

Assessment of Spatial Distribution and Range of Service of Public Health Facilities in Jos South Local Government Area of Plateau State, Nigeria

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The spatial disparity in the distribution of health facilities is a considerable problem in the health care delivery system remarkably in developing countries like Nigeria. This study assessed the spatial distribution and range of service of public health facilities in Jos South Local Government Area of Plateau State. Both primary and secondary data were used in this study. The inventory of all the public health facilities in the area was taken and location of the facilities was geo-coded using handheld Global Positioning System (GPS). Average nearest neighbour analysis was employed to assess the spatial pattern and distribution of the facilities. Network and buffering analyses were employed to analyse the range of service. The study revealed forty public health facilities: one (1) secondary and thirty-nine (39) primary health facilities distributed across the study area. The study concluded that health facilities in Jos South Local Government were spatially dispersed, the pattern which is tending to be more pronounced in the southern part than in the northern part. It, therefore, recommended the development of a strategy plan, which is to integrate non-government stakeholders in the planning of health service delivery.

Keywords: buffering, distribution, GIS, public health, spatial range of service,

Introduction

Human health is a key factor in the sustainable development agenda and goal. Irrespective of the developmental and technological status of the society; health care system is crucial to the welfare of the society (World Health Organisation (WHO), 2010; Bhatt & Joshi, 2013; Owoyele *et al.*, 2015a). Health care systems are organisations established to meet the health needs of target populations; its exact configuration varies among nations. The need for health varies in space as the physical environment varies in characteristics from place to place and this invariably has implications for the pattern of demand for health care (Onokerhoraye, 1999; WHO, 1998). Countries and jurisdictions have different policies and

plans in relation to the personal and population-based health care goals within their societies, so the welfare of the public through the provision of health facilities is one of the key policies and responsibility of government, particularly in Nigeria (Scott-Emuakpor, 2010).

In Nigeria, health care delivery service is provided by a dual system comprising stakeholders from the public and private sectors including the private for-profit as well as the private not-for-profit organisations (Nnamuchi & Metiboba, 2015). The public health care system is the largest and central to Nigeria's health care delivery operating along the lines of primary, secondary and tertiary health care systems at the local government, state and federal levels respectively (National

Primary Health Care Development Agency (NPHCDA), 2013; Umukoro, 2012). The public health institutions including primary healthcare comprising health centres, clinics and health posts; hospitals (secondary healthcare); and tertiary healthcare are prominent for maintaining population health since their services are relatively inexpensive (NPHCDA, 2013). The distribution of the public health facilities was addressed in a policy contained in Nigeria's Fourth National Development Plan (NFNDP) (1981 - 1985) framework (Scott-Emuakpor, 2010) and adopted by the relevant health agencies including National Primary Health Care Development Agency (NPHCDA).

However, the chaotic and lopsided spatial distribution of these public health care facilities which is perceived as unfair and socially biased has drawn a considerable attention of the medical geographical researchers and urban planners mostly in developing countries like Nigeria to consider various measures to assess the spatial distribution impact on the use of healthcare system (Scott-Emuakpor, 2010; Jimoh & Azubike, 2012; Owoyele *et al.*, 2015b).

Analysing the spatial distribution of health facilities provides important information on the location of such health facilities and evaluating the range of health service is one of the most important measures to assess the accessibility of the target population to the health facility (Rob, 2003; Mansour, 2016). Many medical geographical researchers and urban planners have appreciably utilised geographic information system (GIS) to adequately provide information on the spatial patterns, accessibility and the range of service of the health facilities. Using average nearest neighbour analysis, comparing the spatial distribution of health facilities and hypothetically-based random spatial distribution to identify and quantify spatial distribution patterns of the facilities provide good approach (Hazrin *et al.*, 2013; Owoyele *et al.*, 2015b; Mansour, 2016). Also, network analysis can be used to evaluate the shortest accessible routes to the facilities and buffering in order to analyse

the proximity and radius of service of the health facilities (Mansour, 2016; Dobrica *et al.*, 2010; Yerramilli & Fonseca, 2014; Ejiagha *et al.*, 2012). This technology integrates the statistical and geographic data and allow the visualisation of such spatial relationships, hence the underlying cause of the distribution can be determined (Hazrin *et al.*, 2013; Dobrica *et al.*, 2010).

This study is targeted to examine the distribution patterns and range of service of public health facilities in Jos South Local Government Area (LGA) of Plateau State, Nigeria with the view to understand the locational distribution using Geographic Information System (GIS).

Study Area

The study area is Jos South Local Government Area (LGA) of Plateau State, Nigeria. The area, located between latitude 9°48'00"N and longitude 8°52'00"E in North Central Geo-Political Zone of Nigeria, covers about 510 km² with approximately 1,250 metres above sea level and bounded by the Jos North LGA in the northern part, and Jos East LGA in the eastern part, Bassa in the north-western side, Riyom and Barkin Ladi in the southern part (Figure 1).

The indigenous ethnic group of the area is Berom, other ethnic groups commonly found in the area are Jarawa, Hausa, Fulani, Ibo, Tiv, Idoma and Yoruba. The population of Jos South LGA was 306,716 persons with the population density of 503 persons per square kilometre at the 2006 Nigerian national population census (NPC, 2006). The total population as projected based on the Nigerian annual growth rate of 2.7 % (World Bank, 2016) is estimated as 412,200. This population appears to be much denser towards the northern region as a result of a concentration of more settlements due to the influence of political headquarters, commercial and mining activities taking place in the region.

