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# GEOSPATIAL ANALYSIS OF THE SPATIAL DISTRIBUTION PATTERNS OF HEALTHCARE INFRASTRUCTURE FOR SOCIOECONOMIC DEVELOPMENT IN SOUTHERN BORNO REGION, BORNO STATE, NIGERIA

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***ABSTRACT***

*This study analyzes the spatial distribution, concentration, and adequacy of healthcare infrastructure in Southern Borno, Nigeria, and its implications for socioeconomic development. Using 2024 data from the Borno State Ministry of Health, Local Government Health Departments, and field surveys, the locations of hospitals, Primary Health Centres (PHCs), and health posts were georeferenced with a Garmin 76 handheld GPS. Geographic Information System (GIS) techniques were employed to map and evaluate distribution patterns, while Nearest Neighbour Analysis (NNA) was used to assess spatial clustering. Location Quotient (LQ) and Z-scores were used to measure resource adequacy and rank healthcare provision across nine Local Government Areas (LGAs). Results reveal pronounced spatial inequalities and widespread inadequacies in healthcare infrastructure. Seven LGAs- Askira/Uba, Kwaya Kusar, Bayo, Chibok, Biu, Hawul, and Shani were relatively better served, whereas Damboa and Gwoza were critically disadvantaged across most indicators. NNA indicated significantly clustered distributions of PHCs ($Rn = 0.707$, $z = -6.53$, $p < 0.01$) and health posts ($Rn = 0.565$, $z = -6.60$, $p < 0.01$), with health posts exhibiting stronger clustering. LQ analysis showed pervasive shortages of medical personnel, hospital beds, and ambulances. Overall rankings identified Kwaya Kusar, Askira/Uba, and Bayo as the best-resourced, and Shani, Gwoza, and Damboa as the least equipped. The uneven and inadequate distribution of healthcare infrastructure undermines productivity, exacerbates poverty, increases mortality, and constrains rural development. The study concludes that Southern Borno faces both quantitative deficits and a skewed allocation of health resources, necessitating equitable redistribution, targeted deployment of personnel, infrastructure expansion, policy reforms, and continuous geospatial monitoring to promote inclusive socioeconomic development.*

**Keywords:** Geographic Information System, Healthcare Inequality, Spatial Distribution, Resource Adequacy, Spatial Clustering.

## INTRODUCTION

A region is a part of the Earth's surface identified by unique or distinct but shared characteristics, which may be physical, such as climate or terrain; human, such as cultural, ethnic, or economic; and functional, that is, centered on a node of activity. According to Dong et al. (2021), in some cases, regions have no distinct boundaries but are identified by patterns of homogeneity that distinguish them from surrounding areas. The delineation of regions is deliberately guided to align with particular analytical, planning, or administrative objectives. Cuadrado-Roura et al. (2025) emphasize that the definitions of regions are highly fluid and context-dependent; that is,

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what a region is in one study may differ in another, depending on the criteria employed, the terms' versatility, and their theoretical and policy relevance. Regions serve as administrative units and also as socioeconomic and political constructs that guide resource allocation, service delivery, and development trajectories (Okoli et al., 2020). As the world becomes increasingly interconnected, regional development promotes economic growth, reduces inequality, and improves the standard of living across the nation (Seddighi & Mathew, 2020). Uneven distribution of natural endowments, differences in climate and physical conditions, as well as lopsided institutional policies, lead to non-uniform economic opportunities for the population residing in different regions, commonly referred to as regional inequalities (Raheem et al., 2014).

Regional inequality is defined as unevenness in the levels of economic development and social well-being among people living in different geographical areas or regions within the country (Abduazeez et al., 2025). Regional inequalities stem from variations in infrastructure, physical endowments, urbanization, economic opportunities, historical legacies of colonization, and uneven public policies and fiscal transfers, which generally result in uneven development across regions. For instance, differences in physical landscape such as terrain, climate and resource endowments may be advantageous for some areas but constrains to other regions. All these forces lead to persistent disparities in income, employment, health, and education across regions, making regional inequality both a cause and consequence of broader socioeconomic divides. The implications of these disparities are reflected in inequities, inefficiencies, social cohesion, underutilization of regional potential, political discontent, and the reinforcement of inequality of opportunity in the absence of targeted policy interventions. According to Abduazeez (2025), one of the main approaches to proper regional development is regional planning, while the provision of socioeconomic indicators across geographical regions, either rural or urban, is an essential contributor to the regional planning and development. Jha et al. (2021) found that regional planning based on the spatial distribution patterns of these indicators, such as well-equipped and adequately staffed public schools, efficient public healthcare facilities, uninterrupted public power supply, tarred roads, efficient means of communication, and reliable security apparatus, is essential for the socioeconomic development of such regions.

