Cluster and Buffer Analysis of the Distribution of Healthcare Facilities in Plateau State

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ABSTRACT

Nigeria faces significant challenges in providing access to healthcare services for its population. An important aspect of Nigerian health policy that requires timely evaluation, is accessibility to Primary Health Care (PHC) facilities (and, indeed, other healthcare facilities) especially in rural areas. Thus, the need to investigate their distribution and spatial influence. This study employed the technology of Remote Sensing and GIS in generating relevant scientific data on the spatial distribution of healthcare facility in Plateau State. Coordinates of various health facilities were recorded using handheld GPS while various attribute information were also obtained and recorded. The results thus acquired were tabulated and segmented by local government. The type of facility (primary, secondary and tertiary) and, ownership (government or private) was tabulated and prepared for further analysis. There are 1237 health facilities spread across the state. Government PHC facilities; 615, private PHC facilities; 542, government secondary and private secondary healthcare facilities; 31 and 44 respectively and 5 tertiary healthcare facilities were documented and their spatial distribution and relationship represented graphically. Buffer distances of 0.5, 1 and 2 Kilometers and 1, 2, 3, 5 and 10 Kilometers were used for buffer analysis of the spatial relationship between facilities and settlements. This showed a reasonable coverage especially around the location of settlements within the state. Urban centers present clustering of facilities due to density of population in these areas. The cluster analysis reveals similar Nearest Neighbor Ratios for all the types of facilities with private secondary healthcare having the least with 0.606858. This is a direct consequence of the clustering of private secondary facilities around the Jos-Bukuru metropolis in the northern end of the state. Other types of facility are not too far from this ratio with government primary presenting 0.701219, private primary 0.837056 and 0.661641 for government secondary facilities. The northern senatorial district shows much of this clustering with the peak in and around the Jos-Bukuru metropolis. This can be attributed to the important role of Jos as the administrative center of the state and a major urban area. The z-scores for both government (-14.174948) and private primary healthcare facilities (-15.069804) indicates significant clustering. The z-score for government secondary (-1.735602) in correlation with its relatively high Nearest Neighbour Ratio points towards the near-equitable distribution of these facilities.

ARTICLE DETAILS

INTRODUCTION

Health, according to the World Health Organization (WHO), is "a state of complete physical, social, mental and emotional well-being of an individual and not merely the absence of disease and infirmity". Universal Health Coverage (UHC) is a concept that has gained global attention due to its potential to improve the health outcomes of populations by ensuring that everyone has access to quality health services without experiencing financial hardship. The WHO defines UHC as "ensuring that all people have access to needed promotive, preventive, curative and rehabilitative health services, of sufficient quality to be effective, while also ensuring that people do not suffer financial hardship when paying for these services" (WHO, 2021). In Nigeria, the government has made efforts to implement UHC (Universal Health Coverage), but progress has been slow due to several challenges, including inadequate funding, poor infrastructure, and a shortage of health workers.

A healthcare facility is defined as a unit owned by public and private authorities as well as voluntary organizations and which provides healthcare services. 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). Healthcare access is concerned with the processes surrounding the entry of persons and population groups into the healthcare delivery system (Neutens, 2015). There is now a wide recognition of the value of GIS in, among others, mapping the spatial distribution of healthcare needs and utilization, monitoring and evaluating the socio-spatial repercussions of health policy actions, determining optimal health service locations and disentangling the relationships between disparities in accessibility and health outcomes. 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 influences accessibility and utilization, but neither is distributed evenly in space (Wang, 2006).

Nigeria is the most populous country in Africa, with an estimated population of over 200 million people. The country is diverse in terms of geography and culture, with 36 states and a federal capital territory. Health represents one of the most basic human needs and has a profound impact on the welfare and productivity of the individual. As such, numerous attempts have been made by the three tiers of government to provide adequate health facilities particularly at the grass roots to meet the aspirations of the public. Despite its vast resources, Nigeria faces significant challenges in providing access to healthcare services for its population. Furthermore, there is paucity of data regarding the spatial distribution, that is, knowing what is where and in what quantity as far as the provision of health facility is concerned. Thus, the spatial distribution of healthcare facilities is of great significance to policy and development planners. Hence the need for this study.

LEVELS OF HEALTHCARE SYSTEMS IN NIGERIA

There are three main levels of healthcare system in Nigeria, unlike in some advanced countries that have four tiers of healthcare system, including quaternary healthcare. 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.
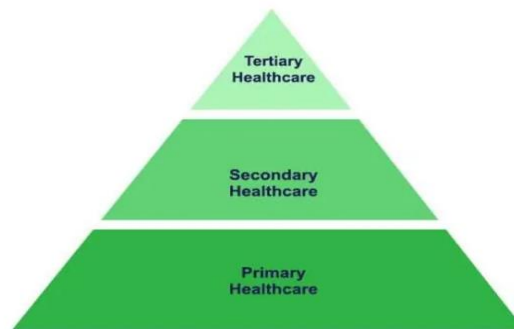

Figure 1: Hierarchy of Healthcare Facility

PRIMARY HEALTHCARE (PHC)

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. However, it was not until 1985, when Professor Olikoye Ransome-Kuti was appointed Minister of Health, that primary healthcare began to receive serious attention. 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.

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. Some patients may bypass the primary healthcare in Nigeria and self-refer themselves to higher levels of healthcare, creating an overload of patients at the referral facilities (secondary and tertiary facilities). This creates problems as minor illnesses which the PHC can handle moves to facilities suited for severe conditions. 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.

