Spatial Distribution of Tuberculosis Cases and Access to Health Care in Ghana

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Abstract

The study analysed spatial distribution of tuberculosis cases and access to health care among tuberculosis patients in West Akim Municipality, Ghana.

The study employed descriptive cross-sectional design and spatial analysis technique. All 66 tuberculosis patients identified during the study period were included.

The results revealed that 15% of the study respondents were HIV positive, 6% HIV status was known and the remaining HIV negative. About 68.2% of the respondents had pulmonary positive cases, 30.3% were pulmonary negative, and the remaining (1.5%) was extra pulmonary tuberculosis. Spatially, Asamankese Central, Anum, and Asikafoamatam communities with high populations had a high density of tuberculosis patients. The results showed evidence of clustering of tuberculosis cases in the municipality (p = <0.001). The respondents' average distance to the nearest health facility was 1.2 kilometers.

The presence of tuberculosis clustering in the municipality requires appropriate educational intervention by the policymakers to create awareness, and education.

Keywords: Clustering; cases; disease; prevalence; tuberculosis

1. Introduction

The top 5 infectious diseases with the highest mortality rates worldwide continue to include tuberculosis (Foster, 2020). It is reported that one person in the world contracts tuberculosis every second, and dies in every 20 seconds. It is further revealed that an estimated 1.7 to 1.8 billion people, approximating a quarter of the world population, are infected with *Mycobacterium tuberculosis*, putting them at a higher risk of acquiring active tuberculosis (TB Alliance, 2021; CDC, 2021). Reports also reveal that around 1.6 million, and 10.6 million individuals die of and fall ill with tuberculosis (TB) respectively, with the highest cases found in people living with the Human Immunodeficiency Virus (HIV) and the highest geographical prevalence in South-East Asia (45%) and Africa (23%) (WHO, 2022).

The World Health Organization (WHO) has iterated that if the disease is not discovered and treated promptly, a single infected individual with active TB may transfer the disease to 10–15 people per year, resulting in a continuous infection cycle. This level or degree of transmission from persons to persons can even be greater in areas of high population density, as those areas are characterised by high frequency of personal contact, poor ventilation, overcrowding, and air pollution. Several studies conducted across the globe, for instance, have confirmed this ability of the disease to transmit rapidly in highly populated dense areas (Kolifarhood et al., 2015; Zaragoza-Bastida et al., 2012; Abdul, Ankamah, Iddrisu, & Danso, 2020; De Abreu E Silva et al., 2016).

Ghana shares the same fate as other developing countries with regards to TB prevalence. The second national TB prevalence survey in 2013 indicated a national TB prevalence of 290 per 100,000, which was four times higher than the WHO's same-year estimate. The current TB prevalence in the country is still found to be high (Addo et al., 2018). In Ghana's Eastern region alone, 1,586 cases of tuberculosis were recorded in 2017, 1,675 in 2018, and 1,647 in 2019 (Regional Health Directorate, 2019). This figure clearly shows that tuberculosis continues to be a burden, particularly in the Eastern Region**.** Other studies in some parts of the country have also indicated that there is poor access to healthcare. For instance, people have to travel more than 5km before getting to a nearby healthcare facility (Boateng et al., 2010; Asaah & Ussiph, 2017). Yet, there is no study on the accessibility and utilisation of healthcare services required to ensure effective case management, which is an essential part of the prevention and control of TB as well as the geospatial distribution of the disease in the region.

In filling this gap, this study was carried out using the geographic information system (GIS) to determine the geospatial distribution of TB cases and access to healthcare in the region, using Akim Oda municipality as the focal point. The study used GIS to identify populations at risk and high-risk locations for tuberculosis so that tuberculosis prevention and control initiatives can be directed to these crucial areas, as well as provide relevant data to inform policies. The primary objective of the study is thus, to determine the spatial distribution of tuberculosis cases and access to healthcare among TB patients in West Akim Municipality in the Eastern Region Ghana.

2. Profile of the study area

West Akim Municipal (see **Fig. 1**) is one of the thirty-three (33) districts in the Eastern Region of Ghana, located in the southern part of the region. It lies between longitude 5.899910 decimal degrees to the north and longitude -0.682352 decimal degrees to the west. The municipality shares common boundaries with some other districts: in the north is Denkyembour District, in the south is Upper West Akim District, in the east is Ayensuonnor District, and to the west is Asene Manso Akroso District. Asamankese, the municipal capital, is located 75 kilometres north-west of Accra, the capital of Ghana, on a land mass of 475 square kilometers. The population of the Municipality in 2021 is 139,358 with an annual growth rate of 2.1% per annum. Out of this, 51% are female, with 49% being male. The population density is 160 persons per square kilometer.