In Borno State, there are three main regions based on the state's political districts. To the north is the Borno North region, in the center is the Borno Central region and in the southern part of the state, where this study was carried out. Regional disparities in Borno State manifest sharply in health, infrastructure, and income levels, with rural and peripheral LGAs critically underserved (Abduazeez, 2025). Based on the study by Yin et al. (2018), regions that lack investment in key areas such as infrastructure and human capital are bound to stagnate, while better-endowed regions thrive. Among the several indicators of socioeconomic development, healthcare infrastructure is a powerful driver of reducing regional inequality; yet its absence increases disparities.

Health infrastructure, which includes health facilities and resources (hospitals, clinics, medical staff, and equipment), is important in fostering the relationship between socioeconomic development and inequality in the Borno South region. Aliyu et al. (2020) reported that areas with underdeveloped health infrastructure tend to experience poorer health outcomes, lower economic productivity, hindered development, and a vicious cycle of inequality. Aliyu et al.

(2020) concluded that increasing regional integration through effective connectivity and coordination can positively enhance health infrastructure and workforce capacity.

Geospatial techniques, through the mapping of facility locations, service coverage, and population distributions, reveal the spatial patterns of hotspots, undersupply, bypassed areas, and unsampled or insecure areas. This study is grounded in concepts of spatial justice, health equity, and the relationship between infrastructure accessibility and socioeconomic development. It posits that equitable distribution of health infrastructure improves livelihoods, education, and resilience, particularly in conflict-affected contexts such as the Borno South region of Borno State. All spatial patterns are critical for equitable resource allocation and planning for socioeconomic development in conflict and displacement settings, such as Borno State in general and the Borno South region in particular. Sbarra et al. (2023) have used model-based geostatistical approaches and GIS cluster/buffer analyses to estimate vaccination and service gaps, quantify clustering of facilities around urban cores, and prioritize underserved LGAs for targeted investment. Abduazeez et al. (2025) have also applied geospatial techniques to mapping and analysis of education indicators for socioeconomic development in the Southern Borno region. The existing research remains narrowly focused on descriptive spatial patterns or on single LGAs, often relying on static surveys or GIS snapshots. There is a notable gap in robust, fine-scale geospatial modeling that links health infrastructure distribution to metrics of economic recovery, livelihood outcomes, or human development, especially in the Southern Borno region, where conflict and displacement persist. Therefore, applying geospatial tools to the spatial distribution patterns of health infrastructure in the Southern Borno region can directly inform interventions that reduce health inequities and catalyze local economic recovery. Therefore, studies of these gaps require adapting dynamic geospatial analyses to evaluate how improvements in the distribution of health infrastructure could catalyze sustained regional development in Borno South.

## STUDY AREA

The Southern Borno region consists of nine (9) LGAs (Askira/Uba, Bayo, Biu, Chibok, Damboa, Gwoza, Hawul, Kwaya-Kusar, and Shani) of the twenty-seven LGAs in Borno State. The region extends from Latitude 10º 02’ 11” to Latitude 11º 29’ 58” N., and from Longitude 11º 31’ 42” to 13º 58’ 20” E. It covers 21,010.39 km$^2$ (29.11%) of Borno State’s total land area of 72,179.88 km2. The Southern Borno region is bounded in the Northeast by the Republic of Cameroon, East by Adamawa State, South-West by Gombe State, West by Yobe State, and in the North by Kaga, Konduga, and Bama LGAs (Fig.1). The relief of the region consists of floodplains (mainly located around the valleys of the major rivers like the Hawul and Ndivana Rivers with elevation range from 178 m to 428 m above sea level.). Highland areas are the landscape separating the Biu plateau from the upland regions (Musa, 2023). The Hawul and Ndivana Rivers have the largest basin within the study area (Ikusemoran et al., 2017).

The climate of the Southern Borno region is tropical, with two distinct seasons: wet and dry. The wet season starts in May and ends in September, with heavy rainfall and high humidity. The dry season on the other hand, runs from October to April, with little or no rainfall (Binbol, 2009). However, rainfall on the Biu Plateau has been variously assessed as higher than in the surrounding areas (Abdullahi, 2014; Ahmed, 2019; Musa, 2023). Biu Plateau has the lowest

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mean temperature, ranging from 32.6 to 33.7 °C, while the southern part of the state, especially in Shani LGA, has the highest mean temperature, ranging from 37 to 38 °C (Musa, 2023; Akawu, 2021). Southern Borno region has a characteristic of Northern Guinea Savanna vegetation (Akawu, 2021). The vegetation includes short bushes, tall grasses, and acacia trees.