Secondary Healthcare

This 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 and specialist hospitals. At the secondary level, there are a good

number of both public and private sector involvement in the provision of healthcare.

Tertiary Healthcare

At the federal healthcare 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.

Study Area

Plateau state is bounded by Bauchi and Kaduna State in the north, Taraba in the east, Nasarawa state in the west and Taraba and Nasarawa states also extend to the south. The area lies between latitudes $8°22'3.219''N$ to $10°23'41.471''N$ and longitudes $8°33'13.242''E$ to $10°38'24.222''E$.
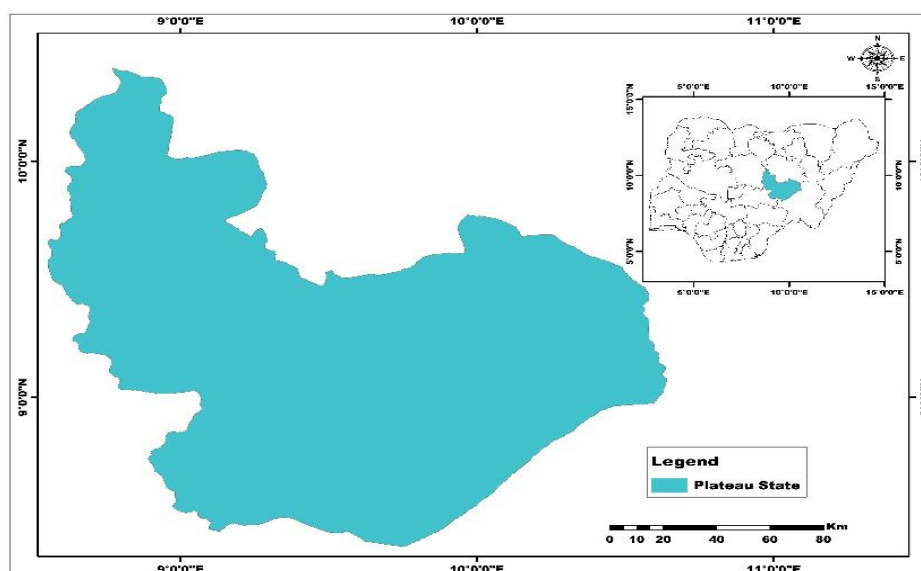

Figure 2: Map of the study area

Plateau state is located in north central Nigeria. It has a 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 government. It includes hospitals, clinics, and primary healthcare centres. In recent years, the government of the state has made investments in improving the health care system. It has built new hospitals and clinics, and it has also provided training for health care workers. However, a lot still needs to be done to meet the healthcare needs of the population.

In Plateau State, the Jos University Teaching Hospital is the largest and most well-equipped hospital. It is a tertiary care facility that provides specialized treatment for a wide range of medical conditions.

The Plateau State Hospital Management Board (PSHMB) is responsible for managing all public hospitals in Plateau State. The PSHMB has a network of health care facilities, including general hospitals, maternity hospitals, and primary health care centres. Plateau State Hospital Management Board in Plateau State

AIM

The aim of this study is to employ the technology of Remote Sensing and GIS to generate relevant scientific data on the spatial distribution of healthcare facility in Plateau State.

OBJECTIVES

1. To map the spatial distribution of healthcare facilities.
2. To determine the pattern or degree clustering of healthcare facility
3. To assess the relationships between the number of facilities and the settlement.
4. To ascertain the physical distance the patients covered to the facilities.
5. To generate appropriate measures in enhancing equitable distribution of healthcare facilities.

MATERIALS AND METHODS

Materials

1. Hand-held GPS
2. ArcGIS Desktop 10.8
3. Microsoft Excel
4. Microsoft Word

Cluster and Buffer Analysis of the Distribution of Healthcare Facilities in Plateau State

METHODS
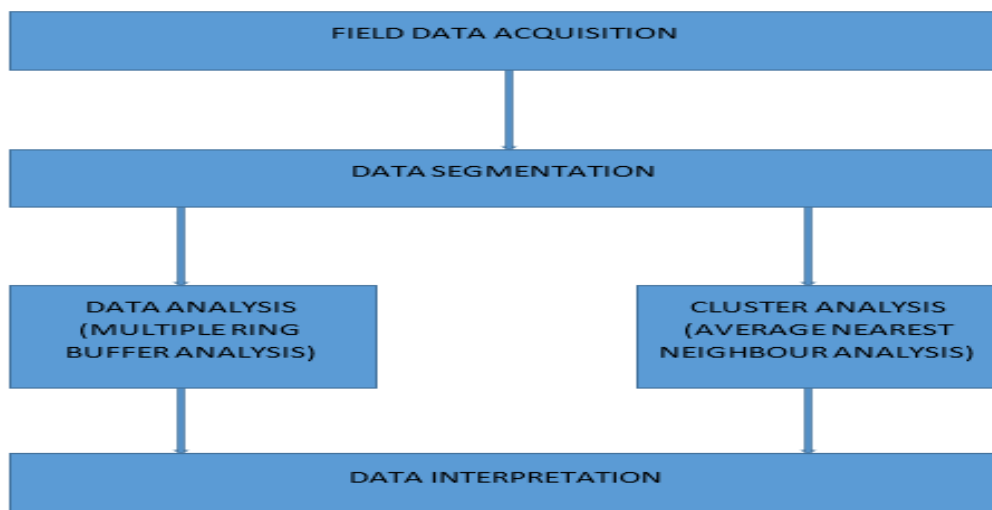
Figure 3: Workflow Chart

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 state and local government. The type of facility (primary, secondary and tertiary healthcare facility) and, ownership (government or private owned) was 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.

