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# Analysis of Spatio-Physical Accessibility of Healthcare Facilities in Nangere Local Government Area of Yobe State, Nigeria

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***Abstract:***
*Accessibility to healthcare facilities has been identified as a major indicator of development. Improving health services is a crucial issue and an immense challenge for the government of any third world country. The paper analyzed the spatio-physical accessibility of healthcare facilities in Nangere local government of Yobe state. Record on the number of healthcare facilities (HCFs) from the Ministry of Health was obtained. Global Positioning System (GPS) receiver was used to obtain geographic coordinates of the HCFs and human settlement. Spider diagram algorithm and ring buffer technique was used to determine the spatio-physical accessibility distance and travel time from designated settlement (ward) to the various physical healthcare facilities. This analysis was applied to settlement in the research area, allowing geographical access to be linked to people. Six queries were run to identify areas that are not within WHO range, the queries include 1000m buffer query, 2000m buffer query, 3000m buffer query, 4000m buffer query, 5000m buffer query and above 5000m buffer query in each ward to check accessibility of the residents. The queries were run using SQL on each buffer set around the health facilities in order to identify the settlements fall within each buffer query. The result further indicated that the minimum distance from the settlement to the nearest facility in each ward was 0.107km while the maximum distance was 12.829km. The settlements that fall above 5000m buffer query had the highest minimum converted travel time on foot of 51.1 minutes while those that fall within a buffer query of 1000m had the least minimum converted travel time on foot while the settlements that fall above 5000m buffer query had the highest maximum converted travel time on foot of 51.1 minutes while those that fall within a buffer query of 1000m had the least minimum converted travel time on foot of 1.4 minute to reach health facility. The study concluded that the wards in the study area have physical access to HCFs but lack of good roads and transport facilities especially in the rainy season and travel time.*

***Keywords:*** *Nangere, Spider diagram, spatio-physical, accessibility, healthcare*

## 1. Introduction

Healthcare is a significant indicator of social development. Access to facilities is an important component in the overall healthcare system and has a direct impact on the burden of disease that encumbers health conditions in many developing countries. Therefore, measuring access to healthcare facilities contributes to a wider understanding of health systems' performance within and between countries and facilitates the development of evidence-based health policies (Mainardi 2007). It is a fundamental human right to have access to health care services when needed. It is desirable for a government to ensure high quality provision and equal and easy access to fundamental health care services to all citizens. Varying spatial distribution of the population, health care facilities and transportation infrastructure in an area often lead to spatial variations in accessibility to health care facilities, which in turn will result in disadvantaged locations and communities having poor spatial accessibility to needed health care facilities.

In many health care systems, adequate, equitable and easy access to health care facilities is often considered one of the main objectives (Powell & Exworthy, 2003). To ensure equal and easy access it is essential to ensure that the population, health care facilities and the transportation infrastructure are positioned in a manner that facilitates high spatial accessibility. Accessibility to healthcare is the ability of a population to obtain a specified set of health care services. In this context, geographic accessibility is often referred to as spatial or physical accessibility (Halden et al. 2000). Physical accessibility addresses the complex relationship between the distribution of the population and the supply of healthcare facilities (Ebener et al. 2005). A health care facility is defined as all units owned by public and private authorities as well as voluntary organizations and which provides health care services, hospitals, and health and maternity centers.

Consequently, Onokerhoroye (1999) defined health care facility as all units owned by public and private authorities as well as voluntary organizations and which provides health care services including hospitals, health and maternity centers. Healthy population and access to healthcare services are significant factors influencing economic development and

prosperity. Thus, accessibility to healthcare facilities has generally been identified as a major indicator of development, and the existing spatial pattern of distribution of healthcare facilities play very prominent role in gauging the level of efficiency or otherwise of the existing level of provision of these facilities within any region (Sanni, 2010). Accessibility to Health Care is a multi-dimensional concept and can be defined as the ability of a population to access healthcare services. It varies across space because neither health professionals nor residents are uniformly distributed (Lou & Wang, 2003).