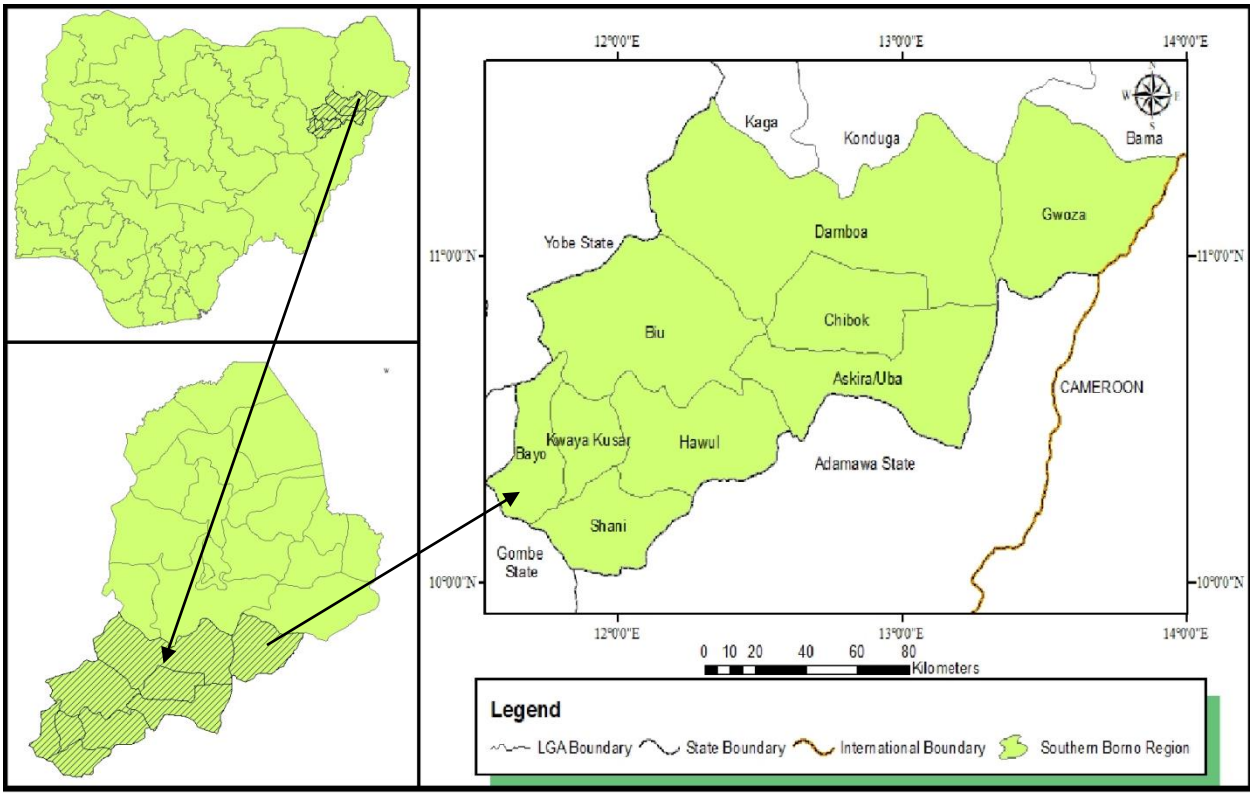


**Figure 1:** Study Area
**Source:** Digitized from the political map of Nigeria (OCHA, 2018)

The Southern Borno region accounts for about 30.18% of Borno State's population of 4,151,193 persons (NPC, 2007). The major ethnic groups that co-exist in the area are Pabur, Bura, Kanakuru, Marghi and Tera. Borno State government, NGOs, and International organizations such as the WHO and the European Union have significantly impacted the health infrastructure in the Southern Borno region (Abduazeez et al., 2025). The region boasts of several PHCs, health posts and especially General Hospital, Biu, which the state government has transformed into a regional specialist hospital serving neigbouring regions and States

## METHODOLOGY

### Data and Sources

The following data on health infrastructure for the year 2024 were collected:

(i) Names & GPS locations of Health Centers per LGA (Hospitals, Primary Health Centers). The names were obtained from the Borno State Ministry of Health and the Health Departments of each LGA in the Southern Borno region. Germin 76 GPS was used to capture the geographic data (Latitude and longitude) of each of the health centers

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(ii) Number of Medical Staff per LGA (Doctors, Pharmacists, Nurses/Midwives, Community Health Officers and Health Technicians. The secondary data were also obtained from the Borno State Ministry of Health, the Department of Planning and Statistics of Borno State, as well as the Health Departments of each of the LGAs

**Methods of Data Analysis**

*Mapping and analysis of the spatial distribution patterns*

Mapping and analysis of the spatial distribution patterns of health resources in the Borno South region was carried out using the following steps:

(i). Acquisition of the coordinates of the locations of each of the health resources in all the LGAs using a handheld GPS Garmin 76.