Buffer sample distances of 0.5, 1 and 2 Kilometers walking distances were adopted for the primary healthcare facilities to accommodate the assumption that 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, 5 and 10 Kilometers were adopted for secondary health facilities (based on M. Karra et al (2017)) 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.

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.

RESULTS AND DISCUSSION

Healthcare facilities are important in Plateau State Nigeria for a number of reasons. First, the state has a large and growing population, with over 3 million people. This means that there is a high demand for healthcare services. Second, about 65% of the settlements are rural. Providing and sustaining a quality healthcare service in rural area is one of the greatest developmental challenges in Nigeria today.

Cluster and Buffer Analysis of the Distribution of Healthcare Facilities in Plateau State
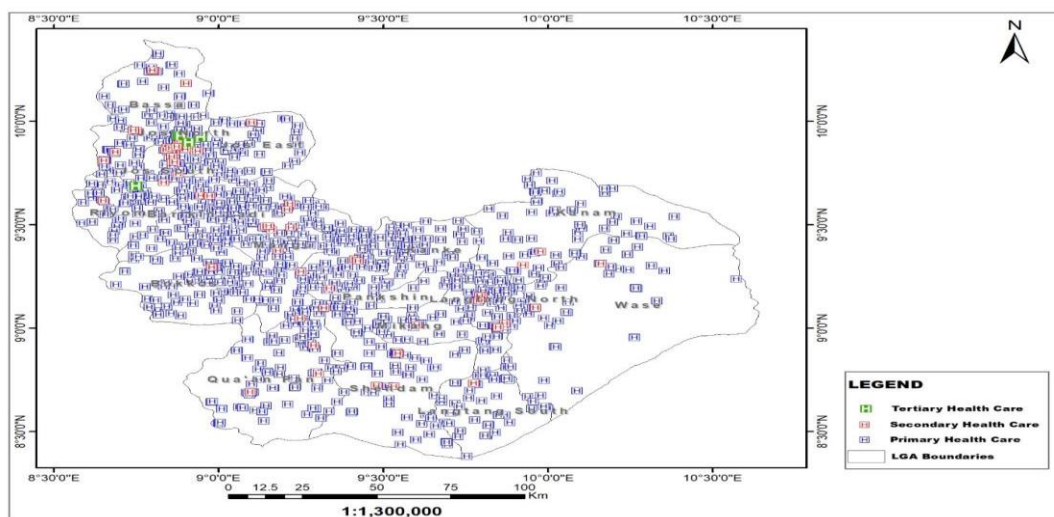
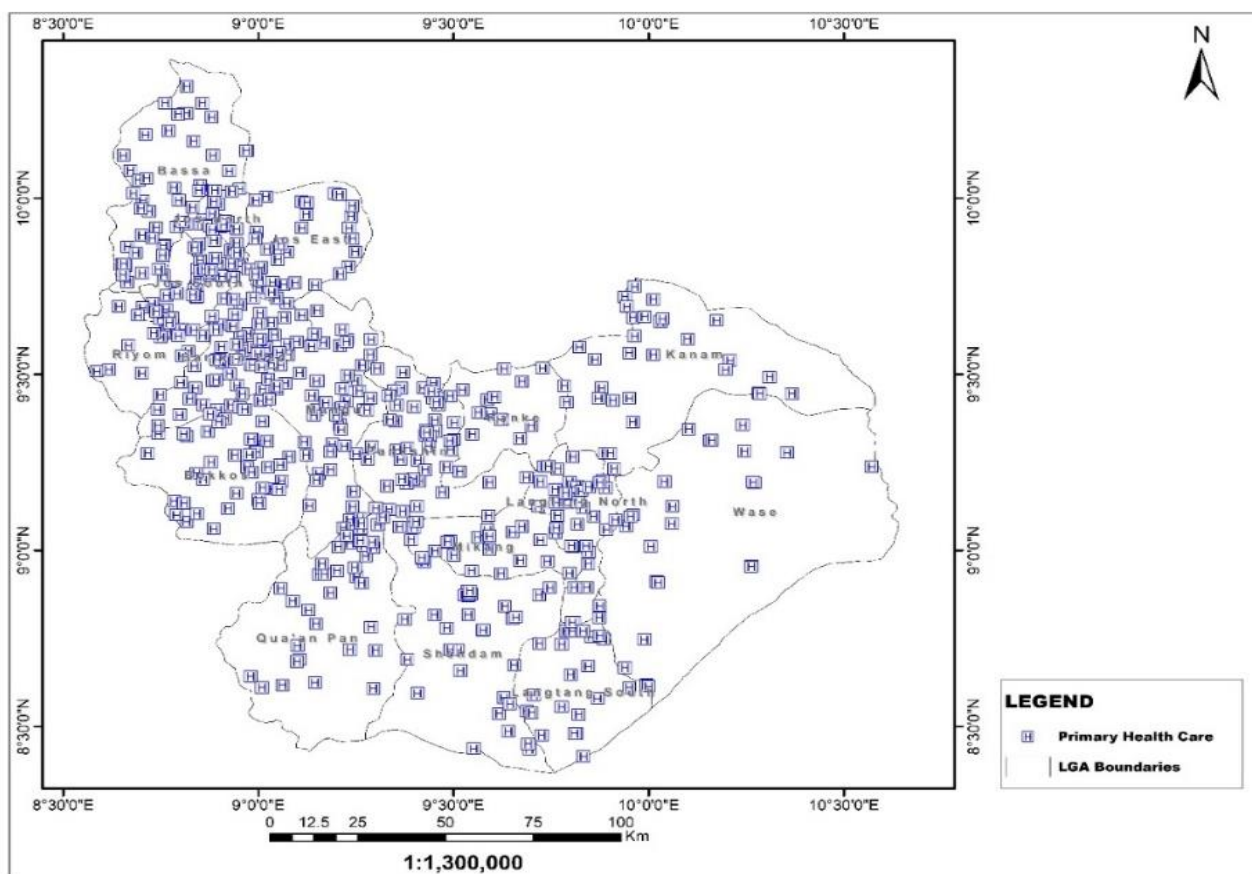**Figure 4: Spatial Distribution of Healthcare Facilities in Plateau State**

