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# Analysis of the Spatial Distribution and Network-Based Accessibility of Public Healthcare Facilities in Ilorin Metropolis, Kwara State, Nigeria

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**Abstract**

Access to healthcare remains a critical challenge in many developing urban centres. This study examined the spatial distribution and network-based accessibility of public healthcare facilities in Ilorin Metropolis, Kwara State, Nigeria. Using ArcGIS Pro, spatial data on 107 public healthcare facilities, road networks, and ward-level population were analysed. Average Nearest Neighbour (ANN) analysis, Closest Facility analysis, and Service Area analysis (time- and distance-based) were performed to evaluate physical accessibility. Results revealed a clustered distribution of facilities (ANN ratio = 0.68, z-score = -3.21, $p < 0.01$), with Ilorin South LGA hosting 38%, Ilorin East LGA hosting 35%, and Ilorin West LGA hosting 27%. Network analysis showed that 89% of the study area is within a 5-minute drive to the nearest facility, while 11% of peripheral wards require 10–15 minutes. Primary healthcare centres (PHCs) dominate coverage in the first 5-minute band (88.1% of the area). However, significant spatial disparities exist: central urban wards enjoy excellent access, while peri-urban wards in Ilorin West and parts of Ilorin South experience moderate to low accessibility. The study concludes that, while geographical coverage appears relatively good, network-based models reveal inequities not captured by simple Euclidean distance measures. Findings provide actionable evidence for the Kwara State Ministry of Health to prioritise facility upgrading and road improvements in underserved wards. Integration of GIS-based accessibility modelling is recommended for equitable healthcare planning in rapidly urbanising Nigerian cities.

Keywords: GIS, spatial accessibility, network analysis, service area, Ilorin Metropolis

**Résumé**

L'accès aux soins de santé demeure un défi majeur dans de nombreux centres urbains en développement. Cette étude examine la répartition spatiale et l'accessibilité en réseau des établissements de santé publique dans la métropole d'Ilorin, État de Kwara, Nigéria. A l'aide d'ArcGIS Pro, les données spatiales de 107 établissements de santé publique, du réseau routier et de la population par quartier ont été analysées. L'accessibilité physique a été évaluée par l'analyse du plus proche voisin (ANN), l'analyse de l'établissement le plus proche et l'analyse de la zone de desserte (basée sur le temps et la distance). Les résultats révèlent une répartition groupée des établissements (ratio ANN = 0,68, score z = -3,21, $p < 0,01$), avec 38 % dans la zone de gouvernement local d'Ilorin Sud, 35 % dans celle d'Ilorin Est et 27 % dans celle d'Ilorin Ouest. L'analyse de réseau a montré que 89 % de la zone d'étude se situe à moins de 5 minutes en voiture de l'établissement le plus proche, tandis que 11 % des quartiers périphériques nécessitent entre 10 et 15 minutes. Les Centres de Soins de Santé Primaires (CSSP) dominent la couverture dans le premier rayon de 5 minutes (88,1 % de la zone). Cependant, d'importantes disparités spatiales existent: les quartiers urbains centraux bénéficient d'une excellente accessibilité, tandis que les quartiers périurbains d'Ilorin Ouest et certaines parties d'Ilorin Sud connaissent une accessibilité faible à modérée. L'étude conclut que, malgré une couverture géographique apparemment satisfaisante, les modèles basés sur le réseau révèlent des inégalités non prises en compte par de simples mesures de distance euclidienne. Ces résultats fournissent des données probantes au ministère de la Santé de l'Etat de Kwara afin de prioriser la modernisation des établissements et l'amélioration du réseau routier dans les quartiers mal desservis. L'intégration de la modélisation de l'accessibilité basée sur un SIG est recommandée pour une planification équitable des soins de santé dans les villes nigérianes en pleine urbanisation.

Mots-clés : SIG, accessibilité spatiale, analyse de réseau, zone de desserte, métropole d'Ilorin

## 1.0 Introduction

Access to healthcare services is widely recognized as a fundamental determinant of population health, well-being, and socio-economic development. It plays a critical role in reducing morbidity and mortality, improving life expectancy, and enhancing overall quality of life (World Health Organization [WHO], 2023; Marmot & Allen, 2020). Ensuring equitable access to healthcare is therefore central to achieving universal health coverage (UHC) and remains a key target of the Sustainable Development Goals (SDGs), particularly Goal 3, which aims to ensure healthy lives and promote well-being for all (United Nations, 2023; WHO, 2019).

Despite global commitments toward strengthening healthcare systems, disparities in access to healthcare services persist, especially in developing countries where infrastructural, economic, and spatial inequalities remain pronounced (World Bank, 2022; Aregbeshola & Khan, 2018). In many parts of sub-Saharan Africa, access to healthcare is constrained not only by the availability of services but also by geographic barriers, poor transportation infrastructure, and inequitable distribution of health resources (Ouma et al., 2018). These challenges are further exacerbated by rapid urbanisation, which increases demand for healthcare services without corresponding improvements in infrastructure and service provision (UN-Habitat, 2020).

Spatial accessibility, defined as the ease with which individuals can reach healthcare services, represents a critical dimension of healthcare access (Delamater et al., 2012). It is influenced by multiple factors, including the spatial distribution of healthcare facilities, population distribution, and the structure and efficiency of transportation networks (McGrail, Humphreys, & Ward, 2019; Luo, 2021). Traditional approaches to measuring accessibility have often relied on Euclidean (straight-line) distance; however, such methods are limited in capturing real-world travel conditions, as they do not account for road networks, travel impedance, or physical barriers (Apparicio *et al.*, 2017)

The advancement of Geographic Information Systems (GIS) has significantly enhanced the analysis of spatial accessibility by enabling the integration of spatial and non-spatial datasets within a unified analytical framework (Khan & Bhardwaj, 2020; Wang & Xu, 2011). GIS-based network analysis, in particular, provides a more realistic assessment of accessibility by modelling actual travel routes and incorporating network impedance such as distance, connectivity, and travel constraints (Luo & Whippo, 2020; Fransen et al., 2015). This approach has been widely applied in healthcare accessibility studies to identify underserved areas and support evidence-based planning and policy decisions (Paez and Martin, 2019).