(ii). Creation of a Digital map of each of the LGAs within the study area with the GIS technique

(iii). Capturing the geographic data of the locations of all the health infrastructure and mapping the locations

(iv). A geostatistical technique in ArcGIS was employed to conduct a Nearest Neighbor Analysis in order to examine the spatial pattern of health infrastructure. The analysis was interpreted based on established criteria. When the Nearest Neighbor Ratio (Rn) is less than 1, the spatial distribution of health facilities is considered clustered, whereas a value greater than 1 indicates a random pattern. Similarly, a negative Z-score signifies a clustered distribution, while a positive Z-score suggests a random pattern. Furthermore, higher absolute Z-scores indicate greater clustering among the health infrastructure points.

*Mapping and analysis of the spatial concentration patterns*

Analysis of the spatial concentration pattern (skewness) of the health resources among the LGAs entails the calculations using the following formula (Chen et al., 2025):

Location Quotient Method (LQ = $e_1$/e divided by $E_1$/E

Where:

LQ = Location Quotient
$e_1$= Total number of facilities in a LGA
e = Total number of facilities in the District
$E_1$=Population of the LGA
E = Total Population of the District
If LQ = 1, Facilities are not skewed; if LQ < 1, Facilities are skewed.

The adequacy of the health infrastructure in each of the LGAs were analyzed using the rule that when the Z-Score is negative, facilities are not adequate

The spatial concentration pattern of each health resources in each of the LGAs were analyzed using the following rules:

i. When the value of the LQs is equal to one (1), the facility or indicator is equally spaced or distributed.

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ii. ii. When the LQ is less than one (1), the facilities or indicators are not sufficient in the region

iii. iii. Where the LQ is greater than one (1), it means that the indicators in the region are in excess.

*Threshold of Determination*

The LQ of the Borno South region is nine (9) because nine health resources were assessed in this study in the region. Therefore, the region's LQ, which is 9, becomes the threshold.

i. All the indicators that have an LQ value of 9 mean the indicator is just sufficient in the region and classified as advantaged.

ii When overall LQ is more than 9, the indicator is in excess and hence, the LGA is advantaged.

iii Indicators with LQ less than 9 reveal that such LGAs are at a disadvantage.

*Ranking of the Health Infrastructure among the LGAs in the region*

The ranking of the level of adequacy of the health resources indicators among the LGAs was analyzed using Z-Score formula and calculated in Microsoft Excel.

Step 1: Compute the Mean (Average). The formula for the mean is $\mu = N\sum X$, where $\sum X$ is the sum of all Health LQ values, and N is the number of LGAs.

Step 2: Compute the Standard Deviation (SD) $\sigma = \sqrt{(\sum (X - \mu)^2 / N)}$

Step 3: Compute Z-Scores $z = (X - \mu) / \sigma$ Mean

## RESULTS AND DISCUSSION

### Spatial distribution patterns of health infrastructure in Borno South Region

The spatial distribution of health resources in Borno South is shown in Table 1.

**Table 1.** Number of public health facilities/resources in Borno South Region

| LGA | Hosp. | PHC | Medical Doctors | Pharm | Other Snr. Med. Officers | Nurses | CHO/CHEWS | Beds | Amb |
|---|---|---|---|---|---|---|---|---|---|
| A/Uba | 3 | 12 | 1 | 2 | 5 | 39 | 57 | 350 | 1 |
| Bayo | 1 | 10 | 2 | 1 | 3 | 12 | 46 | 50 | 1 |
| Biu | 1 | 11 | 2 | 2 | 12 | 60 | 78 | 200 | 2 |
| Chibok | 1 | 11 | 1 | 0 | 3 | 8 | 58 | 50 | 1 |
| Damboa | 0 | 4 | 0 | 0 | 2 | 1 | 32 | 0 | 1 |
| Gwoza | 1 | 5 | 2 | 0 | 0 | 31 | 21 | 100 | 0 |
| Hawul | 2 | 12 | 2 | 1 | 3 | 30 | 22 | 130 | 2 |
| K/Kusar | 1 | 9 | 1 | 1 | 3 | 7 | 32 | 30 | 1 |
| Shani | 1 | 11 | 1 | 0 | 2 | 14 | 40 | 100 | 1 |
| **Total** | **11** | **85** | **12** | **7** | **33** | **202** | **386** | **1010** | **10** |

**Note:** Hosp = Hospitals, Pharm = Pharmacists, CHO/CHEWS = Community Health Officers/Community Health Extension Workers, Amb = Ambulances.

