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Spatial Analysis of Flow Patterns to Healthcare Facilities in Kano Metropolis, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Healthcare facilities in developing countries are most times inadequate and access to the available ones is made difficult by some uncongenial urban environmental conditions. These among other factors results in the poor health indicators normally reported for cities in developing countries. Hence, this study examined the accessibility patterns of people to healthcare facilities and factors responsible for such patterns in Kano Metropolis, Nigeria. The locations of healthcare facilities and respondents in the study area were captured through handheld GPS receivers. Also, a set of 591 questionnaires were administered to elicit information about people's perception of healthcare facilities in the city. Spatial analyses of phenomena of interest were carried out using GIS analytical tools. Specifically, the road network was digitized with a connectivity rule from Ikonos Satellite Image and was converted to network data set. Also, the analysis of travel patterns to each healthcare facility was done using origin-destination matrix in the network analysis within the GIS environment. Results showed that the travel distance of most patients to tertiary healthcare facilities is above the WHO standard; while the travel distance to primary and secondary healthcare facilities is within the WHO standard. Furthermore, result showed disparities in the preference of people to healthcare facilities occasioned by distance, transport cost, travel time, quality of service and socio-economic factors. Approximately 62% of the household patronized hospital for treatment, 23% made use of herb and 15% engaged in self-medication. The result of this study also showed distance covered to healthcare facilities and flow patterns of healthcare users in which the distance

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are geometrically measured in numerical unit which has been rarely employed and these were documented in the study. The study concluded that spatial restructuring and reorganization of healthcare facilities is necessary in order to enhance access to healthcare facilities in Kano city.

Keywords: Network analysis; spatial analysis; flow patterns; healthcare facilities; Kano Nigeria.

1. INTRODUCTION

The study of regional variations in the social services' distribution has raised the interest of geographers, planners and other scientists because of their general interest in the spatial variation of phenomena on the surface of the earth. Fundamental focus of empirical studies on facilities in general, is on the relationship between distance and patronage patterns of the facilities. General consensus among researchers investigating this relationship is that fewer people are willing to patronize a particular facility as the distance from it increases (Shanon and Dever, 1974; Ipinnimo, 1978; Iyun, 1978; Knox, 1979; Olayiwola, 1990; Aloba, 1995; Olatubara, 1996; Ibikunle, 1997) [1].

Accessibility to healthcare facilities has therefore generally been considered as a major factor of development, and the existing spatial patterns of healthcare facilities play a major role in measuring the level of efficiency or otherwise of the existing facilities within any region. Empirical studies in both developed and developing countries have linked inadequate access to healthcare facilities with increasing avoidable and preventable deaths [2], (W.H.O, 1998).

In the investigation of the level of provision of public facilities, like healthcare emphasis has drifted from just provision to the degree of accessibility of people to these facilities. Barton and Tsourou (2000) emphasised that "human beings are the centre of concern for sustainable development and they are entitled to a healthy and productive life in harmony with nature". It is in recognition of the importance of healthcare facilities to sustainable development that various levels of government in Nigeria (Federal, State and Local) always budget huge amounts of money for the health sector. Most times, in planning for healthcare services at all levels of government in Nigeria, sectoral allocation approaches are adopted, without giving much thought to the spatial dimension of the facilities provided. This often brings about lopsidedness in the spatial accessibility to these facilities, with one section of a State (or Local Government Area) experiencing glut, while other part(s) suffers a lack.

Different methods have been used by different scholars to assess accessibility to service centres. One is the use of distance, another is time and also monetary cost [3,4]. Ajala et al. [1] observed accessibility to healthcare facilities as a panacea for sustainable rural development in Osun State, Nigeria. They employed the use of comparative values of three indices, viz: population ratio per medical officer; population ratio per nurse/mid-wife; and population ratio per hospital bed space. They discovered that serious inequalities existed in the provision of healthcare facilities and services by both the public and private sectors, and that the existing distribution patternswas more in favour of urban areas.

Empirical investigations revealed the existence of other factors, in addition to distance, influencing the patronage patterns of healthcare facilities. For instance, Adejuyigbe [3] demonstrated that attendance at each medical centre in Ife region is a function of both the type of service available there and distance from other centres providing similar services. Okafor (1977) analyzed the spatial distribution and efficiency of hospital facilities in the old Bendel (now Edo and Delta) State. He found that there were discrepancies between the population distribution and the distribution of hospital facilities. The rural population of many developing countries including Nigeria have been suffering different kinds of deprivation. This phenomenon of disparity in provision of basic services also extends to post secondary education and not limited to health facilities distribution alone. Accessibility to post-primary education depends on availability of school within minimum spatial distance to children of different economic divide in the society. Spatial distribution of post-primary school has been generally uneven in most developing countries and thus limits the level of accessibility to that level of education [5]. It was also stated in another study that the location of users should be considered when placing a facility [6]. Quality of services for many rural people is considerably poorer than for urban areas [7]. Olajuyin, et al. (1997) investigated the

effect of location on the utilization of healthcare facilities in Irewole Local Government Area of Osun State, Nigeria. They discovered that healthcare facilities were unevenly distributed among the settlements and that distance was a major factor. The urban area with a large population size has a demand for improved accessibility of healthcare centres and services (Murad, 2008; McGrail & Humphreys, 2014; Mansour, 2016). Besides, urban healthcare centres also providing services to their rural counterpart as most of the urban areas acting as a district or block headquarter, particularly in developing countries (Christaller, 1966; Mansour, 2016); [8]. As a result, urban dwellers are neglected from healthcare facilities as to maintaining huge streams of the population flux from the urbanrural fringe areas (Danjuma, 2015; Dinda et al., 2018; Mansour, 2016).

