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Geospatial Mapping and Analysis of the Distribution of Public Primary Healthcare Centers in Kaduna State, Nigeria

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ABSTRACT

This study investigated the geospatial analysis and mapping of the distribution of public primary healthcare centers (PPHCs) in Kaduna State, Nigeria. The study adopted a cross-sectional survey design and employed purposive and systematic random sampling techniques to select three LGAs in each of the three Senatorial zones of Kaduna State. At the State (Subnational), Senatorial, and Local Government Areas (LGAs) levels, a three-step hierarchical geospatial analysis was carried out using nearest neighbor analysis. The coordinates of the PPHCs that the Global Positioning Systems had gathered in the study area were used in the study. In order to determine the distribution pattern of the PPHCs, additional analysis was performed using the coordinates imported into the ArcGIS interface. While the nearest neighbor analysis was used to examine the distribution, patterns present in the location of the PPHCs, descriptive statistics were used to describe the nature of the distribution. Findings showed that at significant spatial scales, the point pattern of PPHCs was random in Kaduna State (z=1.046; p=0.296); Kaduna North Senatorial Zone (z=0.215; p=0.82); Kaduna Central Senatorial Zone (z=1.387; p=0.165) and Kaduna South Senatorial Zone (z= 1.093; p=0.274), while at the LGA level variations were observed with a few clustered and dispersed and yet majority showed random distribution. The World Health Organization's recommendation of 5km for distances between and among PPHCs was exceeded at all levels, according to the Nearest Neighbor Analysis. For instance, the observed mean distance for the senatorial pattern is 5.28 km, 7.29 km, and 7.14 km, respectively, for the senatorial zones of Kaduna North, Kaduna Central, and Kaduna South. According to the study's findings, the distribution pattern was skewed and suggested a non-proportional type. Therefore, it is recommended that additional electoral wards should be created or PPHCs should be built in the underserved LGAs while taking the center's accessibility and population density into consideration.

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1. INTRODUCTION

Sustainable development depends on and results from good health. Everyone should be able to fully enjoy their right to health as a fundamental human right in order to lead socially and economically productive lives (FRN, 2020). Worldwide health systems still fall short of offering care that is easily accessible, of high quality, all-inclusive, and integrated. There is growing interest in primary health care utilization and access in developing countries as the global health community sets ambitious goals of universal health coverage and health equity in accordance with the 2030 agenda for sustainable development (UN DESA, 2022). To plan and support interventions for complex healthcare system, systems, a wide range of stakeholders, including development organizations, global funding agencies, policy planners, and decision-makers need a better understanding of primary healthcare systems (WHO, 2017a). As a result, there is a need to close the knowledge gaps regarding strategic data on national and subnational levels in developing countries related to front-line primary healthcare systems (WHO, 2017b). The complexity of ensuring universal health is exacerbated by population dynamics because the task is constantly changing due to population change. In order to effectively address changes in population growth, composition, and distribution, health systems must adapt. How to balance community epidemiological needs with how they relate health to population dynamics is the challenge facing policy-makers in the health sector. To achieve this, they must democratize the healthcare systems by delegating power to district-based healthcare organizations that can better serve the needs of local communities. All health, population, and development policies must have as their primary objective listening to people and taking into account their concerns in service delivery, research and development, and resource allocation (WHO, 1993).

Primary healthcare systems are designed to serve a specific population and are a major concern for the world's population, which is primarily growing in developing nations. As a result, there may come a time when the infrastructure and public facilities in place are unable to adequately serve the population that is constantly growing (Shrestha, 2010; MHFW, 2020). Population growth places a heavy strain on infrastructure, particularly healthcare facilities, which in turn overstretches staffing levels (Clairin, 1992; Lambo, 2007). The state of health facilities and facilities should be constantly monitored for improved service delivery and viable improvement in the standard of life of the citizenry, as spatiotemporal variability in population is a result of natural increase and migration. According to the WHO, the evaluation and discussion of population patterns must be an integral part of health planning (WHO, 1993; Egwemi, 2010).

In agreement with WHO, the United Nations declared that everyone has the right to a standard of living that is sufficient for their own health and the welfare of their families, including access to food, clothing, housing, medical care, essential social services, and public employment in their country. If the right to health is violated, it can frequently make it more difficult to exercise other human rights, like the right to an education or the right to a job, and vice versa (UN, 2015; WHO, 2008; OHCHR, 2002).

Okafor (2008) noted that treating people and places equally can sometimes be unfair and unjust; equity requires treating everyone equally under the same circumstances, even when those circumstances may justify allocating resources inequitably. In other words, it is just, fair, and equitable to distribute resources (such as healthcare services) unevenly depending on the situation or degree of need. If spatial inequality is not guided by the equity principle, i.e., if it is not a reflection of spatial variations in need, then spatial inequality is equivalent to spatial injustice.

Geographic Information Systems (GIS) have made it possible to measure geographic accessibility for the past 20 years. It has long been used to manage the vast geospatial data sets about the locations and intensities of environmental hazards as well as to map the uneven spatial distribution of those hazards. Furthermore, Geographic Information Science (GISc) and spatial analysis techniques are particularly well suited to environmental health investigations and have had a significant influence on environmental health studies for many years (Maantay and McLafferty, 2011). Mansour (2016) also noted that GIS may be used to evaluate the geographic distribution of health services, particularly the efficacy of health facility coverage in relation to population density. According to the World Health Organization, environmental risk factors like pollution, chemical exposure, climate change, and ultraviolet radiation are responsible for more than 100 diseases and injuries (WHO, 2018). In order to understand how environmental factors, affect health, geography and spatial relationships are crucial (Maantay & McLafferty, 2011).