The local government is sub-divided into twenty political wards namely Bukuru, Chugwi, Dashonong, Du 'A', Du 'B',

Giring, Gyel 'A', Gyel 'B', Hwolshe, Kuru 'A', Kuru 'B', Kushe, Shen, Sot, Tanchol, Turu 'A', Turu 'B', Vwang, Zawang 'A' and Zawang 'B'. The headquarters is located at Bukuru. The study used political ward being the smallest political structure in

Nigeria as the spatial zoning boundary (Figure 2).

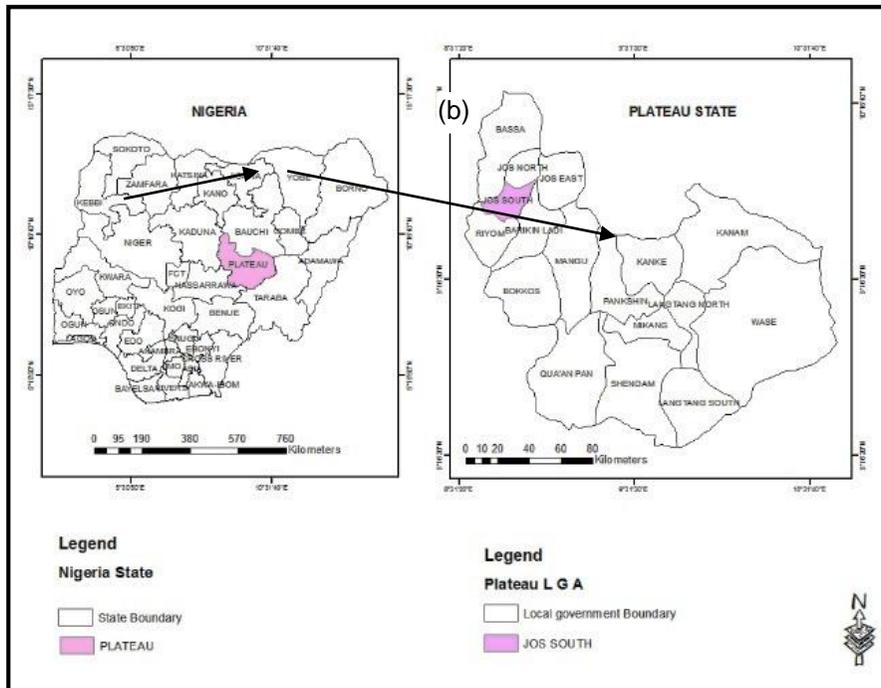


Figure 1: Map of Plateau State in context of Nigeria.

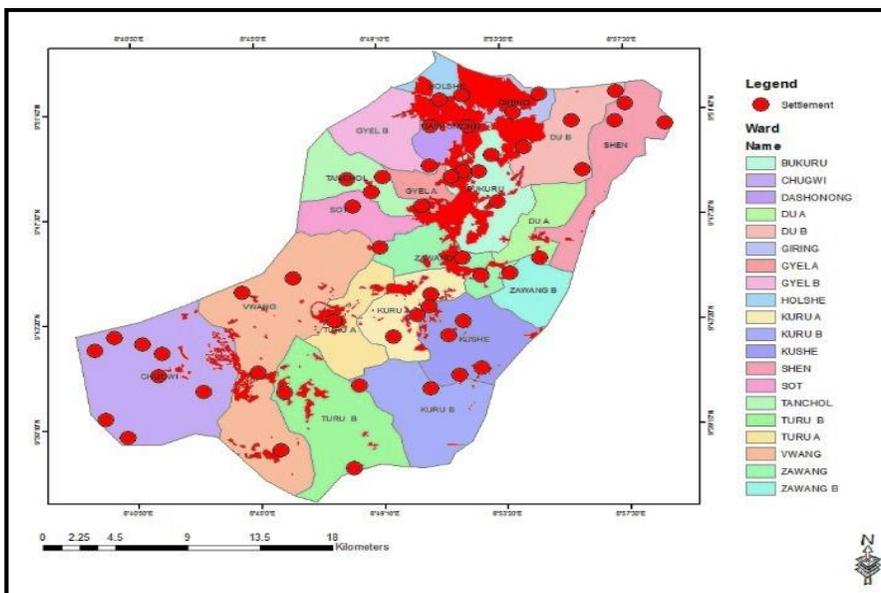


Figure 2: Map of Jos South LGA, Showing wards and Settlements

Materials and Methods

Data Collection

Data on public health facilities was obtained from Jos South LGA headquarters and the Plateau State Ministry of Health and incorporated in GIS environment. All available public health facilities in the area were identified and their location was geo-coded using handheld GPS (Garmin) through *in situ* data collection method. Population information was obtained from the National Population Commission (NPC) based on 1991 national population census. A base map containing ward boundaries, rivers, railway and road networks were acquired from the Plateau State Ministry of Land and Survey and SPOT 5 satellite imagery of Jos south LGA was provided by the National Centre for Remote Sensing (NCRS), Jos; satellite imagery and base map were first geo-referenced with the aid of ArcGIS 10.2 software. The satellite imagery was digitised in the ArcMap environment in order to update the existing base map which was found to be old.

