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

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ABSTRACT
Background: There is geographic variation in accessibility to health care facilities and areas where accessibility to health care facilities is low due to spatial differences in population distribution, transportation infrastructure, and distribution of health care facilities. The aim of this paper was to examine the spatio-physical accessibility to rural healthcare facilities in Nangere Local Government Area of Yobe State.
Materials and Methods: The research was conducted using stratified random sampling, with five (5) settlements chosen at random from each of the study political wards. The Data was collected using a structured questionnaire and Global positioning system (GPS). The questionnaires were administered by means of face-to-face method of data collection. The GPS (Garmin 76CSx) was used to record the geographic locations of the health facilities and 146 villages across the eleven (11) political wards. The geospatial data was analyzed in ArcGIS 10.8 version's environment. The questionnaires were sorted, coded, and processed using SPSS 22.0 software.
Results: The study findings revealed that the majority of the respondent's walks on foot to access health facility in their area; this is because the area lacks means of transportation, as government ban the use of motorcycles which are the area's primary mode of transportation. The physical usability was determined using the spider diagram algorithm and ring buffer technique. The minimum distance between the settlements and the nearest facility in each ward was 0.107 kilometers, while the maximum distance was 12.829 kilometers.
Conclusion: Even if the travel distance is just a few kilometers, the study concluded that spatial mobility can be low for residents who live in areas without sufficient transportation services.The study suggested that the Nangere Local Government increase overall accessibility to health care facilities by either enhancing public transit or relocating health care facilities according to the spatial and needs of the local population.
KEYWORDS: Nangere, spider diagram, spatial, healthcare

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I. INTRODUCTION

Having access to health care facilities when required is a basic human right. It is desirable for a government to ensure that all people have fair and convenient access to basic health care services of high quality. Spatial differences in accessibility to health care facilities are often caused by the spatial distribution of the population, health care facilities, and transportation infrastructure in a region, resulting in deprived areas and communities having poor spatial accessibility to required health care facilities. Access to health care services by local communities in a defined geographical area is adequate, equitable, and convenient is a critical issue of human service provision to the people who live there. It's also a difficult problem for policymakers (Luo& Wang, 2003; Burns &Inglis, 2007) and urban planners (Geertman&Ritsema, 1995; Hewko, 2001).

Healthcare is an important indicator of social growth. Access to services is an integral part of the overall healthcare system, and it has a significant effect on the disease burden that plagues many developed countries' health conditions. 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. A government should ensure the 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 inaccessibility 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 (Black et al., 2004). A health care facility is defined as all units owned by the public and private authorities as well as voluntary organizations and which provide health care services, hospitals, and health and maternity centers. Consequently, Onokerhoraye (1999) defined a health care facility as all units owned by the public and private authorities as well as voluntary organizations and which provide health care services including hospitals, health, and maternity centers.

A 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 a 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 (Wang, 2011).

Many people in Nigeria encounter a range of service delivery and health problems when they try to access healthcare, such problems range from drug stock-out to poor infection prevention practices to shortage of health staff and this can lead to unnecessary suffering by patients or in the worst cases, death. In Yobe State, like in every other State in Nigeria, the general hospitals which are avenues for healthcare delivery are mostly located in the local government headquarters, very far away from many rural areas and usually inaccessible to some settlements within the LGA. It is interesting to note that most people in Nangere Local Government live in scattered farmsteads, hamlets, and village settlements. Most of these local communities are cut off from the basic service centers by lack of good roads or transport facilities especially in the rainy season as most of the roads are paved roads. Considering the landmass of Nangere Local Government which is (980km².) and its dynamic population with an ever-increasing demand for health care services; it is important to analyze their physical accessibility to meet the demand of the growing population.

II. MATERIALS AND METHODS

The study was carried out using stratified random sampling; five (5) settlements were randomly selected from each of the 11political wards of the study area. Structured questionnaire and was used for data collection. The questionnaires were administered using the face-to-face method of data collection, as it is recommended to be the superior and reliable method for data collection. A total of fifty-five (55) questionnaires were used and administered to each of the selected settlements in the study area. The GPS (Garmin 76CSx) was used to record the geographic locations of the health facilities and 146 communities across the eleven (11) political ward of Nangere Local Government.