Nangere local government area is domiciled in Yobe state, North-east geopolitical zone of Nigeria and has its headquarters in the town of Sabon Gari Nangere located between 11°51'50''N 11°04'11''E/ 11.86389°N 11.06972°E. The local government area has an estimated population of 119,694 persons spread over a geographical area of 1,183km$^2$. It is bounded by the following local government areas; to the north by Jakusko, to the east Fune, to the west Dambam local government area of Bauchi state, to the south Potiskum, to the south/east Fika. The local government area has a total of 11Wards. There is a total of 461 villages in Nangere local government area. In Yobe State, like in every other State in Nigeria, the general hospitals which are avenues for healthcare delivery are located very far away in the local government headquarters.

Consequently, the primary healthcare (PHC) that is available for the inhabitants are disgusting, ill-equipped and under-staffed. The primary healthcare services in Nangere local government area are under severe economic constraints with insufficient manpower resources to meet the healthcare needs of the inhabitants. It is interesting to note that most communities in Nangere local government area live in scattered farmsteads, hamlets and village settlements. Most of these communities are cut-off from the basic service centers by lack of good roads or transport facilities especially in the rainy season.Considering the landmass of Nangere local government which is (1,183km$^2$) and its dynamic population with an ever-increasing demand for health care services; it is important to analyze how health care facilities are spatially distributed to meet the demand of growing population and their physical accessibility.

**2. Research Methodology**

Physical accessibility is termed as a measurement of opportunities available to people in a geographical region, the primary concern of this study is to determine the spatio-physical accessibility of healthcare facilities in Nangere local government area. Access to healthcare services denotes people's abilityto employ available facilities at the time of need.

A reconnaissance survey is carried out to identify the healthcare facilities and get a better picture of the study area. The visit assists the researcher to get acquainted with the research problem under investigation. In addition, one will be able to interact with some residents in the study area whereupon some spot assessments will be made regarding the healthcare facilities in the study area. The geographic coordinates of the HCFs is obtained from the field survey using the Global Positioning System (GPS) Garmin GPS map 76CS receiver.

Checklist is used to obtain the attribute data of identified healthcare facilities from the various health facilities. The political map of Nangere LGA is obtained from Nangere LGA Secretariat.

The administrative map of the study area is scanned and imported into ArcGIS 10.5 software for geo-referencing. Geo-referencing will relate space object or raster object that has not been tied to any geographic reference to a coordinate reference system. There by allowing various independent GIS datasets to be brought together as overlay of geographic information.

The geo-referenced map is digitized on-screen under the following themes: The Local government area and the political wards as polygons, LGA and wards boundary, spider networks as lines.

Attribute data are acquired data resources often organized in a database format, usually in tabular form and stored in a database management system. All attribute data for the healthcare facilities are obtain from various healthcare management established using checklist, is typed in Microsoft excel and saved as CSV (format for analysis).

The WHO (1997) recommended standard for locating primary healthcare facilities in developing countries which proposed that the maximum distance people should travel to access primary healthcare facilities should not be more than 5km or 30 minutes' walk along the existing roads will be adopted as a criterion for determining the spatial accessibility of the health care facilities in the study area. A point layer representing settlements with a field in its attribute table giving the distance from each settlement to its nearest or linked facility, this distance can be treated as a continuous variable, to compare averages between facilities or settlements grouped by certain characteristics. Alternatively, threshold distance of 5km is adopted as WHO standard to access health facilities.

**3. Results and Discussion**

The spatio-physical accessibility of healthcare facilities in Nangere local government area was determined using spider diagram algorithm in ArcGIS 10.5 software interface. Spatio-physical accessibility can be assessed by either measuring the distance from residence to the Health Care facility (linear distance or road distance) or by estimating travel time. Some studies have shown that one of the main factors that determines how likely an eligible individual is to utilize a health service is their geographic proximity to a health facility (Al-Taiar et al. 2010, Yao et al. 2012). Therefore, a potential indicator for health service spatio-physical accessibility could be the distance in a straight-line between a population settlement and a linked health facility. It is often convenient to define this linkage in terms of distance, so that a settlement is linked to whichever health facility is nearest to it in a straight line. Analyses performed in this section were based on the measurement of the spatio-physical accessibility of people residing within the boundaries of the LGA to the Health Care facilities.

