., Lynen, L. and Hopewell, P.C. (2016) Factors associated with Prevalent Tuberculosis among Patients receiving active antiretroviral therapy in a Nigerian Tertiary Hospital. *Ann. Med Health Sci Res*, 6: 120-8

Karanjekar, V.D., Lokare, P.O., Gaikwad, A.V., Doibale, M.K., Gujrathi, V.V., Kulkarni, A.P (2014). Treatment Outcome and follow-up of Tuberculosis Patients put on Directly Observed Treatment Short-course under Rural Health Training Center, Paithan, Aurangabad in India. *Ann Med Health Sci Res*, 4(2):222–6.

Kingsley, C.O. (2014) A Review of Community TB Care Intervention in Nigeria- A case study of NGO Intervention- A Capstone Project. *South American Journal of Public Health*, 2:1

Liman, M., Idris, H.A. and Mohammed, U.K. (2014) Weather and Climate. In Tanko, A. I. And Momale S. B. (eds) 2014: *KANO – Environment, Society and Development.* Adonis and Abbey Publishers Ltd UK pp 13-19

MacNeil, A. (2019). Global epidemiology of tuberculosis and progress toward achieving global targets—2017. *MMWR. Morbidity and mortality* weekly report, 68.

Mehta, P. K., Kalra, M., Khuller, G. K., Behera, D., & Verma, I. (2012). Development of an ultrasensitive polymerase chain reaction–amplified immunoassay based on mycobacterial RD antigens: implications for the serodiagnosis of tuberculosis. *Diagnostic microbiology and infectious disease*, *72*(2), 166-174.

Miandad, M., Burke, F., Nawaz-ul-Huda, S. and Azam, M. (2014) Tuberculosis incidence in Karachi: A spatio-temporal analysis. *Geografia online, Malaysian Journal of Society and Space* 10 issue 5 (1 - 8)

Moyo, S., Ismail, F., Walt, M., Ismail, N., Mkhondo, N., Dlaminu, N., et al. (2020) Prevalence of Bacteriologically Confirmed Pulmonary Tuberculosis in South Africa, 2017-19: a Multistage, Cluster-based, Cross-sectional Survey. *Lancet Infect Dis*, 22:1172-80

National HIV Surveillance Report (2024): Nigeria National HIV Surveillance Report January 2024

National Population Commission (2009). *2006 Population and Housing Census of the Federal Republic of Nigeria, Priority Tables*, volume II. Abuja, Nigeria

Natarajan, A., Beena, P. M., Devnikar, A. V., & Mali, S. (2020). A systemic review on tuberculosis. *Indian Journal of Tuberculosis*, *67*(3), 295-311.

Ogbudebe, C.L., Chukwu, J.N., Nwafor, C.C., Meka, A.O., Ekeke, N., Mdichie, N.O., Anyim, M.C., Oasakwe, C., Onyeonoro, U., Ukwaja, K.N., Oshi, D.C. (2015) Reaching the Underserved: Active Tuberculosis Case Finding in Urban Slums in Southeastern Nigeria. *International Journal of Mycobacteriology*, 4: 18-24

Ojiezeh, T.T., Ogundipe, O.O., Adefosoye, V.A. (2015) A Retrospective Study on incidence of Pulmonary Tuberculosis and Human Immunodefiency virus coinfection among Patients attending National Tuberculosis and Leprosy Control Programme, Owe Centre. *Pan African Medical Journal*, 20: 345

Okhovat-Isfahani, B., Bitaraf, S., Mansournia, M. A., & Doosti-Irani, A. (2019). Inequality in the global incidence and prevalence of tuberculosis (TB) and TB/HIV according to the human development index. *Medical journal of the Islamic Republic of Iran*, *33*, 45.