Network Analysis is an analytical tool embedded within the geographic information system's environment for analysing level of accessibility to different facilities and their service areas based on the digitized road network dataset within the Geographic Information platformSince the focus of any development effort by the government is to improve the welfare of the generality of the people it governs, making adequate planning for healthcare delivery will be a step in the right direction [9-11].

Studies have shown that seriuos inequality exists in the provision of healthcare facilities and services by both the public and private sectors in Nigeria. This inequality has always been a result of the distance needed to be covered or quality of services available. However, many studies have been carried out to address the accessibility isssues of healthcare facility, but network analysis approach in which the distance covered to facilities and flow patterns of healthcare users are geometrically measured in numerical unit is rarely employed. Therefore, this study examines the pattern of accessibility of people to healthcare facilities in Kano Metropolis, Kano State With emphases on the distance covered by the residents to healthcare facilities; travel time to healthcare facilities and mapping the flow patterns of residents to healthcae facilities.

1.1 Aim and Objectives of the Study

1.1.1 Aim of the study

This study examines the pattern of accessibility of people to healthcare facilities in Kano Metropolis, Kano State.

1.1.2 Objectives of the study are to:

I. measure the distance covered by residents to healthcare facilities;
II. assess the travel time to healthcare facilities;
III. map the flow patterns of residents to healthcare facilities

2. MATERIALS AND METHODS

The study area is Kano Metropolis, Kano State, Nigeria. Kano lies within Latitudes 11^{O} 56' N and 12^{O} 40' N; and Longitudes 8^{O} 28' E and 8^{O} 32' E (Fig. 1).

2.1 Data types and Sources

Primary and secondary data were used for the study. The primary data include geographic coordinates of healthcare facilities and houses of healthcare users captured with a Global Positioning System Receiver (GPS) and personal interview which was used to elicit information about the healthcare centre being used. Secondary data includes Ikonos Satellite Image with a resolution of one meter which was acquired from Google Earth.

In selecting respondents for the interview, multistage sampling procedure was used. First, Kano State was purposively selected for the study based on the premise of dense population as a major factor of vulnerability. Secondly, three most densely populated LGAs- Gwale, Dala and Kano Municipal in the state were purposively selected based on perceived factors of vulnerability. Third, using Taro Yamane Sample size formula 198, 196 and 197 respondents, respectively (making a total of 591) were randomly selected from the selected LGAs using household listing as frame. The head of each selected household were interviewed.

Network Analysis was used for this study. Network Analysis is an analytical tool embedded in a Geographic Information System (GIS) environment for road network accessibility and service area analysis. This tool is used to run distance analysis, travel time measurement and flow pattern analysis using origin-destination matrix. The distance analysis identifies the shortest route from the incident location (patient's house) to the hospital for emergency response. The origin-destination matrix analysis shows the flow pattern of the patients from their houses to the hospitals they use.