Spatio-physical accessibility analysis rest upon the spatial relationship between the centers of settlement and Health Care facilities, the linkage is mapped visually using Spider-diagrams, at the center of each 'spider' is a point representing a health facility, while the 'legs' represent the shortest distance from the facility to its linked settlements. These diagrams are useful visual tools as it is easy to identify long lines which represent settlements with low access. The coordinates of villages in various political ward was exported from excel to create the spider diagram algorithm showing the accessibility of HealthCare facilities in the area as shown in figure 1, however, the distance variable was exported to a spreadsheet and analyzed using non-spatial analysis techniques.

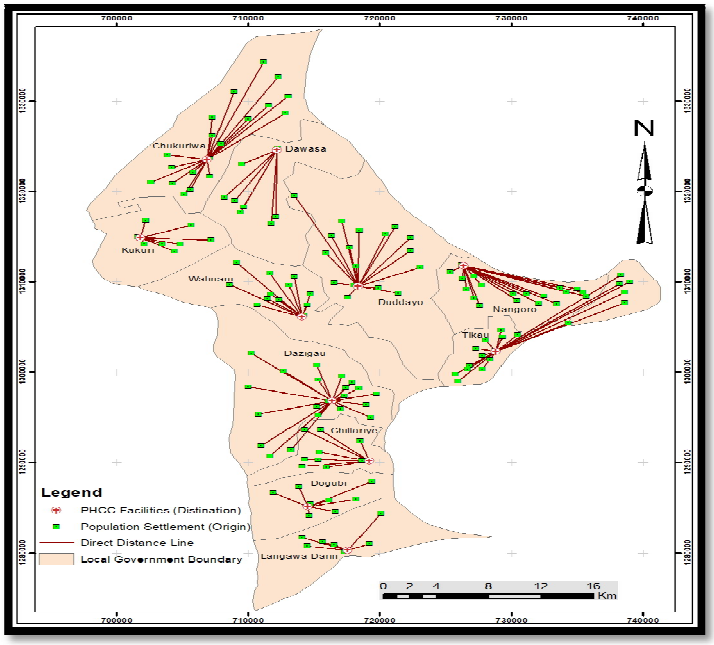


*Figure 1: Spider Graph Map Representing the Straight-Line Distances from Population Settlements to Primary Health Facilities in Every Ward*
*Source: Author's Analysis, 2020*

It could be seen from Figure 1 the various PHCC across the entire 11 geopolitical wards serve as the center of the spider while the legs represent the shortest distance from the facility to its linked settlements, the results obtained helped in identifying the areas that are easily accessible in terms of healthcare facilities within the standard distance recommended by WHO using ring buffer analysis. According to World Health Organization (1997), healthcare facility should not be more than 5km from residential areas and should be of distance not more than 20m from the major road. Ring buffer zones of 1000m, 2000m, 3000, 4000m, 5000m and above 5000m were built around all the PHCC in order to identify the settlements that fall within the buffers build.