**Source:** Fieldwork, Borno State Ministry of Health, (2024)

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Table 1 presents the distribution of health resources across the LGAs in Borno South. The distribution of health resources in the region indicated an unequal allocation among the nine LGAs in Borno South. Unequal patterns of health facilities or resources among political units in an area have resulted from similar work in regions worldwide (Chima et al., 2025). Table 1 reveals significant inequality in healthcare infrastructure among the nine LGAs in the Southern Borno region. Cumulatively, there were only eleven (11) hospitals and twelve (12) medical doctors serving a large population of 1,252,678 (NPC, 2007), which is about 30.18% of the state's total population. The Spatial distribution patterns of health facilities/resources in the Southern Borno region are shown in Fig. 2. This imbalanced distribution of doctors and pharmacists forces the region to rely heavily on nurses and CHOs/CHEWs, thereby reducing the overall quality of healthcare. LGAs like Damboa, without a single functional hospital, doctor, or bed, show stark inequalities that leave residents vulnerable to disease and emergencies.

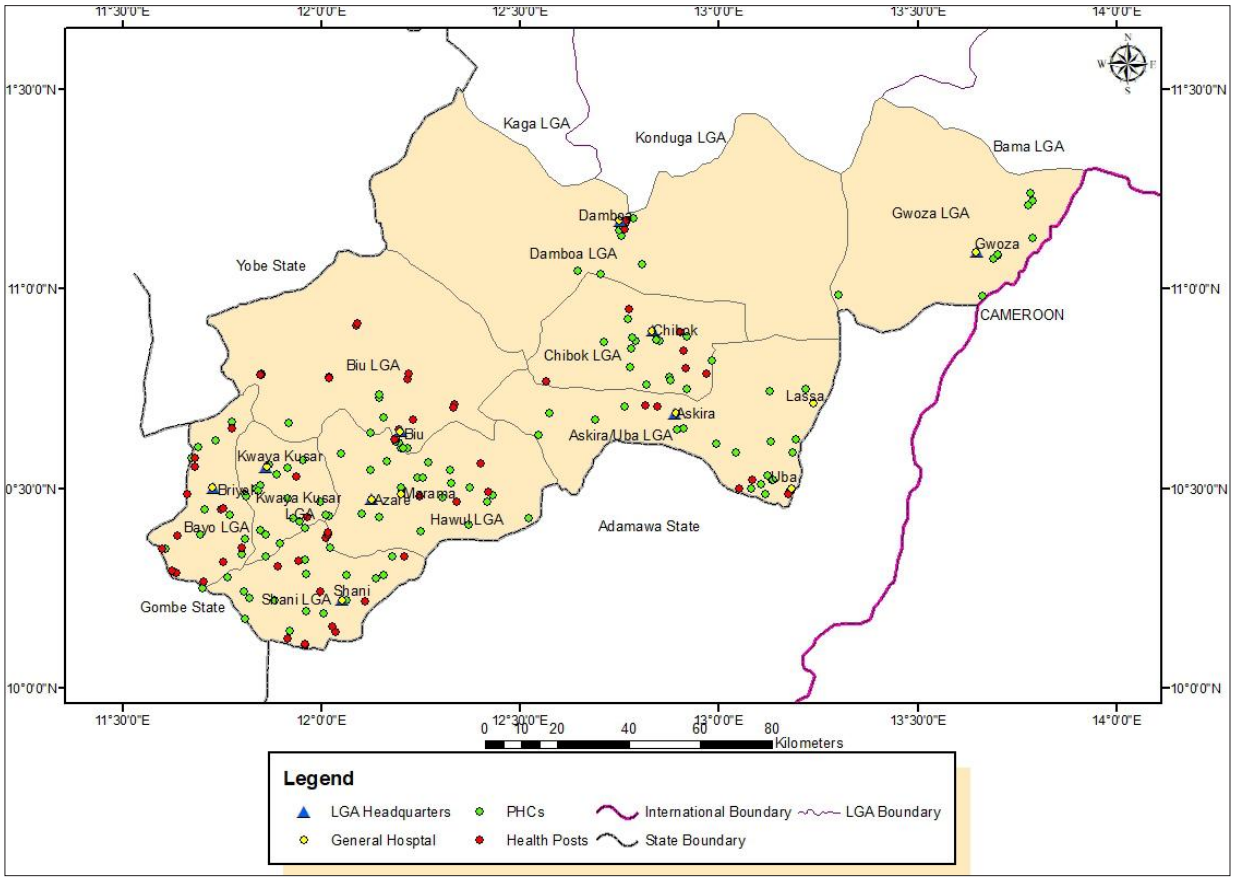


**Figure 2:** Spatial distribution pattern of health facilities/resources in Southern Borno

**Source:** Map digitized from the political map of Nigeria (OCHA, 2018); spatial patterns of health facilities mapped by the researchers.

The inadequate healthcare provisions in the region not only impede human capital development and reduce productivity but also discourage investment, which affects socioeconomic growth. In contrast, LGAs such as Askira/Uba, Bayo, and Biu, which have relatively higher health

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resources, show greater potential for improved health outcomes and community resilience. Therefore, among the consequences of inadequate healthcare are: limited workforce efficiency, increased poverty risks, and hindered sustainable development in the region.