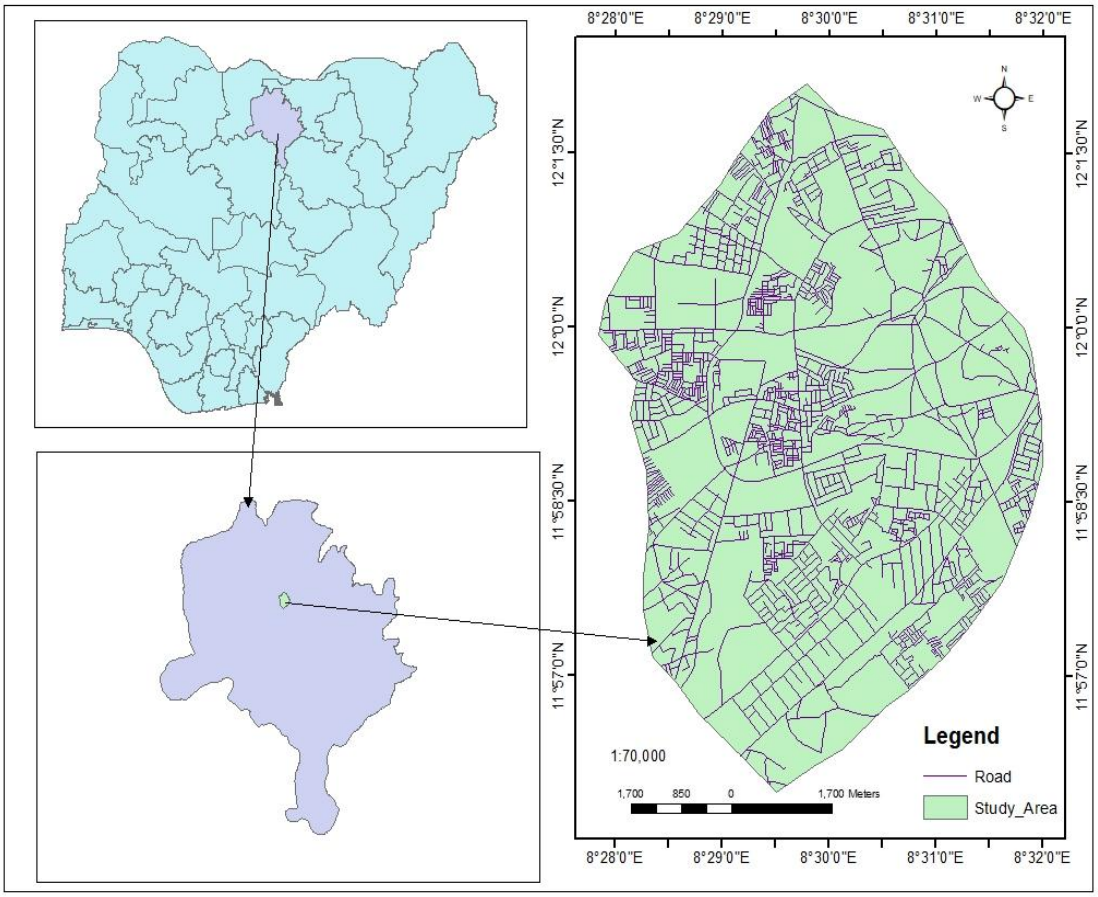

Fig. 1. The Study Area, Kano Metropolis

Road network were digitized from Ikonos (1m resolution) satellite image in a format that will be amenable to network analysis. The digitized road layer was converted to network dataset using a GIS analytical tool so as to be able to obey connectivity rules within the GIS environment. Coordinates of the hospitals were used as the destination and patients' houses coordinates were used as the origin to run distance analysis and origin-destination matrix for emergency response. Calculations of travel cost were done by considering the prevailing price per km in the study area through personal interview. Travel time was calculated using:

$Speed = \frac{\text{Distance}}{\text{Time}}$ as formular. From the formular, $T = \frac{\text{Distance}}{\text{Speed}}$. Distance represents the digitized road length travelled to reach the healthcare centre in the geo-database, speed represents the driving speed (Driving Speed= 60km/hr) for roads within the town as standard (FRSC Nigeria, undated).

3. RESULTS AND DISCUSSION

3.1 Results

The result of the network analysis showed the flow pattern of residents to healthcare facilities patronized and a set of Origin Destination matrix carried out using network analysis tool of Geographic Information System (GIS). The results show pattern of flow, distance covered by the residents to Healthcare Facilities, time spent and cost implication. The study adopted 30 naira for each 1km covered on the road network based on the interview conducted on price of transportation in the study area, and this 30 naira was coded into the geo-database when the digitized road network was being converted to network dataset within GIS environment to generate transport cost for each resident.

Table 1. Distance Travelled to Healthcare Facilities by the People

S/N	Name of Healthcare	No of Healthcare users	Minimum Distance to HC(m)	Maximum Distance to HC(m)	Mean Distance (m)	Standard Deviation (m)
1	Abdulilahi Wase Specialist Hospital	48	2785	5500	4074.29	813.24
2	Standard Specialist Hospital	22	2869	4797	3558.22	620.87
3	Makkah Specialist Hospital	22	331	1953	1006.95	458.1
4	Gadon kaya HC	15	147	809	430.6	215.16
5	Mazauna HC	14	195	1242	746.64	328.14
6	Pediatric Hospital	16	276	2143	971.31	635.2
7	Ginipri Primary HC	11	15	909	378.36	232.38
8	Kofar Matar HC	13	203	2020	890.53	566.29
9	Panshekara	11	410	960	618	172.91
10	Bakin Rariya HC	8	471	1704	821.75	383.82
11	National Orthopadic Hospital Dala	24	501	6402	1620	1249.54
12	Gwamaja clinic	16	279	1463	889.37	358.65
13	Dala Primary Healthcare	8	277	760	496.25	167.99
14	Dala HC	10	663	1291	903.4	159.69
15	Murtala Muhammed General Hospital	81	278	6237	2763.36	1379.54
16	Aminu Kano Teaching Hospital	56	2640	8976	5139.12	1284.6
17	Sharada Bata HC	19	718	2381	1093.21	373.38
18	Kofar Ruwa HC	3	739	1197	955.66	187.78
*19	Sharada Clinic	Nil	-	-	-	-
*20	Federal school of physiotheraphy	Nil	-	-	-	-

**Means Not patronized by any of the respondents but present in the sampled area*
Source: Author's Analysis 2018

Table 2. Travel Time of the People to Healthcare Facilities

Name of Healthcare Facilities	No of Healthcare users	Minimum Travel Time in minute	Maximum Travel Time in minute	Mean Travel Time in minute(to and from)
Abdulilahi Wase Specialist Hospital	48	46.41	91.66	67.90
Standard Specialist Hospital	22	47.81	79.95	59.30
Makkah Specialist Hospital	22	5.51	32.55	16.78
Gadon kaya HC	15	2.45	13.48	7.17
Mazanua	14	3.25	20.7	12.44
Pediatric Hospital	16	4.6	35.71	16.18
Ginipri Primary HC	11	0.25	15.15	6.306
Kofar Matar HC	13	3.38	33.66	14.84
Panshekara	11	6.83	16	10.3
Bakin Rariya	8	7.85	28.4	13.69
National Orthopeadic Hospital Dala	24	8.35	106.7	27
Gwamaja Clinic	16	4.65	24.38	14.82
Dala primary care	8	4.61	12.66	8.27
Dala Health Centre	10	11.05	21.51	15.05
Murtala muhd HC	81	4.63	103.95	46.05
Aminu Kano HC	56	44	149.6	85.65
Sharada Bata HC	19	11.96	39.68	18.22
Kofar Ruwa HC	3	12.31	19.95	15.92
Sharada Clinic	Nil	-	-	-
Federal School of Physiotherapy	Nil	-	-	-