Primary Healthcare is vital healthcare that is universally accessible to all people in the Community through their participation and at a cost that the Community and Country can afford to maintain at every stage of their development in the spirit of self-reliance and self-determination. It is based on practical, scientifically sound, and socially acceptable methods and technology. It is the first point of contact between individuals, families, and communities and the national health system, which aims to provide healthcare as close to people's homes and places of employment as possible. Better health for all is primary healthcare's ultimate objective. In the International Conference on Primary Health's declaration, this ideal healthcare model was adopted. The World Health Organization's mission of "Health for All" was founded on this ideal healthcare model, which was adopted in the declaration of the International Conference on Primary Health Care held in Alma Ata in 1978 (WHO, 1978)

In the past, Nigeria ran the District Health System just like many other developing nations, particularly those in sub-Saharan Africa. However, in the latter, there was no distinct boundary and uniformity of the "district" because all LGAs divided themselves into what they considered to be districts. Because of this, the Federal Government of Nigeria revived the National Primary Health Care Development Agency (NPHCDA) and introduced the Ward Health System

(WHS), which is the policy of allocating at least one functional PHC per electoral ward (10,000 to 30,000 people), in response to UNICEF and WHO's 1992 recommendation that "community mobilization would greatly be assisted" (WHO, 1992, FMoH, 1988, and NPHCDA 1990 cited in Abosede et al., 2012). In order to achieve UHC through community participation, as mandated by the National Health Act, Kaduna State adopted and put into practice the Ward Health System (NPHCDA 2010, 2018, FGN 2014, and FMoH 2016). As a result, the state, which has 255 electoral wards and 23 LGAs, has 255 "model" public PHCs, one in each ward.

The private and public healthcare sectors coexist in Kaduna State's pluralistic healthcare delivery system. There are 5,263 healthcare facilities in Kaduna State, including public, private, and faith-based organizations, according to the state's 2018 Health Facility Census Report. 1,937 hospitals—secondary, primary, and health clinics—are among these facilities. Two hundred fifty-five (255) PHCs have received upgrades and modern equipment as part of the state's infrastructure development to enable them to offer round-the-clock services in accordance with the one (1) PHC per ward strategy (KDSDP, 2020; NPHCDA, 2010).

In Kaduna State, however, in spite of the infrastructure and prior efforts on government-owned facilities, healthcare delivery is still below-optimal with many citizens lacking access to basic primary healthcare services due to unfair distribution (distributive injustice). Where these services were available, the quality remained a major concern and in some cases was very expensive and difficult for the communities' predominately low-income population to afford.

Despite this outstanding development, the industry still faces infrastructure gaps. In terms of implementing Primary Health Care Under One Roof, the state placed sixth out of seven states in the North-West geopolitical zone, indicating poor health indicators (NPHCDA, 2015). Additionally, Kaduna State was found to be among the worst states in Nigeria for residents in need of healthcare, according to a report on the state of primary healthcare service delivery in Nigeria from 2019–2021. The report, which was on the analysis and ranking of health system performance across states, provided an overview of the 36 states of Nigeria's health delivery system as well as an assessment of each state's compliance with the National Health Act and National Health Policy (Sphcn, 2022). Furthermore, according to the Kaduna State Bureau of Statistics (KDBS) report for 2021, only 0.5% of Kaduna state's populace has access to sanitation services that are properly managed. Moreover, there is a lack of political commitment to effective health leadership and health development, particularly at the local government level. Both the health management information system and the referral systems are underdeveloped and do not include the private sector. There are no research budget lines, and neither the state nor the LGAs carry out health research (KDSG, 2010; KSDP, 2015). However, one of the most fundamental conditions for the placement and distribution of PPHCs is accessibility to PHCs. Health equity research rarely addresses location-related issues because it typically focuses on describing and analyzing how social determinants affect health outcomes (Pons-Vigués *et al.,* 2014).

The aforementioned suggests that Kaduna State's population access to primary healthcare facilities requires adequate attention and at the very least, nearly equitable distribution.

2. Related Work

The United Nations Department of Economic and Social Affairs (UNDESA, 2022) observed that health systems around the World continue to fall short of offering accessible and all-inclusive healthcare. Therefore, the poor performance of the primary healthcare system has attracted several studies in most countries. Some researchers have made an effort to study accessibility to healthcare services and facilities at the national or regional level (Okafor, 1987; Adesanya *et al.,* 2002; Adagbasa, 2008; Arokoyu & Weje, 2015). While most researchers carried out their studies at very small or local scales, rural or urban only (Aminu & Dinye 2014; Joshua *et al.,* 2015; Agofure & Sarki, 2017; Abubakar & Adamu, 2020; Usman, 2020; Idoko, *et al.,* 2021; Mshana *et al.,* 2023).

For instance, Ishaq (1994) studied the Impact of the Primary Health Care Delivery Policy in Zaria L.G.A of Kaduna state. Olajuyin *et al.,* (1997) investigated the effect of location on the utilization of healthcare centers in the Irewole local government area of Osun State, Nigeria. Massoud (2007) conducted research on the Implementation of the Primary Health Care Delivery System in Birnin-Gwari L.G.A, Kaduna State. Abbas (2009) did an analysis of the accessibility and utilization of healthcare facilities in Kachia Local Government Area of Kaduna State. Abbas, *et al.,* (2012) investigated the spatial distribution of healthcare centers in Chikun local government area of Kaduna state, Nigeria using the Geographic Information Systems (GIS) technique in healthcare management planning. Njoku and Akpan (2013) in their study evaluated the locational efficiency of available health facilities in Ikot-

Ekpene LGA, Akwa Ibom State to ascertain the distributional pattern of the healthcare centers in the study area. These studies did not consider the use of geo-information to generate the distribution pattern of healthcare at the subnational scale.

Michael & Alonge (2021) conducted a qualitative analysis of the "One PHC per ward" in Ekiti state, Nigeria not from a geographical perspective but a sociological point of view. While Lawal & Anyim (2019) researched modelling geographic accessibility to all types of PHC facilities in Akwa Ibom state in the Niger Delta region of Nigeria and produced a Map.