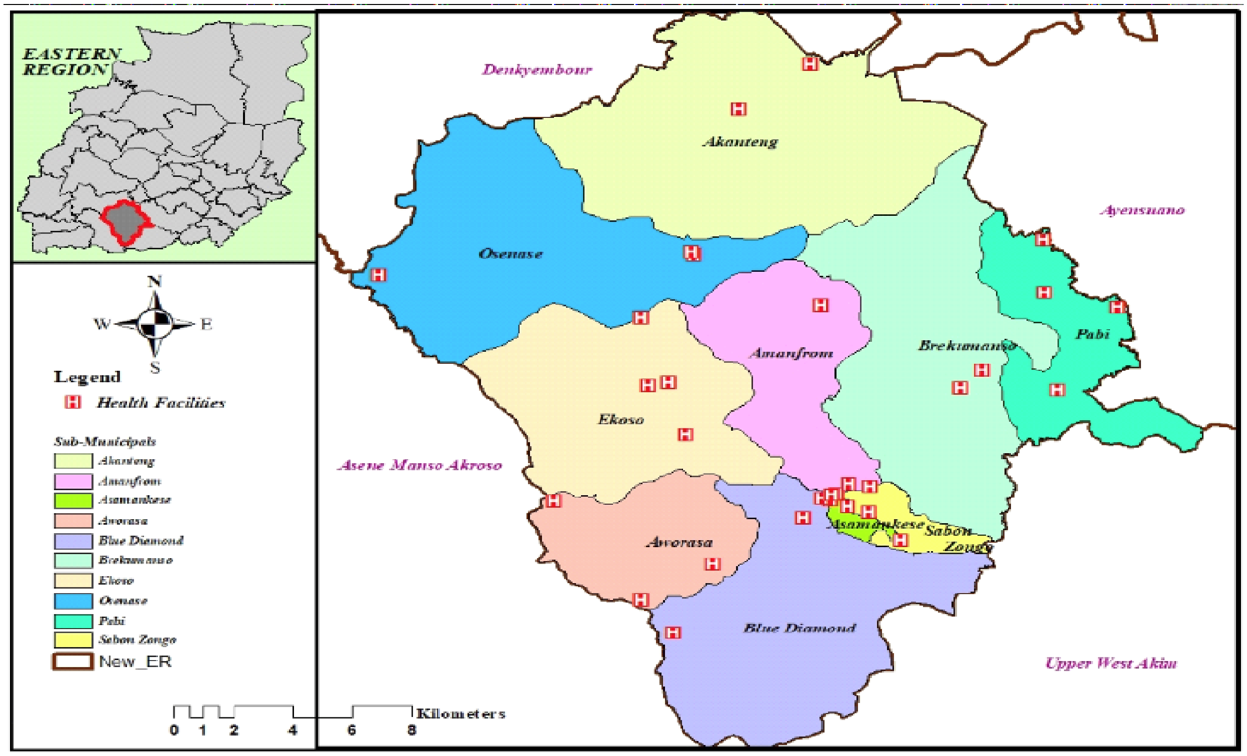

Figure 1: **A map showing the geographical space of the study setting**

3.0 Materials and Methods

3.1 Study design, Population and Sampling Technique

The distribution of tuberculosis and access to healthcare among TB patients in the Akim Oda Municipality in the Eastern Region of Ghana was analysed using a descriptive cross-sectional design and a spatial analysis technique in conjunction with GIS. The technique is renowned for its capacity to offer substantial clues into the biological mechanisms and patterns that underpin the spread of disease (Pfeiffer et al., 2008) in this context TB.

The study population comprised all TB patients who were at least 18 years old, whose details were captured in the TB registers at the various health facilities in the municipality, and who were put on treatment from January 2021 to December 2021. The TB patients as described above were traced to their places of residence (homes), and their coordinates were taken as well as their distance in kilometres to the nearest health facility by health workers trained as research assistants for the study. The tracing process required minimal effort due to the verification policy, which requires that the homes of TB patients be visited before treatment is initiated. Other relevant information about the patients was obtained from TB registers at the sub-districts and the municipal health directorate. A total of 66 TB patients who were registered and put on medication within the study period were all included in the study, so there was no need for sample size determination.

3.2 Data Collection Tool and Technique

A special instrument (form) was designed to collect data from TB patients for the study. The data collection instrument was developed in consultation with the district disease control officers. The instrument included items relating to patients' background characteristics, HIV status, and distance to the nearest health facility, as well as the coordinates (points) of the places of residence of patients and health facilities using a global positioning system device (GPS) (see **Appendix 1**). Data collection from the TB patients by research assistants was restricted to areas such as the coordinates (points) of the place of residence, health facilities, and distance in kilometres to the nearest health facility. Other aspects of participant data relevant to the study were obtained from the health facilities and the health directorate.

3.3 Data Analysis

The pre-coded data were entered into Excel, cleaned, and later exported to STATA version 16 software for statistical analysis. A frequency distribution was used to compute the proportions for age, education level, sex, religion, marital status, occupation, and distance to health facilities. The mean age and mean distance in kilometres to health facilities, as well as their respective standard deviations, were also computed. The coordinates (points) for the place of residence and the health facilities were organised in Excel and later migrated to Geographic Information System (GIS) version 10.7.1 software for spatial analysis. A density analysis was performed to determine the density of tuberculosis in the municipality. Clustering analysis was also conducted using the average nearest neighbour to determine whether there were clusters of tuberculosis cases in specific areas within the municipality. A buffer analysis was performed to determine the distance TB patients have to travel to access health care within the municipality.