*Source: Author's Analysis, 2018, *Means "Not patronized by any of the respondents"*

Table 3. Measured Travel Cost of Residents to Healthcare Facilities

Name of Healthcare Facilities	No of Healthcare users	Minimum Cost to Healthcare Facility	Maximum Cost to Healthcare Facility	Standard Deviation	Mean cost
Abdulilahi Wase Specialist Hospital	48	167.1	330	20.4	122
Standard Specialist Hospital	22	172.14	287.82	27.24	106.74
Makkah Specialist Hospital	22	19.8	117.18	27.48	30.2
Gadon kaya HC	15	8.82	48.54	12.9	12.91
Mazanua HC	14	11.7	74.52	19.6	22.39
Pediatric Hospital	16	16.56	128.58	38.1	29.13
Ginipri Primary HC	11	9.06	54.54	13.94	11.35
Kofar Matar HC	13	12.18	121.2	33.96	26.71
Panshekara	11	24.6	57.6	10.36	18.54
Bakin Rariya	8	28.26	102.24	23.02	24.65
National Orthopeadic Hospital Dala	24	30.06	384.12	74.96	48.61
Gwamaja Clinic	16	16.74	87.78	21.58	26.64
Dala primary care	8	16.62	45.6	10.06	14.88
Dala Health Centre	10	39.78	77.46	9.4	27.1
Murtala muhd HC	81	16.68	374.22	82.76	82.9
Aminu Kano HC	56	158.4	538.56	77.08	154.17
Sharada Bata HC	19	43.08	142.86	22.4	32.97
Kofar Ruwa HC	3	44.34	71.82	11.26	28.67
Sharada Clinic	Nil	-	-	-	-
Federal School of Physiotherapy	Nil	-	-	-	-