Table 2 shows the results of the NNA on the spatial distribution patterns of health institutions in the Southern Borno Region.

**Table 2:** Nearest Neighbour Analysis of Health Institutions in Southern Borno

| Health Institutions | Nearest Neighbour Values | Z-Score | P-Values |
|---|---|---|---|
| PHC | 0.707422 | -6.527428 | 0.000000 |
| Health Posts | 0.565472 | -6.598099 | 0.000000 |

**Source:** Calculated using Geostatistical Analysis (Researcher, 2024)

The NNA values for PHC, though, were higher than those for Health Posts, but both NNA values indicated a clustered distribution because they were less than 1. However, Health Post is more clustered than PHC because PHC tends more toward one (1) than Health Post does. The P-values for both health institutions were very low, indicating that the distributions were clustered. The Z-score values were very close, and both were negative, further supporting the cluster nature of the distribution.

The output of the spatial patterns of the locations of all the health posts and PHCs, as analyzed using Nearest Neighbour Analysis, was presented in Figs 3a and 3b

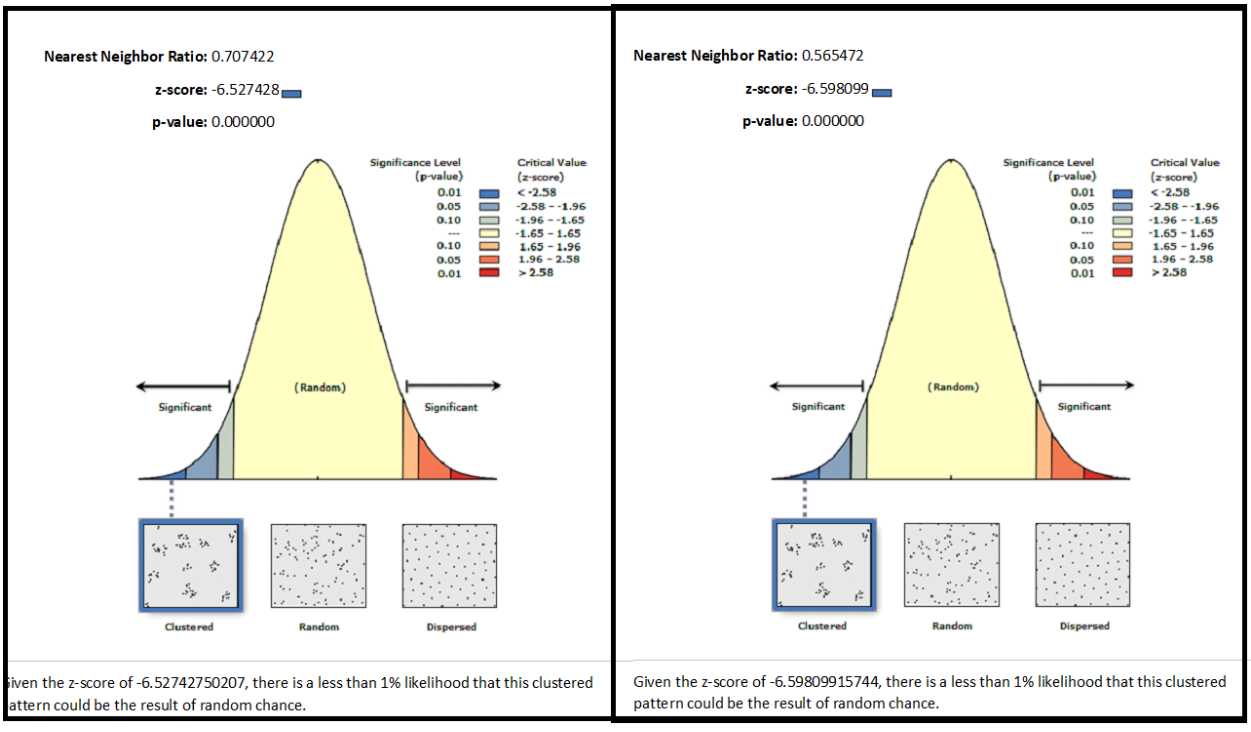

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**Figure 3a.** NNA of Health Posts in Borno South. **Figure 3b.** NNA of PHC in Borno South

The Nearest Neighbour Analysis values (Figs. 3a and 3b) show that both PHCs and Health Posts in the Southern Borno region are highly clustered rather than evenly distributed, as reflected by the low NN values and significant p-values. The clustered nature of the health infrastructure affects socioeconomic development in the region, as clustering implies unequal spatial access, with some communities underserved while others may experience duplication of facilities. Such uneven distribution increases rural–urban health disparities, limiting timely access to care and worsening preventable disease burdens. Poor access in remote areas discourages socioeconomic activities, reduces labor productivity, and deepens poverty. Therefore, to foster balanced development, the equitable distribution of health institutions is crucial for improving health outcomes, workforce efficiency, and overall resilience in the region.