To date, it has been repeatedly demonstrated that substantial subnational spatial variations in the delivery and utilization of healthcare are concealed by national or regional aggregate data (UNDP Nigeria, 2016). Consequently, data from studies conducted at the national or regional levels are frequently inappropriate for state and local policymaking and intervention. The data at the LGA scale is also insufficient for planning PPHCs and services at the state level. Furthermore, there has not been much research done into the specific geographic patterns and accessibility of Kaduna State's health facilities. As a result, the state (subnational) level of this study's analysis focused on the nature of variation in the distribution and accessibility of PPHCs on a hierarchical scale at the state (subnational), senatorial, and LGA levels with maps.

3. Study Area

The research area was Kaduna state and is between latitudes 09^{o} 02' N through 11^{o} 32' N and longitudes 06^{o}15' E through 08^{o} 38' E. (See below Figure 3.1 for the Map of the study area). It is a highly populated (third in the country) area with a population of 6.06 million (2006 census), and at the end of 2020, the state's population is estimated at 9,476,053; and geographically large (45,711.2 km^2), is well-suited for the analysis and geospatial mapping of the distribution of PPHCs (NPHCDA, 2015; KDSG, 2010 & 2012; KDSDP, 2020; NPC, 2009).

The state was created on May 27, 1967, and occupies part of the central position of the Northern part of Nigeria (with Kaduna as its capital) and the North-West geo-political zone. It shares common borders with Katsina State to the North, Nasarawa State and the Federal Capital Territory, Abuja to the South, Kano, and Bauchi States to the Northeast, Zamfara State to the Northwest, Niger State to the West, and Plateau State to the Southeast. Administratively, the study area has 3 senatorial zones, 23 LGAs, and 255 electoral wards.

The population is culturally very diverse with distinct differences in religion, ethnicity, traditions and social norms between the predominantly Hausa/Muslim population in the northern part of the State and Christians of a variety of ethnic groups to the south. Over 60 ethnic groups namely, Adara (Kudara), Atyap (Kataf), Bajju (Kaje), Fulani, Gbagyi (Gwari), Gwandara, Gwong (Kagoma), Ham (Jaba), Hausa, Igbo, Ninkyop (Kaninkon), Ninzo, Numana, Nyenkpa (Yeskwa), Oegworok (Kagoro), Tsam (Chawai) and Yoruba among others populate the state (KDSG 2010 and 2017; Hayab, 2015).

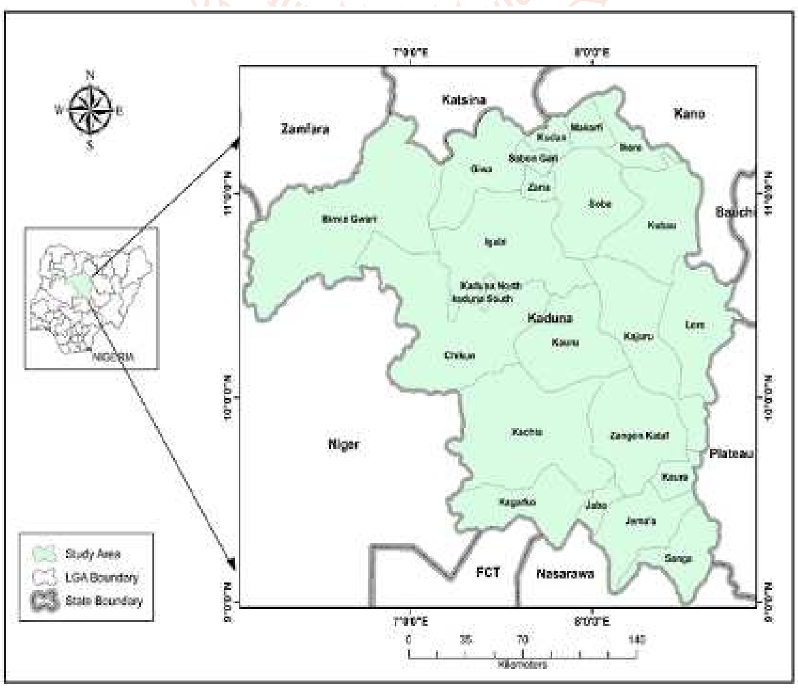


Figure 1: Kaduna State showing the 23 Local Government Areas (study area)
Source: Adapted from the Administrative Map of Kaduna State

The entire Kaduna state is underlain by a basement complex of igneous and metamorphic rocks of mainly Jurassic to Pre-Cambrian ages. The basement complex rocks are essentially granites, gneisses, migmatites, schists, and quartzites (Benett, 1979;13 cited in Kaduna North, 2003 *Wikipedia*). The typical red-brown to red-yellow tropical ferruginous soils and savannah grassland with a few scattered trees and woody shrubs make up the soils and vegetation in this region (Ogbozige et al, 2018). The vegetation is divided into two areas: the southern Guinea and northern Guinea savannahs (Abaje, 2007). The tropical dry-and-wet type of climate found in Kaduna State is classified as Aw by Koppen's. The dry season runs from mid-October of one calendar year to April of the following, while the wet season is from April through mid-October with a peak in August (Abaje, *et al.,* 2015). The state as a whole receives about 1323mm of rainfall on average annually (Oladipo, 1993).

4. Method and Materials

This study adopted a cross-sectional survey design and employed purposive and systematic random sampling techniques to select three LGAs in each of the three Senatorial zones of the study area. The main GIS-based procedures included geo-referencing, which involved scanning and importing the administrative map of the study area into the ArcGIS 10.3 version of software. By using geo-referencing, we can connect a coordinate reference system to a space object or raster object that hasn't been associated with a location. This makes it possible to combine different independent GIS datasets as an overlay of geographic data. The scanned map was therefore geo-referenced. The geo-referenced map was digitized on-screen under the following themes: Local government areas and the political ward as polygon, LGA and ward boundary as lines, and road. The second major process was digitizing whereby the geo-referenced map was digitized on-screen under the following themes, the Local government areas and the political ward as polygon, LGA and ward boundary as lines and road network as lines. All attribute data for the primary health care facilities obtained from the various health care management through inventory using the checklist were typed in Microsoft excel and saved as CSV (comma deliminated) format for analysis. Attribute data are acquired data resources often organized in a database format, usually in tabular form and stored in a database management system.