3.4 Ethical Consideration

Approval for the study was sought at three levels. First, the Ghana Health Service Ethics Review Committee was approached for ethical approval and was granted (GHS-ERC: 051/12/21). It was then followed by permission from the municipality in which the study was conducted and, finally, approval from the sub-districts and health facilities utilized. Various Covid 19 protocols were also strictly adhered to. As part of the ethical clearance process, all participants were asked to provide written consent prior to their participation in the study after being fully informed about all aspects of the study, including the voluntary nature of the study.

4. Results

4.1 Demographic Characteristics

Table 1 details the demographic characteristics of the study participants. The table depicts that the majority of the respondents (29) were aged 45 or older, representing 43.9% of the total respondents' TB cases, compared to age groups below 20 years and between 26-30 years, which both recorded 4.5 the least. Most of the respondents 40 (60.6%) were males whiles 26 (39.4%) were females. Also, majority of the respondents were 22 (33.3%) were middle/JHS leavers. Christians were predominant in terms of religion, accounting for 52 (78.8%) of the respondents. Again, 38 (57.6%) of the respondents were married, with the least being a widow (1.5%). It is observed that the majority of the respondents 55 (83.3%) were self-employed, with the least 2 (3.0%) being public sector workers.

Table 1: Socio-demographic characteristics of participants (N=66)

VARIABLE	FREQUENCY	PERCENTAGE
Age in years (M±SD)	**44.7±15.4**	
Age in Groups		
≤ 20	3	4.5
21-25	4	6.1
26-30	3	4.5
31-35	7	10.6
36-40	12	18.2
41-45	8	12.1
45+	29	43.9
Sex		
Male	40	60.6
Female	26	39.4
Educational level		
No formal education	7	10.6
Primary	15	22.7
Middle/JHS	22	33.3
SHS	16	24.2
Tertiary	6	9.1
Religion		
Christians	52	78.8
Muslims	6	9.1
Traditionalists	8	12.1

Marital status		
Married	38	57.6
Single	15	22.7
Divorced	1	1.5
Widow	1	1.5
Co-habitat	11	16.7
Occupation		
Public sector	2	3.0
Self employed	55	83.3
Student/apprentice	4	6.1
Unemployed	5	7.6

4.2 HIV Status of Participants

The HIV status of the participants was analyzed. As can be observed in **Figure 2,** 52 of the respondents representing 78.8% were HIV negative, whereas 10 respondents representing 15.2% were HIV positive, and 4 respondents representing 6.1 percent had not had an HIV test done and hence their HIV status was not known.