**Spatial concentration patterns of health facilities in Southern Borno Region**

The concentration pattern of the assessed health resources in Borno South is presented in Table 3. Taking the number of Public Health Centers (PHC) which are saddled with the responsibility of rural health, for example, Borno South, which is typically a rural community, has three (3) LGAs (Biu, Gwoza, and Damboa) out of the nine LGAs in the region with insufficient health facilities and resources because the LQs of 0.92, 0.27 and 0.25 of the three LGAs respectively were all below the sufficient level of 1. The concentration of nurses who are the principal health officers in rural regions was also insufficient in most parts of Borno South, as only three (3) LGAs (Askira/Uba, Biu and Hawul) out of the nine (9) LGAs in the region recorded a sufficient number of nurses in the region (Table 4.14). Similar cases were recorded, especially in health resource indicators such as the numbers of Medical Doctors, Pharmacists, and other health officers, such as Radiographers, Physiotherapists, and Dentists (Table 3). Therefore, health facilities and resources in some LGAs in the region are insufficient. Similar findings were recorded in Bauchi State (Abah et al., 2022) and Adamawa State (Zira et al., 2024).

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| LGA | Population | No of Hospital | No of PHC | No. of Medi. Drs | No of Pham. | Other Med. Officers | Nurses | CHO/CHEW | No of Beds | Amb | LQ | Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| K/Kusar | 88439 | 2.01 | 2.34 | 1.84 | 3.15 | 2.01 | 0.77 | 1.83 | 0.66 | 2.21 | 16.81 | Advantaged |
| Askira Uba | 223519 | 2.38 | 1.23 | 0.73 | 2.50 | 1.32 | 1.69 | 1.29 | 3.03 | 0.87 | 15.04 | Advantaged |
| Bayo | 123335 | 1.44 | 1.86 | 2.64 | 2.26 | 1.44 | 0.94 | 1.89 | 0.78 | 1.58 | 14.84 | Advantaged |
| Chibok | 103457 | 1.72 | 2.44 | 1.57 | 0.00 | 1.72 | 0.75 | 2.84 | 0.93 | 1.89 | 13.85 | Advantaged |
| Biu | 274126 | 0.65 | 0.92 | 1.19 | 2.04 | 2.59 | 2.12 | 1.44 | 1.41 | 1.42 | 13.77 | Advantaged |
| Hawul | 188302 | 1.89 | 1.46 | 1.73 | 1.48 | 0.94 | 1.54 | 0.59 | 1.33 | 2.07 | 13.04 | Advantaged |
| Shani | 157508 | 1.13 | 1.60 | 1.03 | 0.00 | 0.75 | 0.86 | 1.28 | 1.23 | 1.24 | 9.13 | Advantaged |
| Gwoza | 431352 | 0.41 | 0.27 | 0.75 | 0.00 | 0.00 | 0.69 | 0.25 | 0.45 | 0.00 | 2.82 | Disadvantaged |
| Damboa | 362712 | 0.00 | 0.25 | 0.00 | 0.00 | 0.33 | 0.03 | 0.45 | 0.00 | 0.54 | 1.59 | Disadvantaged |
| **LQ Average** | | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **9** | |

**Table 3. Spatial concentration patterns of health resources in Borno State**

**Source: Calculated from the population and the existing health resources in each of the LGAs in Borno South**

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Assessing the overall skewness of the concentration pattern of health facilities and resources in the Borno South region, seven (7) LGAs, including Askira/Uba, Bayo, Biu, Chibok, Hawul, Kwaya Kusar, and Sani LQs, exceeded the regional average of 9. All seven LGAs are therefore advantaged in the concentration of health facilities and resources in the region. The remaining two (2) LGAs, Damboa and Gwoza, recorded LQ values below the regional average of 9. The two LGAs with LQs below the regional average of 9 were categorized as disadvantaged in the concentration of health facilities and resources in the region. The skewed spatial concentration of health facilities and resources has also been reported in other parts of the country, including Adamawa State (Zira et al., 2024).

The skewness of the health infrastructure reveals stark disparities in the spatial distribution of health resources across the region, with LGAs such as Gwoza and Damboa at a disadvantage due to severe shortages of hospitals, doctors, and beds, despite their large populations. In contrast, smaller LGAs such as K/Kusar, Bayo, and Askira Uba are at an advantage, indicating better healthcare relative to their populations. This imbalance undermines equitable access to health services, leading to higher morbidity and mortality in disadvantaged areas. Such inequalities hinder human capital development, deepen poverty, and may fuel migration pressures toward better-served LGAs. Overall, uneven concentration of health resources weakens regional socioeconomic growth and sustains structural inequalities.