Application of GIS Technique and Spatial Data Analysis

A geodatabase was created for the GIS analysis, which contained a collection of geographic datasets including the base map, GPS coordinates, attribute data, geographic features and satellite imagery for easy access and management using ArcGIS 10.2. The spatial distribution pattern of public health facilities in Jos South LGA of Plateaus State, Nigeria was examined using average nearest neighbour spatial statistical tool within the ArcGIS 10.2. This was used to analyse whether the distribution of the health facilities in this area is clustered, random or dispersed. Average nearest neighbour index is the ratio of the observed mean distance between each feature (health facilities) centroid and its nearest neighbour's centroid location to the expected mean distance of the null hypothetical random distribution with the same number of features covering the same total area. If the index is less than one, the pattern exhibits clustering; if the index is greater than one, the features are considered

dispersed (Environmental Systems Research Institute (ESRI), 2016; Hazrin *et al.*, 2013).

In order to effectively and efficiently analyse the physical accessibility and health service coverage, a variable-radius measure was used in this study in line with NFNDP (1981-1985) recommendations for different categories of health facilities ranging from hospitals, health centres, clinics to health posts/dispensaries. The variable-radius measure defines a healthcare service radius based on the facility's characteristics and characteristics of the local population as well as the land area. Radii of 15, 3, 2 and 1 km were adopted for Hospital (secondary health facility), health centres, clinics and health posts respectively. Buffering analysis was performed to measure proximity (coverage) of the residents to the health facilities while network analysis was done to identify the most efficient routes or paths to only referral secondary health facility found in the area. This involves finding the shortest routes from different regions of the LGA to the facility. The main goal is to proffer solution to the problem of geographical accessibility from all the wards of Jos South LGA with respect to referral cases from lower level of health facilities in those political wards. All the analyses were carried out using ArcGIS 10.2.

Discussion of Results

Public Health Facilities in Jos South LGA

A total number of forty (40) public health facilities were identified in Jos South LGA, this comprises of thirty-eight (38) functional and two (2) non-functional. From the tertiary health facility identified, there was only one (1) secondary health facility (Hospital) which is located at Dadin-Kowa in Dashonong ward, while the remaining 39 were primary health centre, consisting of two (2) health centres (Model Primary Healthcare Centres), fifteen (15) Health Clinics (Maternities and Basic Health Centres) and twenty-two (22) are Health Posts/Dispensaries (Table 1).

Table 1: Public Health Facilities in Jos South LGA

S/N	Name/Address	Category	Type	Ward
1	PHC, Bukuru Central	Health Centre	Primary	Bukuru
2	PHC, Heita	Health Post	Primary	Chugwi
3	PHC, Chugwi	Clinic	Primary	Chugwi
4	PHC, Du	Clinic	Primary	Du 'A'
5	PHC, Guratop	Clinic	Primary	Du 'B'
6	PHC, Rayfield	Clinic	Primary	Du 'B'
7	PHC, Kwang	Health Post	Primary	Du 'B'
8	PHC, Doi	Health Post	Primary	Du 'B'
9	PHC, Giring	Health Post	Primary	Giring
10	PHC, Gyel	Health Post	Primary	Gyel 'A'
11	PHC, Bukuru Express	Health Centre	Primary	Gyel 'A'
12	PHC, Nyango	Clinic	Primary	Gyel 'B'
13	Dadin-Kowa Hospital	Hospital	Secondary	Dashonong
14	PHC, Rantya	Health Post	Primary	Gyel 'B'
15	PHC, State Low Cost	Health Post	Primary	Gyel 'B'
16	PHC, Hwolshe	Clinic	Primary	Hwolshe
17	PHC, Dabwak	Clinic	Primary	Kuru 'A'
18	Govt Comp Training Clinic, Trade Centre	Clinic	Primary	Kuru 'A'
19	PHC, Kushe	Clinic	Primary	Kushe
20	PHC, Shen	Clinic	Primary	Shen
21	PHC, Kazong	Health Post	Primary	Shen
22	PHC, Waduruku	Health Post	Primary	Shen
23	PHC, Sot	Clinic	Primary	Sot
24	PHC, Gura Ryom	Clinic	Primary	Sot
25	PHC, Gatong (Gero)	Health Post	Primary	Tanchol
26	PHC, Tahel (Tanchol)	Health Post	Primary	Tanchol
27	PHC, Vom Vet	Health Post	Primary	Turu 'A'
28	PHC, Dahwolalua	Health Post	Primary	Turu 'B'
29	PHC, Farin-Lamba	Health Post	Primary	Turu 'B'
30	PHC, Chaha	Health Post	Primary	Vwang
31	PHC, Vom-Vwang	Clinic	Primary	Vwang
32	PHC, Fwil	Health Post	Primary	Vwang
33	PHC, Kogom	Health Post	Primary	Vwang
34	PHC, Chakarum	Health Post	Primary	Vwang
35	PHC, Zawan	Health Post	Primary	Zawan 'A'
36	PHC, Kwata-Zawon	Health Post	Primary	Zawang 'A'
37	PHC, Lo-Dung	Health Post	Primary	Zawang 'A'
38	PHC, Dura	Clinic	Primary	Du 'B'
39	PHC, Gakok	Clinic	Primary	Chugwi
40	PHC, GSST Kuru	Health Post	Primary	Kuru 'A'

Locational Distribution of Public Healthcare Facilities

The ArcGIS spatial analyst was used to assess the geographical location and distribution of public healthcare facilities in Jos South LGA. This was carried out in the ArcGIS environment using the created geodatabase.