The Study Area:

The Nangere Local Government Area is located in Yobe State in Nigeria's North-East geopolitical region, with its headquarters in Sabon Garin Nangere. It's bordered on the north by Jakusko Local Government, on the east by Fune Local Government, on the west by the Dambam Local Government area of Bauchi state, on the south by Potiskum Local Government, and on the south/east by Fika Local Government. The population of the Local Government area is estimated to be 119,694 people, spread out over 980 km^2 (NPC, 2021). Nangere Local Government is situated between 11°51'50" and 12°00'00" north latitude and 10°50'00" and 11°04'11" east longitude of the Meridian (figure 1). In Nangere Local Government, there are approximately 416 villages. The study area has a total of eleven (11) geopolitical wards namely: Degubi, Langawa/Darin, Nangere, Pakarau, Tikau, Watinani, Chukuriwa, Dawasa, Dazigau, and Chilariye wards (INEC, 2019).

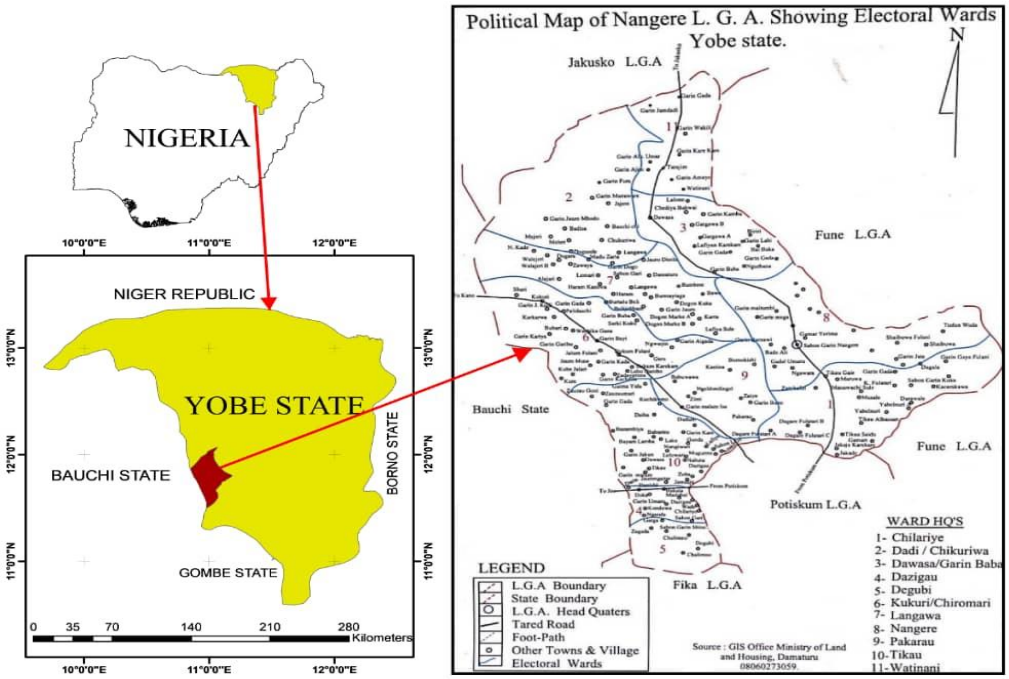

Figure 1: The Study Area
Source: GIS Department of Ministry of Land and Housing Damaturu (2021)

Method of Data Processing and Analysis:

