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Space Based Application for the Inventory, Distribution and Analysis of Healthcare Facilities in Nasarawa State, Nigeria

Halilu A. Shaba[1], Emmanual Omomoh[2], Sunday Nannim[2], Gujahar Rengje Rogers Danlami[2], Boyi Mairiga[2], Moses Omitunde Omirinde[2], Gyang Davou[2], Gwamzhi E. Ponsah[2]

[1]National Space Research and Development Agency (NASRDA), Airport Road, P.M.B 437, Abuja, Nigeria

[2]Zonal Advanced Space Technology Applications Laboratory (ZASTAL), P.M.B 47, Pajat, Langtang North, Plateau State, Nigeria.

ABSTRACT: The study aimed at carrying out the inventory, distribution and analysis of healthcare facilities in Nasarawa state using remote sensing and geographic information system (GIS) techniques. Field mapping was conducted and coordinates with attributes of these healthcare facilities were recorded. GIS analysis using multiple ring buffer and cluster extension of the spatial analysis tool in ArcGIS 10.8 version was used. Result revealed a total of 1,119 healthcare facilities distributed across the state. Out of which 807 are government primary healthcare, while 227 are private primary and 24 government secondary whereas 60 are private secondary and one tertiary healthcare facility. Result also revealed significant disparities in the distribution of government tertiary healthcare facilities across the local government areas with only having such facility in the whole of Nasarawa State. This indicates limited access to specialized healthcare services. The general trend of health facilities in Nasarawa state is towards clustering because these facilities are intended to reside close to settlements and thus will present some degree of clustering though the level may differ between different types of facilities. The buffer analysis in secondary healthcare showed a wide number of settlements by local government that need more present of secondary healthcare facility in Nasarawa state showing good accessibility of health care facility to the settlement within 1 km and 10 km radius. The government own primary healthcare facilities record a z-score of -17.52725 and 0.677488 nearest neighbour ratio suggesting a very strong trend towards clustering, and from the analysis, there is a less than 1% chance of randomness or dispersion. This indicates that there is a lot needs to be done to ensure a more dispersed and competitive distribution of these facilities. The private primary healthcare facilities have a z-score of -18.527370 and nearest neighbour ratio of 0.357209, which shows very significant clustering alongside an identical 1% probability of random distribution. This clearly indicates that there is need for strategic planning and resource allocation to the health sector to ensure an equitable, dispersed and competitive distribution of these facilities. The findings from this study have implications for the actualization of the United Nations' health-related Sustainable Development Goal (SDG-3) and also to achieve the Universal health coverage.

KEYWORDS: Healthcare, Cluster, Geographic, Information, Buffer, Nearest neighbour

1.0 INTRODUCTION

Healthcare facilities form integral component of healthcare system. It is centers where preventive and curative services are provided and allow referral from simple to complex service provision (Doyani et al 2020). The World Health Organization defined health as a state of complete physical, social, mental and emotional well-being of an individual and not merely the absence of disease and infirmity. According to "health is a state of complete physical, social and mental wellbeing and not just the absence of disease and infirmity" (WHO, 2022). Ogoh (2010) asserted that this definition is recognition of the material basis of health and ill-health because a complete state physical and mental wellbeing goes beyond medicaments. He further argued that health is fundamentally rooted in the structures of power, privileges and what people have access to as well as what they need but do without. In Nigeria, the government has made efforts to implement UHC (Universal Health Coverage), but progress has been slow due to a number of challenges, including inadequate funding, poor infrastructure, and a shortage of health workers.

An important aspect of Nigerian health policy that requires timely evaluation is accessibility to Primary Health Care (PHC) facilities, especially in rural areas. Thus, their locations and spatial structures influence accessibility and utilization, but neither is distributed evenly in space (Wang, 2006). A healthcare facility is defined as a unit owned by public and private authorities as well as voluntary organizations and which provides healthcare services.

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Accessibility to healthcare is a multidimensional concept and can be seen as the ability of a population to access healthcare services. It varies across space because neither health professionals nor residents are uniformly distributed (Lou and Wang 2003). The primary health care system, which is designed as the first contact for individuals within the community, is based on practical, scientifically proven and socially acceptable methods and techniques, and is available to everyone (Wallerstein & Duran, 2010).

There are three main levels of healthcare system in Nigeria, the structure or levels of healthcare systems in Nigeria follow the structure of the government. The federal government handles the tertiary healthcare, while the state handles the secondary healthcare, and the local government takes charge of the primary healthcare.

The Primary healthcare operates at the community level and is the first point of contact for patient. Most of the healthcare providers in the primary healthcare centers are nurses and community health workers. The National Primary Health Care Development Agency (NPHCDA) is expected to streamline the referral system of patients from the PHC to the secondary or tertiary healthcare. The secondary healthcare is an intermediate structure of our healthcare. The states government through their ministries of health handles the system while also providing technical support for the primary healthcare. The different secondary healthcare facilities are general hospitals, comprehensive health center, district hospital and specialist. At the secondary level, there are a good number of both public and private sector involvement in the provision of healthcare. The tertiary healthcare is at the federal level, the Federal Ministry of Health (FMOH) handles the policy making, technical support, national health management, health services delivery, among others. The federal government handles the tertiary health care in Nigeria through institutions such as teaching hospitals, federal medical centers (FMCs) and national laboratories. It also helps to coordinate the activities of the other lower healthcare tiers such as the secondary and primary healthcare.

In 2019, the government launched the Nasarawa State Health Insurance Scheme (NSHIS), which aims to provide affordable health insurance to all residents of the state. The scheme has been slow to roll out, but it has the potential to make a significant impact on access to healthcare in Nasarawa State.

After Nigeria gained independence in 1960, the federal government took over the responsibility for healthcare delivery. It established a number of new healthcare facilities, and as well as provided financial support to existing ones. As states were created, they also established their own healthcare facilities. Despite these improvements, there are still a number of challenges to healthcare delivery in Nasarawa State. One challenge is comprehensive data regarding the spatial distribution of the existence healthcare facilities. Hence, the study focuses on; mapping the spatial distribution of healthcare facilities, determined the pattern or degree clustering of healthcare facility and to generate appropriate measures in enhancing equitable distribution of healthcare facilities.

2.0 STUDY AREA

Nasarawa state is geographically located in north central Nigeria. It's bounded by Kaduna State in the north, Taraba and Plateau in the east, FCT (Abuja) in the west and Kogi and Benue to the south. The area lies between latitudes 7°45′50.867″N to 10°23′42.689″N and longitudes 6°55′56.223″E to 10°38′26.149″E (Figure1).

Nasarawa state has an estimated population of over 3 million people. The health care system in the state is a mix of public and private facilities.The public healthcare system is run by the state governments. It includes hospitals, clinics, and primary healthcare centres. In recent years, the governments of Nasarawa state have made investments in improving the health care system. They have built new hospitals and clinics, and they have also provided training for health care workers. However, a lot needs to be done to meet the healthcare needs of the population.Here are some specific examples of health care facilities in Nasarawa state.

The Nasarawa State Hospitals Management Board (NSHMB) is responsible for managing all public hospitals in Nasarawa State. The NSHMB has a network of hospitals and clinics, including general hospitals.