Secondary Health Facility

Figure 3 shows the location of the secondary health facility. Only one secondary public health facility is located at Dadin-Kowa in Dashonong ward. This implies that the facility is not centrally located within the LGA, as it is closer to the northern part. However, the location of the facility may be justified, considering population density. On the other hand, the location of this facility can consequently hinder physical access from the wards in the south as a result of time and travel distance to access the facility.

Primary Health Facilities

The primary health facilities identified are classified as health centres, clinics and health posts/dispensaries. The GIS maps clearly show the discrepancy between the distribution and the location of these health facilities. The findings identified two health centres in Jos South LGA namely Bukuru Central and Bukuru Express Primary Health

Centres located in Bukuru and Gyel 'A' wards respectively as shown in Figures 4 -6. The result shows that the facilities are located close to the northern part of the LGA as well close to each other.

Fifteen clinics were identified which are distributed across ten political wards in the LGA. They constitute about 37.5% of the total public health facilities (Figure 5). The result shows that the identified clinics are not geographically equitably distributed, leaving some wards without clinics and where available are poorly covered.

The findings further revealed that twenty-two Health Posts were available and this constitutes about 55% of the total number of public health facilities in Jos South LGA. They are distributed across thirteen out of twenty political wards of the LGA but having one not functional which is located in the Tanchol ward (Figure 6). The further findings discovered that the health posts are not equitably and sufficiently distributed, leaving some wards without health posts and where available, are poorly covered indicating that the number of health post in the study area greatly fall below the recommendation given by NFNDP (1981-1985) framework.

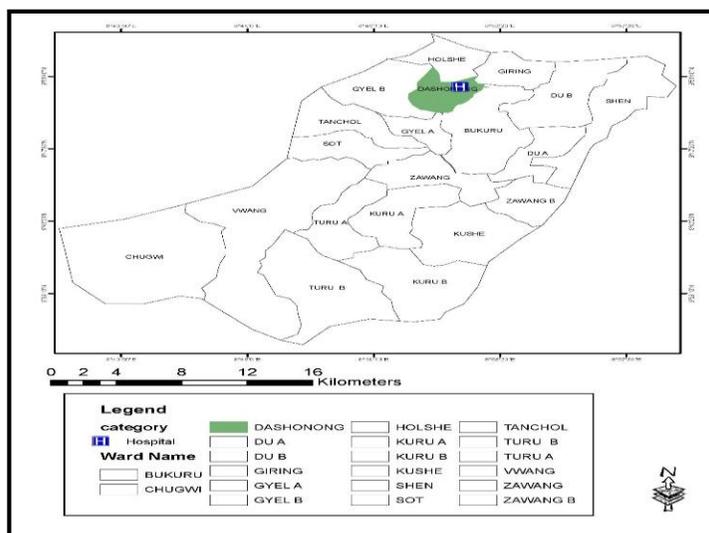


Figure 3: Geographical location of secondary health facility in Jos South LGA

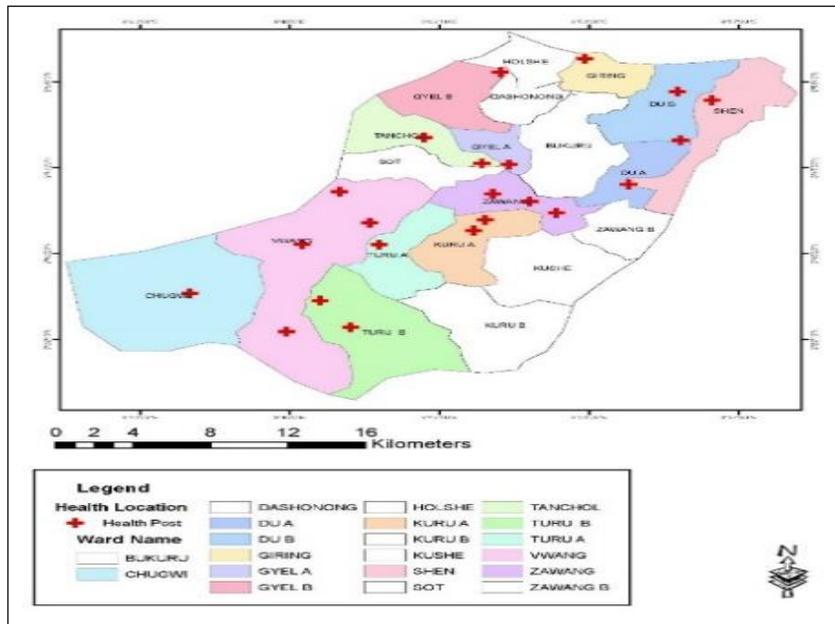


Figure 6: Locational distributions of Health Posts in Jos South LGA

Spatial Pattern of Public Health Facilities

The result of the spatial distribution pattern of all public health facilities (Figure 4) based on the type or level within the Jos South LGA using average nearest neighbour analysis.