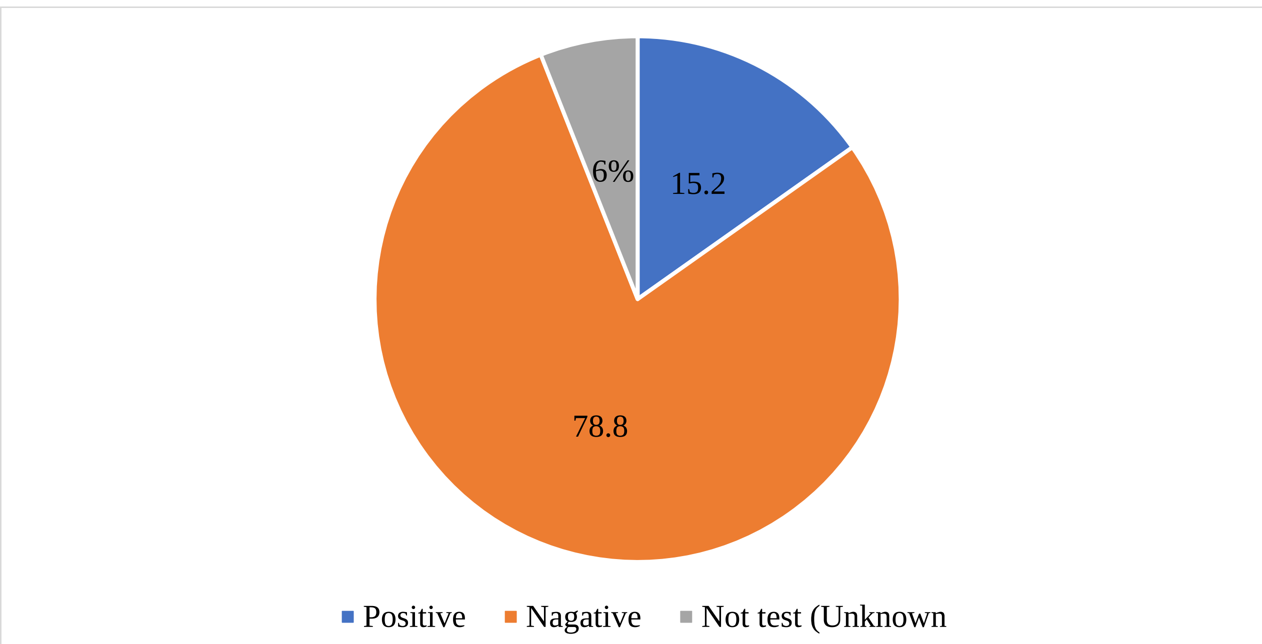

Figure 1: HIV status among the study participants

4.3 Distribution of Tuberculosis Cases

Since one of the objectives of this study was to look at the distribution of TB cases in the study environment, the distribution of TB cases among the study respondents was also examined. The results (see Figure 3) showed that out of the 66 tuberculosis cases recorded during the study period, 45 cases (68.2%) were pulmonary positive cases, 20 cases (30.3%) were pulmonary negative cases, and the remaining one case (1.5%) was extra pulmonary tuberculosis, which is tuberculosis found outside the lungs.

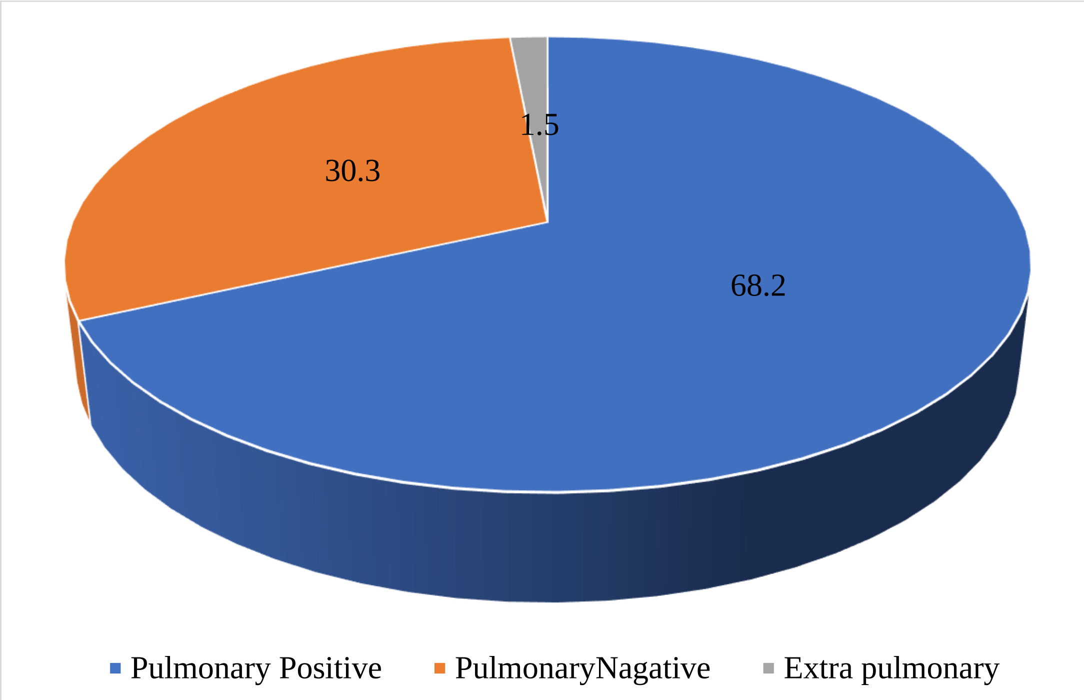

Figure 2: Distribution of tuberculosis cases

4.4 Spatial Distribution of TB Cases

We further carried out spatial analysis for tuberculosis cases to determine the spatial distribution of the disease in the district, which was separated into sub-districts to make the disease distribution easier to describe, as shown in figure 4. TB cases in the municipality were not distributed randomly, and some communities in the municipality were observed to have recorded more cases than others. The municipality's TB case detection rate ranged from 4 to 21 cases per 100,000 people at risk based on the 2020 population. Between January 2022 and December 2022, 66 cases of tuberculosis were reported, with 55 cases accounting for 82.3% of the total cases being positive. In comparison to the target for 2020, the case detection rate for tuberculosis in Asamankese, Brekumanso, and Sabon Zongo sub-municipals was 97.6 percent, 88.0 percent, and 63.2 percent, respectively. As a result, these sub-districts might be classified as high-risk zones or locations where tuberculosis patients predominate in the district.