The state is made up of 17 local government areas. There are 1237 health facilities spread across those local government areas. Government operated primary health care (PHC) facilities account for 615 while the private owned PHC facilities are 542 in number. Government secondary health facilities and private secondary health care facilities are 31 and 44 respectively. The state is served by 5 tertiary healthcare facilities of which 3 (Bingham University Teaching, Vom Christian and Our Lady of Apostles Hospitals) are private owned and 2 (Jos University Teaching Hospital and Plateau Specialist Hospital) are government operated.

Table 1: Number of Healthcare Facilities in Plateau state

S/N	LOCAL GOVERNMENT AREA	GOVERNMENT PRIMARY HEALTHCARE FACILITIES	PRIVATE PRIMARY HEALTHCARE FACILITIES	GOVERNMENT SECONDARY HEALTHCARE FACILITIES	PRIVATE SECONDARY HEALTHCARE FACILITIES	GOVERNMENT TERTIARY HEALTHCARE FACILITIES	PRIVATE TERTIARY HEALTHCARE FACILITIES
1	BARKIN LADI	56	23	1	1	0	0
2	BASSA	51	17	4	4	0	0
3	BOKKOS	46	46	0	2	0	0
4	JOS EAST	38	13	1	0	0	0
5	JOS NORTH	28	28	3	9	2	2
6	JOS SOUTH	42	10	6	10	0	1
7	KANAM	31	37	1	1	0	0
8	KANKE	17	44	0	0	0	0
9	LANGTANG NORTH	36	29	3	3	0	0
10	LANGTANG SOUTH	26	21	0	1	0	0
11	MANGU	58	55	4	3	0	0
12	MIKANG	21	21	1	0	0	0
13	PANKSHIN	48	42	1	3	0	0
14	QUA'AN PAN	36	70	1	4	0	0
15	RIYOM	18	30	1	0	0	0
16	SHENDAM	37	32	2	2	0	0
17	WASE	26	24	2	1	0	0
	TOTAL	615	542	31	44	2	3

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Cluster and Buffer Analysis of the Distribution of Healthcare Facilities in Plateau State

Figure 5: Spatial Distribution of Government Primary Healthcare Facilities in Plateau State
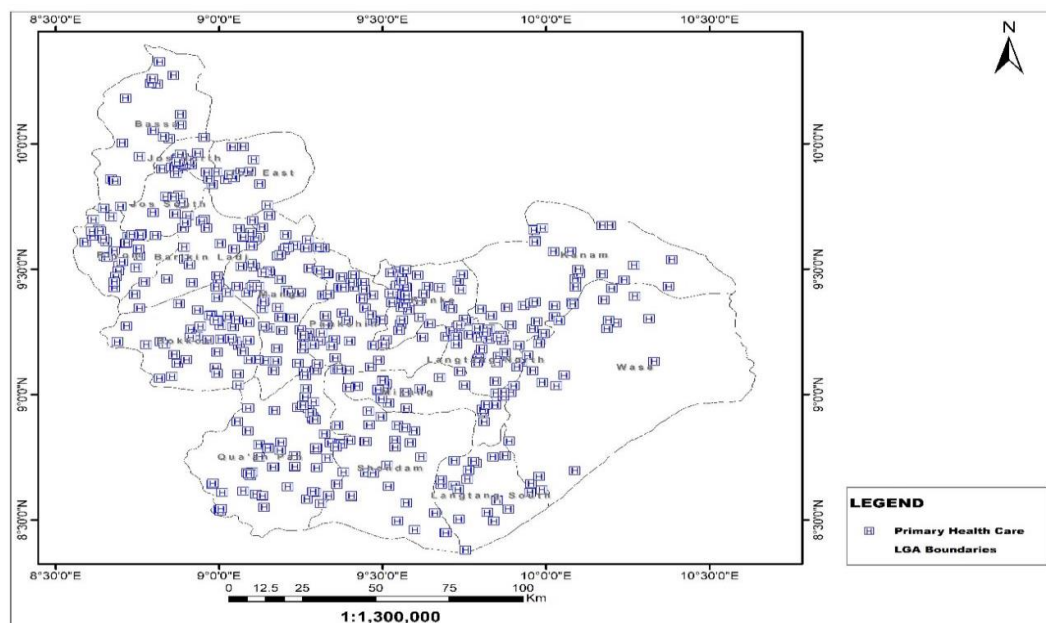
Government Primary Healthcare Facilities

Government PHCs in Plateau state are 615 in number. Their distribution across the state is quite equitable, with every local government having no fewer than 17 facilities. The local government area with the most government owned primary facilities is Mangu with 58. This is closely followed by Barkin Ladi and Bassa with 56 and 51 facilities respectively. The areas with the least facilities are Kanke, Riyom and Mikang with 17, 18 and 21 facilities respectively. Of course, urban centers present clustering of these facilities due to density of population in these areas. The northern senatorial district shows much of this clustering with the peak in and around the Jos-Bukuru metropolis. This can also be attributed to the important role of Jos as the administrative center of the state.