Source: Author's Analysis, 2018

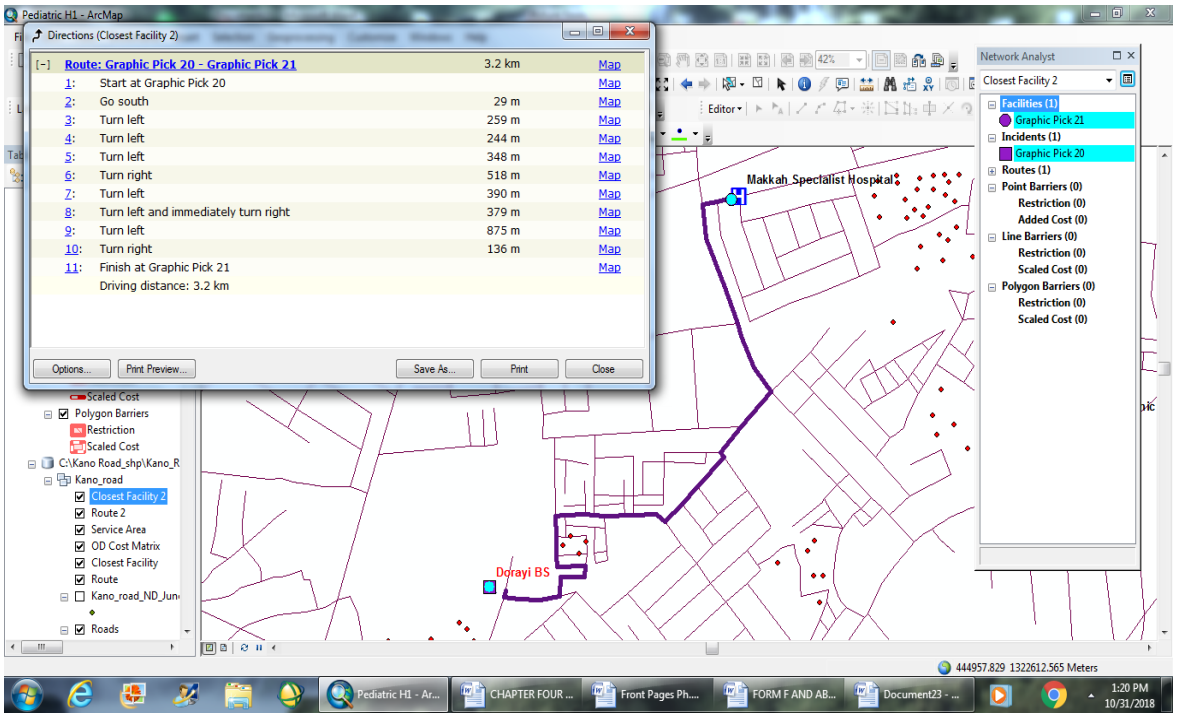

Fig. 2. Shortest Route from Dorayi to Makkah Specialist Hospital

Note: Distance measured = 3,200m

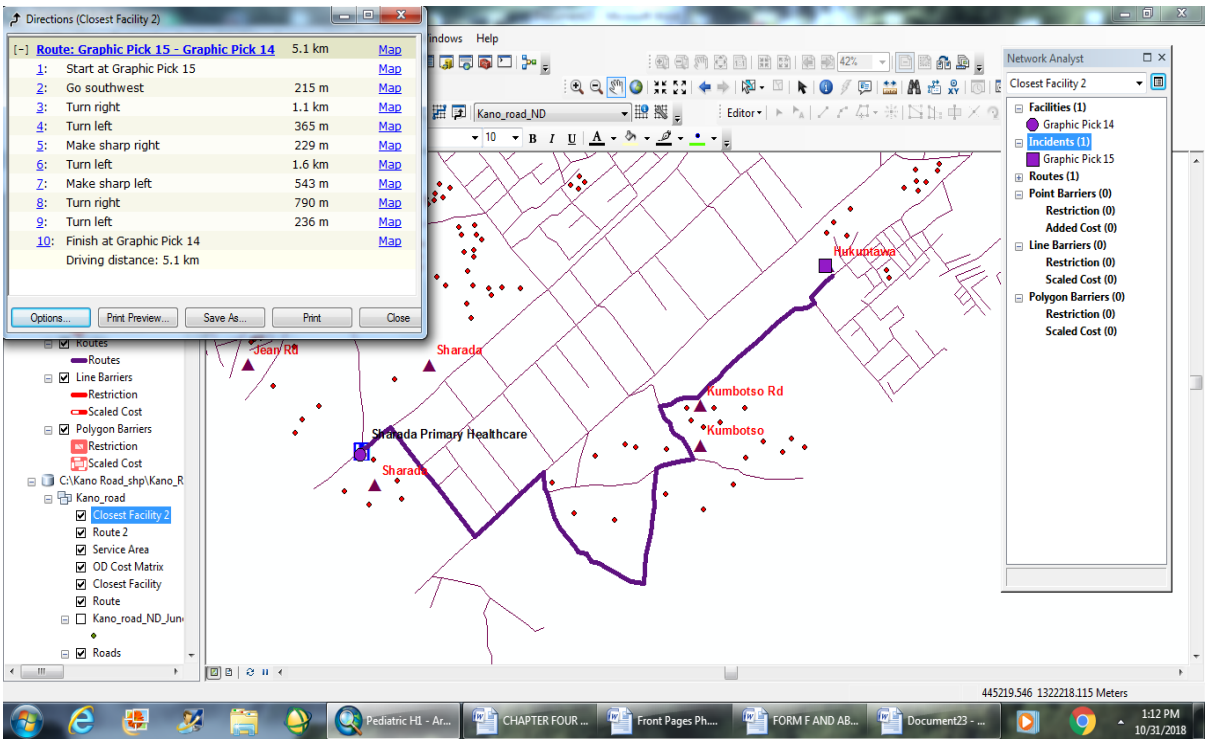

Fig. 3. Shortest Route from Hukumtawa to Sharada Healthcare Centre

Note: Distance measured = 5,100.m

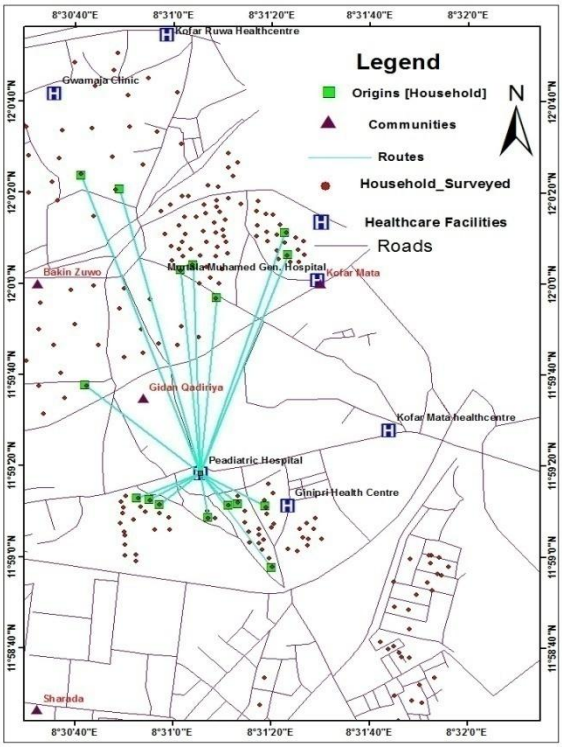

Fig. 4. Flow pattern of Residents to Pediatric Hospital, Kano

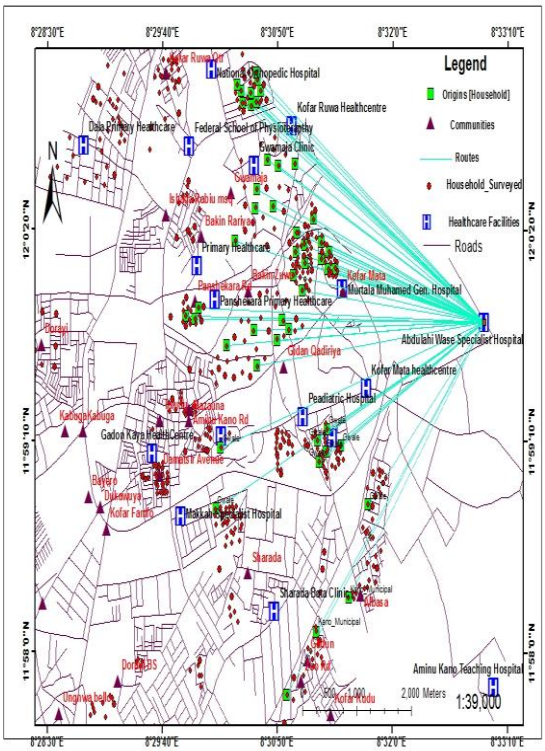

Fig. 5. Flow pattern of Residents to Abdullahi Wase Specialist Hospital, Kano

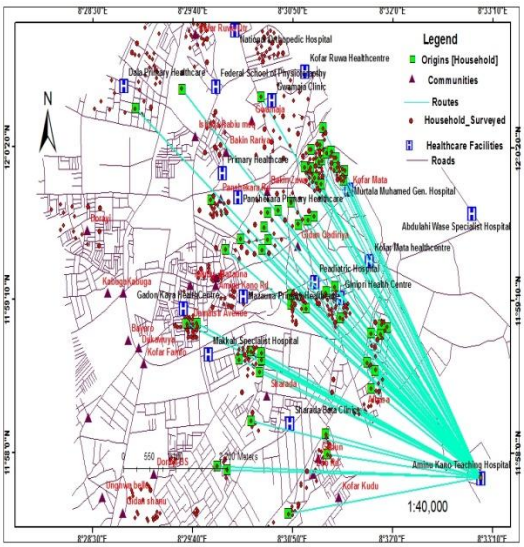

Fig. 6. Flow pattern of Residents to Aminu Kano Teaching Hospital, Kano

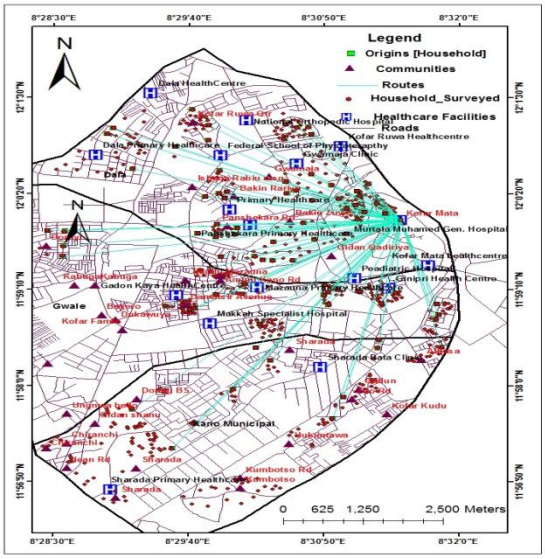

Fig. 7. Flow pattern of Residents to Murtala Muhammed General Hospital, Kano

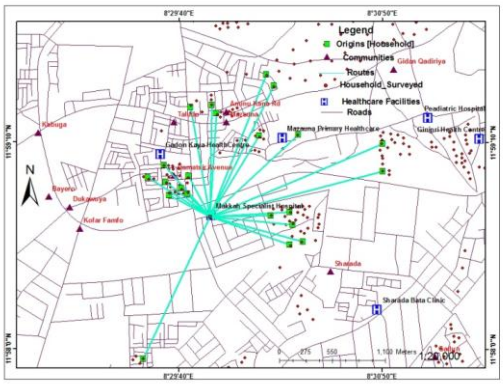

Fig. 8. Flow pattern of Residents to Makka Specialist Hospital, Kano

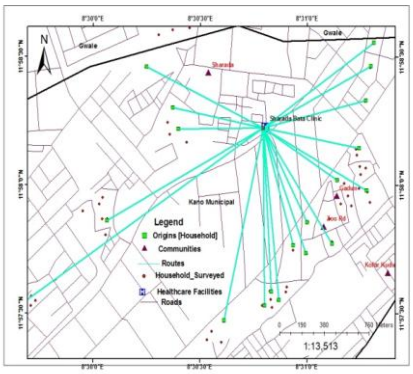

Fig. 9. Flow pattern of Residents to Sharada Bata Clinic, Kano

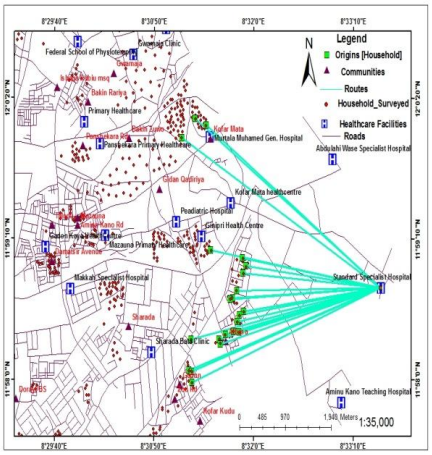

Fig. 10. Flow pattern of Residents to Standard Specialist Hospital, Kano

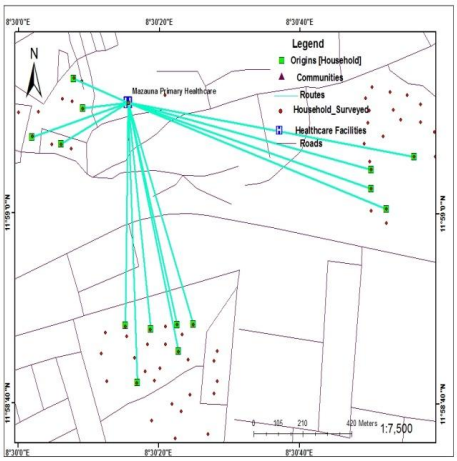

Fig. 11. Flow pattern of Residents to Mazauna Health Centre, Kano

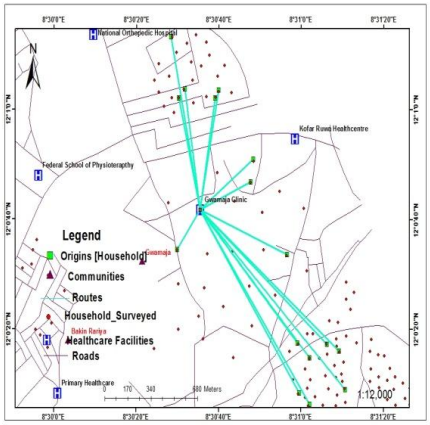

Fig. 12. Flow pattern of Residents to Gwamaja Clinic, Kano

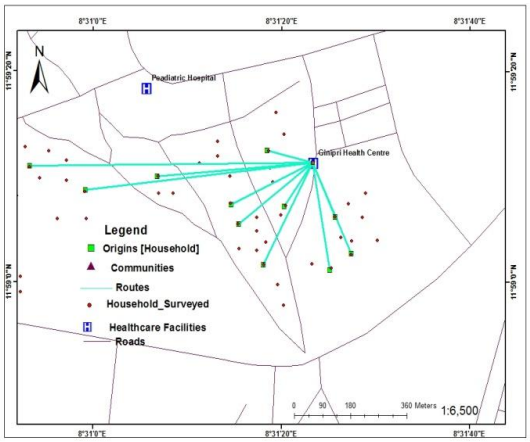

Fig. 13. Flow pattern of Residents to Ginipri Health Centre, Kano