The geographic coordinates of the PPHCs in Kaduna state were collected using the handheld GPS (Averik, *et al.,* 2023). The coordinates were structured into Microsoft Excel and exported into ArcGIS 10.3 interface. As such, all the shape files holding the relevant data layers were then spatially overlaid to create a combination of visual map of polygon, line and point feature classes.

The study further built on the output map of the PPHCs distribution to determine the spatial pattern. Hence, the Nearest Neighbor Analysis (NNA) inferential statistical tool in ArcGIS10.3 was used to investigate the spatial pattern in the data. This tool automatically calculated for the LGAs the average nearest neighbor ratio by dividing the observed average distance by the expected average distance. NNA is the method of exploring pattern in the location data by comparing mean distance (Do) of phenomena to the same expected mean distance (De) usually under random distribution. The locations of the public PHCs were used to determine whether the spaces are concentrated or evenly distributed. The NNA formula is as follows:

The NNA formula is as follows: $Rn = \frac{Do}{De}$ ……………………………… (1)

Were Rn = description of distribution (NNI), Do =observed distance, De=expected distance

$Do = \sum D/N$ ……………………………… (2)

$De = \frac{1}{2\sqrt{N/A}}$ ……………………………… (3)

The NNA will always have or return five (5) values; observed mean distance (Do), expected mean distance (De), nearest neighbor ratio, z-score, and p-value. A negative Z-score indicates clustering, while a positive Z-score means disperse or evenness. Moreover, the Z-score usually returns a range of values between -2.58 to 2.58. Therefore, a negative Z-score less than -2.58 indicates a significant clustering at 0.01 probability level. On the other hand, a positive Z-score greater than 2.58 indicates a significant regularity or dispersal at 0.01 probability level (Getis and Ord 1998). The NNA is observed at three (3) scales; State, Senatorial zones and LGAs knowing that scale of observation can influence the point pattern of distribution.

5. Results and Discussions

The Spatial distribution of PPHCs is presented using hierarchical scale Maps from State, Senatorial and LGAs as follows;

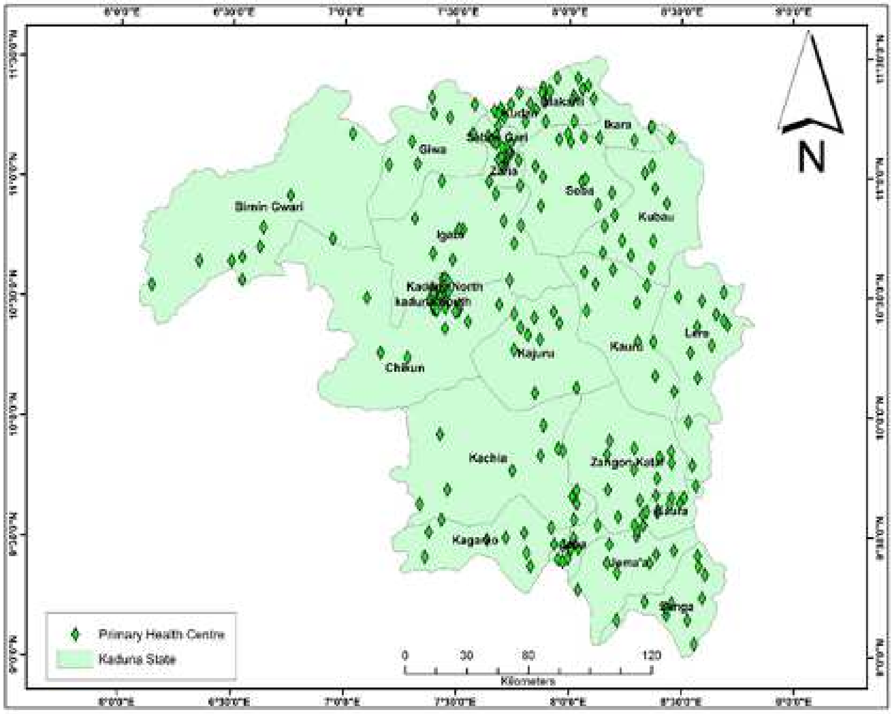


Figure 2: Kaduna State showing the distribution of PPHCs.