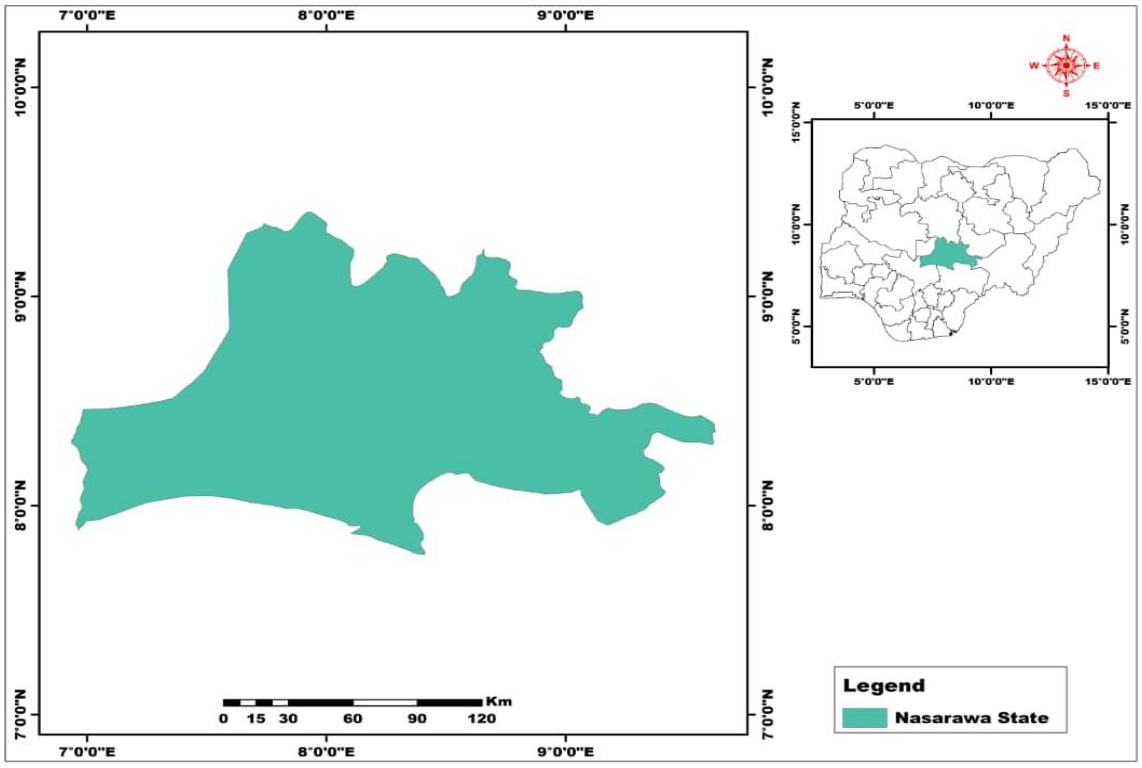

Figure 1: The Study Area (Nasarawa State)

3.0 MATERIALS AND METHOD

3.1 Materials

The materials used for this study includes; hand-held GPS, ArcGIS Desktop 10.8, Microsoft Excel, Microsoft Word.

1. Method

In carrying out this research, intensive fieldwork was undertaken during which the coordinates of various health facilities were recorded using handheld GPS. Other attribute information such as type, name, ownership of facility and (where possible) number of available healthcare personnel, key environmental features were also obtained and recorded. The results thus acquired were tabulated and segmented by local government. The type of facility (primary, secondary and tertiary healthcare facility) and, ownership (government or private owned) were tabulated in excel worksheets and prepared for further analysis. The segmented data was then imported into a Geographic Information System (ArcGIS) and displayed as spatial data to enable further analysis and interpretation. The work flow chart for the study is shown in Figure 2.

Buffer sample distances of 500 meters, 1 and 2 kilometers walking distances were adopted for the primary healthcare facilities to accommodate the assumption that the facilities are intended to be within walking distance of prospective patients and others who may want to access the facility. On the other hand, travel distances of 1, 2, 3, 4, 5 and 10 kilometers were adopted for secondary health facilities (Karra et al (2016)) with due consideration for the referral nature of such establishments being facilities that handle cases that are either too complicated for the primary healthcare facilities or are of a nature that requires specialized attention. Tertiary institutions were also enumerated and their distribution displayed.

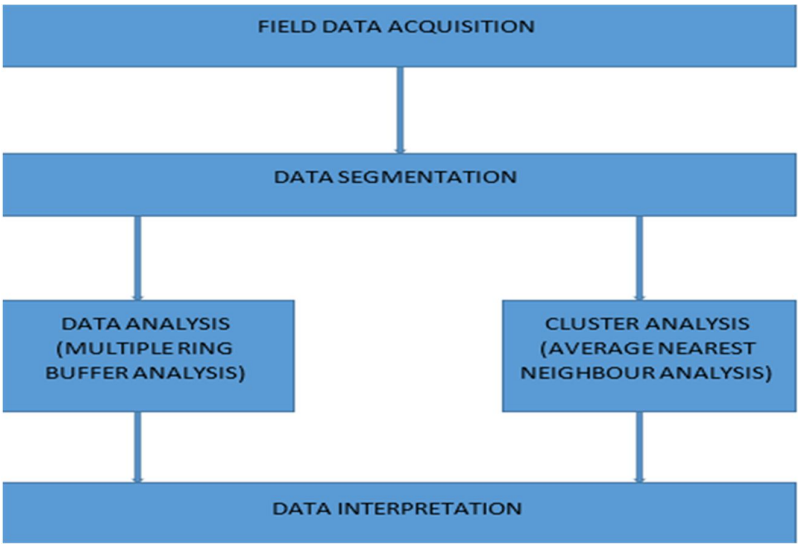

Figure 2: Workflow Chart

Special care was taken to assess the distribution of all the categories of healthcare facilities to ascertain their equitable spread (or lack thereof) and their capacity to render adequate service to the communities, which they are meant to serve. This distribution was investigated using cluster analysis (Average Nearest Neighbour) which gives a measure of randomness of the distribution of the sample data. This supplies interpretable information about the geospatial composition of the research targets and their spatial relationships.

4.0 RESULTS AND DISCUSSION

The finding in this study reveals the existence of 1, 119 healthcare facilities in the Nasarawa state. The distribution of these facilities is uneven across the state (Figure 3 and Table 1). At the primary level, numerous (807) primary healthcare Centers (PHCs) were established and spread across the state, especially in rural areas, serving as the first point of contact for healthcare needs). These PHCs offer basic medical services, preventive care, maternal and child health services, and vaccinations as well as playing a crucial role in promoting community health and early intervention.