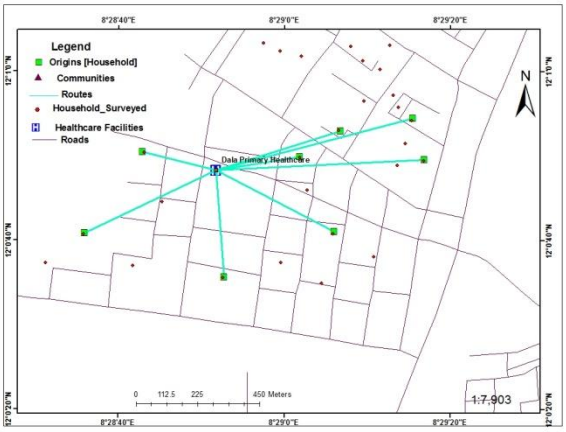

Fig. 14. Flow pattern of Residents to Dala Primary Health Centre, Kano

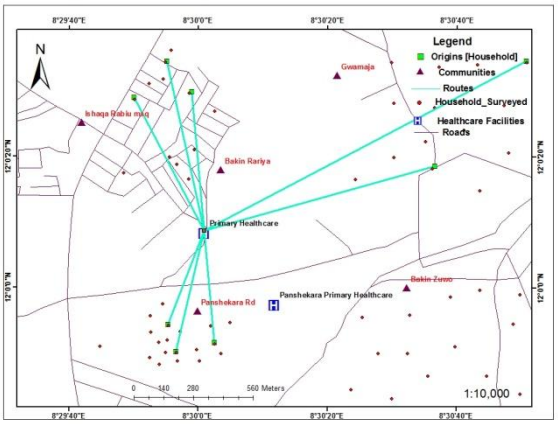

Fig. 15. Flow pattern of Residents to Bakin Rariya Health Centre, Kano

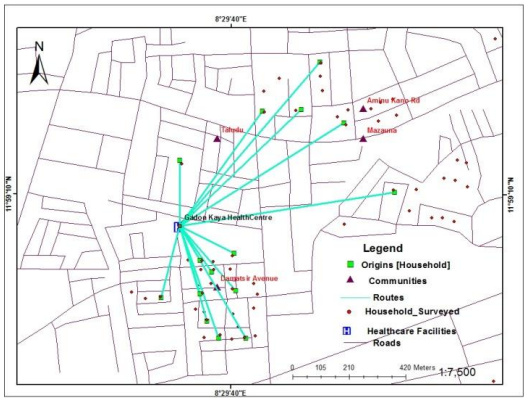

Fig. 16. Flow pattern of Residents to Gadon Kaya Health Centre, Kano

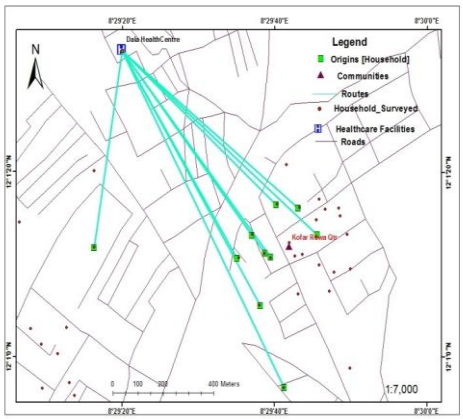

Fig. 17. Flow pattern of Residents to Dala Clinic, Kano

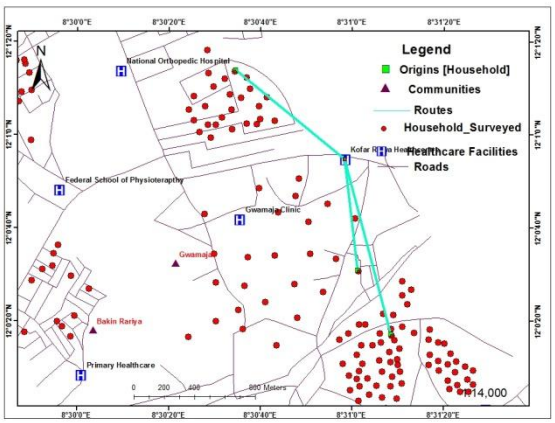

Fig. 18. Flow pattern of Residents to Kofar Ruwa Health Centre, Kano

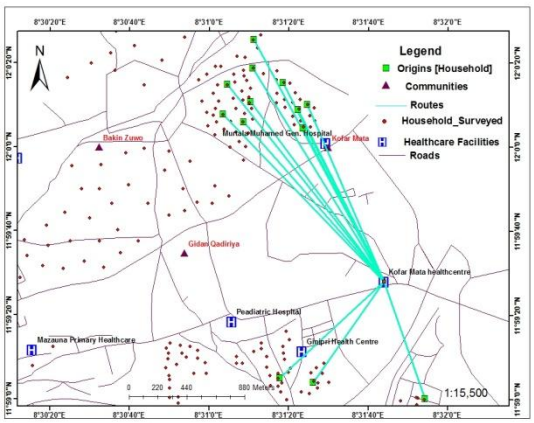

Fig. 19. Flow Pattern of Residents to Kofar Mata Health Centre, Kano

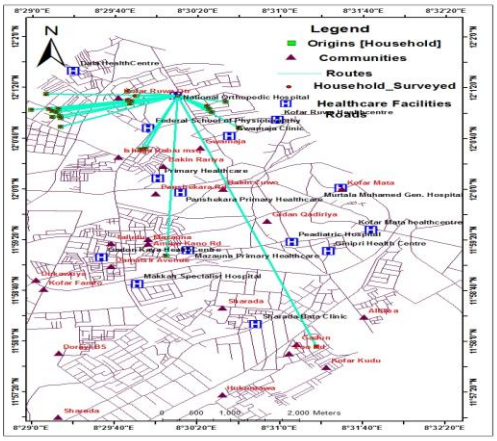

Fig. 20. Flow pattern of Residents to National Orthopedic Hospital, Kano

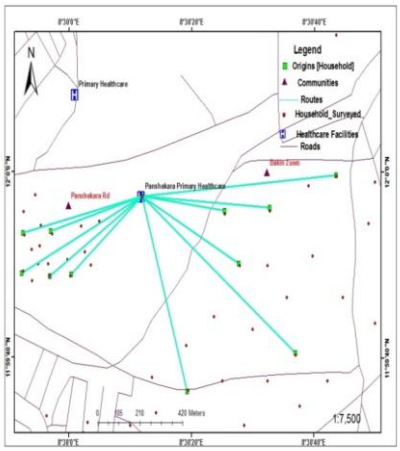

Fig. 21. Flow pattern of Residents to Panshekara Health Centre, Kano

The total numbers of healthcare facilities being patronized by the residents are 20 in number. Out of 591 respondents 412 make use of Healthcare Facilities while the remaining 179 make use of traditional medicine and self medication as revealed by the survey. The flow patterns to each of this healthcare facility using Origin-Destination matrix are therefore shown in the Figs. 4 to 21 below. Also, the result of the distance measurements carried during network analysis in terms of the mean distance, standard deviation, minimum, and maximum distance travelled to the hospital, their respective travel time and transport cost are documented in the Table 1, 2 and 3.