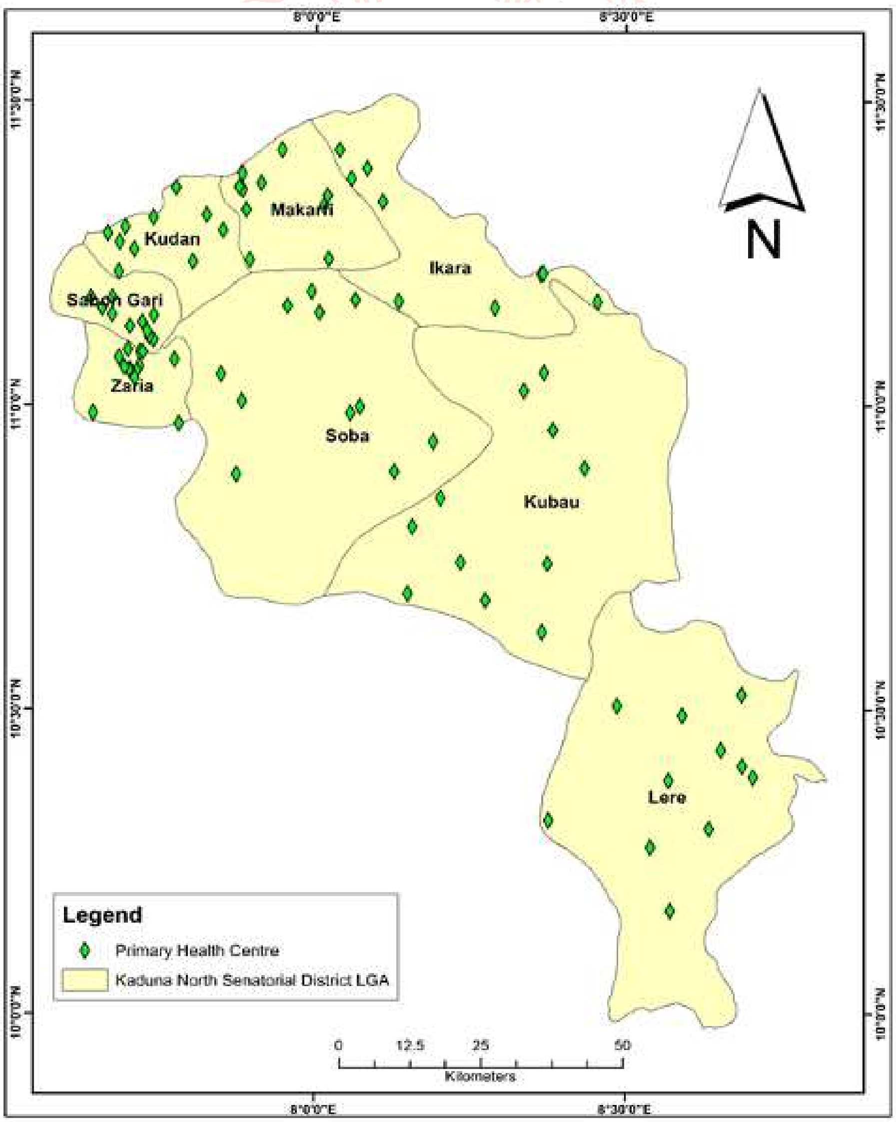


Figure 3: Kaduna North Senatorial Zone showing the distribution of PPHCs

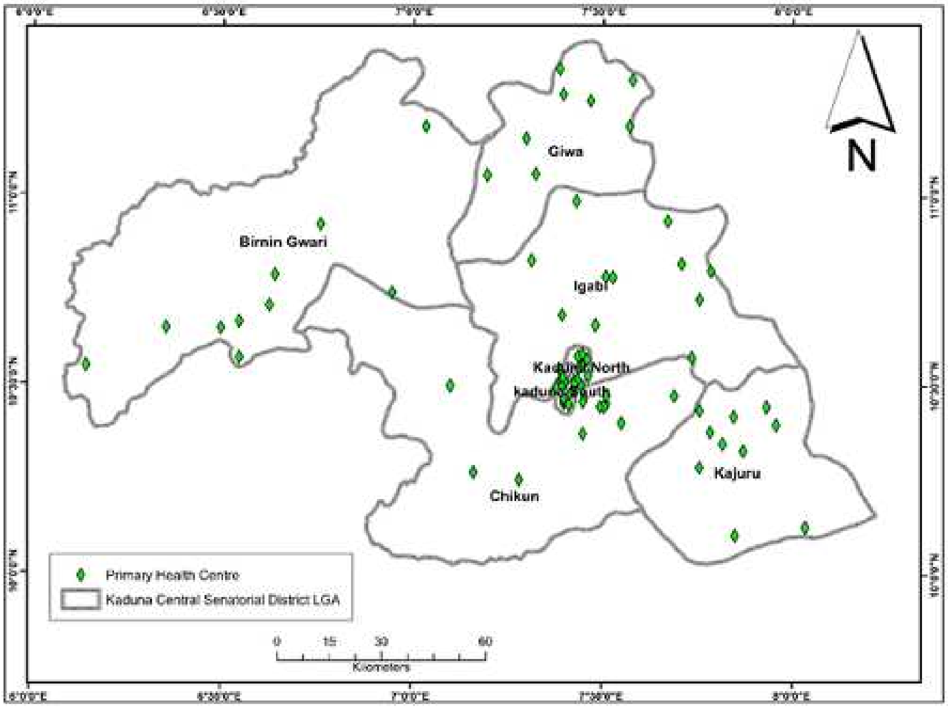


Figure 4: Kaduna Central Senatorial Zone showing the distribution of PPHCs

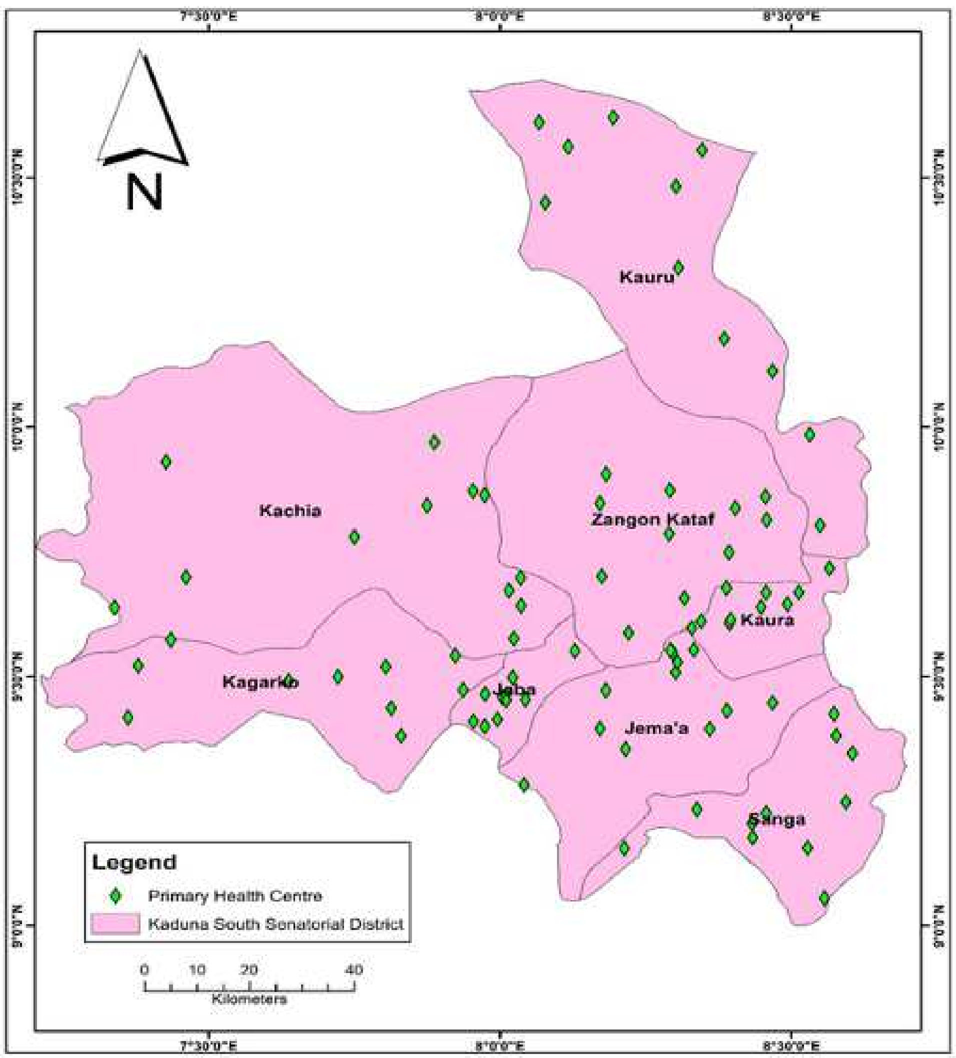


Figure 5: Map Kaduna South Senatorial Zone showing the distribution of PPHCs

Figures 2, 3, 4, and 5 show the visual distribution of PPHCs in Kaduna State and the three senatorial zones. The primary healthcare centers are not equitably and equally distributed across the study area with clustered distribution of these centers in Kaduna North and Kaduna South LGAs, this might be attributed to the denser population and urbanization. This goes in line with Lou and Wang (2009) that said a series of locational factors may be responsible for the distribution of Health Care facilities in an area, the factors may include: population size, availability of good roads, mode of transport, etc. Also, this agrees with the findings of Abbas *et al.,* (2012) which revealed that there was inequality in the distribution of healthcare facilities in Chikun LGA of Kaduna State. The public health