In Nigeria, healthcare accessibility remains a major concern due to the uneven distribution of healthcare facilities, inadequate transportation infrastructure, and disparities in resource allocation (Welcome, 2020). Empirical studies indicate that healthcare services are often concentrated in urban centres, leaving peri-urban and rural populations underserved (Adesanya et al., 2020; Uzochukwu et al., 2024). In rapidly growing cities, this imbalance is intensified by population expansion and urban sprawl, which increase demand for healthcare services while overstretching existing infrastructure (Adeloye et al., 2019).

Ilorin Metropolis, the capital of Kwara State, exemplifies a rapidly urbanising environment where population growth has not been matched by proportional development of healthcare infrastructure. The metropolis has experienced significant demographic expansion in recent decades, leading to increased demand for healthcare services and mounting pressure on existing facilities. The uneven spatial distribution of healthcare facilities across the metropolis, coupled with variations in road network connectivity, raises important concerns regarding spatial equity in healthcare access.

While previous studies on healthcare accessibility in Nigeria have provided valuable insights, many have relied on simplistic distance-based approaches that do not adequately capture the complexity of real-world accessibility (Abiodun et al., 2020). There is therefore a need for more robust analytical approaches that incorporate transportation networks and spatial interactions between population and healthcare facilities.

This study addresses the identified gap by applying GIS-based network analysis to evaluate spatial accessibility to public healthcare facilities in Ilorin Metropolis. Through a combination of spatial distribution mapping, service area modelling, and closest facility analysis on the road network, the study provides a realistic assessment of healthcare accessibility.

By adopting a network-based approach, this research contributes to the growing body of literature on spatial health analysis in developing countries. It offers practical insights for improving healthcare planning, infrastructure development, and equitable service delivery in rapidly urbanising regions such as Ilorin Metropolis.

## 2.0 Material and Method

### 2.1 Study Area

Ilorin is the capital of Kwara State and is located in the transitional zone between the deciduous woodland of the South and the dry savannah of the North central Zone of

Nigeria. It lies between latitude 8°00' and 8°46' North of the equator and longitude 4°31' and 5°00' East of the Greenwich meridian. Covers an approximate area of about 100km² (Kwara State Government, 2012).

Ilorin metropolis comprises three local government areas: Ilorin East, Ilorin South, and Ilorin West (Figure 1). It is bounded by Moro LGA to the northwest, Ifelodun LGA to the east and northeast, and Asa LGA to the south. It serves as a strategic urban center due to its geographical position as a gateway between the northern and southern parts of Nigeria. Founded in the early 19th century, Ilorin has evolved into a rapidly growing metropolitan city with a diverse population comprising different ethnic groups, notably the Yoruba, Hausa, Nupe, and Fulani communities. The city functions as the political, commercial, and administrative hub of Kwara State. Ilorin covers approximately 100 square kilometres (Kwara State Government, 2012).

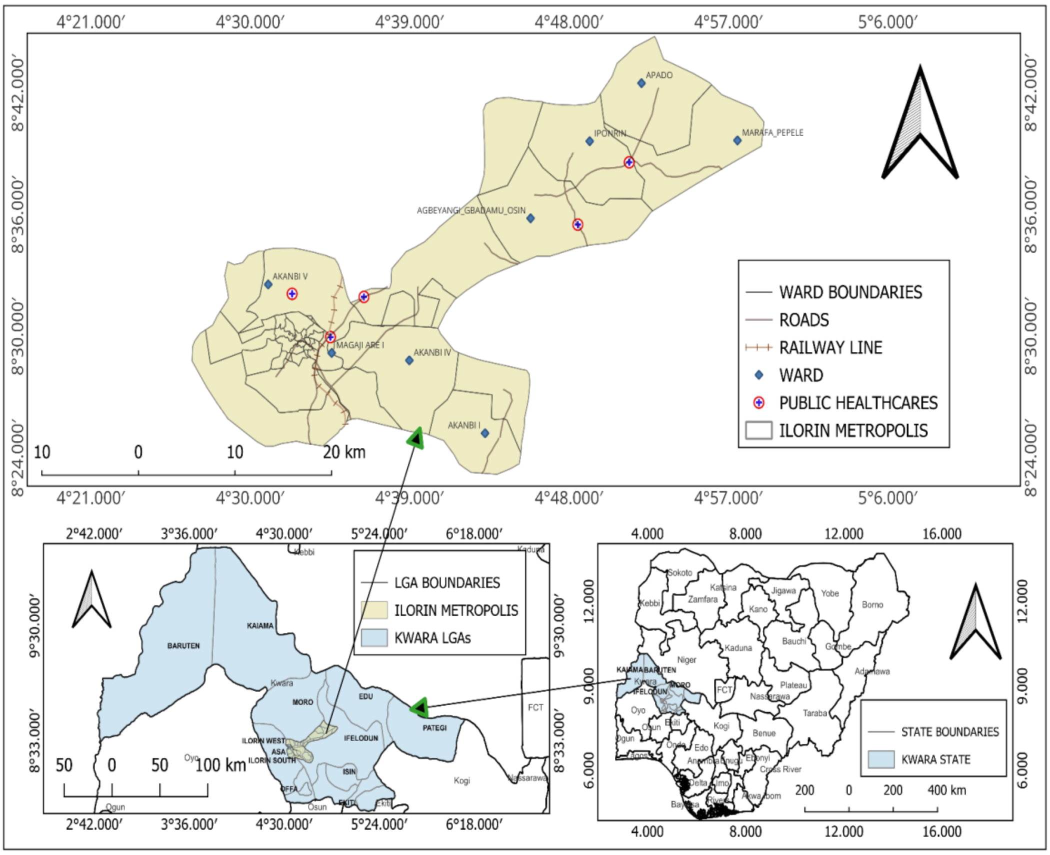


Figure 1: Ilorin Metropolis,

With a population of 781,934 as at 2006 (2009 FGN Gazetter Census-2006), and projected to be 1,436,413 people by 2025 based on the national average annual growth rate of 3.2%. Ilorin is characterised by a mix of urban, peri-urban, and rural settlements, making the equitable distribution and accessibility of healthcare services a significant planning and public health priority.