Olofin, E.A. (2008) The physical setting. In Olofin, E.A., Nabegu, A.B. and Dambazau, A.M. (eds). *Wudil within Kano region: a geographical synthesis.* A publication of the department of Geography, Kano University of Science and Technology Wudil. Revised Edition. Adamu Joji Publishers Kano City. Pp 5-42

Omote, V., Ukwamedua, H., Etaghene, J., Oseji, M.E., Agwai, I.C. (2018) Pulmonary Tuberculosis (PTB) among suspected cases in Delta State, South-South Nigeria. *Journal of Lung, Pulmonary and Respiratory Research*, 5(5):1145-149

Sarker, M., Homayra, F., Rawal, L.B., Kabir, R., Afrab, A., Bari, R., et al, (2019). Urban-rural and Sex Differential in Tuberculosis Mortality in Bangladesh: Result from a Populatio-based Survey. *Tropical Med Int Health*, 24(1): 109-15

Sharma, S. K., Mohan, A., & Sharma, A. (2016). Miliary tuberculosis: A new look at an old foe. *Journal of Clinical Tuberculosis and other mycobacterial diseases*, *3*, 13-27.

Shaweno, D., Shaweno, T., Trauer. J.M., Denholm, J.T., McBryde, E.S (2017). Heterogeneity of distribution of tuberculosis in Sheka Zone,Ethiopia: Drivers and Temporal Trends. *Int J. Tuberc Lung Dis*, 21 (1):78–85

Sikalengo, G., Hella, J., Mhimbira, F., Rutaihwa, L.K., Bani, F., Ndege, R. et al. (2018). Distinct Clinical Characteristics and Helminth Co-infection in Adult Tuberculosis Patients from Urban compared to Rural Tanzania. *Infect Dis Poverty*, 7(1): 24

Tabatabaee, H., Zadeh, J.H., Nia, F.Y., Akbarpoor, M.A., Javanmard, S., Honarvar, B. (2015) Spatio-Temporal Pattern of Tuberculosis in the Regions Supervised by Shiraz University of Medical Sciences 2006-2012. *Iran Journal of Public Health*, 44(9): 1253- 1261

Tadesse, S., Enqueselassie, F., Hagos, S (2018). Spatial and space-time clustering of tuberculosis in Gurage Zone, Southern Ethiopia. *PLoS One*, 13(6):e0198353.

Tefera Firdie, Dejene Tariku, Tewelde Tsegaye (2016). Treatment outcomes of tuberculosis patients at Debre Berhan Hospital, Amhara Region, Northern Ethiopia. *Ethiop J Health Sci*, 26(1):65–72.

Trauer, J. M., Dodd, P. J., Gomes, M. G. M., Gomez, G. B., Houben, R. M., McBryde, E. S., ... & Dowdy, D. W. (2019). The importance of heterogeneity to the epidemiology of tuberculosis. *Clinical infectious diseases*, *69*(1), 159-166.

Ugwu, K.O., Agbo, M.C., and Ezeonu, I.M (2021). Prevalence of Tuberculosis, Drug-resistant Tuberculosis and HIV/TB Co-infection in Enugu, Nigeria. *Afr. J. Infect Dis*, 15(2): 24-30

United States Embassy in Nigeria (2012). Nigeria Tuberculosis Fact Sheet. Available at http://nigeria.usembassy.gov

Wang, L., Xu, C., Hu, M., Qiao, J., Chen, W., Qian, S. et al. (2021). Spatio-temporal Variation in Tuberculosis Incidence and Risk Factors for the Disease in a Region of Unbalanced Socio-economic Development. *BMC Public Health*, 21:1817

World Health Organization (2018). *Global Tuberculosis Report*. Geneva: World Health Organization; 2018. Licence: CC BY-NC-SA 3.0 IGO

World Health Organization (WHO). *Global Tuberculosis Report 2021*. Accessed on 5/9/2022.

Xia, L., Zhu, S., Chen, C., Rao, Z., Xia, Y., Wang, D. et al. (2020). Spatio-temporal Analysis of Socio-economic Characteristics for Pulmonary Tuberculosis in Sichuan Province of China, 2006-2015. *BMC, Infectious Diseases*, 20:433