The finding showed that the average nearest neighbour index for public health facilities was 1.240 ($p < 0.01$) indicating that the observed spatial pattern of the facilities was spatially dispersed as shown in Figure 7. The z-score was 2.906 ($p < 0.01$), the health facilities gave large z-score indicated that there is a less than 1% likelihood that this dispersed pattern could be the result of random chance.

Meanwhile, further study was carried out to examine the spatial distribution pattern of clinics and health posts as the results are shown in Figure 8. The findings showed that the average nearest neighbour index for clinics and health posts was 1.407 ($p < 0.01$) and 4.535 ($p < 0.001$) respectively, this clearly indicates that the observed spatial patterns for both clinics and health posts in the study area are dispersed as indicated in Figure 8.

The z-score for clinics was 3.02 ($p < 0.01$) while for health posts was 33.13 ($p < 0.001$), hence, the null hypothesis of no spatial pattern among clinics and health posts in the study area was rejected, both clinics and health posts gave large z-score indicated that there is a less than 1% likelihood that this dispersed pattern could be the result of random chance.

Range of Service of Public Health Facilities

The ease of access that people have to healthcare services is an important element of the quality of service they receive, and this includes the geographical location of health services. The distance that people travel for especially emergency care is very important. Thus, network and buffering analyses were employed to detect areas that are poorly or well served relative to the availability and accessibility to the identified public healthcare facilities. The road network analysis is based on the travelling distance to gain access to the nearest available public health facilities within the respective service area.

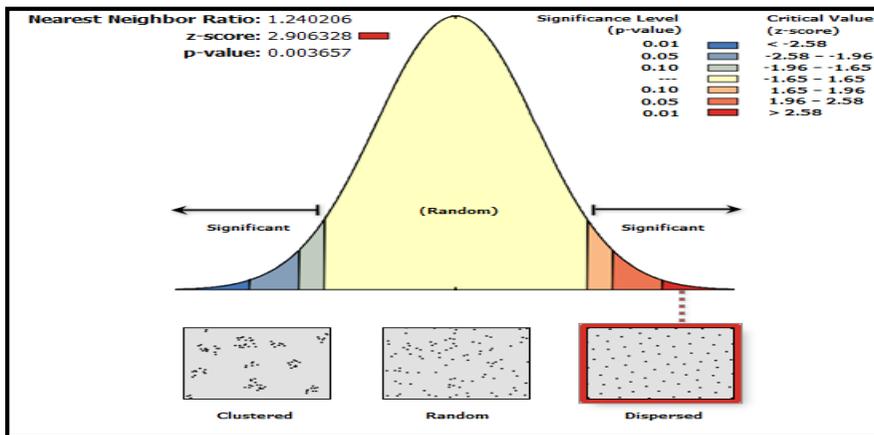


Figure 7: Average nearest neighbour result for Public Health Facilities

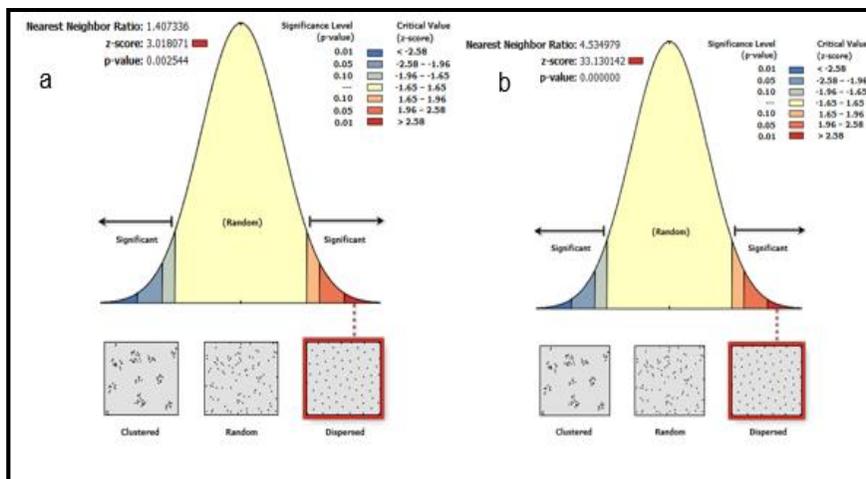


Figure 8 Average nearest neighbour result for (a) Clinics (b) Health posts

Radius of Service and Proximity

Investigating proximity to public health facilities, a buffer analysis was applied and a buffer zone with radii of 15, 3, 2 and 1 km were created around the hospital (secondary health facility), health centres, clinics and health posts respectively as shown in Figures 9 -12.

The finding showed that most wards in the north and central region of the study area are adequately covered within the 15-km catchment zone of the only secondary health facility (Hospital) meant for the entire local government area as shown in figure 6a. However, most wards in the south are located outside of the 15-km catchment zone; these wards fall outside the hospital radius of service are Chugwi, Turu ‘B’,

Kuru ‘B’, major parts of Vwang, Turu ‘A’, Kuru ‘A’ and Kushe, the finding reveals that complicated health issues as well as accident and emergency cases will find it very difficult to access this facility from the said region.

