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SPATIAL ANALYSIS OF HEALTH CARE FACILITIES FOR EQUITABLE ACCESS: A CASE STUDY OF ABAKALIKI LOCAL GOVERNMENT AREA, EBONYI STATE

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Abstract

This study presents the development of a comprehensive geospatial database and digital mapping of healthcare facilities within Abakaliki Local Government Area, Ebonyi State, utilizing Geographic Information System (GIS) techniques. Primary geospatial data were collected through Global Positioning System (GPS) field surveys, complemented by secondary data obtained from the archival resources of the GIS department within the Office of the Surveyor General of Ebonyi State. Spatial data processing and analysis were conducted using QGIS version 2.4.0. The spatial analysis of health care facilities in Abakaliki Local Government Area revealed significant disparities in their distribution, underscoring challenges in equitable access to healthcare services across the metropolis. A total of 151 health care facilities were identified and categorized into clinics (130), hospitals (8), primary health centers (7), and health laboratories (6). This composition highlights a predominance of clinics with relatively fewer hospitals and other specialized facilities, reflecting the general structure of health service provision in the area. These findings highlight critical gaps in healthcare accessibility, underscoring the need for strategic planning and policy interventions aimed at enhancing the spatial equity of healthcare service delivery within Abakaliki LGA.

Keywords: Geographic Information System (GIS), Health Care Facilities, Geodatabase, Spatial Analysis, Ebonyi State

1.Introduction

Access to quality health care services is a fundamental determinant of public health and socioeconomic development, making the spatial distribution of health care facilities a critical concern in urban and rural planning [21]. In many developing countries, including Nigeria, rapid population growth and urbanization have placed significant pressure on existing health infrastructure, exposing inequalities in service availability and accessibility [1]. The lack of comprehensive spatial data on health care facility locations further compounds these challenges, hindering effective health system planning, management, and equitable resource allocation [16]. Geographic Information System (GIS) technology has increasingly been recognized as an essential tool to overcome these impediments by enabling the creation of detailed geospatial databases and facilitating spatial analyses that inform health facility planning and decision-making [7].

GIS supports the integration of multiple layers of health-related data such as population density, road networks, land use, terrain, and existing health facility locations, providing powerful capabilities for assessing service coverage and identifying underserved regions [11]. Such spatial analysis can guide the optimal siting of new health care facilities to enhance accessibility, minimize travel times, and respond effectively to demographic dynamics [2]. Studies conducted in comparable sub-Saharan African contexts have demonstrated the utility of GIS in mapping health infrastructure and evaluating spatial equity, contributing to evidence-based policymaking and more efficient distribution of health resources [6].

Abakaliki Local Government Area (LGA) in Ebonyi State exemplifies a region where demographic expansion and urban growth have intensified demand for improved health services, yet spatial data gaps impede targeted infrastructure development [5]. The topographic, socioeconomic, and infrastructural characteristics of Abakaliki LGA necessitate a rigorous spatial assessment to identify geographic disparities in health facility distribution and accessibility [13]. Although a variety of health facilities exist, their spatial arrangement has not been comprehensively mapped or analyzed, which risks excluding certain population segments from timely and adequate healthcare [21]. Developing a geo-database and mapping these facilities using GIS and GPS data collection is therefore imperative for informing strategic planning and equitable health service delivery at local and state levels [8].

Existing literature emphasizes the importance of combining primary data collection through GPS surveys with secondary data from government archives to generate accurate geospatial repositories critical for health planning [7] [17]. Digital maps and geo-databases facilitate dynamic spatial analyses such as proximity assessment, service area delineation, and accessibility modeling, which are essential for identifying facility clustering, gaps, and appropriate locations for new installations [11]). The use of open-source GIS software like QGIS enhances data processing efficiency and democratizes access to spatial decision-support tools for local institutions and policymakers [12].