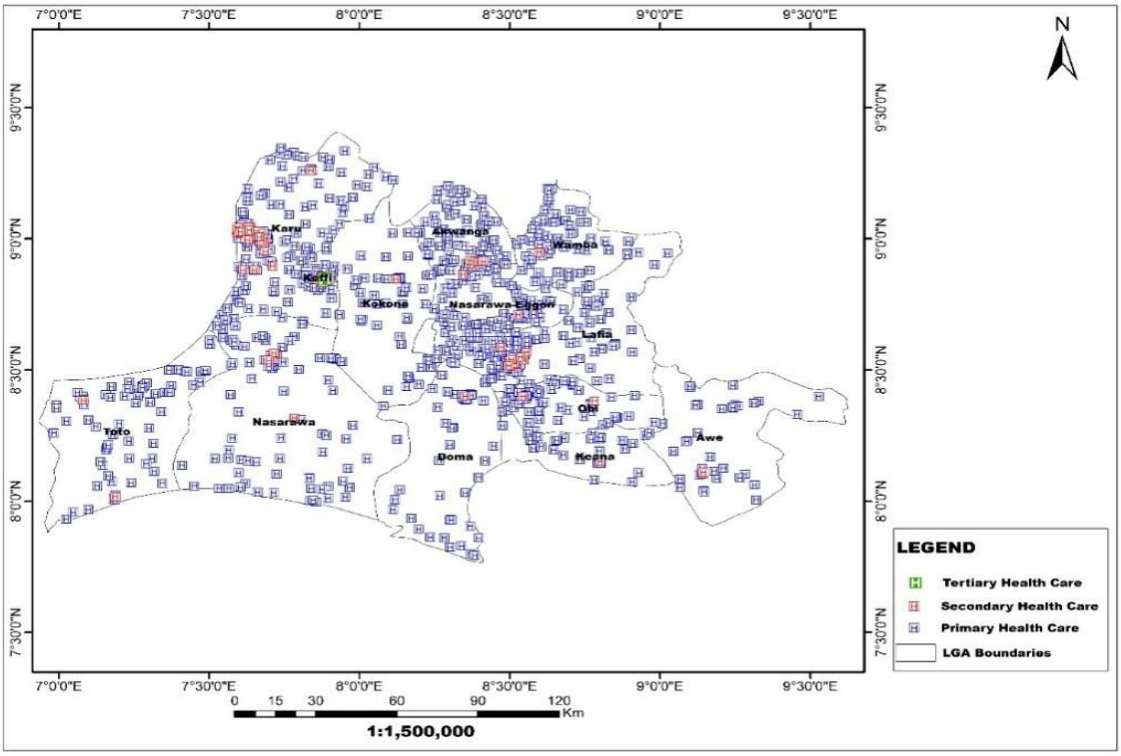

Figure 3: Spatial Distribution of Healthcare Facilities in Nasarawa State

Table 1: Number of Healthcare Facilities in Nasarawa state

S/N	LOCAL GOVERNMENT AREA	GOVERNMENT PRIMARY HEALTHCARE FACILITIES	PRIVATE PRIMARY HEALTHCARE FACILITIES	GOVERNMENT SECONDARY HEALTH CARE FACILITIES	PRIVATE SECONDARY HEALTH CARE FACILITIES	GOVERNMENT TERTIARY HEALTHCARE FACILITIES
1	AKWANGA	53	6	3		
2	AWE	33	7	2		
3	DOMA	41	12	1		
4	KARU	110	71	5	30	
5	KEANA	34	7	1		
6	KEFFI	17	22	3		1
7	KOKONA	58	8	1	7	
8	LAFIA	92	40	0	16	
9	NASARAWA	80	17	2	4	
10	NASARAWA – EGGON	100	7	1	2	
11	OBI	60	11	1	1	
12	TOTO	74	16	2		
13	WAMBA	55	3	2		
TOTAL		**807**	**227**	**24**	**60**	**1**

Nasarawa State has a network of secondary healthcare facilities, including general hospitals and comprehensive health centres. Relative to the PHC, the secondary health care provides a higher level of care, with specialized medical staff, more advanced diagnostic capabilities, and a broader range of medical services. Furthermore, they contribute significantly to addressing a wider spectrum of health issues and serve as referral points for cases that require more specialized care especially from the PHC.

At the apex of the healthcare system are the tertiary facilities, most notably the Federal Medical Centre, Keffi, which serves as the primary referral centre in the state. Tertiary hospitals are expected to be equipped with highly skilled medical professionals, and specialized departments to handle complex medical cases, advanced surgeries, and specialized treatments. These facilities play a pivotal role in providing advanced care to patients from Nasarawa State and even neighbouring regions, demonstrating the commitment of the state to delivering quality healthcare services to its population.

1. Government Primary Health Care Facilities

The presence of 807 government-owned primary health care facilities across the 13 LGAs (Figure 4) is indicative of the state's commitment to improving healthcare accessibility for its citizens, particularly in rural areas. The distribution of these facilities is a strategic move to ensure that healthcare services are easily accessible to people, regardless of their location within the state. This approach aligns with the World Health Organization's (WHO) principle of "Health for All," which emphasizes equitable access to essential healthcare services. In 1978, the Nigerian government adopted the Alma-Ata Declaration, which called for the development of primary healthcare systems as the foundation for universal health coverage. Today, Nigeria has over 30,000 primary healthcare centers, but only about 20% of these facilities are fully functional (Awa, 2019). This means that millions of Nigerians do not have access to basic healthcare services, such as immunization, maternal and child health care, and treatment for common diseases. Despite the challenges, there have been some recent positive developments in primary healthcare in Nigeria. In 2019, the Nigerian government launched the Basic Health Care Provision Fund (BHCPF), which is a one percent allocation from the Consolidated Revenue Fund for primary healthcare. The BHCPF is expected to help improve the quality and accessibility of primary healthcare services in Nigeria.

A comparative analysis of similar research conducted on geospatial distribution of tertiary hospitals across Australian cities by Bazeem et al, (2023), revealed that majority of the hospitals were located in the three most populated cities of New South Wales (NSW), Sydney, Wollongong and Newcastle, which contain a total of 32 hospitals, with 23 (72%) of the hospitals in Sydney. There were 7.8, 24.0, 53.4 and 81.0% of the population in NSW within buffer of 1.5, 3, 6 and 50 km of the hospitals, respectively.

Similarly, research carried out by Yemi et al (2020) on Urbanization, Spatial Distribution of Healthcare Facilities and Inverse Care in Ibadan, Nigeria. Result shows that within a period of 16 years, the population of Ibadan grew by 12.4% while the number of hospitals and doctors changed by -53% and 38% respectively. This scenario worsened the hospital to population ratio, from an

average of 1 hospital to 1,000 people, to 1 hospital to 2,600 people. In spite of the increase in the number of doctors over the period of study, the doctor to population ratio also increased to 85,000 people to a doctor as against 79,000 people to a doctor at the outset. Furthermore, Amoah-Nuamah et al (2023) conducted an analysis of Spatial Distribution of Health Care Facilities and its Effects on Access to Primary Healthcare in Rural Communities in Kpandai District, Ghana. The study found that the poor spatial distribution of health facilities has negative implications on access to primary health care in the district. Poor conditions of roads were a major barrier to the household's accessibility to district hospitals.