The questionnaires were sorted, coded, and processed using SPSS 22.0 software. The administrative map of the study area was scanned and imported into ArcGIS 10.8 version software for geo-referencing. The geo-referenced map was digitized on-screen under the following themes: the political ward as polygon, LGA boundary as lines to depict the extent of the study area. The questionnaire data in this research was analyzed using descriptive statistics in SPSS 20.1 software, for physical accessibility of health care facilities (HCFs) from the surrounding settlements within each of the political wards, Spider graph tool of MapInfo was used to create desire-lines to connect the PHCC and the population settlements in the area, the polyline as a layer or the spider-diagram represents or stands for the direct routes from settlements to PHCC facility are created, this layer contained the distance field in its attribute table and this is required for the analysis. This technique was alternatively deemed fit because the area under study is typically a semi-urban locale that has no proper networks of tarred roads which preferably be used to apply network analysis to determine the physical accessibility of the HCFs from each of the settlement.

Spider diagram or desire-line have been traditionally used to study healthcare and other social facilities accessibility particularly in data poverty region, the coordinates of villages in the various political ward were exported from excel, multiple ring buffers of 1000m, 2000m, 3000m, 4000m, and 5000m were created over each of the PHCC in the study area as depicted. This choice was decided based on the benchmark standards of the World Health Organization (WHO, 1997), which ruled out 5km as mean accessibility, the varying spatial accessibility of the population settlements to the available PHCC of each ward was then determined using spatial and attributes query using structured query language known as structured query language (SQL) function tool of ArcGIS 10.8. The data from questionnaires administered were analyzed using SPSS 22.0 software and display the results as frequency and percentage.

Study Duration: January, 2021 to April, 2021.

III. RESULTS

Physical accessibility to rural health care facilities in Nangere Local Government Area using the questionnaires administered and analyzed using SPSS 22.0 software.

Which transportation mode did you use to reach Healthcare Facility?

Table 1. Means of Transportation to Healthcare Facility

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Walking on foot	20	36.4	36.4	36.4
	Pushcart	2	3.6	3.6	40.0
	Animal cart	17	30.9	30.9	70.9
	Keke-Napep (Tricycle)	11	20.0	20.0	90.9
	Car	5	9.1	9.1	100.0
	Total	55	100.0	100.0	

Source: Author's Analysis, 2021

The survey revealed that out of the total respondent's 20 (36.4%) walks on foot to healthcare facility, 2 (3.6%) use pushcart as their means of transport to the healthcare facility, 17 (30.9%) use an animal cart as means of transport, 11 (20%) use Keke Napep (Tricycle) as means of transport and 5 (9.1%) use the car as their means of transport to the health facility. .

Do you encounter difficulty in accessing healthcare facility in your area?

Table 2. Difficulty in accessing healthcare facility

	Frequency	Percent	Valid Percent	Cumulative Percent
ValidYes	39	70.9	70.9	70.9
No	16	29.1	29.1	100.0
Total	55	100.0	100.0	

Source: Author's Analysis, 2021

The survey revealed that 39 (70.9%) agreed that they encounter difficulty in accessing health facilities in their area while 16 (29.1%) did not agree that they encounter difficulty in accessing health facilities.

Do you have healthcare facility in your village?

Table 3. Healthcare facility in villages

	Frequency	Percent	Valid Percent	Cumulative Percent
ValidYes	20	36.4	36.4	36.4
No	35	63.6	63.6	100.0
Total	55	100.0	100.0	

Source: Author's Analysis, 2021

The survey revealed that 20 (36.4%) agreed that they have a healthcare facility in their village while 35 (63.6%) did not agree that they have a healthcare facility in their village.

Does seasonal condition (raining or dry season) affect your accessibility to healthcare facility

Table 4. Effect of seasonal condition in accessing health care facility

	Frequency	Percent	Valid Percent	Cumulative Percent
ValidYes	42	76.4	76.4	76.4
No	13	23.6	23.6	100.0
Total	55	100.0	100.0	

Source: Author's Analysis, 2021

The table revealed how seasonal conditions (raining or dry season) affect your accessibility to the healthcare facility, 42 (76.4%) agreed that seasonal condition affects their accessibility to health facility while 13 (23.6%) did not agree that seasonal condition affects their access to the health facility.