This study therefore undertakes the creation of a comprehensive digital geo-database and mapping of health care facilities within Abakaliki LGA, leveraging GPS and existing secondary spatial data integrated into QGIS for detailed spatial analysis. The research aims to evaluate the spatial pattern of health care infrastructure, assess site appropriateness, and identify underserved areas, thereby contributing to evidence-based health service planning in Ebonyi State. By addressing the spatial disparities in health care access revealed through this geospatial approach, the study supports efforts aligned with the United Nations' Sustainable Development Goal 3—ensuring healthy lives and promoting well-being for all [20]. The insights derived will equip health planners, government agencies, and development partners with the geospatial intelligence necessary to optimize health infrastructure deployment and improve the quality of healthcare delivery in Abakaliki and similar contexts.

2. Study Area Description

2.1 Location and Geographic Setting

Abakaliki Local Government Area (LGA) is the capital and administrative center of Ebonyi State, located in southeastern Nigeria. It lies approximately between latitude 6°19′ and 6°20′N and longitude 8°05′ and 8°06′E, covering an area of about 540 to 585 square kilometers [18]. The terrain is generally undulating, with elevations ranging from 70 to 150 meters above sea level. Abakaliki is strategically positioned at the crossroads of roads linking Enugu, Afikpo, and Ogoja, making it a key regional hub for commerce and governance [3] [5] (see figure 1).

Abakaliki benefits from a network of major roads connecting it to neighboring states and cities, which eases movement of people and goods. Infrastructure includes federal health institutions like the Federal Teaching Hospital, educational facilities, markets, and administrative offices. Despite

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improvements, growing population density increases demand on infrastructure, necessitating spatially informed planning for equitable health and service delivery.

2.2 Population and Demographics

As of 2019, Abakaliki LGA had an estimated population of approximately 271,600, resulting in a population density of about 465 persons per square kilometer, which is higher than the state average [4]. The area has experienced rapid population growth — over 300% increase from 57,000 in 1975 to around 240,000 in 2015 — projected to reach 500,000 by 2040 [17]. The population is young, with a median age near 18 years, reflecting typical demographics of sub-Saharan African urban centers. This rapid and youthful growth adds pressure on housing, infrastructure, and health services.