As observed, most wards except Bukuru and Gyel ‘A’ are without health centres in the study area, so most of these wards have no buffers belonging to health centres. The catchment zones of the two health centres found in the two wards overlap each other while some parts of those wards are not covered as shown in Figure 10. Likewise, most wards in the south and some in the north of the study area are poorly covered or under served by clinics with the 2-km service radius as shown in Figure 11. Figure

12 reveals that most wards are poorly covered or under served by health posts with the 1-km service radius. Generally, most wards from south of the study area were observed to have a low public healthcare accessibility. Therefore, additional public healthcare facilities need to be located within these areas.

Network Analysis

The secondary health facility's network service area covers entire Jos South LGA. The routes from different directions across the area to the Hospital are determined to reveal the shortest accessible distance. Spatial accessibility to the secondary health facility is shown in figure 7.

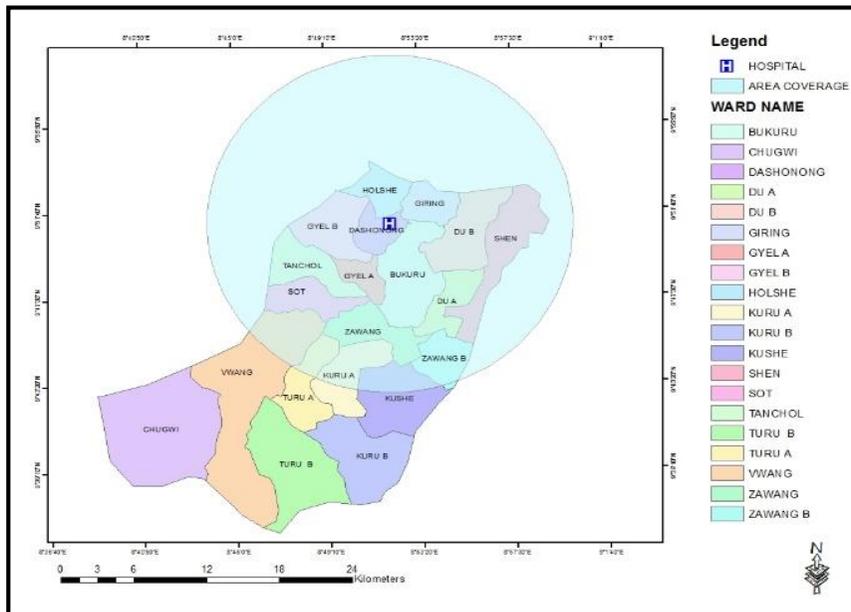


Figure 9: Service radius of Hospital

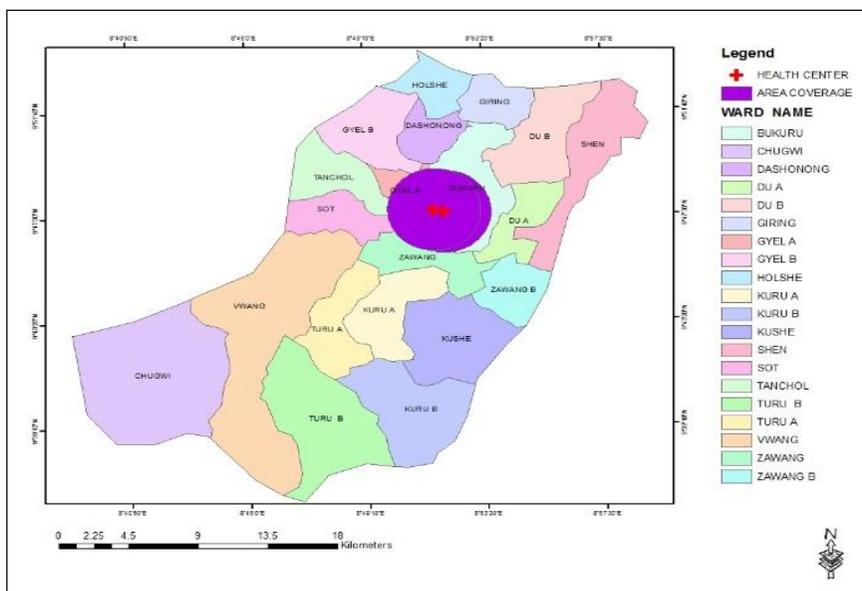


Figure 10: Service radius of Health Centres

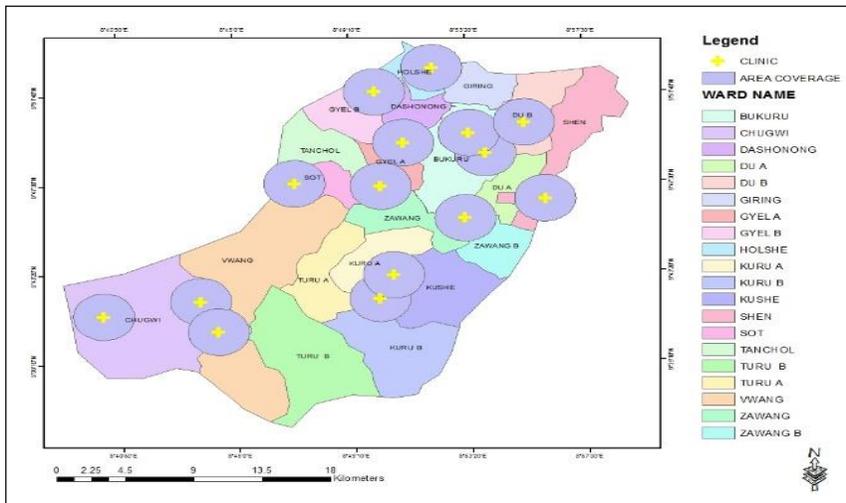