The climate of Ilorin is humid tropical lies under the influence of the two trade winds (southeast and northeast) prevailing over the country (Ajani and Adeniyi, 2017). It has a tropical savanna climate (Köppen climate classification *Aw*). The average annual temperature is around 26.2°C (79.1°F) (Olaniran, 2002).

### 2.2 Data Needs and Sources

The study utilized both spatial and non-spatial datasets obtained from relevant government agencies and institutional sources.

Spatial Data

This study utilised both spatial and attribute datasets, all of which were secondary sources. Spatial data included administrative boundaries, road networks, locations of public healthcare facilities, and population proxies.

Administrative boundary shapefiles for Ilorin Metropolis, encompassing the three Local Government Areas (Ilorin East, Ilorin South, and Ilorin West) and the 35 wards, were obtained from the Office of the Surveyor General of the Federation (OSGoF) (https://osgof.gov.ng/). and the Independent National Electoral Commission (INEC). These datasets defined the spatial extent of the study area and served as the basic geographic units for analysis.

The road network dataset, sourced from BBBike and OpenStreetMap (OSM), provided the transportation infrastructure necessary for network-based modelling. This dataset enabled the calculation of realistic travel distances and times along actual road networks, thereby improving the accuracy of accessibility measurements.

Geographic locations of the 107 public healthcare facilities were obtained from GRID3 and represented as point features. These facilities, categorised into primary, secondary, and tertiary levels, served as supply points in the accessibility models.

To represent population distribution, gridded population data (nga_pop_2025_CN_100m_R2024B) from WorldPop (www.worldpop.org) were used. Population density was calculated at the ward level using zonal statistics, and ward centroids were generated as demand points for network analysis and accessibility modelling.

Attribute data provided essential information on the characteristics of each healthcare facility. Key attributes included facility name, type (primary, secondary, or tertiary), ownership status, address, and the number of medical personnel (doctors, nurses, and community health workers). This variable represents the service capacity of each facility and served as an important input in the accessibility modelling process.

### 2.3 Data Presentation and processing

All spatial datasets were imported into QGIS and ArcGIS Pro for processing and analysis. The datasets were reprojected to Universal Transverse Mercator (UTM) Zone 31 North (EPSG:32631) in QGIS to ensure spatial consistency and measurement accuracy. Attribute tables were examined for completeness, and necessary corrections were made to remove duplication and ensure data reliability also, additional fields were created where Geometry, Field calculator were used to do calculations where necessary. The road network dataset was checked, topologically cleaned in ArcMap while the dangles and duplicates were removed for connectivity to support network-based analysis. Network datasets were built on roads, with travel impedance (distance in km and estimated travel time in minutes) defined based on Nigeria Road Safety Corps' road classification guidelines and local traffic conditions. These were integrated into a geodatabase for analysis in ArcGIS Pro environment.

### 2.4 Method of data analysis

Spatial Distribution of Healthcare Facilities

This study examines the spatial distribution of healthcare facilities in Ilorin Metropolis, Nigeria. The analysis is based on projected healthcare facilities and Ilorin Metropolis wards shapefiles. The projected healthcare facilities shapefile was imported into the ArcGIS Pro environment, also the ward Shapefile were combined to create the database for analysis. Using this database, distribution maps of the healthcare facilities by types was produced. Tables were also used to display the total number of primary, secondary, and tertiary healthcare facilities across the State. Additionally, the tables show the population figures for both the State and its local government areas, along with the supply ratio of healthcare facilities to the population.

### 2.5 Average Nearest Neighbour (ANN)

The spatial pattern of public healthcare facilities was analysed using equation (1) the Average Nearest Neighbour (ANN) technique, an inferential statistical tool in GIS which compares the observed mean distance between each facility and its nearest neighbour with the expected mean distance for a random distribution. The ANN ratio is calculated as the ratio of observed mean distance ($D_0$) equation (2) to expected mean distance ($D_E$) equation (3). An ANN ratio less than 1 indicates clustering, while a value greater than 1 suggests dispersion. Statistical significance is assessed using the z-score equation (4) and corresponding p-value.

Mathematically,

$$ANN = \frac{D_0}{D_E} \tag{1}$$

Where $D_0$ is the observed mean distance between each feature and its nearest neighbour, $D_E$ is the expected mean distance for the features given in a random pattern.

$$D_o = \frac{\sum_{i=1}^{n} d_i}{D_E} \tag{2}$$

Where $d_i$ is the distance between feature i and its nearest neighbouring feature and n is the total number of features

$$D_E = \frac{0.5}{\sqrt{n}/A} \tag{3}$$

*n* corresponds to the total number of features, and *A* is the area of a minimum enclosing rectangle around all features, or the corresponding study area.

The average nearest neighbour z-score for the statistic is given as:

$$z = \frac{D_O - D_E}{S_E} \tag{4}$$

And $S_E$ is given as equation (5)

$$S_E = \frac{0.26136}{\sqrt{n^2}/A} \tag{5}$$

Where $S_E$ is the Standard Error which is used to calculate the z-score, it helps determine the statistical significance of the ANN ratio. If the index (average nearest neighbour ratio) is less than 1, the pattern exhibits clustering. If the index is greater than 1, the trend is toward dispersion.

### 2.6 Spatial accessibility of healthcare facilities in Ilorin Metropolis

Spatial accessibility analysis in this study was conducted using two major network-based techniques in ArcGIS Pro: Service Area Analysis and Closest Facility Analysis. Service Area Analysis was employed to evaluate the spatial coverage of public healthcare facilities based on actual road network travel distances. Catchment zones were generated around each facility using network distance impedance with specified thresholds of 1,000 m, 3,000 m, and 5,000 m (and corresponding travel time thresholds). This approach enabled the delineation of overlapping service areas, reflecting realistic conditions where residents can access multiple facilities. The resulting service area polygons were overlaid with ward boundaries and population data to assess the extent of healthcare coverage across the metropolis.