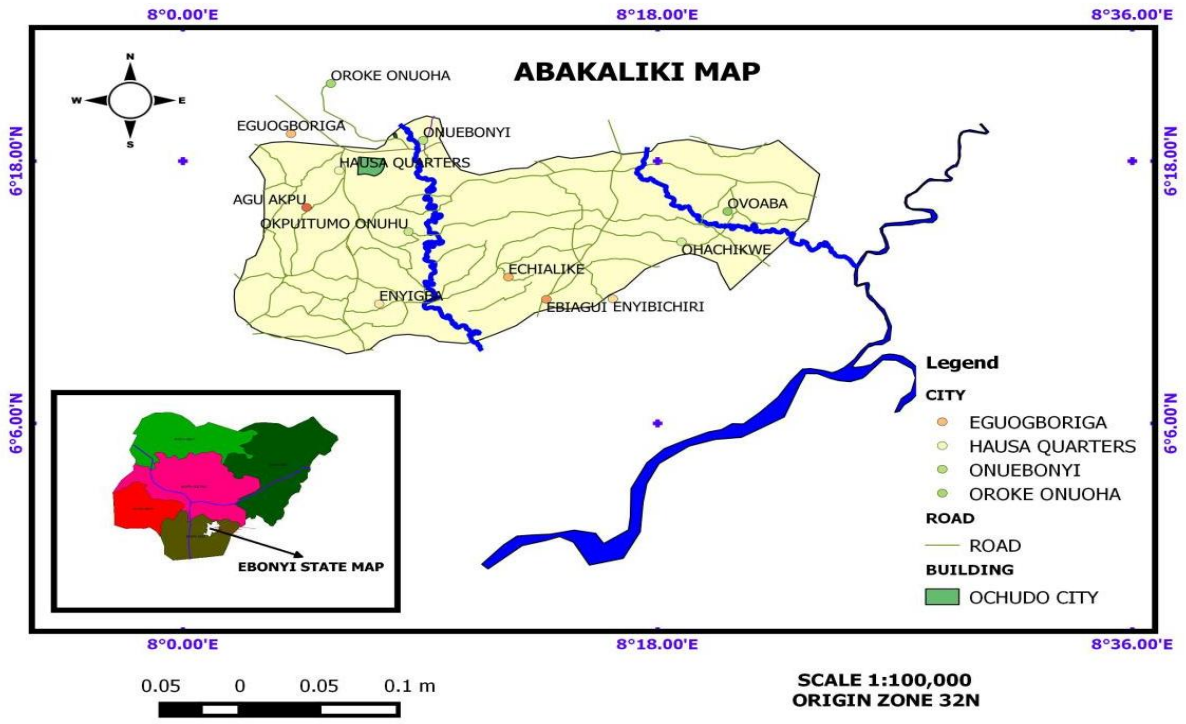

Figure 1: Map of Abakaliki

2.3 Land Use and Urbanization

Land use in Abakaliki LGA has undergone substantial changes between 2000 and 2022. Multi-temporal remote sensing analysis revealed a loss of more than 21,000 hectares of vegetative cover, largely tropical secondary forest and woodland savanna, due to conversion to built-up areas and bare land [17]. Built-up areas increased by about 7,500 hectares, primarily as residential, commercial, and industrial development expanded. Bare land, often indicative of degraded or

fallow terrain, also increased, signaling land degradation. These trends reflect rapid urbanization and underscore challenges for sustainable land management and ecosystem conservation.

Abakaliki economy is diversified yet strongly anchored in agriculture, including yam, cassava, rice, and palm oil production [3]. It serves as an agricultural trade center in Ebonyi State, supplying food products and raw materials. Mining activities, such as lead, zinc, and limestone extraction, contribute to industrial growth. The city also hosts tertiary educational institutions, further diversifying economic activity through education and research sectors. Small and medium enterprises complement the economic landscape, primarily servicing local markets.

2.4 Vegetation and Climate

Originally, the area featured fragmented tropical rainforests intermixed with agricultural lands and woodland savanna, though deforestation and land conversion have significantly reduced forest patches [17]. The climate is tropical with notable wet (April–October) and dry (November–March) seasons. Annual rainfall ranges from 1,500 to 2,000 mm, and average temperatures remain between 22°C and 32°C [14]. These conditions support crop cultivation and also influence health profiles, such as malaria prevalence linked to the wet season.

3. Methodology

This study employed a comprehensive geospatial methodology integrating primary data collection, secondary data acquisition, spatial data processing, and Geographic Information System (GIS) analysis to create a geo-database and digital map of health care facilities in Abakaliki Local Government Area (LGA), Ebonyi State. The approach ensured accurate spatial representation and thorough analysis of health infrastructure distribution to support planning and decision-making. The flow chart below was adapted for this methodology.