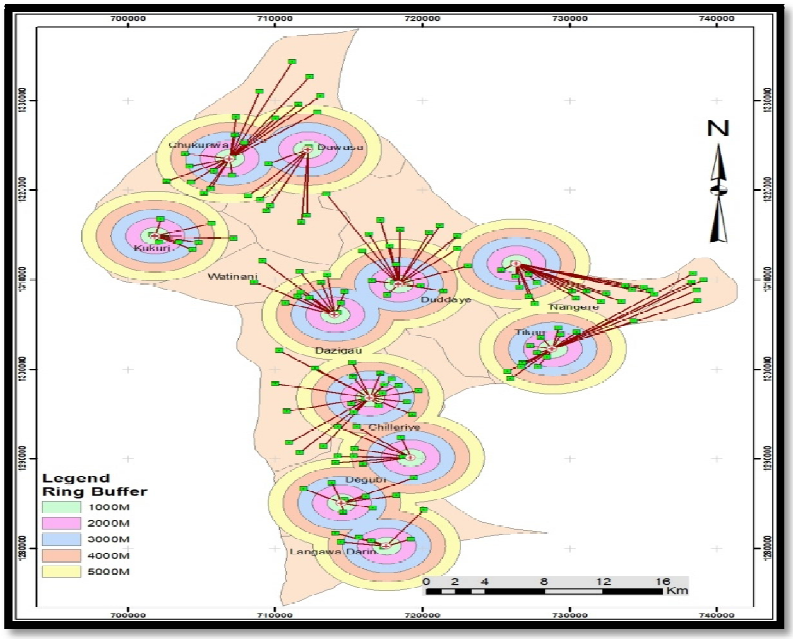


*Figure 2: Population Settlement Within 1000m, 2000m, 3000m, 4000m, and 5000m Radius of the PHCC*
*Source: Author's Analysis, 2020*

The 1000m, 2000m, 3000m, 4000m, and 5000m radius buffer show the settlements that are within the WHO standard of 5000m distance to access healthcare facility.

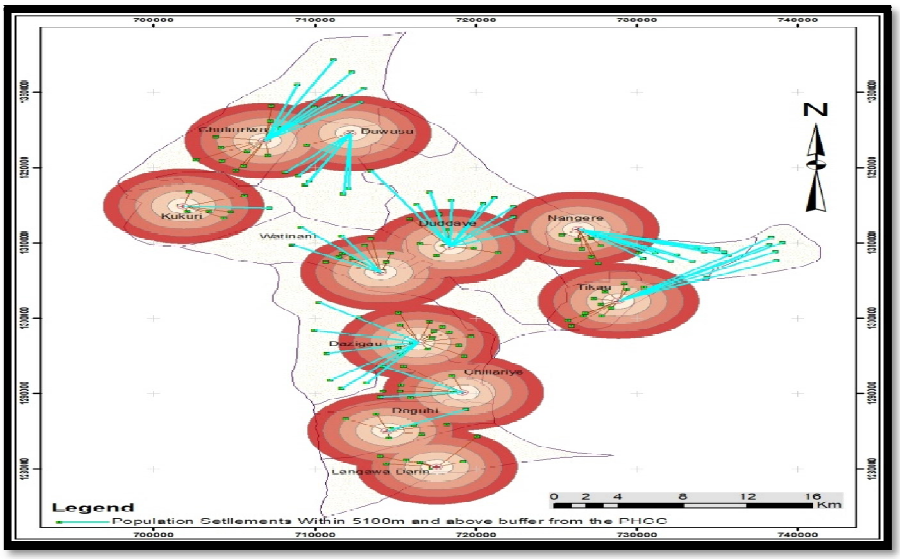


*Figure 3: Population Settlement within 5000m and Above Radius of the PHCC*
*Source: Author's Analysis, 2020*

Figure 3 show the settlements that did not fall within the WHO standard, this means that households within those areas have to travel farther to access a healthcare facility. Hence, all these variations in terms of spatial accessibility to healthcare facilities in those locations might have restricted movement in the deprived areas due to the frictional effect of distance as the public transport is very difficult to find. Six queries were run to identify areas that are not within WHO range, the queries include 1000m buffer query, 2000m buffer query, 3000m buffer query, 4000m buffer query, 5000m buffer query and above 5000m buffer query in each ward to check accessibility of the residents. Areas outside 5000m buffer zone indicate areas that find difficulty accessing the healthcare facility which also connotes that the facilities are not adequate for the population. The queries were run using SQL on each buffer set around the health facilities in order to identify the settlements fall within each buffer query as shown in figure 4.