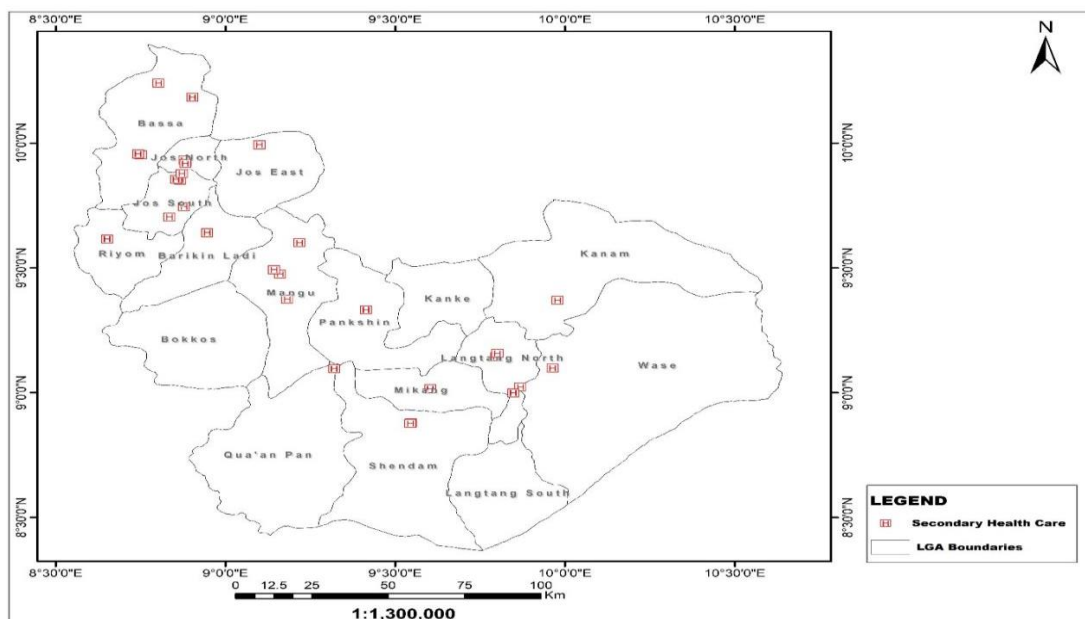**Private Primary Health Care Facilities**

Private PHCs are not as widespread as government owned establishments in the state. This is quite as expected, taking cognizance of the fact that the private facilities are driven by profit and other economic considerations and therefore would gravitate towards urban areas where the economic capacity is available. Thus, even though the number of private PHCs is quite large (542), there is still noticeable clustering around economic centers and large towns. The local governments with the most private primary healthcare facilities are Qua'an Pan, Mangu and Bokkos with 70, 55 and 46 respectively. On the other hand, those with the least are Jos South, Jos East and

Bassa with 10, 13 and 17 facilities. These local governments are, paradoxically, parts of the greater Jos metropolitan area. This may be due to the relative concentration of government primary facilities around the metropolis, negating the need for more facilities. Those with the highest numbers are areas, which host large and important towns, on the verge of becoming urban centers.

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Figure 6: Spatial Distribution of Private Primary Healthcare Facilities in Plateau State
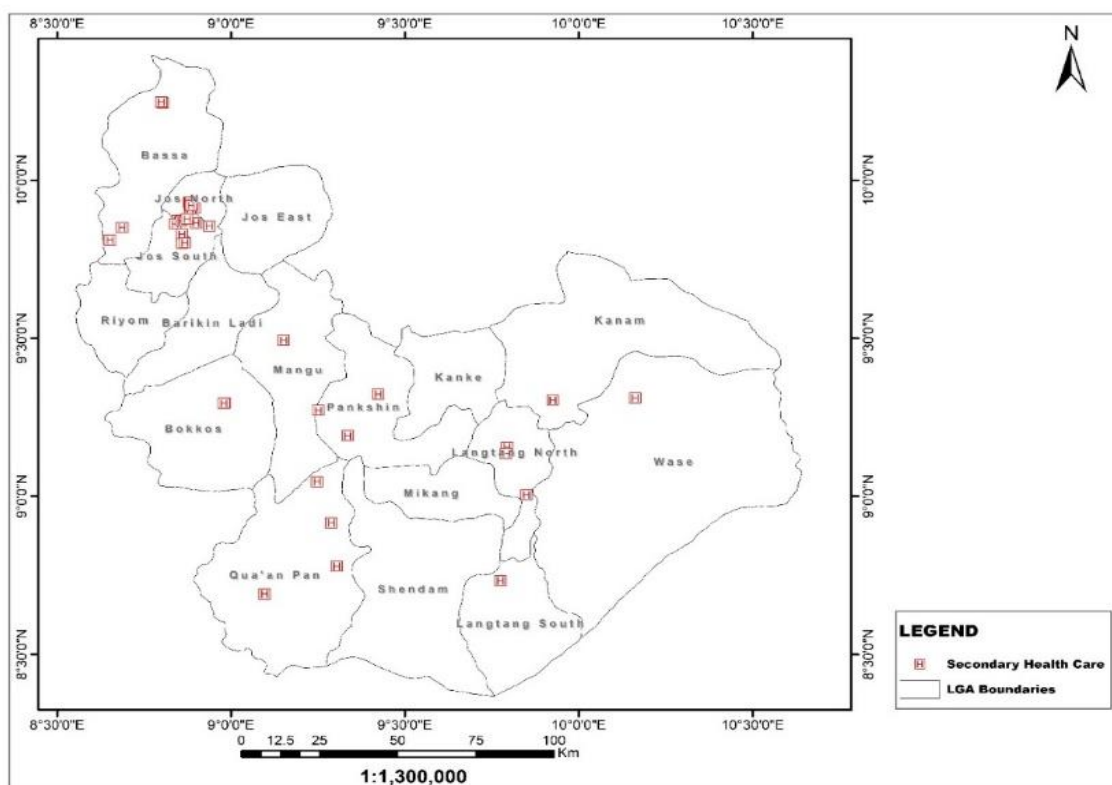