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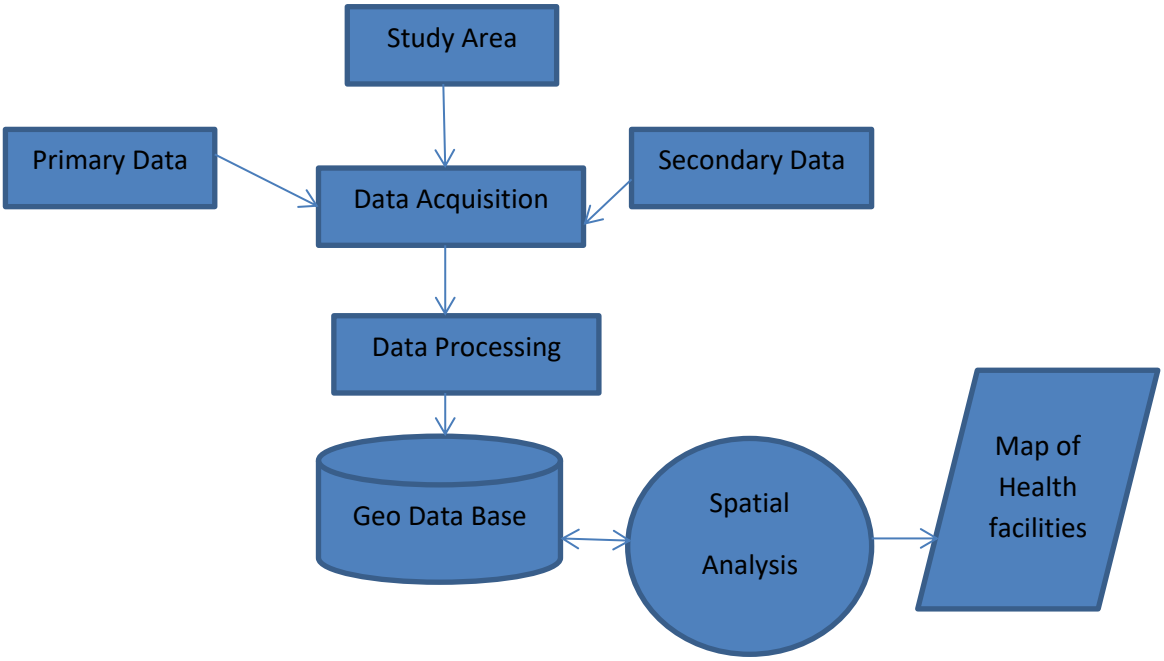

Figure 2: Flow Chart of Methodology

3.1 Primary Data Collection

Extensive field surveys were conducted to acquire accurate geographic coordinates of health care facilities and referential landmarks. Ground control points (GCPs) were collected using handheld GPS devices with sub-meter accuracy to ensure spatial precision. These points included road intersections, prominent landmarks, and known monuments, which later served as spatial reference during image georeferencing. The survey also gathered non-spatial attribute data, such as facility type, operational status, and accessibility features.

3.2 Secondary Data Collection

Secondary datasets comprised the administrative boundaries and base maps obtained in hardcopy from the state Ministry of Lands and Survey. Additionally, recent satellite imagery was sourced from Google Earth Pro, selected for its high spatial resolution and temporal relevance. The list of health care facilities was supplied by the Ministry of Health, providing essential contextual information on existing facilities.

3.3 Data Processing and Geospatial Preparation

Scanning and Digitization of Administrative Maps: The administrative maps were scanned using high-precision AO scanners at high resolution, saved in Tagged Image File Format (TIFF) to preserve spatial detail and image quality. These raster images were imported into QGIS 2.4.0 for subsequent georeferencing and digitizing of relevant spatial features including boundaries, roads, and water bodies.

Georeferencing and Image Rectification: Georeferencing of raster images was performed by aligning scanned maps and satellite imagery to the World Geodetic System (WGS) 1984 UTM Zone 32N coordinate system. This process involved polynomial transformation algorithms that corrected geometric distortions within the images, thereby accurately overlaying them with the collected ground control points (GCPs). Control points used in registration included road junctions, institutional landmarks, and other identifiable features.

3.4 Geo-database Creation

A geodatabase was developed within QGIS to store, manage, and maintain attribute and positional data relating to health facilities. The database schema incorporated fields for facility name, category (e.g., hospital, clinic), operational status, geographic coordinates, and accessibility parameters. This structure facilitated efficient data querying, retrieval, and future updating, supporting dynamic health facility management.