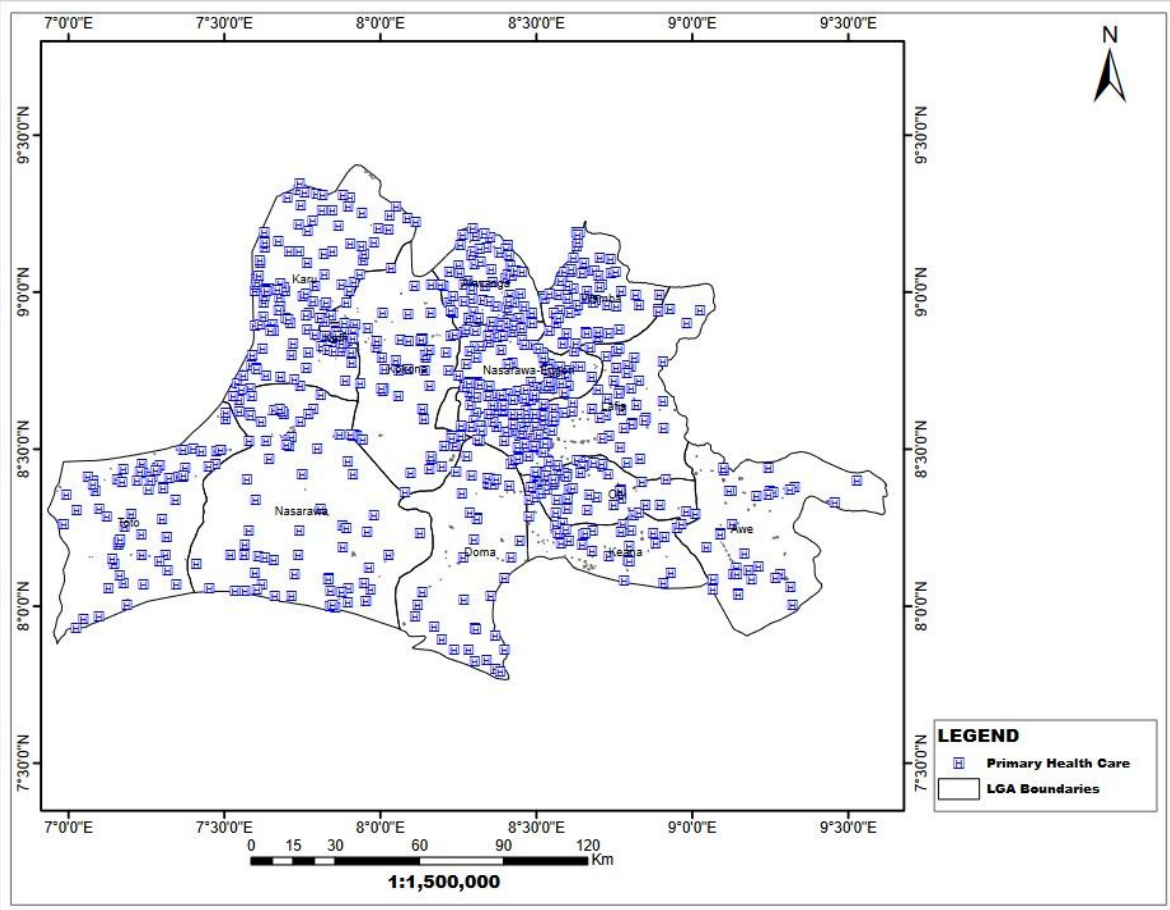

Figure 4: Spatial distribution of Government Primary Health Care Facilities in Nasarawa State

4.2 Private Primary Health Care Facilities

The distribution of private primary health care facilities in Nasarawa State is not uniform across all LGAs as shown in figure 5. The data reveals an interesting pattern regarding the distribution of private health care facilities. Out of a total of 227, Karu LGA accounts for 31.3%, showing a substantial private sector investment in healthcare in this area as detailed in table 1. While Lafia accounts for 17.6% indicating that not only is Lafia prominent in government primary facilities, but it also attracts significant private sector involvement. This prominence of private facilities in key LGAs highlights the potential role of the private sector in supplementing the public healthcare system.

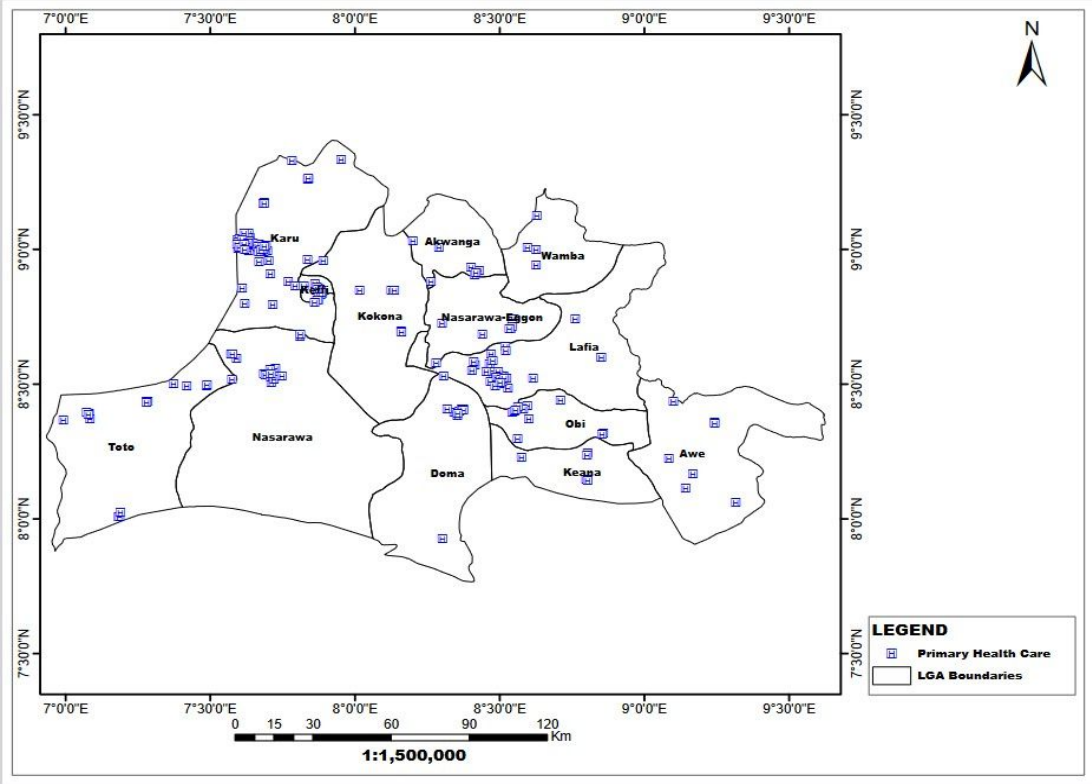

Figure 5: Spatial distribution of Private Primary Health Care Facilities in Nasarawa State

The presence of privately owned primary healthcare facilities in Nasarawa State reflects the diversification of healthcare provision beyond the public sector, offering potential benefits as well as raising important considerations. While these facilities are profit-driven, they play a role in expanding access to healthcare services, especially in areas where government-run facilities might be limited. One significant advantage is increased accessibility. Private facilities can be strategically located, helping to bridge the healthcare gap that may be experience in remote areas where public facilities may be insufficient. This can lead to improved healthcare outcomes by reducing travel distances and wait times for patients, making essential medical services more convenient and accessible.

4.3 Government Secondary Health Care Facilities

In Nasarawa State, the availability of government secondary healthcare facilities varies significantly across its local government areas (LGAs). The data in table 1 reveals that some LGAs, such as Doma, Kokona, Keana have a relatively limited number of government secondary healthcare facilities, with only 1 facility reported. This suggests that residents in such LGAs may have limited access to more advanced medical services beyond primary care within their local government area. This emphasizes the need for potential improvements in healthcare infrastructure and resource allocation in those LGAs. Figure 6 offers a comprehensive overview of the distribution of government secondary healthcare facilities across the different local government areas in the state.