Figure 11: Service radius of Clinics

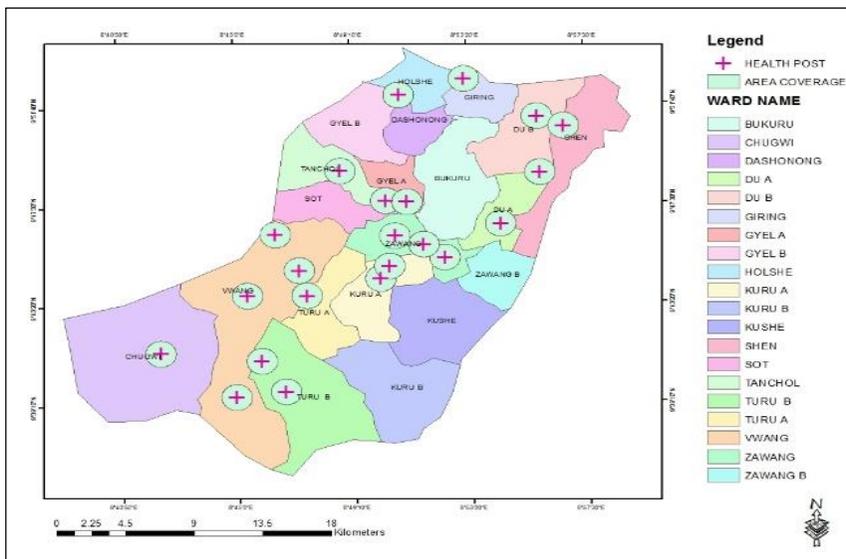


Figure 12: Service radius of Health Posts

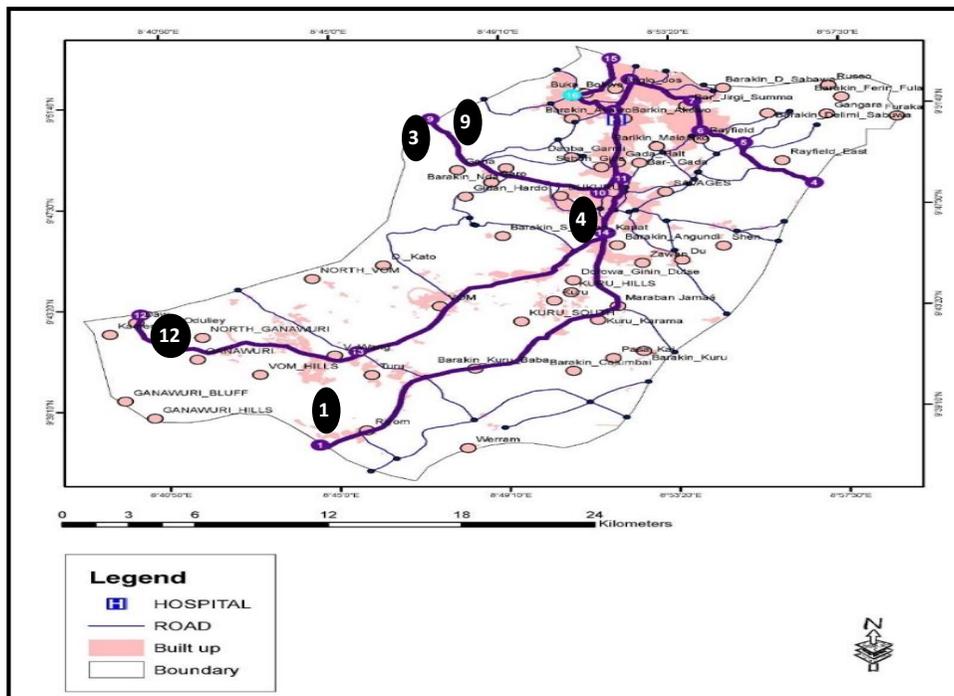


Figure 13: Network analysis for Hospital in Jos South LGA

The facility is located at Dadin-Kowa, Dashonong ward and depicted as ‘pick 3’ (Figure 13). The shortest accessible route from southern part of the LGA comprising Turu ‘B’, Kuru ‘B’ and part of Vwang (pick 1) wards to Dadin-Kowa (pick 3) was determined to cover the distance of 34.2 km routing through Fwil road, Dabwak road, Lo Dung Road, then Bukuru Road as seen in Figure 13. Similarly, the shortest accessible route from the south-western area comprising Chigwu and part of Vwang (pick 12) wards to Dadin-Kowa (pick 3) is 43.3 km routing through Gakok Helta road, Chugwi road, Vomvet road, Gctc Gsst kuru road, Kwata road, Bukuru Road then Bukuru Road. The shortest accessible route from north-east comprising Shen, Zawang ‘B’ Du ‘A’ and Du ‘B’ (pick 4) wards to Dadin-Kowa (pick 3) is 15.4 km routing through Guratopp Road 2, Doi Road, Rayfield Road 2, Rayfield Road, Giring Road, Hwoshe Road, then Bukuru Road. Lastly, the shortest accessible path from north-west comprising Sot, Tanchol and Gyel ‘B’ (pick 9) wards to Dadin-Kowa (pick 3) is 17.4 km routing through Gatong

Road, then Bukuru road as indicated in Figure 13.