Closest Facility Analysis was performed to determine the shortest travel distance and time from ward centroids (representing population demand points) to the nearest public healthcare facility along the road network. Public healthcare facilities served as origin points, while ward centroids acted as destination incidents. A search tolerance of 500 metres and snap tolerance of 5 metres were applied to ensure accurate connectivity to the road network. This analysis provided valuable insights into the actual travel impedance experienced by residents and helped identify wards with poor accessibility to healthcare services.

## 3.0 Results

### 3.1 Spatial Distribution of Public Healthcare Facilities (HCF) in Ilorin Metropolis

The spatial distribution of public healthcare facilities (HCFs) in Ilorin Metropolis, as shown in Figure 2, exhibits a distinct pattern of central clustering with marked scarcity at the urban fringes. The study area spans 35 wards across three Local Government Areas (Ilorin East, Ilorin West, and Ilorin South), accommodating a total of 107 public healthcare facilities. These facilities are distributed across all wards except Balogun Gambari II and Okaka II, which currently have no public HCFs.

As illustrated in Figure 2, the majority of facilities are primary healthcare centres, predominantly concentrated in the densely populated central wards of Balogun Fulani, Okaka I, Magaji Ngeri, Ojuekun Sarumi, and Balogun Alanamu. In contrast, only a few primary healthcare facilities are scattered at the urban fringes, particularly in wards such as Iponrin, Apado, and Maya Ile Apa. Secondary healthcare facilities are also largely located in the central zone, particularly around the traditional administrative core, with approximately two facilities observed in Ilorin East LGA. Tertiary healthcare services are limited to two main locations: the University of Ilorin Teaching Hospital at Oke-Oyi in Ilorin East LGA and the facility at Balogun Fulani III in Ilorin South LGA.

Figure 3 shows the number of public healthcare facilities (HCFs) in each ward. The Akanbi (I–V) wards collectively host the highest number with 29 facilities. In contrast, several peripheral wards such as Apado, Badari, and Magaji II have only one healthcare facility each.

Figure 4 illustrates the spatial distribution of public HCFs by type across the wards. Out of the total 107 facilities, only two are tertiary healthcare centres — the University of Ilorin Teaching Hospital and the Kwara State University Teaching Hospital. Approximately eight are secondary healthcare facilities, mostly concentrated in the central area, while the remaining 97 are primary healthcare centres.