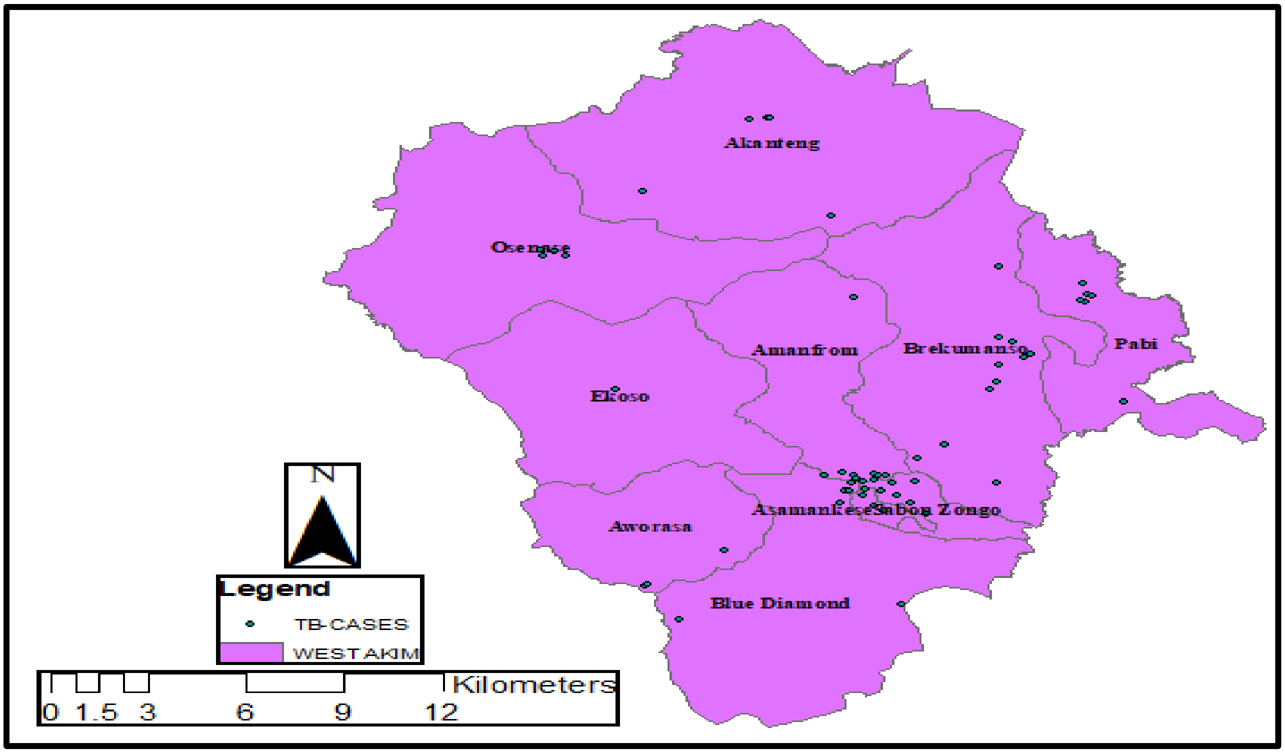

Figure 4: Spatial distribution of TB cases

4.5 Density of Tuberculosis cases

The density of tuberculosis cases registered in the district is depicted in figure 5. The density surface revealed that the Asamankese Central, Anum, and Asikafoamatam communities had a high density of tuberculosis patients. The findings also reveal that tuberculosis cases are uncommon in other communities. In general, communities on the outskirts of town with low population density had fewer tuberculosis cases as compared with communities with high population density. As can be observed, Asanamankese Central, which is part of the Asamankese sub-municipal, has the highest density of tuberculosis cases in the municipality, with a very high density.