The finding of this analysis validated that most of the distance of the shortest accessible route from the political wards located in the southern part is all beyond the 15 km service radius of only referral secondary health facility in Jos South LGA.

Planning Strategy on the Locational Distribution of Public Health Facilities

A planning strategy for the locational distribution of public health facilities in Jos South LGA was designed (Table 3) based on the findings of this study to give a roadmap for the establishment of new public health facilities by suggesting appropriate locations to enhance accessibility and effectiveness of healthcare delivery towards improving the health being of the people of the area. The outline of the strategy is given in Table 3 which shows the number of existing facilities in each ward, the number of expected facilities to be provided according to NPHCDA (2013) and also the number of facilities required to meet up with the expected. For instance, Du ‘A’ has only

one existing clinic, whereas one health centre, two clinics and four health posts are expected to be located in this ward; therefore, one health centre, additional one clinic and four health posts are required to be added to the existing facilities. Meanwhile, if there an excess in the number of lower level of health facilities, such facility can be upgraded to a higher level so as to meet the requirement of category like the case of Kushe, the clinic can be upgraded to health centre being of higher rank and required.

The plan can be a very useful strategy to assist stakeholders, authorities and other interested Non-governmental organisation in the planning of health service delivery and also serve as a reference guide for future actions and decisions. The plan can be a very useful strategy to assist stakeholders, authorities and other interested Non-governmental organisation in the planning of health service delivery and also serve as a reference guide for future actions and decisions.

Table 3 Proposed locational distribution of public health facilities in Jos South LGA

S/N	Ward	Available/Existing				Expected				Required			
		Hospital	Health centre	Clinic	Health post	Hospital	Health centre	Clinic	Health post	Hospital	Health centre	Clinic	Health post
1	Bukuru	0	+1	0	0	0	+1	+4	+8	0	0	+4	+8
2	Chugwi	0	0	+2	+1	0	+1	+1	+2	0	+1	+1	+1
3	Dashong	+1	0	0	0	0	+1	+2	+4	0	+1	+2	+4
4	Du 'A'	0	0	+1	0	0	+1	+2	+4	0	+1	+1	+4
5	Du 'B'	0	0	+2	+3	0	+1	+1	+2	0	+1	-1	+1
6	Giring	0	0	+1	0	0	+1	+2	+4	0	+1	+1	+4
7	Gyel 'A'	0	+1	0	+1	0	+1	+1	+2	0	0	+1	+1
8	Gyel 'B'	0	0	+1	+2	0	+1	+1	+1	0	+1	0	-1
9	Hwolshe	0	0	+1	0	0	+1	+2	+4	0	+1	+1	+4
10	Kuru 'A'	0	0	+1	+2	0	+1	+1	+2	0	+1	0	0
11	Kuru 'B'	0	0	0	0	0	+1	+1	+2	0	+1	+1	+2
12	Kushe	0	0	+1	0	0	+1	0	+2	0	+1	-1	+2
13	Shen	0	0	+1	+2	0	+1	0	+2	0	+1	-1	0
14	Sot	0	0	+2	0	0	+1	+1	+2	0	+1	-1	+2
15	Tanchol	0	0	+1	+1	0	+1	0	+2	0	+1	-1	+1
16	Turu 'A'	0	0	0	+1	+1	+1	+1	+2	+1	+1	+1	+1
17	Turu 'B'	0	0	0	+2	0	+1	+1	+2	0	+1	+1	0
18	Vwang	0	0	+1	+4	0	+1	+1	+2	0	+1	0	-2
19	Zawang 'A'	0	0	0	+3	0	+1	+1	+2	0	+1	+1	+2
20	Zawang 'B'	0	0	0	0	0	+1	0	+2	0	+1	0	+2
Total	Jos South LGA	+1	+2	+15	+22	+2	+20	+23	+53	+1	+18	+10	+36

Conclusion and Recommendations

This study has documented the distribution patterns and assesses the range of service of public health care in Jos South Local Government Area (LGA) of Plateau State, Nigeria with respect to their locational distribution using Geographic Information

System (GIS). The results showed total number public healthcare facilities available in the Jos South LGA area. The study identified a total number of forty (40) public primary health care centre; comprising of one secondary and thirty-nine primary health facilities. The analysis revealed that

the health facilities across Jos South are not dispersedly distributed, this is owing to the nature of the areas. This study has identified the deprivation in public health care facilities in the area: one (1) additional hospital; eighteen (18) healthcare centres; ten (10) clinic and thirty-six health post are required for even distribution of health care facilities in Jos South Local Government Area. A sustainable strategic plan to guide the distribution and location of health care facility should be given a serious attention, as this shall assist different stakeholders in health sector, as well as the authorities and other interested Non-governmental organisations in the planning of health service delivery.

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