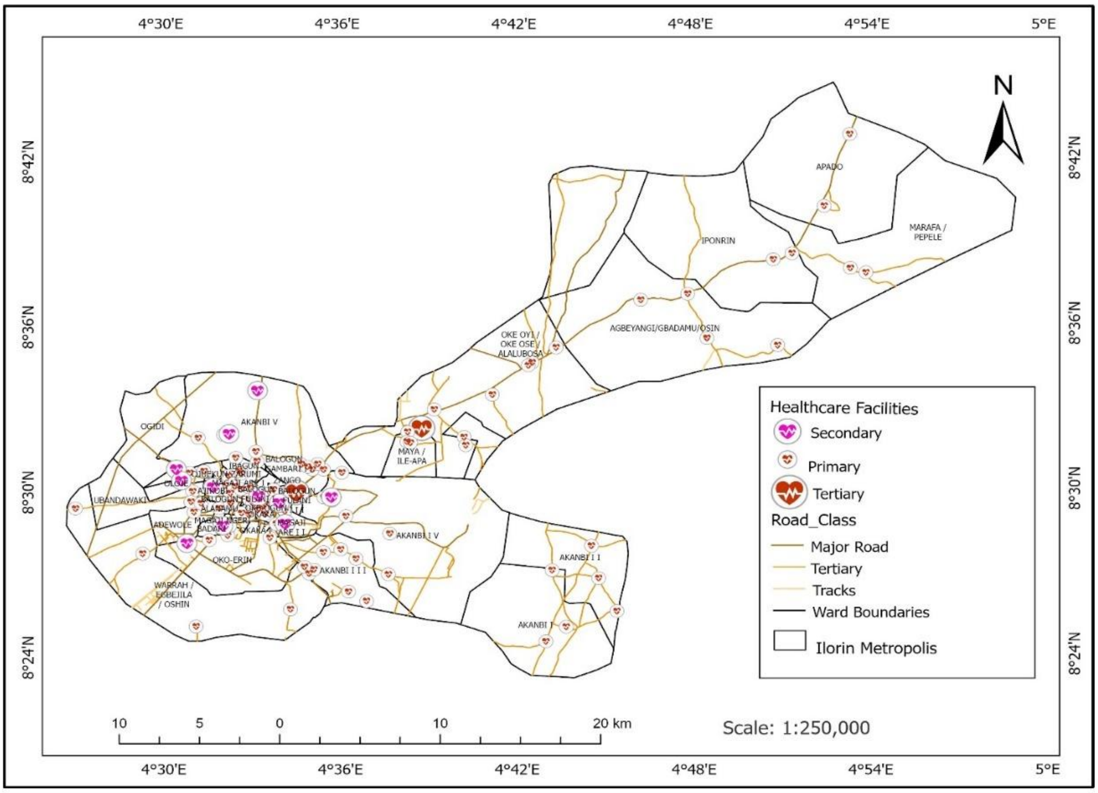


Figure 2: Spatial Distribution of Healthcare Facilities

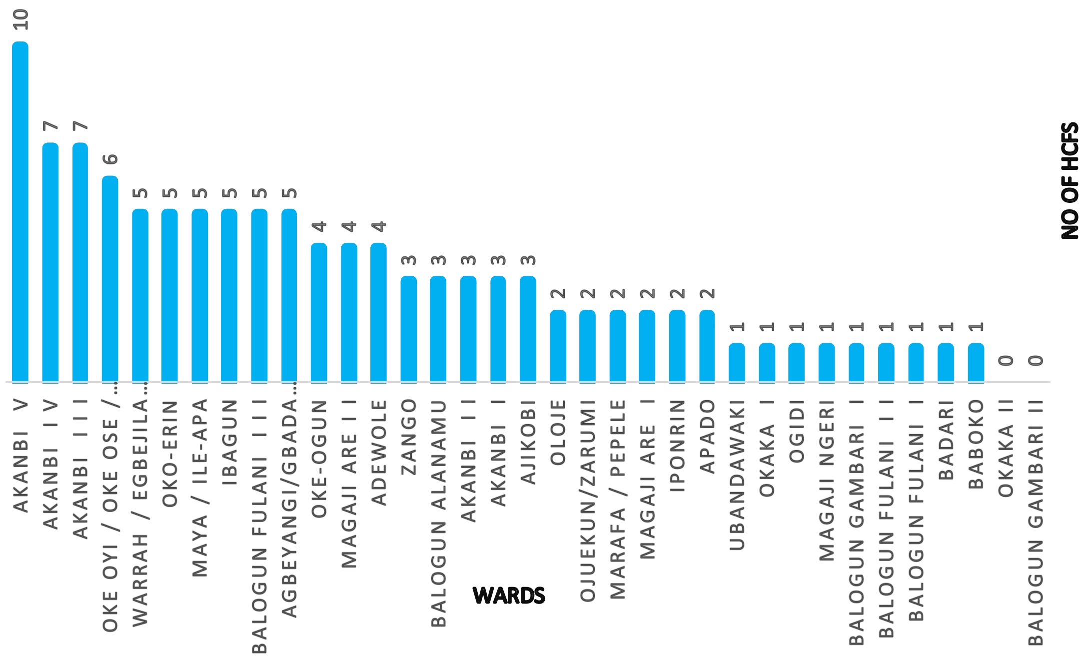


Figure 3: Graphical representation of the Healthcare Facilities Distribution

Figure 5 presents the percentage distribution of public healthcare facilities (HCFs) by type in the study area. Primary healthcare facilities dominate with 92%, followed by secondary facilities at 6% and tertiary facilities at 2%. This composition highlights a significant imbalance in both the spatial distribution and the types of healthcare facilities. Given the relatively small number of secondary facilities in relation to the large population of the study area, these facilities are expected to experience considerable pressure.

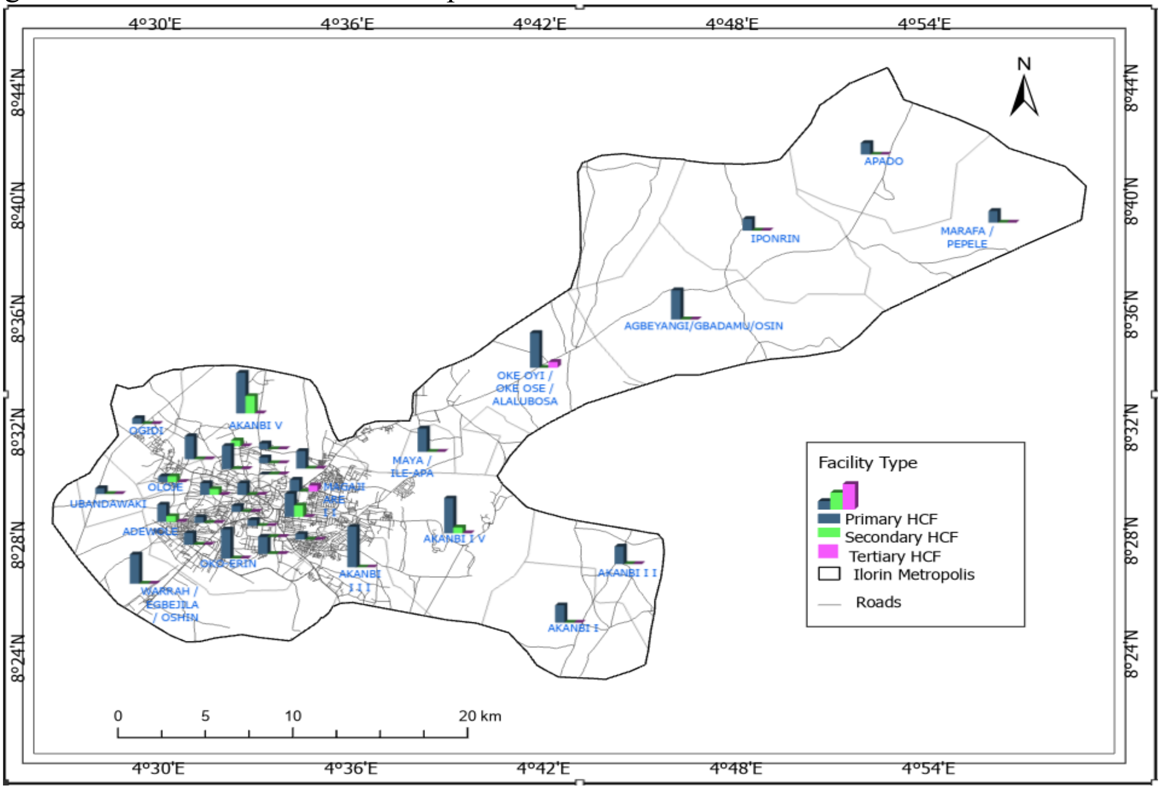


Figure 4: Facility Type per Ward

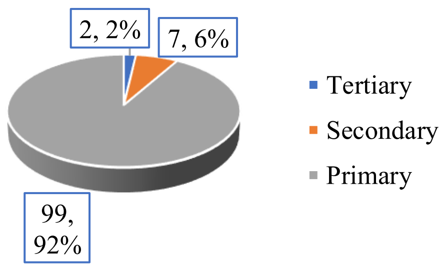


Figure 5: Percentage Distribution of Healthcare Facilities by Types

### 3.2 Average Nearest Neighbour (ANN)

An Average Nearest neighbour (ANN) analysis was performed to statistically validate the spatial clustering of public healthcare facilities. As shown in Table 1 and Figure 6, the Nearest neighbour Ratio of 0.6012 indicates a strong clustering tendency. The z-score of -8.73 and p-value (< 0.001) confirm that the observed clustering is statistically significant at the 99% confidence level. There is less than a 1% probability that this pattern occurred by random chance, suggesting that the distribution of healthcare facilities is strongly influenced by urban density, infrastructure, and administrative priorities.