How much is the cost of transportation to access healthcare facility in your area

Table 5. Transportation cost to access healthcare facility

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid10-50	12	21.8	21.8	21.8
50-100	18	32.7	32.7	54.5
100-150	17	30.9	30.9	85.5
Above 150	8	14.5	14.5	100.0
Total	55	100.0	100.0	

Source: Author's Analysis, 2021

The survey revealed the cost of transportation to access healthcare facility in the study area, 12 (21.8%) spent 10 to 50 as transportation cost, 18 (32.7%) spent 50 to 100 as transportation cost, 17 (30.9%) spent 100 to 150 as transportation cost to access health facility and 8 (14.5%) spent above 150 as transportation cost to access health facility from their various settlement.

How much distance did you travel to reach healthcare facility?

Table 6. Distance to nearest healthcare facility

	Frequency	Percent	Valid Percent	Cumulative Percent
ValidBelow 1km	7	12.7	12.7	12.7
1-5km	11	20.0	20.0	32.7
5-10km	11	20.0	20.0	52.7
Above 10km	26	47.3	47.3	100.0
Total	55	100.0	100.0	

Source: Author's Analysis, 2021

The table revealed the distance to the nearest healthcare facility, 7 (12.7%) of the respondents cover below 1km to access health facility, while 11 (20%) cover 5km to 10km to access health facility and 26 (47.3%) cover above 10km to access health facility.

How much time did it take to reach healthcare facility?

Table 7. Travel time to reach the nearest healthcare facility

	Frequency	Percent	Valid Percent	Cumulative Percent
ValidBelow 5 minutes	4	7.3	7.3	7.3
5-10 minutes	11	20.0	20.0	27.3
10-15 minutes	6	10.9	10.9	38.2
15-20 minutes	14	25.5	25.5	63.6
Above 20 minutes	20	36.4	36.4	100.0
Total	55	100.0	100.0	

Source: Author's Analysis, 2021

The table revealed travel time by road transport system to the nearest healthcare facility, 4 (7.3%) travel below 5 minutes to access health facility, 11 (20%) travel for 5 to 10 minutes to access health facility, 6 (10.9%) travel for 10 to 15 minutes to access health facility, 14 (25.5%) travel for 15 to 20 minutes to access health facility and 20 (36.4%) travel above 20 minutes to access health facility.

What is nature of road from your village to the healthcare facility?

Table 8. Nature of road to the nearest facility

	Frequency	Percent	Valid Percent	Cumulative Percent
ValidVery Good	9	16.4	16.4	16.4
Good	9	16.4	16.4	32.7
Fair	13	23.6	23.6	56.4
Poor	24	43.6	43.6	100.0
Total	55	100.0	100.0	

Source: Author's Analysis, 2021

The survey revealed the nature of the road to the healthcare facility in the study area, 9 (16.4%) out of the total respondent rate the nature of the road as very good and good while 13 (23.6%) rate as fair, and 24 (43.6%) rate the nature of the road as poor.

How is your accessibility to healthcare facility from your village?

Table 9. Accessibility to healthcare facility

	Frequency	Percent	Valid Percent	Cumulative Percent
ValidVery Good	3	5.5	5.5	5.5
Good	13	23.6	23.6	29.1
Fair	11	20.0	20.0	49.1
Poor	28	50.9	50.9	100.0
Total	55	100.0	100.0	

Source: Author's Analysis, 2021

The table revealed the accessibility to healthcare facility in the study area, 3 (5.5%) rate the accessibility as very good, 13 (23.6%) rate as good, while 11 (20%) rate as fair, and 28 (50.9%) rate the accessibility to the health facility in the study area as poor.

Does healthcare facility in your area have adequate staff and equipment?