Figure 7: Spatial Distribution of Government Secondary Healthcare Facilities in Plateau State

Government Secondary Health Care Facilities

Almost all local governments in Plateau state can boast of at least one secondary healthcare facility. With the total number of governments operated secondary facilities about 31, it is noticeable that quite a few local governments have more than one with the greatest number of facilities in and around Jos North and South. This also is a measure of the inevitability of such facilities clustering around urban centers and important towns. Jos south has the most facilities numbering about 6. It is followed by Mangu and Bassa with about 4 each; Jos North with about 3; Shendam and Wase with about 2 each, **while Langtang South, Kanke and Bokkos do not have any facilities at all.** Even though there are multiple secondary facilities in several local government areas, there are still vast areas uncovered by standard referral facilities and great distance to travel between primary health care facilities and these secondary facilities with the attendant issues surrounding travel especially while travelling with an invalid.

Cluster and Buffer Analysis of the Distribution of Healthcare Facilities in Plateau State

Figure 8: Spatial Distribution of Private Secondary Healthcare Facilities in Plateau State

Private Secondary Health Care Facilities

The economic strength and purchasing power of the urban areas is most visible when considering the distribution of private secondary healthcare facilities. They clustered very noticeably around the economic centers with little or no spread. Outliers can be found in or around other major towns and their spread is not linked to the political (local government) divisions. The private secondary healthcare facilities in Plateau state are 46. Their numbers compare favorably against similar facilities owned by the government, being more in number. This proliferation can also be linked to the profit motive for establishment of such private facilities. Bokkos, Kanke and Mikang have no private secondary healthcare facilities. The highest number of facilities are in Jos South and Jos North with 10 and 9 followed by Bassa and Qua'an Pan with 4 each. Langtang North and Pankshin each have 3 facilities while Bokkos and

Shendam each have 2. Every other local government has one facility each.
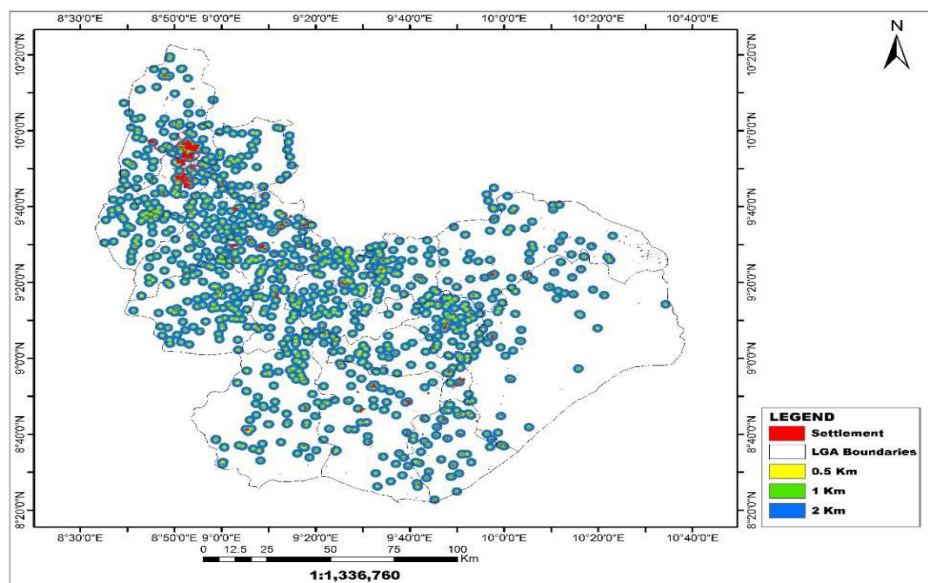
Buffer of Primary Healthcare Facilities