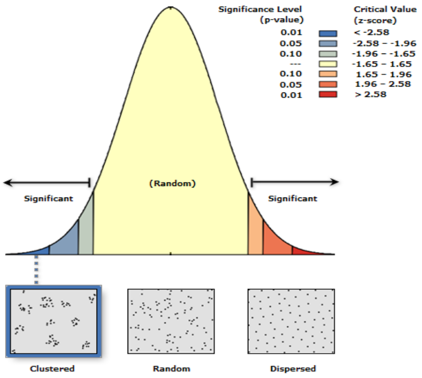


Figure 6: Average Nearest Neighbour

Table 1: Average Nearest Neighbour Summary

| | |
|---|---|
| Observed Mean Distance: | 928.4258 m |
| Expected Mean Distance: | 1544.3452m |
| Nearest Neighbour Ratio: | 0.601178 |
| z-score: | -8.732649 |
| p-value: | 0.000000 |

**Network-Based Accessibility**

### 3.3 Closet Facility Analysis (CFA)

**Finding the closet facility to each of the ward centroid point**

Figure 7 indicates a pronounced spatial disparity in accessibility to public healthcare facilities across Ilorin metropolis. While central wards exhibit short travel times and distances due to dense facility distribution and well-connected road networks, peripheral wards experience significantly longer journeys, reflecting infrastructural and service deficiencies. These findings underscore the need for spatially equitable healthcare planning and support the integration of facility capacity and personnel distribution into advanced accessibility models. The distance-based results further reinforce the observed disparities in accessibility. Specifically, Table 2 reveals that network distances to the nearest facility range from approximately 28.6 m to over 9.32 km, indicating substantial variation in accessibility levels. Wards such as Balogun Gambari I, Balogun Fulani I, and Ibagun enjoy very high proximity, whereas wards such as Ogidi, Iponrin and Maya/Ile-Apa are relatively distant from healthcare services.

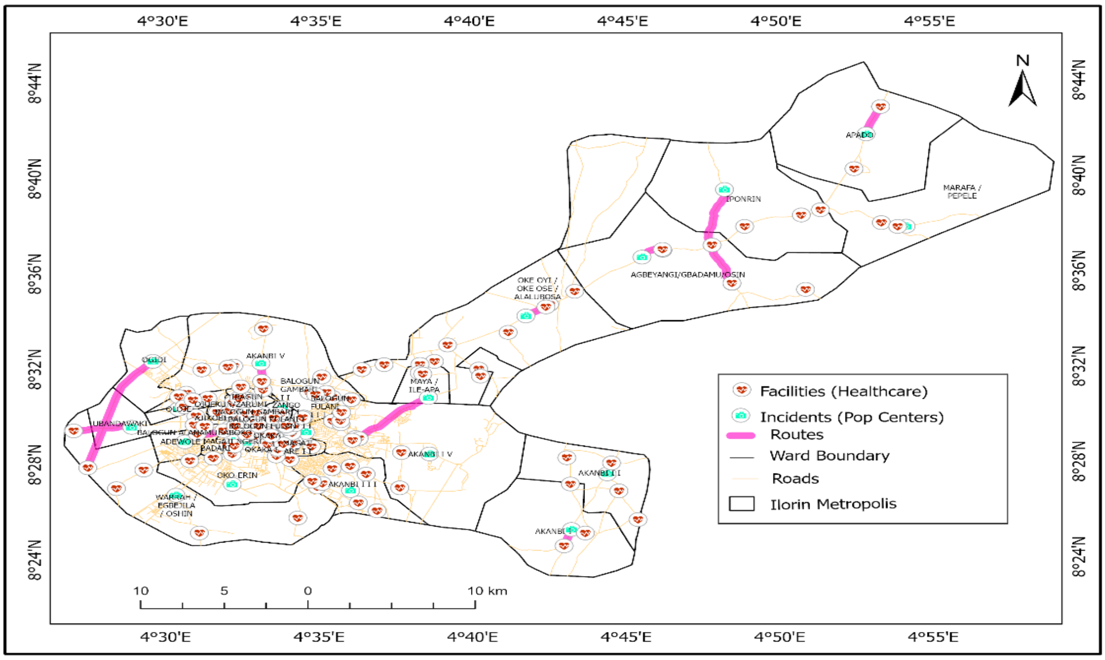


Figure 7: Closet/Nearest facility to each of the incident / Ward

Table 2: Results of Closest Facility Analysis Showing Travel Time and Distance from Ward Centroids to Nearest Healthcare Facilities in Ilorin Metropolis