Table 10.Adequate staff and equipment in healthcare facility

	Frequency	Percent	Valid Percent	Cumulative Percent
ValidStrongly agree	3	5.5	5.5	5.5
Agree	15	27.3	27.3	32.7
Disagree	26	47.3	47.3	80.0
Strongly disagree	8	14.5	14.5	94.5
Neither agrees nor disagrees	3	5.5	5.5	100.0
Total	55	100.0	100.0	

Source: Author's Analysis, 2021

The table revealed that 3 (5.5%) out of the total respondents strongly agreed that the health facilities have adequate staffs and equipment's, 15 (27.3%) agreed, 26 (47.3%) disagreed, while 8 (14.5%) strongly disagreed, and 3 (5.5%) neither agrees nor disagrees that the facilities have adequate staffs and equipment.

Spatio-physical analysis of physical accessibility to rural health care facilities in Nangere Local Government Area was determined spatially using spider diagram algorithm in ArcGIS 10.8 software interface. Spatio-physical physical accessibility analysis using spider graph map (Desire Lines) 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.

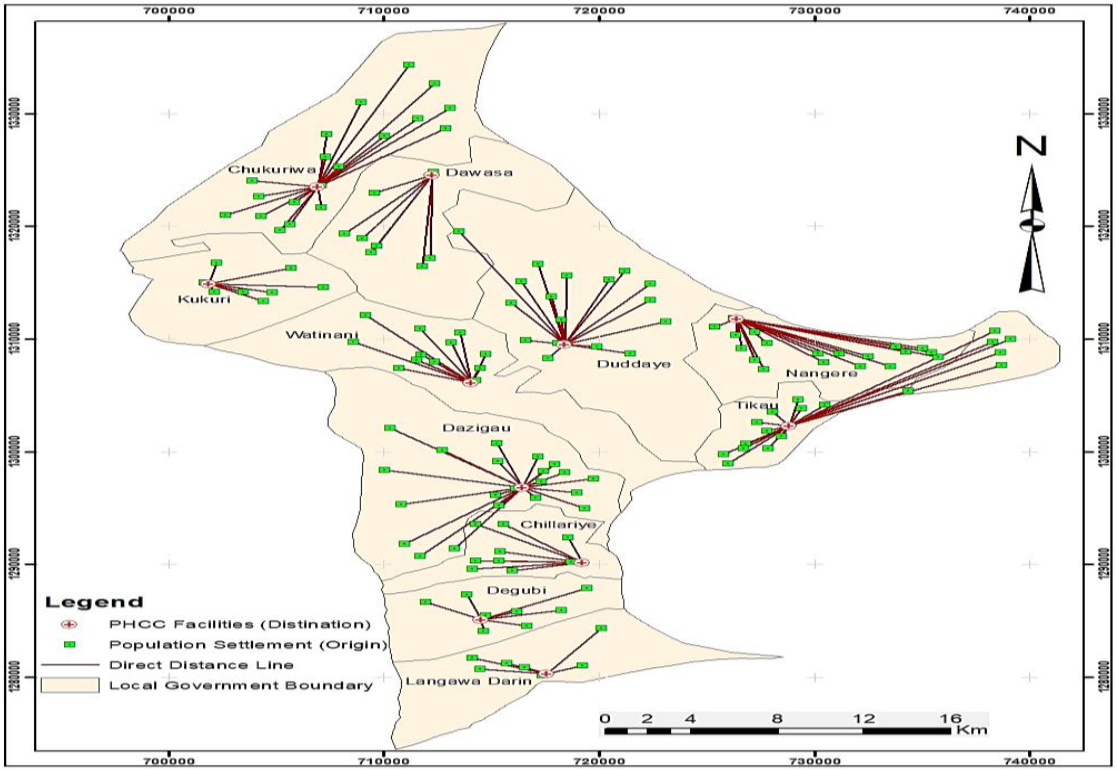

Figure 1. Spider Graph Map

Source: Author's Analysis, 2021

Table 11: Minimum, Maximum, and Average Distance to the Nearest 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