centers were found to be clustered along the Eastern part of Chikun LGA in Kamazou, Kujama, Kakau, and Sabon Gaya districts while 6 (33.4%) of the public health centres were found in the southern part of the study area in Chikun and Gwagwada districts and none existed at the northwestern part of the study area. A similarity can also be drawn with the study conducted by Ismail *et al.,* (2014) that revealed uneven distribution of health facilities in Giwa LGA of Kaduna state and Tofa LGA in Kano State.

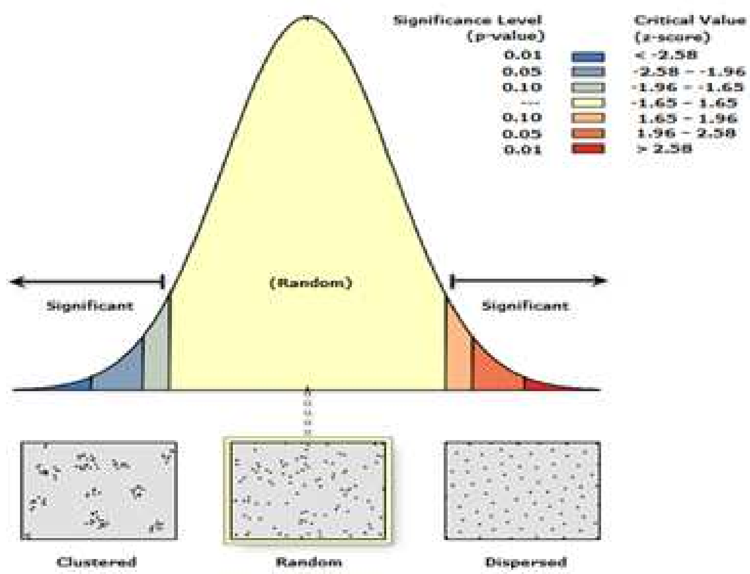
5.1. Point Pattern of Spatial Distribution

The pattern of PPHCs distribution for the twenty-three (23) LGAs are in our work (Averik, *et al.,* 2023), while the pattern of PPHCs distribution and the average nearest neighbor summary for Kaduna state, the three (3) Senatorial zones and the average nearest neighbor summary for the 23 LGAs are presented below;

Table 2: Showing the Average Nearest Neighbor Summary for Kaduna state

Observed Mean Distance:	6337.7871 Meters
Expected Mean Distance:	6125.1234 Meters
Nearest Neighbor Ratio:	1.034720
Z-score:	1.046008
P-value:	0.295557

Source: Author's Fieldwork, 2022.