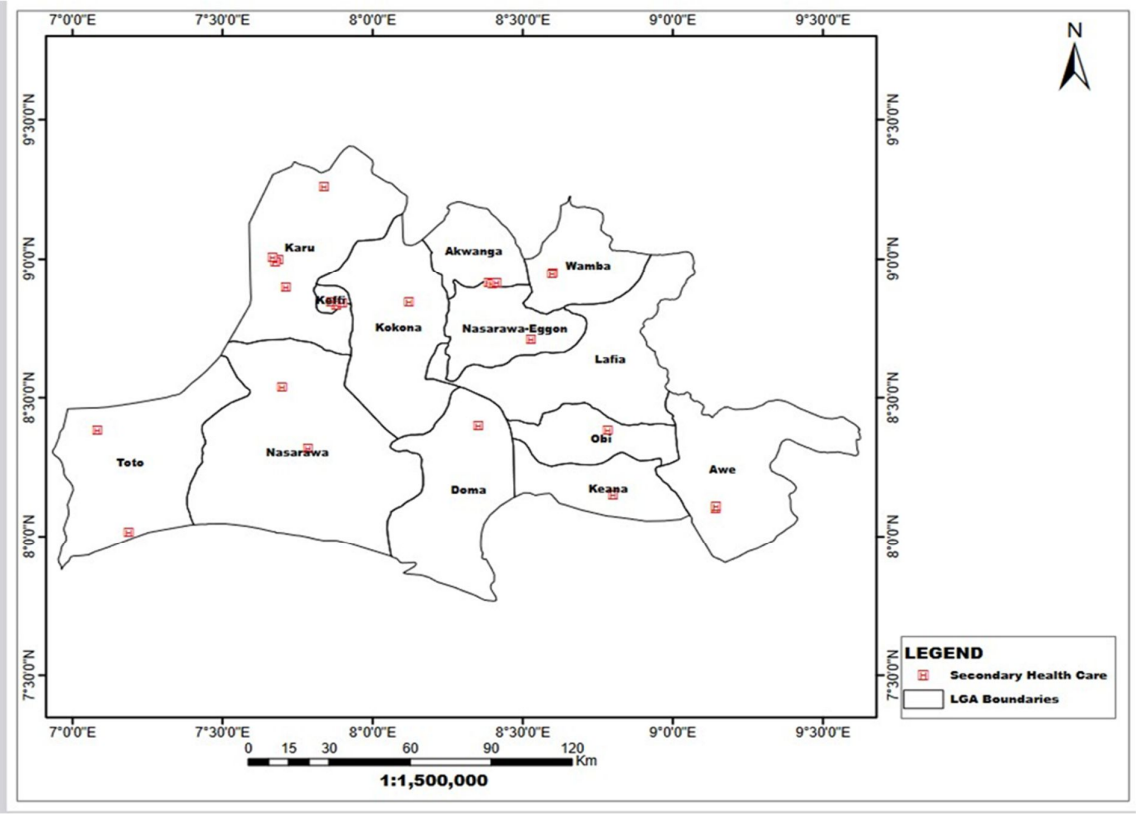

Figure 6: Spatial distribution of Government Secondary Health Care Facilities in Nasarawa State

It is evident that there is a varying degree of availability of these facilities across the regions. Among the local government areas, Karu stands out with the highest number of government secondary healthcare facilities, partly because of the influence/pull factor from FCT. This concentration might indicate a greater focus on healthcare provision in this urban centre, likely due to its larger population and higher demand for healthcare services. The disparities in the number of government secondary healthcare facilities between different local government areas highlight the need for targeted healthcare planning and resource allocation to address these discrepancies and ensure equitable access to healthcare services for all residents of the state.

4.4 Private Secondary Health Care Facilities

While the availability of government secondary healthcare facilities is presented in figure 7, the focus on private secondary facilities in Karu LGA is conspicuous. The presence of 16 private secondary health care facilities in Karu indicates a relatively better access to private secondary healthcare services in this specific LGA. Figure 8 indicates significant variations in the availability of these facilities, highlighting areas where private secondary healthcare options are more prominent and others where they are relatively scarce.

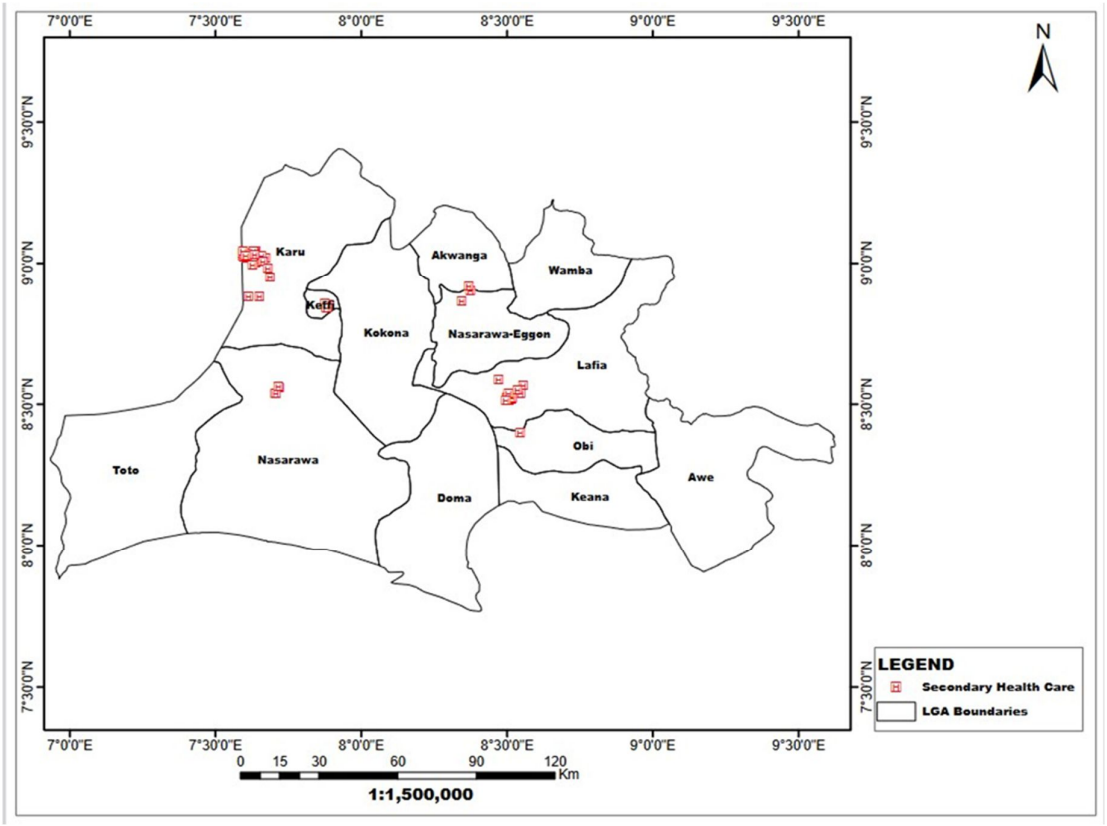

Figure 7: Spatial distribution of Private Secondary Health Care Facilities in Nasarawa State

The data presented in figure 8 indicates a robust private healthcare sector in this region (Karu about 30 private PHC). The services render by this private operators especially at PHC level call for further study. On the other hand, some areas, like Nasarawa-Eggon, have a lower count of private secondary facilities, with only 2 reported. The explanation for this is simple. The private PHC will certainly not be as viable in Nasarawa-Eggon and other rural communities as it is in Karu.