| Object ID | Facility ID | Facility Rank | Facility Name | Incident Curb Approach | Facility Curb Approach | Total Time (mins) | Total Distance (m) | Shape Length (m) |
|---|---|---|---|---|---|---|---|---|
| 1 | 34 | 1 | Agbeyangi/Gbadamu/Osin - Christianah Maternity Clinic | 1 | 1 | 2.96 | 1,477.3 | 1,477.3 |
| 2 | 30 | 1 | Akanbi I - Bada Ifedapo Primary Health Care Center | 2 | 1 | 4.67 | 1,332.3 | 1,332.3 |
| 3 | 18 | 1 | Akanbi V - Alimayaki Health Center | 2 | 1 | 8.15 | 2,076.0 | 2,075.9 |
| 4 | 128 | 1 | Apado - Woru Health Post | 1 | 1 | 9.59 | 2,292.1 | 2,292.3 |
| 5 | 6 | 1 | Balogun Alanamu - Adewole Health Center | 1 | 1 | 12.14 | 2,069.4 | 2,069.3 |
| 6 | 56 | 1 | Balogun Fulani I - Igboro Children Hospital Specialist Centre | 2 | 1 | 13.01 | 54,509.0 | 54,507.0 |
| 7 | 123 | 1 | Balogun Fulani II - Temitope Hospital | 2 | 2 | 14.99 | 493.6 | 493.5 |
| 8 | 53 | 1 | Balogun Gambari I - Ibukan Oluwa Health Clinic Centre | 1 | 2 | 16.06 | 28,593.0 | 28,592.0 |
| 9 | 91 | 1 | Ibagun - Ojagboro Primary Health Care Center | 2 | 1 | 18.21 | 103.1 | 103.1 |
| 10 | 9 | 1 | Iponrin - Agbeyagi Primary Health Care Center | 2 | 2 | 19.16 | 8,008.2 | 8,008.9 |
| 11 | 81 | 1 | Marafa/Pepele - Marafa Primary Health Center | 2 | 1 | 23.99 | 4,990.1 | 4,996.0 |
| 12 | 51 | 1 | Maya/Ile-Apa - Group Medical Center | 1 | 2 | 24.11 | 5,356.5 | 5,356.4 |
| 13 | 55 | 1 | Ogidi - Ife Olu Gaa Clinic and Maternity | 1 | 2 | 25.18 | 9,319.5 | 9,318.9 |
| 14 | 8 | 1 | Oke Oyi/Oke Ose/Alalubosa - Agbaku Eji Primary Health Centre | 2 | 2 | 30.28 | 1,382.1 | 1,382.1 |
| 15 | 90 | 1 | Ubandawaki - Ogundele Health Center | 1 | 1 | 33.70 | 3,509.8 | 3,509.8 |

### 3.4 Service Area Coverage Analysis

Service Area Analysis is a network-based GIS technique used to delineate the geographic areas that can be reached from healthcare facilities within specified travel distances or times along the actual road network. It generates service area polygons representing all accessible streets and locations within a defined impedance threshold (e.g., 5 minutes or 1 km). By creating multiple concentric zones, the method reveals variations in accessibility levels, showing how coverage changes as travel distance or time increases. This approach enables researchers to quantify the proportion of the population, land area, or settlements falling within different accessibility thresholds, thereby providing a more realistic assessment of spatial coverage than simple Euclidean buffers.

**Driving Distance-Based Service Area Accessibility**

The driving distance-based service area analysis in Ilorin Metropolis delineated three concentric accessibility zones: 0–1,000 m (high accessibility), 1,000–3,000 m (moderate accessibility), and 3,000–5,000 m (low accessibility). These zones were generated using the road network as impedance, providing a realistic assessment of spatial coverage around public healthcare facilities.

Results revealed a strong concentration of healthcare services in the central urban core. The 0–1,000 m band overwhelmingly dominated, covering approximately 801 million m² and accounting for 88.4% of the total service area. This zone primarily encompasses central wards such as Balogun Fulani, Baboko, Balogun Alanamu, and Okaka, offering excellent proximity-based access to residents. In contrast, peripheral wards including Agbeyangi/Gbadamu/Osin, Marafa Pepele, Apado, Oke-Oyi/Oke-Ose, and Warah/Egbejila/Osin fell predominantly within the 3,000–5,000 m band, indicating significantly lower accessibility.

The 3,000–5,000 m service area was the smallest, covering only about 41.6 million m² (4.6% of the total area). This sharp decline in coverage beyond 1,000 m highlights the combined effect of facility clustering in the urban centre and weaker road network connectivity in fringe areas. The findings underscore marked spatial inequity in healthcare access, with central wards benefiting from dense facility distribution and good connectivity, while peripheral zones experience substantial barriers to timely access.

- 0–1000 m: ≈ 88.4% (high accessibility)
- 1000–3000 m: ≈ 7.1% (moderate accessibility)
- 3000–5000 m: ≈ 4.6% (low accessibility)