Source: Author's Analysis, 2021

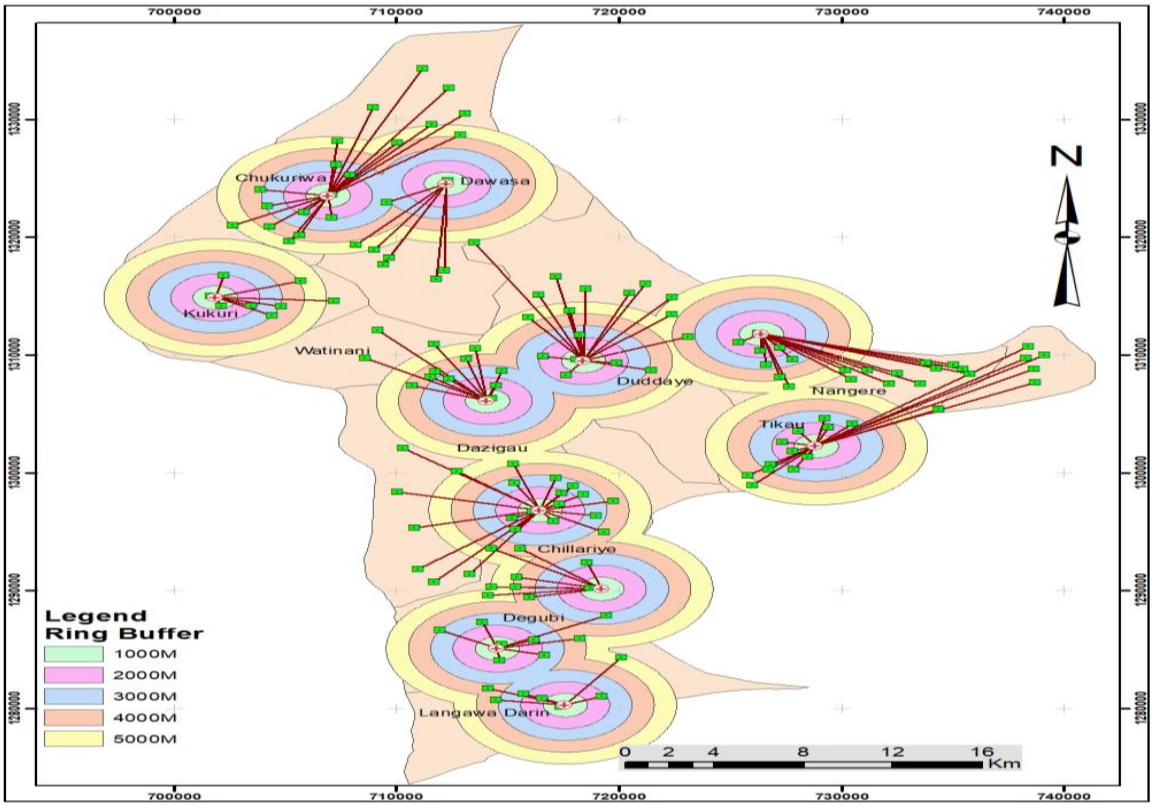

Figure 2: Population settlement within 1000m, 2000m to 5000m radius of the PHCC
Source: Author's Analysis, 2021

IV. DISCUSSION

Table 1 revealed that the majority of the respondent's walks on foot to access health facility in their area; this is because the area lack means of transportation as government ban the use of the motorcycle which is the major means of transportation in the area. The people in the study area encounter difficulty concerning means of transportation as most of the settlements a located far from the major roads linking to urban area. Table 2 revealed that the majority of the respondents (70.9%) agreed that they encounter difficulty in accessing health facilities. This may be attributed to the problems with transportation from their settlements to the health facility. Table 3 findings revealed that the majority of the respondents (63.6%) did not agree that they have a healthcare facility in their village; this is true because the study area has about 416 villages which make it impossible for each village to have a facility in their villages. Table 4 revealed that the majority of the respondents agreed that seasonal condition affects their accessibility to a health facility; this is because during the raining season they find it difficult to access health facility because of nature of the road leading to the facilities.