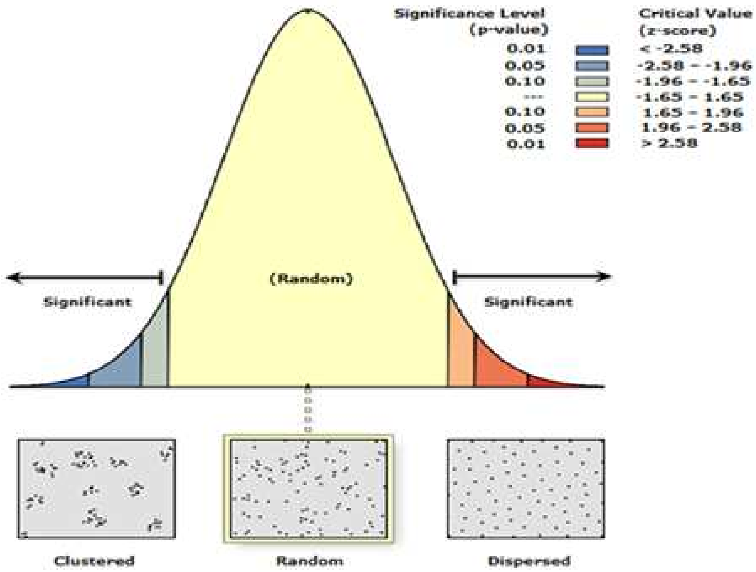
Given the z-score of 1.04600845106, the pattern does not appear to be significantly different than random.

Figure 6: Pattern of distribution of PPHCs in Kaduna State.
Source: Author's Fieldwork, 2022.

Table 3: Showing the Average Nearest Neighbor Summary for Kaduna North Senatorial Zone

Observed Mean Distance:	5280.2070 Meters
Expected Mean Distance:	5216.6301 Meters
Nearest Neighbor Ratio:	1.012187
Z-score:	0.214956
P-value:	0.829802

Source: Author's Fieldwork, 2022.



Given the z-score of 0.214956021769, the pattern does not appear to be significantly different than random.

Figure 7: Pattern of Distribution of PPHCs in Kaduna North Senatorial Zone.

***Source:* Author's Fieldwork, 2022.**

Table 4: Average Nearest Neighbor Summary of PPHCs in the LGAs in Kaduna North Senatorial Zone

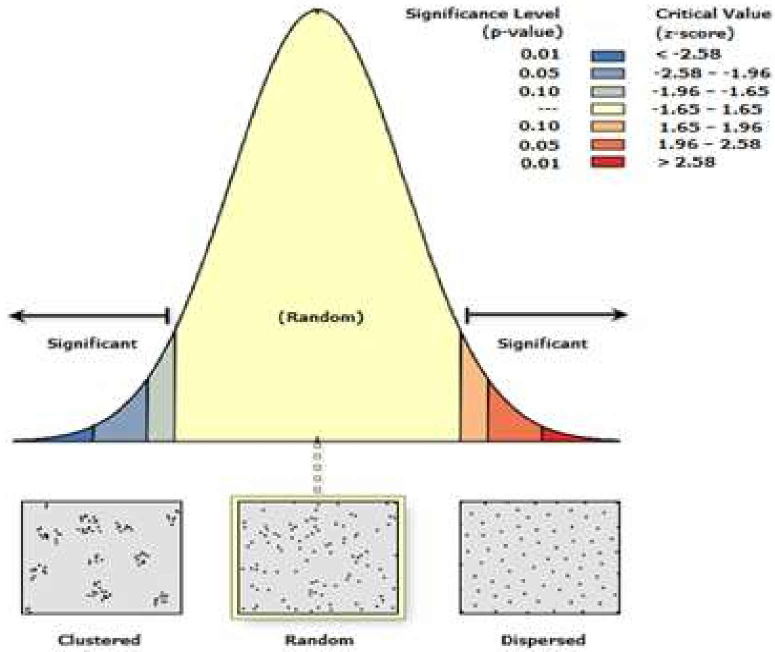
S/No	LGA	NNA	EMD (Meters)	OMD (Meters)	z-score	p-value	Remark
1	Ikara	1.320652	4867.6339	6428.4511	1.840290	0.065726	Dispersed
2	Kubau	1.120258	7545.1688	8452.5382	0.763031	0.445445	Random
3	Kudan	1.387313	3161.6655	4386.2211	2.343114	0.019124	Dispersed
4	Lere	1.365194	7002.0219	9559.1201	2.317134	0.020496	Dispersed
5	Makarfi	1.119391	3676.2367	4115.1445	0.722272	0.470127	Random
6	Sabon Gari	0.741291	2566.5768	1902.5807	-1.565100	0.117559	Random
7	Soba	0.856683	7124.8858	6103.7710	-0.909335	0.363173	Random
8	Zaria	1.200324	2353.3936	2824.8352	1.381770	0.167042	Random

Source: Author's Fieldwork, 2022.

Table 5: Showing the Average Nearest Neighbor Summary for Kaduna Central Senatorial Zone

Observed Mean Distance:	7290.7563 Meters
Expected Mean Distance:	7952.2074 Meters
Nearest Neighbor Ratio:	.916822
Z-score:	-1.387228
P-value:	0.165372

Source: Author's Fieldwork, 2022.



Given the z-score of -1.38722754983, the pattern does not appear to be significantly different than random.

Figure 8: Pattern of Distribution of PPHCs in Kaduna Central Senatorial Zone

Source: Author's Fieldwork, 2022.

Table 6: Summary of Spatial Pattern of Near Neighbor Analysis of LGAs in Kaduna Central Senatorial Zone