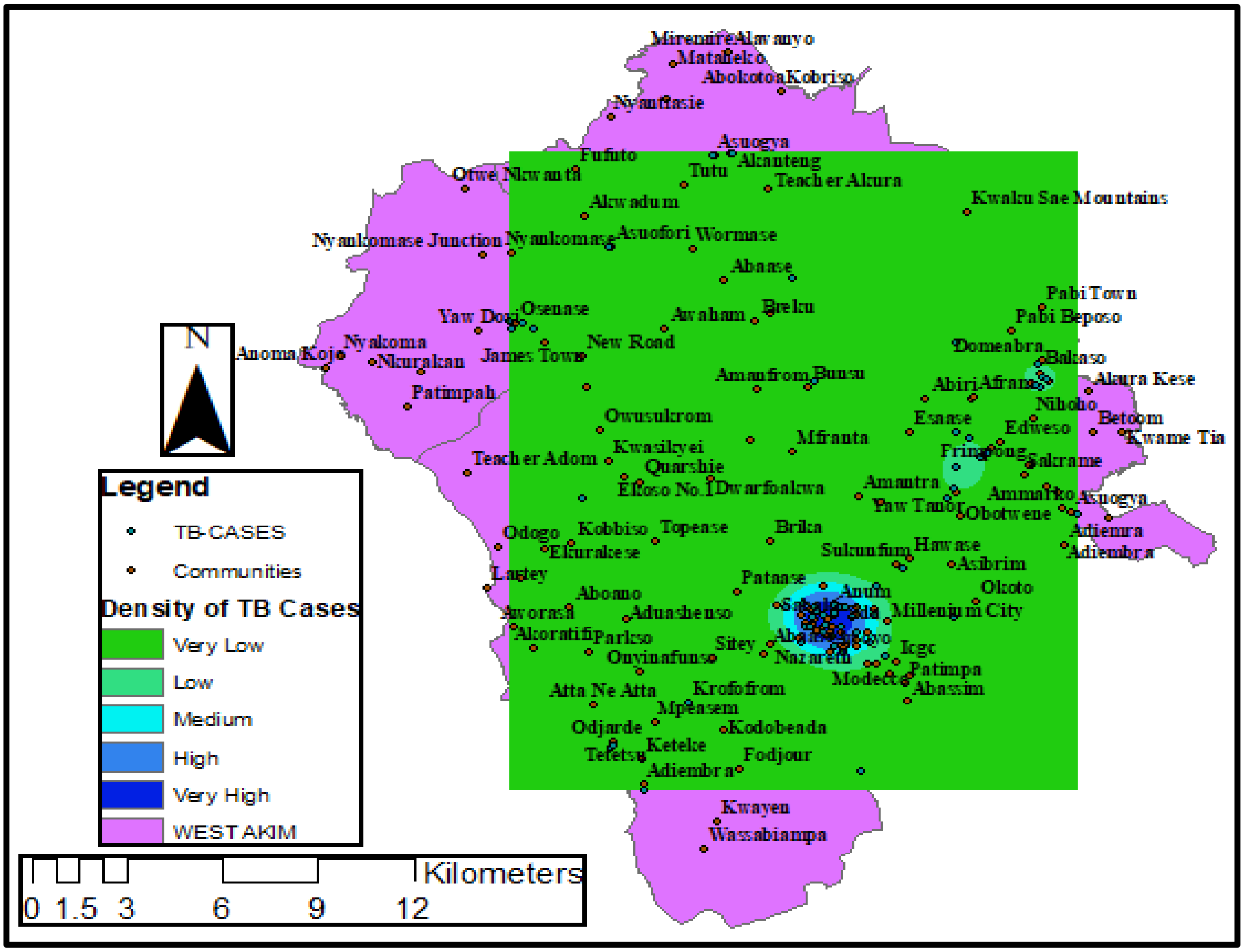

Figure 3: Density of Tuberculosis cases

4.6 Clustering of tuberculosis cases

To determine tuberculosis case clustering in the municipality, the average nearest neighbour analysis in metres was employed. Figure 6 indicates that tuberculosis cases in the municipality appear to be clustered or concentrated in some specific places. With an observed mean distance of 735.431675, an expected mean distance of 1161.436949, a z-score of -5.700621, and a p-value of <0.000001, there is enough evidence of clustering of tuberculosis cases in the municipality, and it is statistically significant because the p-value is < 0.05. Additionally, given the z-score of -5.700621, there is less than 1.0% likelihood that this clustered pattern could be the result of random chance. This suggests that tuberculosis cases in the municipality were not randomly or uniformly distributed, and that specific area, especially the Asamankese community, which is associated with high population density, recorded a high concentration of tuberculosis cases and can therefore be classified as a high-risk area in the municipality.