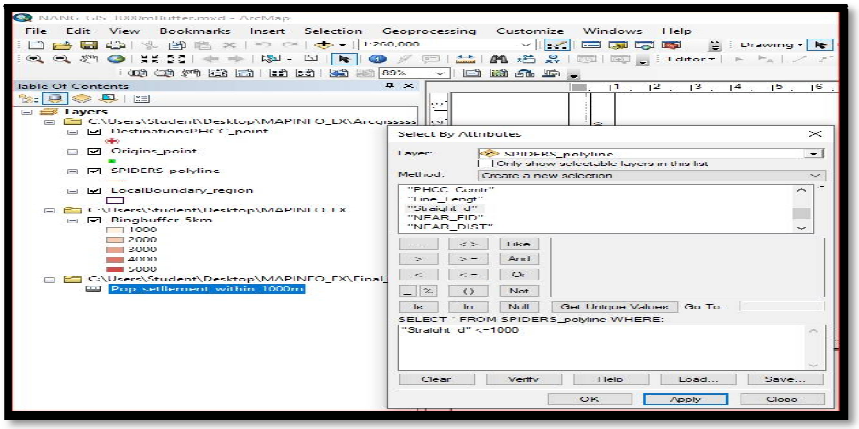


*Figure 4: SQL Function Used for Query (1000m Buffer)*

Same SQL query were run on 2000m, 3000m, 4000m, 5000m and above which help in obtaining Population Settlement within the various radius of the PHCC. The straight-line distances from the settlement to the healthcare facilities were obtained from the query result which was then subjected to non-spatial analysis in order to obtain the minimum, maximum, average and count. The results in Table 1 shows the query, the minimum, the maximum, the count and the average distances covered along the straight line to access the nearest healthcare facilities.

| Query (m) | Minimum Distance to the Nearest Facilities (M) | Minimum Distance to the Nearest Facilities (Km) | Maximum Distance to the Nearest Facilities (M) | Maximum Distance to the Nearest Facilities (Km) | Average Distance to the Nearest Facilities (M) | Average Distance to the Nearest Facilities (Km) | Count |
|---|---|---|---|---|---|---|---|
| 1000 Buffer | 107 | 0.107 | 975 | 0.975 | 372.462 | 0.372 | 13 |
| 2000 Buffer | 1015 | 1.015 | 1990 | 1.990 | 1547.640 | 1.548 | 25 |
| 3000 Buffer | 2095 | 2.095 | 2984 | 2.984 | 2521.591 | 2.522 | 22 |
| 4000 Buffer | 3025 | 3.025 | 3980 | 3.980 | 3505.476 | 3.505 | 21 |
| 5000 Buffer | 4081 | 4.081 | 4961 | 4.961 | 4562.786 | 4.563 | 14 |
| Above 5000 Buffer | 5117 | 5.117 | 12829 | 12.829 | 7709.078 | 7.709 | 51 |

*Table 1: Minimum, Maximum, and Average Distance to the Nearest Facilities*
*Source: Author's Analysis, 2020*

From table 1 it's clear that the minimum distance to the nearest facilities in 1000m buffer query was 107m (0.107km), the maximum distance to the nearest facilities was 975m (o.975km), the average distance to the nearest facilities was 372.462m (0.372km) and the count was 13 villages. The minimum distance to the nearest facilities in 2000m buffer query was 1015m (1.015km), the maximum distance to the nearest facilities was 1990m (1.990km), the average distance was 1547.640m (1.548km) and the count was 25 villages. The minimum distance to the nearest facilities in 3000m buffer query was 2095m (2.095km), the maximum distance to the nearest facilities was 2984m (2.984km), the average distance was 2521.591m (2.522km) and the count was 22 villages. The minimum distance to the nearest facilities in 4000m buffer query was 3025m (3.025km), the maximum distance to the nearest facilities was 3980m (3.980km), the average distance was 3505.476m (3.505km) and the count was 21 villages. The minimum distance to the nearest facilities in 5000m buffer query was 4081m (4.081km), the maximum distance to the nearest facilities was 4961m (4.961km), the average distance was 4562.786m (4.563km) and the count was 14 villages. The minimum distance to the nearest facilities above 5000m buffer query was 5117m (5.117km), the maximum distance to the nearest facilities was 12829m (12.829km), the average distance was 7709.078m (7.709km) and the count was 51 villages.
The above table shows the minimum, maximum, and averages of the 146 villages across the 11 geopolitical wards of Nangere local government. According to Quetelet 2013, an average person's walking speed per 10 minutes is 1000m (1km), the minimum and maximum distance from all the queries is converted to travel time (minutes) on foot based on the speed of the average person (i.e. 1km per minutes) and was plotted using line chart.