The uneven distribution of government and private secondary healthcare facilities, particularly the significantly higher number of private facilities in Karu, raises questions about the balance between the public and private sectors' involvement in providing healthcare services in Nasarawa State. While the private sector's active participation can contribute positively to healthcare delivery, the government's role remains crucial in ensuring equitable access to quality healthcare, especially for rural populace. The relatively low number of government secondary healthcare facilities in some areas, as seen in the comparison with private facilities, highlights the potential need for public-private partnerships. Collaborative efforts between the government and private sector can help bridge gaps in healthcare service provision, particularly in regions where government facilities are limited. These partnerships can lead to a more comprehensive and efficient healthcare system that caters to the diverse needs of the population.

4.5 Government Tertiary Health Care Facility

Tertiary health care facilities are often considered the highest level of healthcare, offering specialized and advanced medical services. The data indicates that there is a presence of government tertiary health care facilities in some of the local government areas. These facilities play a crucial role in providing specialized medical treatment, advanced surgeries, and specialized diagnostics that require highly trained medical professionals and advanced medical equipment. Figure 8 reveals significant disparities in the distribution of government tertiary health care facilities across the local government areas with only Keffi LGA having such facility in the whole of Nasarawa State indicating limited access to specialized healthcare services.

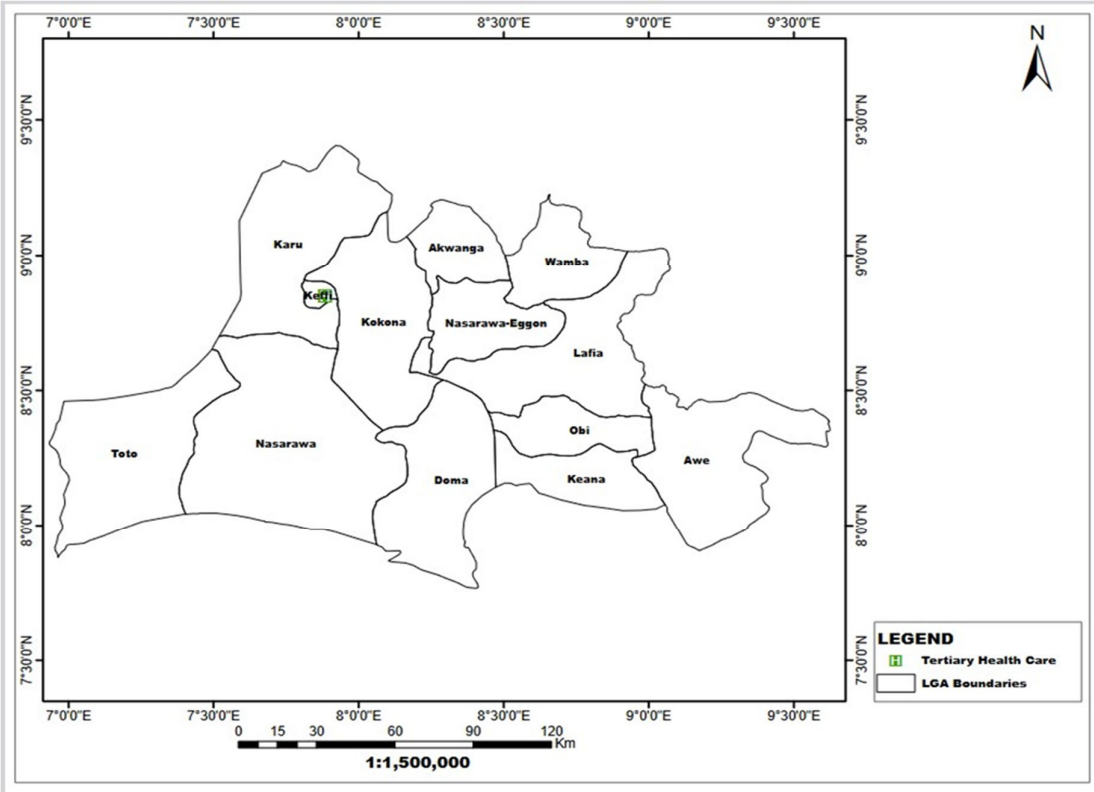

Figure 8: Spatial distribution of Government Tertiary Health Care Facilities in Nasarawa State

The absence of government tertiary health care facilities in the other 12 local government areas suggests potential challenges for residents seeking specialized medical attention. This could result in patients traveling long distances to access these services in neighbouring areas, leading to increased healthcare costs, inconvenience, and delayed treatment. The lack of government tertiary facilities might also affect referral systems, as primary and secondary healthcare centres may struggle to refer patients to higher-level care especially that Patients often rely on these facilities for expert consultations, access to cutting-edge medical technology, and specialized treatments.

4.6 Buffer of Primary HealthCare Facility

Multiple buffering-based Proximity analysis measuring physical accessibility was done by creating a three-ring buffer around the health facility location. This was done by employing feature-based proximity tool to create vector polygons at three varied specified buffer distances enclosing the spatial location of settlements center as can be seen in figure 9.