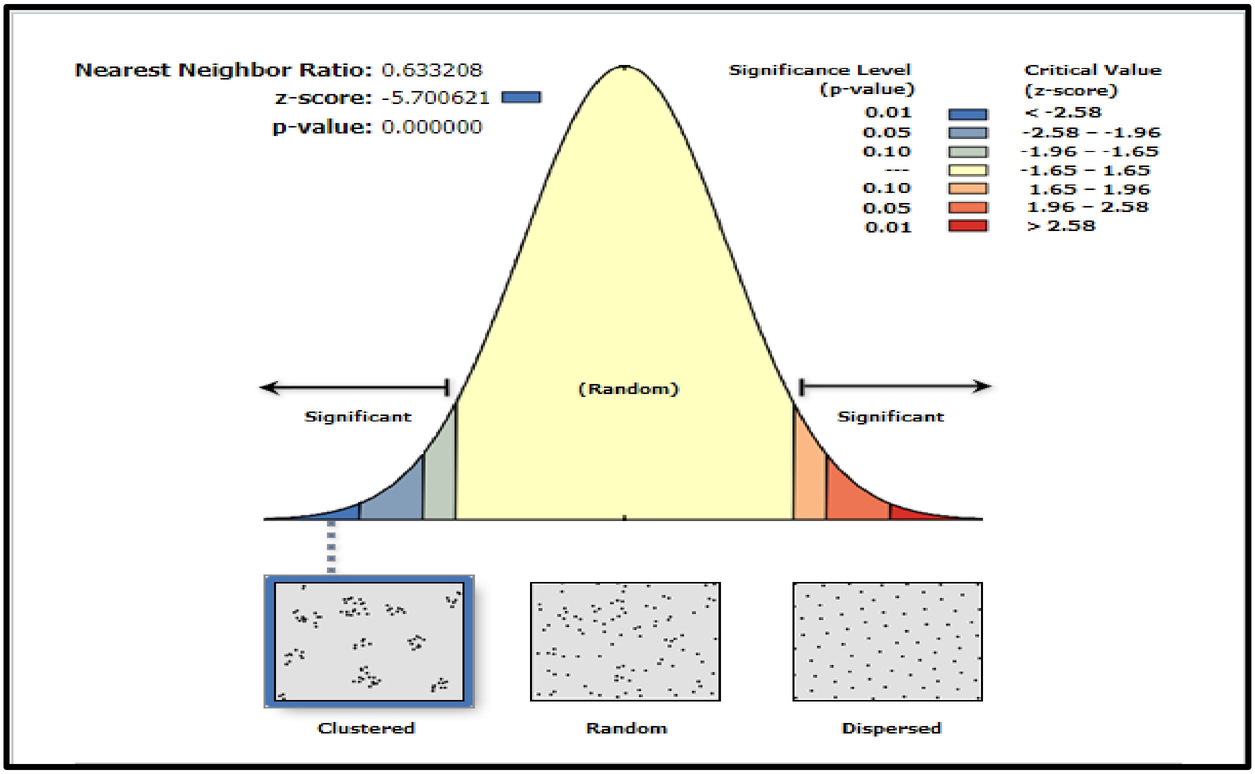

Figure 6: Clustering of tuberculosis cases

4.7 Geographical access to healthcare

Figure 7 depicts the number of health care facilities in the municipality where tuberculosis patients can receive treatment. The figure also displays the distribution of tuberculosis cases among municipal health facilities that provide tuberculosis care or treatment. The figure further illustrates that no tuberculosis cases were recorded outside of a Euclidean distance of 5 kilometres, with all 66 cases, representing 100.0% of the TB cases registered for this study, being located within a 5 kilometre radius of health facility coverage. A further analysis reveals that 59 cases (88.1%) were recoded inside a 3 km Euclidean radius, with only 8 cases (11.9%) recorded outside of this radius.

A more close analysis shows that a total of 56 cases representing 83.6 percent were recorded within a Euclidean distance of 2 kilometers, while 11 cases representing 16.4 percent were recorded outside of this radius. The study found that the average distance for the respondents to the nearest health facility was 1.2 kilometres with a standard deviation (0.93 km), implying that the participants' places of residence were not far from health facilities in the municipality. As a result, it may be inferred that geographic accessibility, specifically proximity to healthcare facilities where healthcare is provided, is acceptable. This is in line with the CHPS concept, which stipulates that the distance from communities to healthcare facilities should not exceed 5 kilometers.