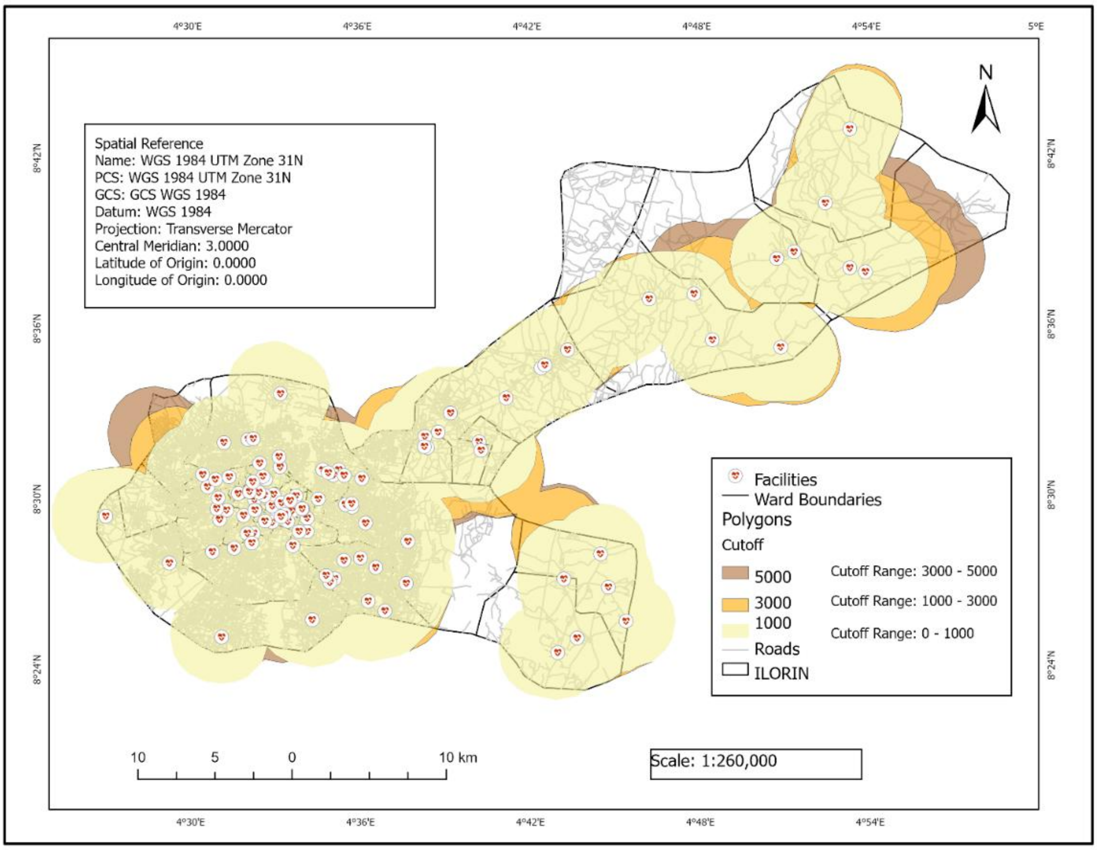


Figure 8: Driving Distance–Based Service Area Coverage for Public HCFs

Table 3 Summary of distance-based service area coverage around public healthcare facilities in Ilorin Metropolis

| Cutoff (meters) | From Break (m) | To Break (m) | Shape Area (m²) | % Coverage Area |
|---|---|---|---|---|
| 0 – 1,000 | 0 | 1,000 | 801,070,313 | 88.4 |
| 1,000 – 3,000 | 1,000 | 3,000 | 63,956,250 | 7.1 |
| 3,000 – 5,000 | 3,000 | 5,000 | 41,599,687.5 | 4.6 |

Table 4: Service Jurisdictions and Driving Distance Bands in Ilorin Metropolis

| PHC Name | Ward (Service Jurisdiction) | LGA | Driving Distance Band (m) | Accessibility Level |
|---|---|---|---|---|
| Balogun Fulani PHC | Balogun Fulani I–III | Ilorin West | 0–1,000 | High |
| Oja-Oba PHC | Oja-Oba | Ilorin West | 0–1,000 | High |
| Baboko PHC | Baboko | Ilorin West | 0–1,000 | High |
| Oloje PHC | Oloje | Ilorin West | 0–1,000 | High |

| PHC Name | Ward (Service Jurisdiction) | LGA | Driving Distance Band (m) | Accessibility Level |
|---|---|---|---|---|
| Akanbi I PHC | Akanbi I | Ilorin South | 0–1,000 | High |
| Akanbi IV PHC | Akanbi IV | Ilorin South | 1,000–3,000 | Moderate |
| Akanbi V PHC | Akanbi V | Ilorin South | 1,000–3,000 | Moderate |
| Adewole PHC | Adewole | Ilorin South | 1,000–3,000 | Moderate |
| Apado PHC | Apado | Ilorin East | 3,000–5,000 | Low |
| Oke-Oyi PHC | Oke-Oyi / Oke-Ose | Ilorin East | 3,000–5,000 | Low |
| Agbeyangi PHC | Agbeyangi / Gbadamu / Osin | Ilorin West | 3,000–5,000 | Low |
| Marafa PHC | Marafa / Pepele | Ilorin East | 3,000–5,000 | Low |

**4. Discussion**

The spatial distribution of public healthcare facilities in Ilorin Metropolis exhibits significant disparities across the three Local Government Areas and 35 wards. With 107 facilities identified, Ilorin South LGA recorded the highest share (41 facilities), followed by Ilorin East (37) and Ilorin West (29). This uneven pattern, characterised by heavy concentration in certain LGAs and central wards, aligns with findings from previous studies in Nigeria and Ghana (Amoah-Nuamah et al., 2023; Mohammed et al., 2024; Ishaq et al., 2024; Abdulkarim et *a*l., 2017). Consequently, Ilorin East LGA falls below both state and WHO recommended facility-to-population ratios, potentially resulting in long waiting times, staff shortages, and compromised service quality due to high population pressure on limited facilities.

Average Nearest Neighbour analysis revealed a Nearest Neighbour Ratio (NNR) below 1, confirming a statistically significant clustered distribution of healthcare facilities (ESRI, 2023). This clustering implies over-servicing in central areas and under-servicing in peripheral wards, thereby increasing travel distance and time for residents in less developed zones.

Network-based accessibility analysis further exposed substantial spatial inequities. Closest Facility Analysis highlighted a distinct core–periphery pattern, with central wards enjoying significantly shorter travel distances and times compared to peripheral areas. Although service area analysis indicated that over 88% of the study area lies within a 5-minute drive or 1 km of a facility, this proximity-based measure tends to overestimate true accessibility. As noted by Luo (2022), such approaches often fail to account for service capacity and population demand, thereby masking underlying disparities in effective healthcare access.

Overall, the findings demonstrate that while geographical coverage appears relatively adequate, network-based models reveal persistent inequities in both facility distribution and accessibility, driven by central clustering and inadequate staffing in peripheral locations.

## 5.0 Conclusion and Recommendation

This study examined the spatial distribution and network-based accessibility of public healthcare facilities in Ilorin Metropolis using GIS techniques. Findings revealed that healthcare facilities are unevenly distributed and clustered within central urban wards, while peripheral areas experience lower accessibility and longer travel distances. Although many residents fall within acceptable travel thresholds, significant inequalities in healthcare access persist across the metropolis.

The study further demonstrated the effectiveness of GIS and network analysis in identifying underserved areas and evaluating healthcare accessibility. However, the use of ward centroids may not fully capture intra-ward accessibility variations, especially in large wards such as Warah/Egbejila, Agbabiaka, and Oke-Oyi. The study recommends the adoption of advanced models such as the Enhanced Two-Step Floating Catchment Area (E2SFCA) method to better account for distance decay, service competition, and medical personnel shortages, while emphasizing the need for improved healthcare infrastructure and road networks in underserved areas.

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