Table 5 revealed that the majority of the respondents spent 50 to 100 as transportation fees to access at least a facility from their villages. Table 6 revealed that the majority of the respondents travel for more than 10km to access health facilities. Table 7 revealed that the majority of the respondents travel above 20 minutes to access health facilities; this may be attributed to the nature of public transport and road network in the area. Table 8 revealed that the majority of the respondents rate the nature of the road as poor; this is because there is no good road network in the area. Table 9 findings revealed that the majority of the respondents rate their accessibility to a health facility as poor. Table 10 revealed that the majority of the respondent disagreed that the facilities did not have adequate staff and equipment's; this may be attributed to the remoteness of the area.

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. 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 WHO (1997), healthcare facilities should not be more than 5km from residential areas and should be of distance not more than 20m from the major road. Multiple ring buffer zones of 1000m, 2000m, 3000, 4000m, 5000m, and above 5000m were built around all the PHCC to identify the settlements that fall within the buffer's build.

Buffer analysis is used for identifying areas surrounding geographic features is also used to show the served and un-served area for PHC"s in the study area. It has been used to identify the villages within a given buffer limit of the facility. Euclidean buffer is drawn around each PHC. The villages of a ward can be easily determined whether they are served or un-served. A village within the buffer was considered to have access to a facility, while those outside the buffer were assumed not to have access. SQL function of 'select statement' was used to mine-out the population settlements that spatially falls within each of the buffers, and the outputs of these queries result-sets were used to calculate the minimum and maximum distance of each of population settlement to the PHCC of each ward from the exported queried tables.

From table 11 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 (0.975km), 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 the 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 the 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 the 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 the 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, this indicates how the distance of health facilities affect access and utilization of the facilities a significant association exists between utilization of the health facilities and distance traveled to reach a facility, the above table shows the minimum, maximum, and averages of the 146 villages across the 11 political ward of Nangere Local Government Area.

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 political ward to check the accessibility of the residents. Areas outside the 5000m buffer zone indicate areas that find difficulty in accessing the healthcare facility which also connotes that the facilities are not adequate for the population. 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 to obtain the minimum, maximum, average, and count. The results in Table 13 show the query, the minimum, the maximum, the count, and the average distances covered along the straight line to access the nearest healthcare facilities. Figure 2 shows the 1000m, 2000m, 3000m, 4000m, and 5000m radius buffer and the settlements that are within the WHO standard of 5000m (5km) distance to access healthcare facility.

V. CONCLUSIONS

This study investigated spatial accessibility to health care facilities in Nangere LGA and developed a GIS-based approach to the identification of disadvantaged villages in terms of spatial accessibility to health care facilities. Through the investigation, this study established that within the Nangere LGA there exist spatial variations in the distribution of healthcare facilities. The study findings concluded that the majority of the respondent's walks on foot to access health facility in their area; this is because the area lack means of transportation as government ban the use of the motorcycle which is the major means of transportation in the area. The people in the study area encounter difficulty concerning means of transportation as most of the settlements a located far from the major roads linking to urban areas. The study also concluded that the majority of the respondents did not agree that they have healthcare facility in their village, this is true because the study area has about 416 village which makes it impossible for each village to have a facility in their villages, and the majority of the respondents travel for more than 10km to access health facility.

There were 416 villages within the study area, and 370 of them have no health care facilities available. A large proportion of the villages have to travel a long way to access the health care facilities. Most villages' accessibility to health care facilities is very poor, as public transport is both inadequate and infrequent due to inadequate and low frequent availability of the public transportation services. In Nangere LGA, health care facilities were distributed in such a way that only a small proportion of the population can access those facilities by walking. A large proportion of the population resides beyond 10km of travel distance or 15 to 20 minutes of driving time to nearest health care facilities. However, spatial accessibility may be poor for residents live in areas in absence of adequate transportation services even when the travel distance is only a few kilometers. The study recommended that the improvement of overall access to health care facilities in the Nangere LGA can be

achieved by either improving the public transportation system or re-allocating health care facilities according to the spatial and needs of the resident population.

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