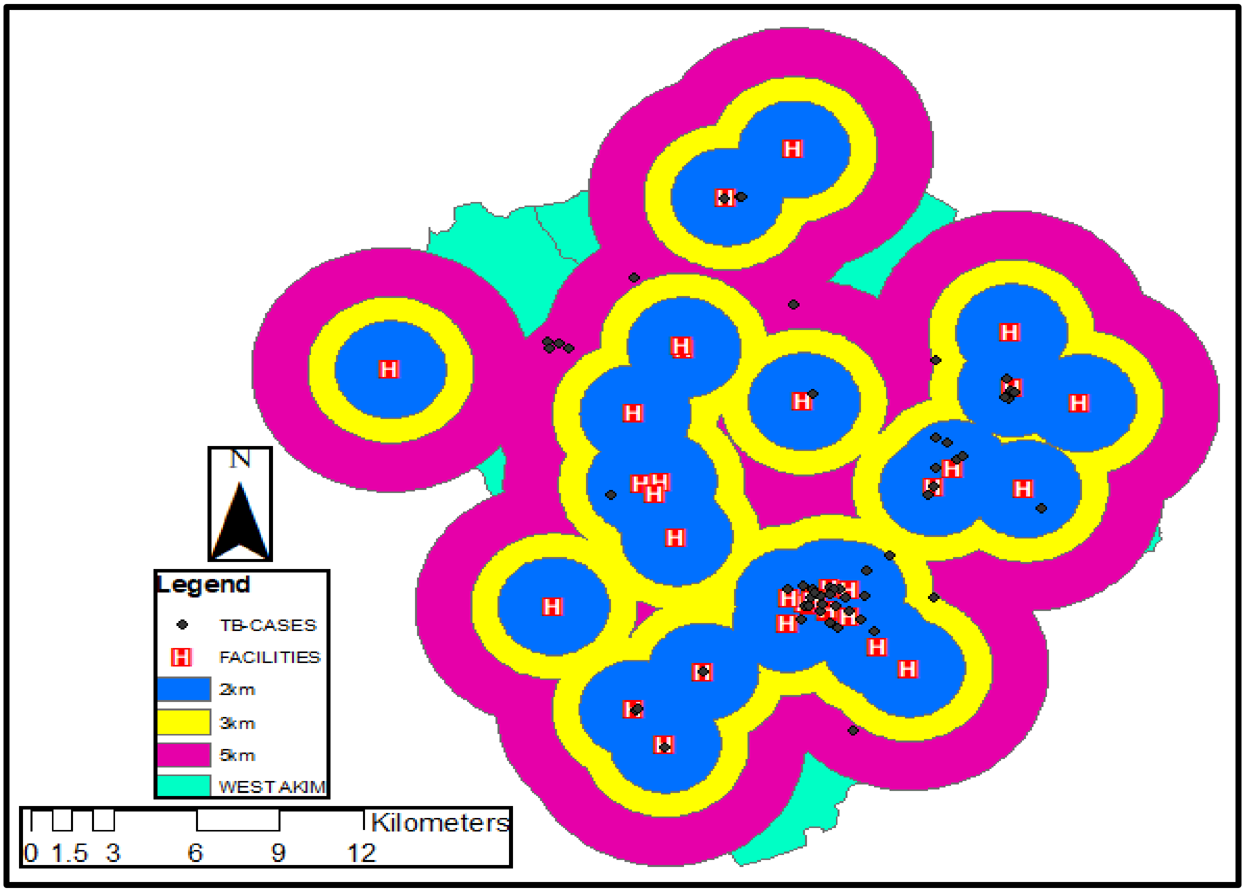

Figure 4: Geographical access to healthcare

5. Discussion

HIV and tuberculosis have long been referred to as twins because there appears to be a strong link between the two. The link between HIV and TB is well understood by the scientific community given HIV infection's tendency to weaken and impair an infected person's immune system, allowing TB, an opportunistic infection, to take advantage, thrive, and multiply and cause sickness (Pawlowski et al., 2012). It has therefore been observed that geographical areas with high HIV prevalence also have high TB cases (Narasimhan et al., 2013; Couceiro et al., 2011; Bell et al., 2016). In this study, however, such a strong link is not strongly observed. Supposedly, even when the 6% of the respondents whose HIV status is not known are claimed to be positive, there would be approximately 21% of the study respondents who are HIV positive, suggesting that the district may be unusual and that the general assumption that HIV and TB are twins may not apply strongly in the district. The sample size, which is not very large, may contribute to this aspect of the study's findings. The other possible explanation is that in Ghana, due to stigma, it is common for HIV patients to travel far outside their respective regions for treatment in order not to expose their HIV status in the community or district in which they find themselves, and so the actual cases of TB in a district may exceed the number of patients under treatment in the district, meaning that many patients with the two conditions may have been seeking care outside the district.

With regard to the distribution of the disease in the district, the spatial analysis revealed that tuberculosis cases in the various communities within the municipality were not randomly distributed, as some communities, such as Asamankese, which is associated with high population density, recorded more tuberculosis cases as compared to other communities, especially communities at the peripheries with low population density. This observation from the study is consistent with other similar studies (Kolifarhood et al., 2015; Zaragoza Bastida et al., 2012; Abdul, Ankamah, Iddrisu, & Danso, 2020; De Abreu E Silva et al., 2016). This consistency in research findings is not surprising given the nature of the disease (airborne) and its ability to spread easily when there is greater engagement or contact among groups of people. Overcrowding, poor ventilation, and air pollution, which are mostly associated with densely populated areas or communities, are therefore possible explanatory factors.

Access to healthcare is crucial in combating diseases. Though there is a general limitation in accessing healthcare in Ghana, the study found that the average distance for the respondents to the nearest health facility was 1.2 kilometres with a standard deviation of 0.93 kilometres, implying that the participants' places of residence were not far from health facilities in the municipality. As a result, it may be inferred that geographic accessibility, specifically proximity to a healthcare facility, which is the distance between the respondents' place of residence and the nearest facilities, is quite acceptable. The country's commitment to primary healthcare strategy through the Community-Based Health Planning and Services (CHPS), which stipulates that the distance from communities to healthcare facilities should not exceed 5 kilometers, seems to be bridging the accessibility gap in the country since studies in the previous years in some parts of the country have indicated the otherwise (Boateng et al., 2010; Asaah & Ussiph, 2017). Whether comprehensive TB services are available in all healthcare facilities in the municipality and that appropriate care is being rendered to TB patients is an issue that is strictly beyond the scope of the study.

5.1 Conclusion

The study has described the distribution of TB in the Akim Oda Municipality revealing most of the TB cases to be in high populated communities in the municipality. The presence of tuberculosis clustering in the municipality requires appropriate educational intervention by the policymakers to create awareness, and educate the general public about the disease. There is also the need for the government to commit more resources to enhance more testing to identify the disease among the populace before it escalates to all parts of the country.

5.2 Limitations and Future Research

The study design has some limitations because it is contingent on the number of patients who were started on TB therapy throughout the study period, which ran from January 2022 to December

2022. Patients who had been on tuberculosis treatment in the previous years were excluded from the study. As a result, the current situation may differ from what occurred in prior years. Moreover, the study was restricted to only one municipality, imposing a greater limitation on generalising the findings of the study to the entire country.

This study used a geographic information system to describe the spatial distribution of tuberculosis cases in the West Akim municipality. A geographic information system can perform geographical analysis and provide a level of understanding that few other information systems can, making it one of the most effective applications for displaying health issues. Even so, this application is not mostly utilised by modern researchers. We recommend future public health researchers deploy this modern tool in studies with similar characteristics. Given the limitations of cross-sectional studies, we also recommend large-scale longitudinal studies, which will also consider the health-seeking behaviour and medication compliance of the TB patients.

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