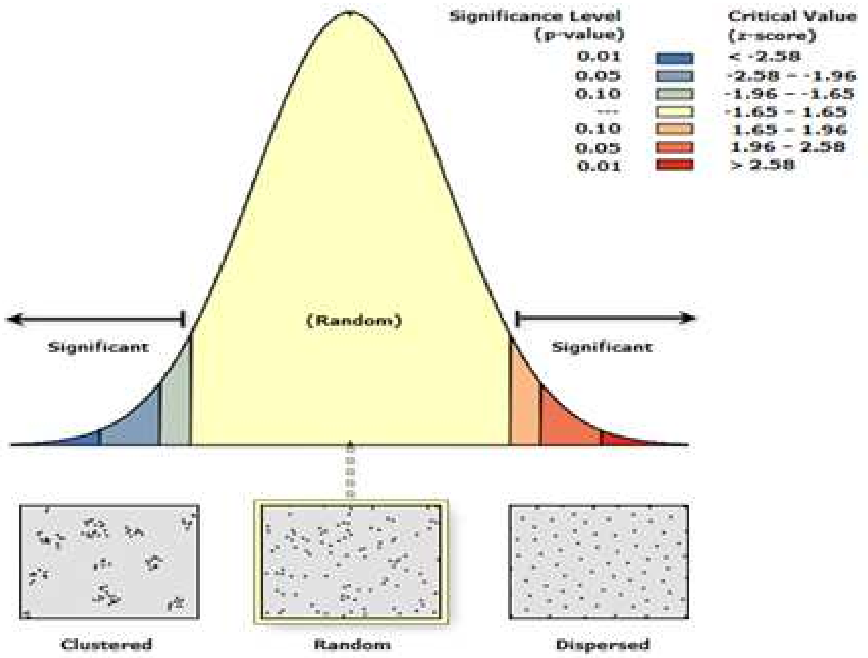
S/No	LGA	NNA	EMD (Meters)	OMD (Meters)	z-score	p-value	Remark
1	Birnin Gwari	1.372924	12437.7346	17076.0585	2.256060	0.024067	Dispersed
2	Chikun	0.79956	9838.7326	7866.7163	-1.328290	0.184082	Random
3	Giwa	1.332850	8035.6011	10710.2549	1.801047	0.071695	Dispersed
4	Igabi	1.290995	8812.2582	11376.5794	1.928443	0.053800	Dispersed
5	Kaduna North	0.323911	3884.2823	1258.1608	-4.480490	0.000007	Clustered
6	Kaduna South	0.115970	9824.2735	1139.3253	-5.858525	0.000000	Clustered
7	Kajuru	1.195593	7849.1951	9384.4458	1.183273	0.236701	Random

***Source:* Author's Fieldwork, 2022.**

Table 7: Showing the Average Nearest Neighbor Summary for Kaduna South Senatorial Zone

Observed Mean Distance:	7138.3177 Meters
Expected Mean Distance:	6726.1799 Meters
Nearest Neighbor Ratio:	1.061274
Z-score:	1.093363
P-value:	0.274234

***Source:* Author's Fieldwork, 2022.**



Given the z-score of 0.09336308168, the pattern does not appear to be significantly different than random.

Figure 9: Pattern of Distribution of PPHCs in Kaduna South Senatorial Zone

***Source:* Author's Fieldwork, 2022**

Table 8: Summary of Spatial Pattern of Near Neighbor Analysis of LGAs in Kaduna South Senatorial Zone

S/No	LGA	NNA	EMD (Meters)	OMD (Meters)	z-score	p-value	Remark
1	Jaba	1.131 885	3034.4804	3434.6837	0.797861	0.424951	Random
2	Jema'a	0.989941	5882.7484	5823.5756	-0.066660	0.946853	Random
3	Kachia	0.991762	9824.2735	9743.3373	-0.054596	0.956460	Random
4	Kagarko	1.240297	6862.1498	8466.4540	1.453716	0.146025	Random
5	Kaura	0.993020	3481.8370	3457.5351	-0.042224	0.966320	Random
6	Kauru	0.1534758	7991.7337	12265.3784	3.393006	0.000691	Dispersed
7	Sanga	1.436827	5341.7440	7675.1618	2.771639	0.005577	Dispersed
8	Zangon Kataf	1.148779	7785.9726	8944.3651	0.943996	0.345172	Random

***Source:* Author's Fieldwork, 2022.**

The distribution pattern of PPHCs in the study area was determined by the average nearest neighbor in the ArcGIS 10.3 software interface. The average nearest neighbor analysis calculates the nearest neighbor index, which is a measure of the distance between each facility centroid and its nearest neighbor's centroid location; it then averages all these nearest neighbor distances. These parameters were used as the basis for determining whether the distribution is random, dispersed, or clustered. The average nearest neighbor summary for the study area (spatial pattern of the PPHCs, the average nearest neighbor statistics, and the results) is presented in Figures 6, 7, 8, and 9; and Tables 2, 3, 5, and 7 above. Tables 4, 6, and 8 show the summary of spatial patterns of Near Neighbor Analysis of LGAs in the 3 senatorial zones in Kaduna State. The summary shows the average nearest neighbor summary for the study area; the significant level and the critical level indicate a random distribution pattern of healthcare facilities in the area. Furthermore, the spatial pattern of PPHCs in the study area was statistically proven to be random in thirteen (13) LGAs including Zaria, Sabon-Gari, Makarfi, Soba, Kubau, Kajuru, Chikun, Zangon-Kataf, Kaura, Jema'a, Jaba, Kagarko and Kachia; dispersedly distributed in Eight (8) LGAs, which are Kudan, Ikara, Lere, Kauru, Sanga, Giwa, Birnin-Gwari and Igabi, and clustered in two (2) LGAs in Kaduna North and Kaduna South. It is possible to deduce that the clustered pattern of PPHC facilities in Kaduna North and Kaduna South LGAs can be attributed majorly to the fact that they had developed prior to the concept of PHC (WHO recommended 5km distance interval) with houses occupying everywhere as such most of the occupants were unwilling to give out their property or land for the proper siting of the PPHCs, this is in addition to lack of political will to pay compensation in the side of the government to ensure spatial justice in the distribution of the facility (Massoud, 2007). Also, the clustered pattern may be due to political reasons, whereby most of the facilities are located within limited locations where the human population is dense. This corroborates with the study of Kibon and Ahmed (2013), who discovered that pattern of healthcare facilities in Kano Metropolis Kano State, Nigeria is clustered and haphazardly distributed.

6. Conclusion and Recommendations

The study concluded that the distribution of PPHCs in Kaduna State is being characterized by significant disparity as lack of proportional distribution is observed in the nearest neighbor analysis. It is therefore recommended that Government should build more PPHCs or create additional electoral wards in the identified underserved LGAs bearing in mind the population density and accessibility of the facilities.

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