3.2 Discussion

Undoubtedly, some social services like health care services, where certain standard required for such service is not met among the closest ones, people tend to go far distance to access another standard healthcare facilities. This scenario was also observed in this study as many people moved to some specific standard healthcare facilities in the study area. This was reflected in the flow pattern maps in the Figs. 2 - 18 above. The hospital with high patronage as a result of their high quality of service include, Murtala Muhamed General Hospital (81 users) with mean distance of 4,074.29m, Abdullahi Wase General Hospital (48 users) with mean distance of 2,763.36m and Aminu Kano Teaching Hospital (56 users), with mean distance 5,139.12m. However, some people who are lucky to reside close to these categories of standard healthcare have advantage in terms of distance needed to be covered as revealed in the flow pattern maps (Figs. 4 to 21). The red dot represents the healthcare users' location, while the symbol "H" represents the healthcare facilities on flow pattern maps. The healthcare users' locations serve as the origin while the healthcare facilities used serve as the destinations. The results of the geometrically measured distance, time spent and cost implications are summarized in the Tables 1, 2 and 3.

4. CONCLUSION

In conclusion, using this method, the bias of qualitative approach in which the responses of the healthcare users interviewed about the distance they travel, time spent and cost implication to healthcare facilities are documented and taken as valid results are eliminated. This is because most healthcare users including the educated ones tend to give wrong answers when they are asked about the distance they travel to the healthcare facilities they patronize. Analysis based on the concept of accessibility is thereforeideally suitable to be integrated with GIS [12]. However, knowing the coordinate of the healthcare used and the coordinate of the house of the user distance measurement, time spent and cost calculation becomes easy using network analysis which is the methodological gap this study has filled in accessibility to healthcare facility's studies.

5. RECOMMENDATION

The study recommends that the Nigerian's Health centres should integrate coordinate of the location of the patients in their record file so as to

make accessibility analysis and other related issues easier. Also, hospital should be evenly distributed in the kano metropolis

6. FUTURE STUDY

Future Study need to focus on the use of the health record with the associated geographic coordinates of the patients to solve the accessibility problem in Nigeria.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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