Figure 5 indicates the minimum distance from settlement to the nearest facility in kilometers (km),so the 1000m to 5000m and above minimum distance along straight line was 0.107km, 1.015km, 2.095km, 3.025km, 4.081km and 5.117km respectively. This shows that settlements that fall above 5000m buffer query had a greatest minimum distance from the nearest health facility with a minimum distance of 5.117km to the nearest facility and those that fall within a buffer zone of 1000m had a least distance from the nearest health facility with a minimum distance of 0.107km to the nearest facility.

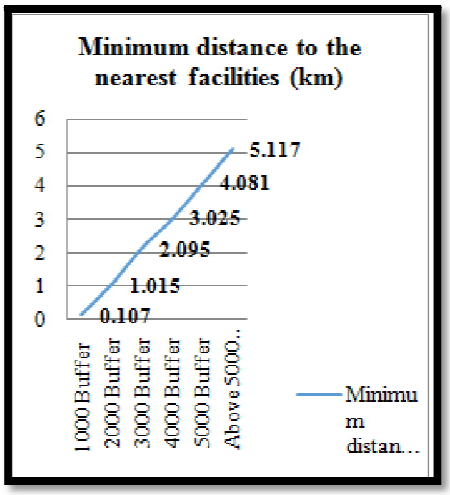


*Figure 5: Minimum Travel Time on Foot*
*Source: Author's Analysis, 2020*

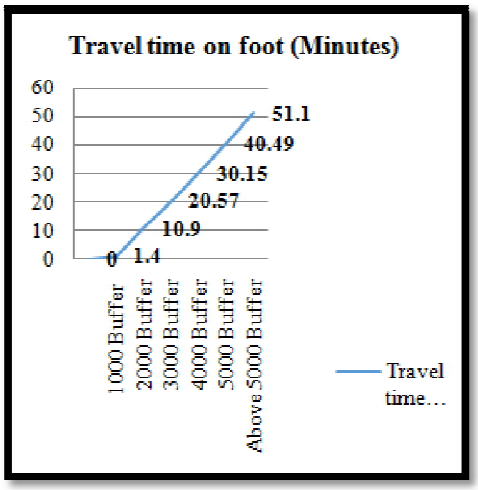


*Figure 6: Minimum Distance to the Nearest Facilities*
*Source: Author's Analysis, 2020*

Figure 6 show the query and converted minimum travel time on foot in minutes based on the straight-line distance to the nearest healthcare facility, so the 1000m to 5000m and above query had the minimum travel time on foot of 1.4 minutes, 10.9 minutes, 20.57 minutes, 30.15 minutes, 40.49 minute and 51.1 minutes respectively. This shows that settlements that fall above 5000m buffer query had the highest maximum converted travel time on foot of 51.1 minutes while those that fall within a buffer query of 1000m had the least minimum converted travel time on foot of 1.4 minute to reach health facility.