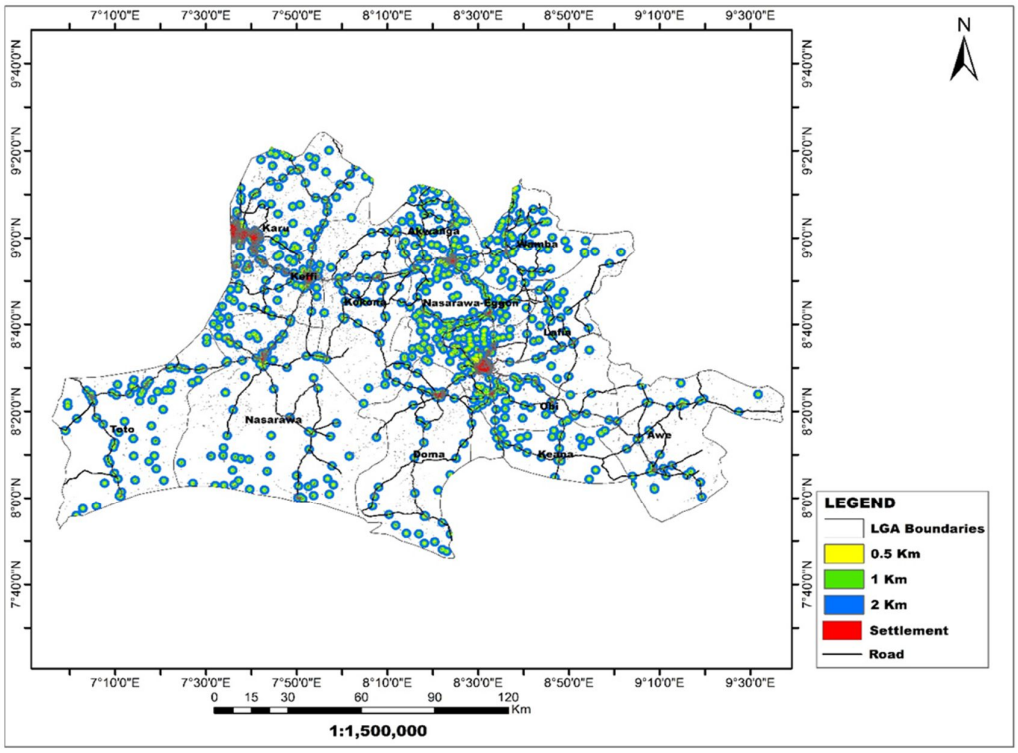

Figure 10: Primary Healthcare Facility Buffering in Nasarawa State

Buffers were chosen over population buffers as features were concentrated in small and scattered areas. The buffers circumscribed 0.5,1 and 2 km distances for fixed and outreach for health care service delivery. Settlement layers were overlaid on the facilities buffer created and a spatial join was performed to discern settlements that are within 0.5km, 1km, and 2km buffer with those outside the buffers indicating settlements that are not served by any of the health facility within the local government. The simplest way of proximity analysis is by multiple ring buffers by generating buffering based maps, and it is based on physical distances from the settlement's center to the health facilities, as illustrated in (Figure 10).The map depicts the number of settlements covered by each health facility, which are highlighted by overlaying the settlements within the facility 0.5km, 1km and 2km buffer defining the service areas covered by the health care facilities, suggesting adequate accessibility. The settlements in the local government area of each health facility are denoted by yellow, green and blue color respectively, while the settlements represented by red denote settlements that are not covered by any health facility in the local government without any health facilities. The settlements without health care facilities are found in all the local government in Nasarawa state base on the united nation standard of distance between settlements to health care facility.

4.7 Buffer of Secondary Healthcare Facility

The buffering analysis in secondary health care in (Figure 11) show a wide number of settlements by local government that need more present of secondary health care facility in Nasarawa state showing good accessibility of health care facility to the settlement within (1 km and 10 km radius). The settlements outside the 10km buffer are considered not served by any health care facility. Using the 1- 5 km buffer, the proportion of settlements with no coverage of health care facility is about (40%). However, after extending the radius to 10 km, the proportion of settlements with no coverage increases to (30%).

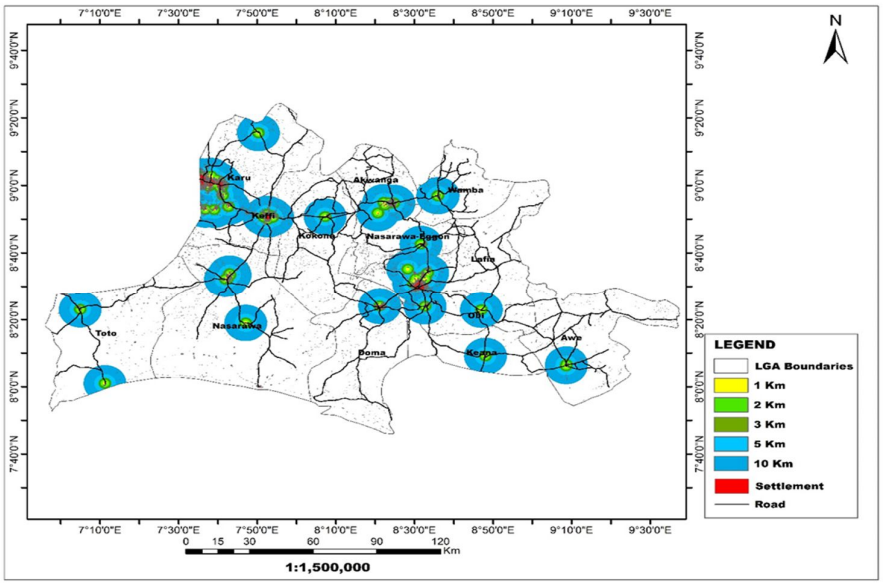

Figure 11: Buffer of Secondary Healthcare Facility in Nasarawa State

In this analysis, accessibility and spatial coverage of the existing health facility network in the Nasarawa Local government was conducted. The study illustrated how spatial data will be integrated and analyzed using GIS techniques to support policymakers in making decisions towards optimizing resource allocation. It brings out the number of settlements/villages that are not served by any of the existing health facilities in the local government. Therefore, there is the need to consider equity in the distribution of health facility with more emphasis on rural, scattered, and hard-to-reach areas to address the equality towards achieving even development of healthcare facility. Although in the context of this study, coverage for accessibility is delineated by creating buffers at various levels of distance based on the buffering (straight-line) distance.

4.8 Average Nearest Neighbor Analysis

In ascertaining the degree of clustering of health facilities, average nearest neighbor analysis was employed. This analysis calculates a nearest neighbor index based on the average distance from each facility to its nearest neighboring facility. The nearest neighbor index is expressed as the ratio of the Observed Mean Distance to the Expected Mean Distance. The expected distance is the average distance between neighbors in a hypothetical random distribution. Where the index is less than 1, the pattern exhibits clustering. When it is greater than 1, the trend is towards dispersion. For the purpose of this study, Euclidean Distance was preferred over Manhattan Distance during the analysis.

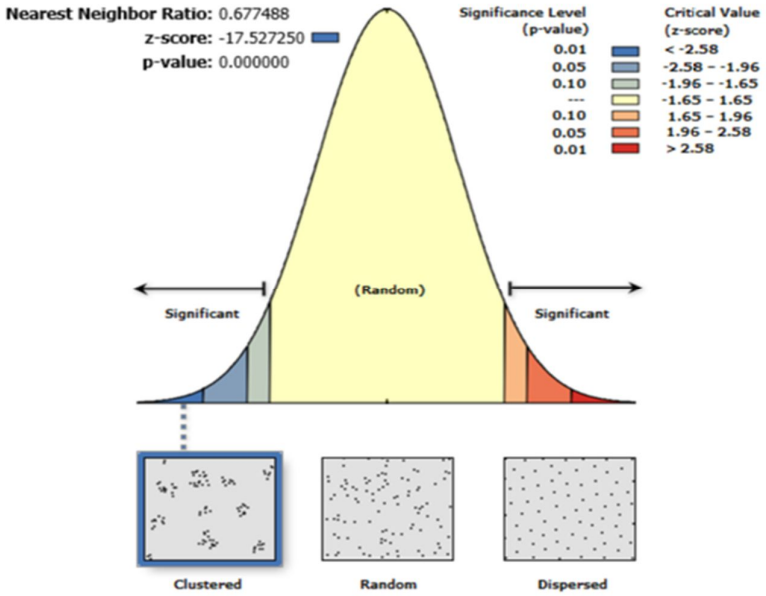

Figure 11: Average Nearest Neighbour Analysis for Government Primary Facilities in Nasarawa State

The general trend of health facilities in Nasarawa state is towards clustering. This is as expected since the facilities are intended to reside close to settlements and thus will present some degree of clustering though the level may differ between different types of facilities. The government own primary healthcare facilities record a z-score of -17.52725 and 0.677488 Nearest Neighbour ratios (figure 11). These both indicate a very strong trend towards clustering and, from the analysis, there is a less than 1% chance of randomness or dispersion. This indicates that there is more work to be done to ensure a more dispersed and competitive distribution of these facilities.