**Ranking of health resources in Southern Borno**

The ranking of existing health resources across the nine LGAs in the region was derived from the Z-Score values of the LQs in each LGA (Table 4). The calculated Z-scores and ranks of health infrastructure for each LGA in the Southern Borno region are presented in Table 4.

**Table 4.** Rank of health infrastructure among the LGAs in Borno South Region

| LGA | LQ | Mean | Z-score | Rank |
|---|---|---|---|---|
| Kwaya Kusar | 16.81 | 11.21 | 1.42 | 1 |
| Askira Uba | 15.04 | 11.21 | 1.02 | 2 |
| Bayo | 14.84 | 11.21 | 0.98 | 3 |
| Chibok | 13.85 | 11.21 | 0.78 | 4 |
| Biu | 13.77 | 11.21 | 0.76 | 5 |
| Hawul | 13.04 | 11.21 | 0.62 | 6 |
| Shani | 9.13 | 11.21 | -0.41 | 7 |
| Gwoza | 2.82 | 11.21 | -1.68 | 8 |
| Damboa | 1.59 | 11.21 | -1.99 | 9 |
| **LQ Average** | **9** | | | |

**Source:** Authors' work (2025)

The ranking in Table 4 shows that Kwaya Kusar, Askira Uba, and Bayo LGAs ranked first, second, and third, respectively, in the availability of health infrastructure. While the last three were Shani, Gwoza, and Damboa LGAs. Based on the LQ values, only Kwaya Kusar and Askira Uba LGAs had Z-scores up to 1. The generally low Z-values of the LGAs within the Borno South region indicate

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limited availability of health infrastructure. The last three LGAs in the ranking, comprising Shani, Gwoza, and Damboa, all recorded negative Z-scores, revealing the gross inadequacy of health infrastructure in these LGAs. The ranking of health resources in the region is higher in four LGAs (Kwaya Kusar, Askra/Uba, Bayo, and Chibok) than in Biu, the regional headquarters. This finding is in contrast to that of the health resources in the neighbouring Adamawa State, where the facilities are clustered around the state capital (Zira et al., 2024)

The disparities indicate that access to quality healthcare is uneven, leaving highly populated but disadvantaged LGAs vulnerable to poor health outcomes. Limited infrastructure in lower-ranked areas reduces resilience to disease outbreaks, hinders workforce productivity, and perpetuates cycles of poverty (Adewole et al., 2018). In contrast, better-ranked LGAs are more likely to attract investment, sustain healthier populations, and foster local development. Such imbalances, if unaddressed, will continue to widen socioeconomic inequalities across the region.

## CONCLUSION AND RECOMMENDATIONS

The study concludes that the spatial distribution and concentration of public health resources in the Borno South region are both inadequate and highly uneven, with a clear pattern of clustering that leaves certain LGAs significantly disadvantaged. The Nearest Neighbour Analysis (NNA) confirmed that both PHCs and health posts are clustered rather than evenly dispersed, which undermines accessibility for rural communities. While a few LGAs, such as Kwaya Kusar, Askira Uba, Bayo, and Chibok, demonstrated a relative advantage in the availability of health infrastructure, the majority of LGAs fell below sufficiency thresholds, with Damboa and Gwoza standing out as the most disadvantaged across almost all health resource indicators. The low concentration of critical health personnel, particularly nurses, doctors, and pharmacists, and the limited provision of hospital beds and ambulances reveal systemic gaps that hinder effective healthcare delivery in the region. The ranking of health resources further illustrates that even the regional headquarters, Biu, does not top the list, suggesting a decentralized yet still skewed distribution that contrasts with patterns observed in other states where resources cluster around urban centres. Overall, the research highlights that Borno South suffers from both quantitative shortages and spatial inequities in healthcare provision, reinforcing the urgent need for deliberate policy interventions, equitable resource allocation, and investment in both health infrastructure and human capital to bridge the disparities and strengthen healthcare accessibility across the region.

The following recommendations were derived from the study’ s findings

(i) The findings of this study call for fair allocation of health facilities and resources across the LGAs within the region, while prioritizing disadvantaged areas like Damboa and Gwoza.
(ii) There is a need to increase health resources, such as the recruitment and deployment of more medical personnel, especially doctors, nurses, and pharmacists, to underserved LGAs.
(iii) Increase the number of health facilities such as hospitals, PHCs, beds, and ambulances in regions with critical shortages.
(iv) It is also necessary for the Borno State Government to implement targeted health policies and funding strategies that address rural healthcare disparities.
(v) Establishment of continuous spatial and statistical assessments to track distribution and ensure balanced resource allocation by the appropriate authorities.

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