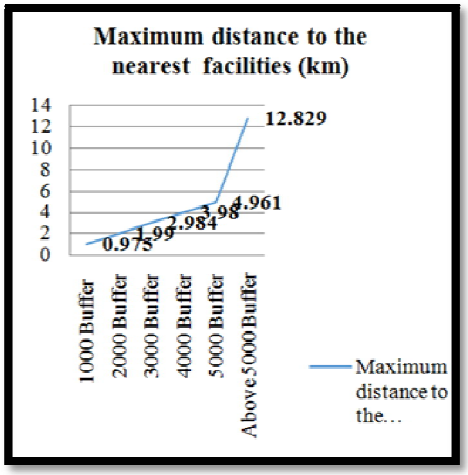


*Figure 7: Maximum Distance to the Nearest Facilities*
*Source: Author's Analysis, 2020*

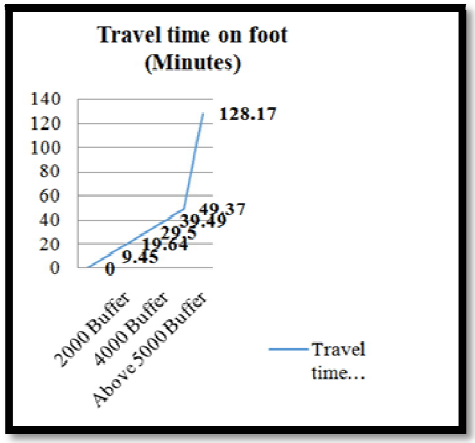


*Figure 8: Maximum Travel Time on Foot*
*Source: Author's Analysis, 2020*

Figure 7 indicates the maximum distance from settlement to the nearest facility in kilometers (km), so the 1000m to 5000m and above query had minimum distance along straight line was 0.975km, 1.99km, 2.984km, 3.98km, 4.961km

and 12.829km respectively. The settlement that fall above 5000m buffer query had a greatest maximum distance from the nearest health facility with a maximum distance of 12.829km to the nearest facility and those that fall within a buffer query of 1000m had the least maximum distance of 0,975km to nearest facility. Figure 8 show the query and converted maximum travel time on foot in minutes based on the straight-line distance to the nearest healthcare facility, so the 1000m to 5000m and above buffer query had the maximum travel time on foot of 9.45 minutes, 19.64 minutes, 29.5 minutes, 39.49 minutes, 49.37 minute and 128.17 minutes respectively. This shows that settlements that fall above 5000m buffer query had the highest maximum converted travel time on foot of 128.17 minutes while those that fall within a buffer query of 1000m had the least minimum converted travel time on foot of 9.45 minute to reach health facility.

**4. Conclusions**

This study on the spatio-physical accessibility of healthcare facilities in Nangere local government area would certainly facilitate policy development at the national level. In our study we have described and demonstrated using spider diagram algorithm in ArcGIS 10.5 software interfaces how spatio-physical accessibility can provide the framework for further research in the field. The aim of the Yobe state government is to ensure health services for all at a reasonable cost and distance; provision of healthcare is one of its primary responsibilities. However, the current state of the health sector in Yobe state is not very favorable. To attain the government's goal, the current accessibility to health facilities must be understood. Although this study is based only on Nangere LGA, we believe it can be replicated throughout the state and the country in general. Such a study would enable to identify precise locations where healthcare services need to be delivered to ensure optimum levelof outcome.

As stated in the introduction, accessibility has many dimensions. There can be a difference between actual and perceived accessibility, and it requires close monitoring. The physical accessibility results from this study could be compared with qualitative studies of the public perception of hospital accessibility. Our study shows that GIS can be used to assess accessibility over large networks. Greater emphasis is now being placed on the need to maintain geographical databases relating to such services. The idea of spider diagram algorithm and ring buffer considering human settlement distance and travel time could be replicated in many developing countries, where delivery of the meager healthcare services available for the population is severely impeded by lack of good planning and initiatives. Findings of our study will help address these shortcomings by providing useful information to policymakers to aid them in an effective decision-making process. This therefore calls for the concerted effort by the various stakeholders in the health sector towards the provision of Health Care facilities in order to improve access to the Health Care facilities by the people.

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