A comparative analysis of similar work conducted by Abu et al (2022) on the geospatial distribution of healthcare centers in Dass local government area of Bauchi state, using geographic information system. Their result shows that there is less than 1% (0.01 level of significance) likelihood that the spatial pattern of the distribution of health care facilities in Dass Local Government Area is dispersed and this could be as a result of random chance.

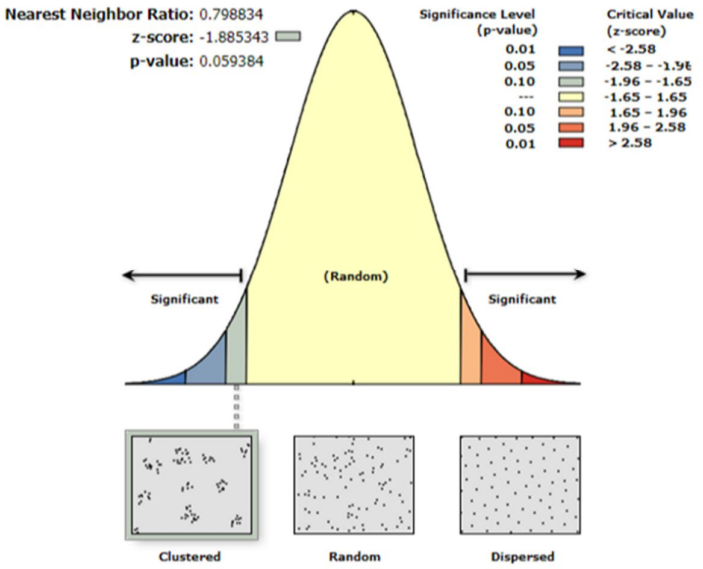

Figure 12: Average Nearest Neighbour Analysis for Government Secondary Facilities in Nasarawa State

Likewise, private primary healthcare facilities have a z-score of -18.527370 and Nearest Neighbour Ratio of 0.357209 shows very significant clustering alongside an identical 1% probability of random distribution (figure 13).

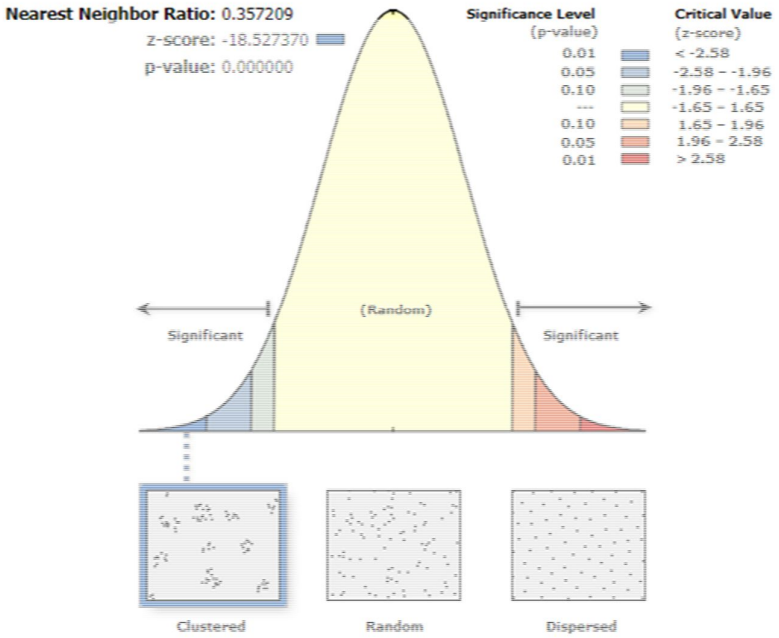

Figure 13: Average Nearest Neighbour Analysis for Private Primary Facilities in Nasarawa State

For the government secondary and private secondary healthcare facilities there are some notable differences in their statistics. The private secondary facilities present a very high level of clustering with Nearest Neighbour ratio of 0.255379 which is the lowest value for this variable among all the types of facilities. In contrast, government secondary facilities have Nearest Neighbour Ratio of 0.798834, which indicates a trend towards dispersion and therefore a better spread of the facilities. Recorded z-scores are also in tandem with the previous observations with government secondary facilities recording -1.885343 while private secondary facilities stand at -11.034210 (figures 11 and 13).

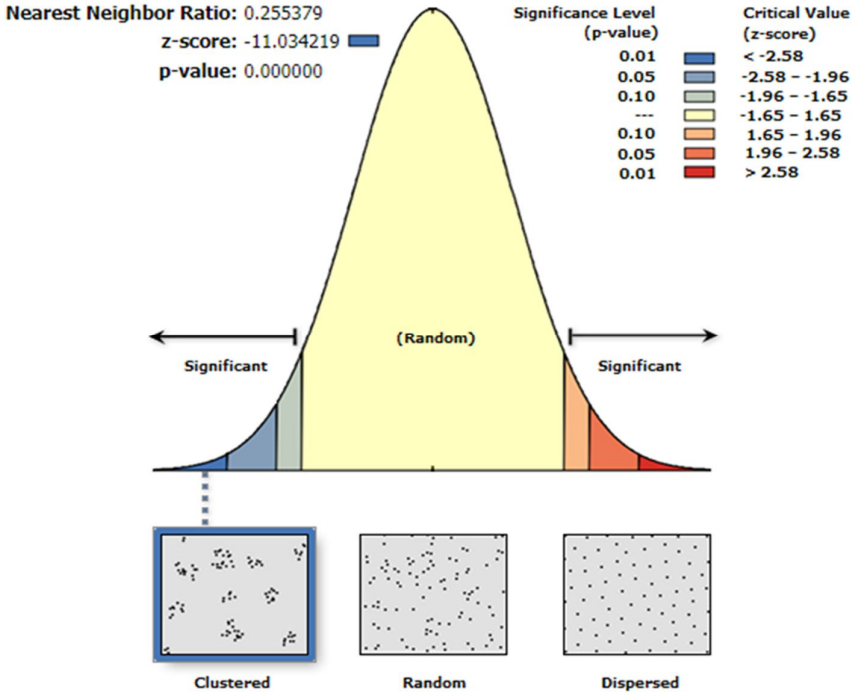

Figure 14: Average Nearest Neighbour Analysis for Private Secondary Facilities in Nasarawa State

CONCLUSION

Overall, the study established the fact that healthcare facilities in Nasarawa state has been characterized by both progress and setbacks. Despite the challenges, some of which are the distribution and accessibility of these facilities, healthcare remains essential to improving the health and well-being of the people.

RECOMMENDATION

1. The study recommends the need for more tertiary healthcare facilities be established in each of the local government headquarter.
2. These findings will serve as a basis for strategic planning and resource allocation to address disparities and ensure healthcare services are adequately distributed throughout the state.
3. The Health sector in Nasarawa State should leverage on the outcome of this study for the realization of United Nation's health related Sustainable Development Goal.

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