Multiple Ring buffers were generated for measuring physical accessibility to the facilities. Buffer distances of 0.5, 1 and 2 kilometers were used for the analysis of the spatial relationship between facilities and settlements. This showed a reasonable coverage especially around the location of settlements within the state. However, this spatial relationship is not universal as several smaller settlements are located quite a distance from the nearest primary healthcare facility. Also, of note is the vast areas without adequate representation along the southeastern edge of the state (part of Wase local government) where facilities are sparsely located
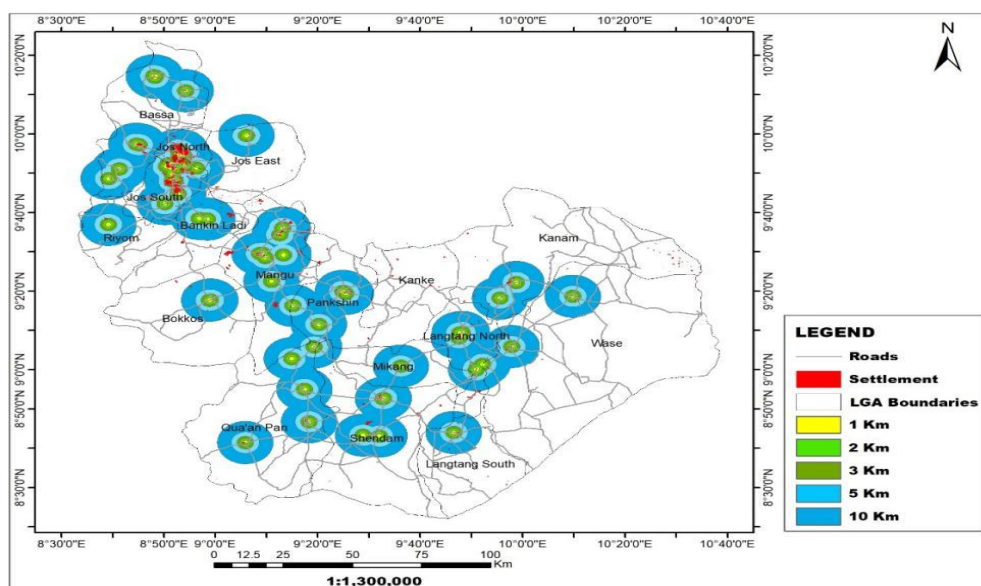
Figure 9: Buffer of Primary Healthcare Facility in Plateau State

Figure 10: Buffer of Secondary Healthcare Facility in Plateau State

Buffer of Secondary Healthcare Facilities

The buffering analysis of secondary healthcare facilities in Plateau state shows relatively good accessibility to secondary healthcare facilities particularly in and around the northern senatorial zone (comprising of Barkin Ladi, Bassa, Jos East, North and South as well as Riyom) where only around 20% percent of the land area is not within 10 kilometers of a secondary facility while almost every local government area in the zone is covered by at least on referral facility. Bearing in mind that this zone also has all the tertiary health facilities in the state, it is quite well covered by healthcare facilities. Nevertheless, the population size served in this zone makes a case for the establishment of more secondary healthcare facilities. Other parts of the state are less well served as large parts of Kanke, Kanam, Langtang South, Mikang, Qua'an Pan and Wase reveal poor accessibility to secondary healthcare facilities. Of course, this will result in extended travel times from either settlements or primary facilities (based on reference) in those areas to secondary facilities with the attendant delay in treatment, financial pressure and even loss of life. **These rural hinterlands (for the most part), therefore require, as a matter of urgency, an increase in the number of facilities serving their health needs**.

Average Nearest Neighbor Analysis

The cluster analysis reveals similar Nearest Neighbor Ratios for all the types of facilities with private secondary healthcare, unsurprisingly, having the least with 0.606858 (figure 23). This is a direct consequence of the clustering of private secondary facilities around the Jos-Bukuru metropolis in the northern end of the state. Other types of facility are not too far from this ratio with government primary presenting 0.701219, private primary 0.837056 and 0.661641 for government secondary facilities (figures 20, 21 and 22). It is

noticeable that all these values are close to 1 (above which the distribution would be considered random or dispersed). This indicates that there is quite some dispersal of facilities in Plateau state. This, however, does not negate the need for more facilities, particularly secondary facilities in and around rural areas of the state.
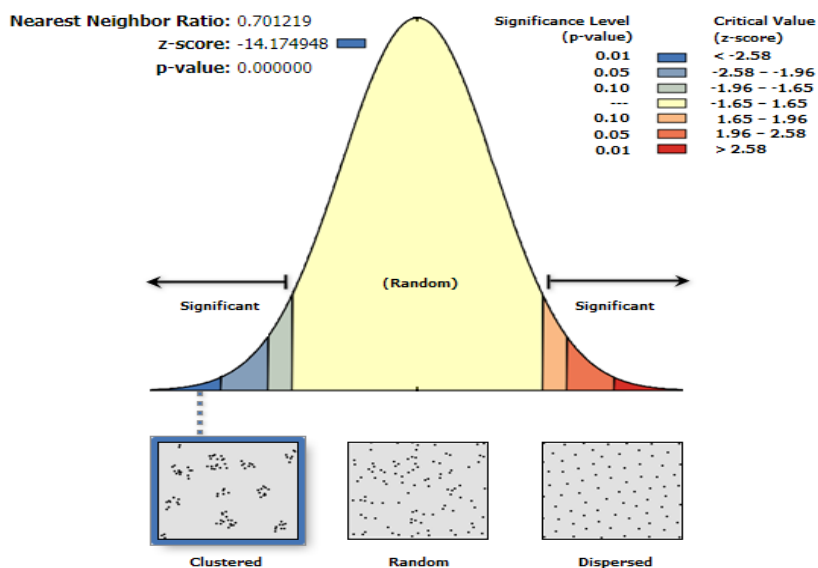

Figure 11: Average Nearest Neighbour Analysis for Government Primary Healthcare Facilities in Plateau State

The z-scores for both government (-14.174948) and private primary healthcare facilities (-15.069804) indicates significant clustering. The z-score for government secondary (-1.735602) in correlation with its relatively high Nearest Neighbour Ratio point towards the near-equitable distribution of these facilities.
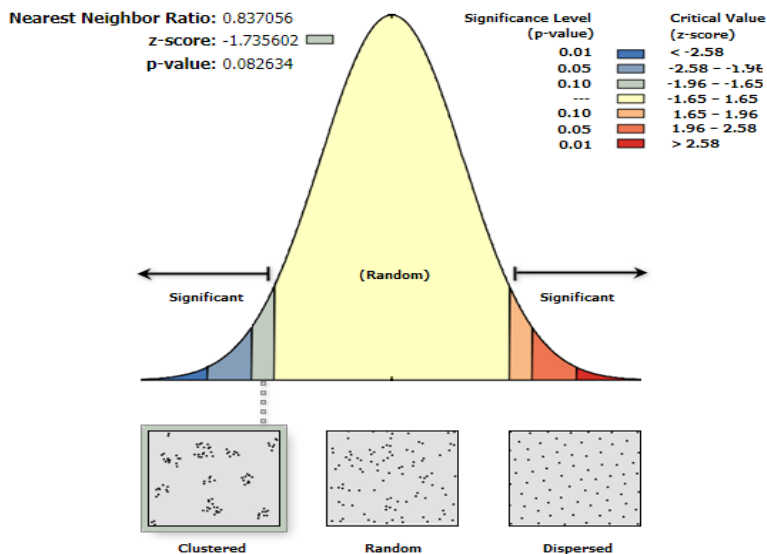

Figure 12: Average Nearest Neighbour Analysis for Government Secondary Facilities in Plateau State
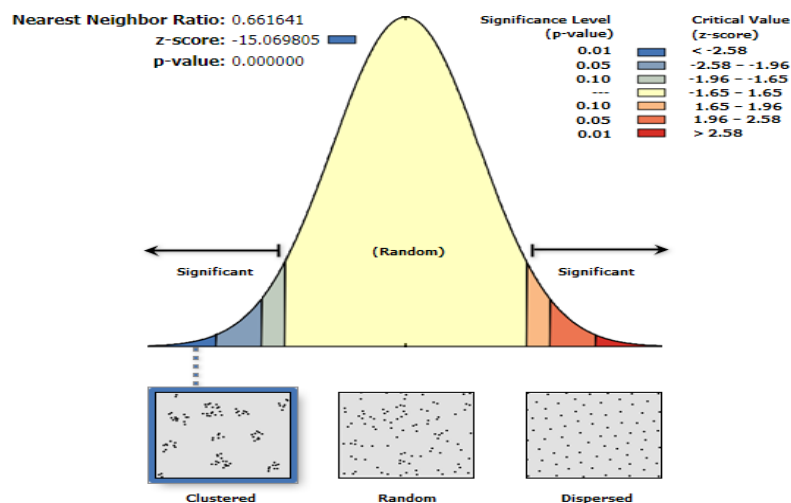
Figure 13: Average Nearest Neighbour Analysis for Private Primary Facilities in Plateau State
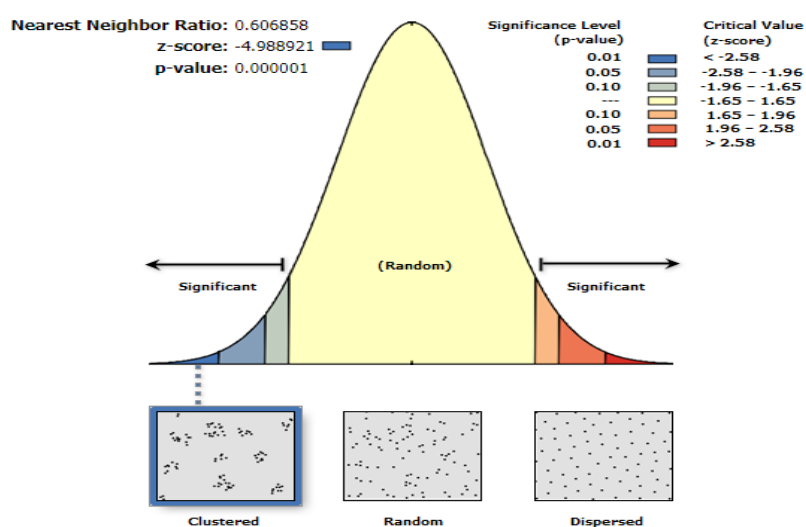

Figure 14: Average nearest Neighbour Analysis for Private Secondary Facilities in Plateau State

CONCLUSION

Nigerians, as elsewhere, attached great importance to health as brought home by a host of aphorisms: "health is wealth", "a healthy nation is a wealthy nation," etc. This importance may be seen in daily lives as people greet and ask after each other's health. The importance is also reflected in annual budget both at the national and state levels, where the health sector allocations are consistently among the top four. Healthcare is gradually being pushed beyond the reach of the poor both in terms of opportunity for medical education and access to doctors' services.

RECOMMENDATION

There is need for the refurbishment and adequate staffing of Primary Healthcare facilities that are not working at full capacity so as to attend to the unreached, especially, in the rural hinterlands.

The role of Plateau State Contributory Healthcare Management Agency (PLASCHEMA) should be extended to cover the rural poor (possibly by means of some token annual or monthly payments). This would give better access both to the primary and referral healthcare services and at a relatively low premium. Furthermore, unused funds can be redirected into building and equipping more healthcare outposts.

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