3.5 Spatial Analysis and Mapping

Post geo-database creation, health care facility locations were plotted upon the spatial base maps using QGIS 2.4.0. Several spatial analyses were conducted, including: Spatial distribution analysis to assess clustering patterns and identify spatial inequalities in facility locations. Proximity and accessibility analysis using buffer and network analyses to estimate service coverage areas and identify underserved populations.

Overlay analysis integrating health facility locations with land use, road networks, and population density layers to evaluate spatial appropriateness and access barriers.

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4. Results and Discussion

The spatial analysis of health care facilities in Abakaliki Local Government Area revealed significant disparities in their distribution, underscoring challenges in equitable access to healthcare services across the metropolis. A total of 151 health care facilities were identified and categorized into clinics (130), hospitals (8), primary health centers (7), and health laboratories (6). This composition highlights a predominance of clinics with relatively fewer hospitals and other specialized facilities, reflecting the general structure of health service provision in the area (see figure 3).

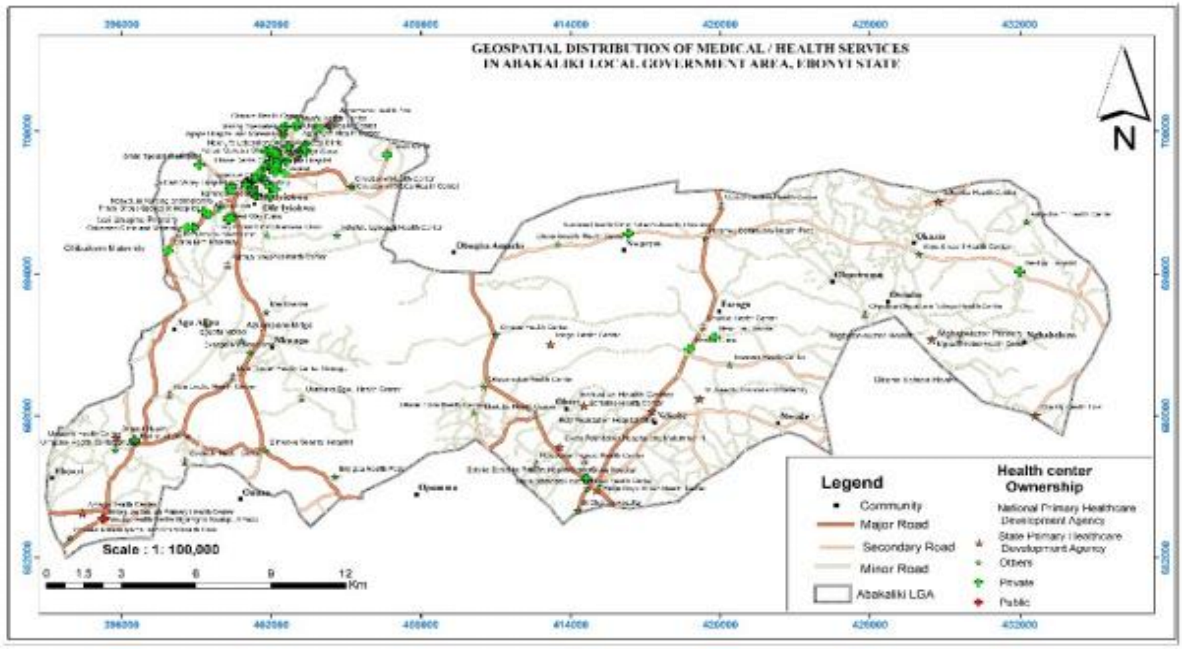

Figure 3: Map Showing Spatial Distribution of Health Facilities in Abakaliki LGA

Buffer analysis with a radius of 1.5 km around existing health care facilities demonstrated uneven coverage, particularly in suburban and peri-urban districts such as parts of Nkaliki, Kpirikpiri, Eke-Aba, and Agbaja Unuhu. These zones fell outside the spatial range of accessible standard health facilities, suggesting that residents in these localities face challenges in obtaining timely medical attention due to geographic barriers [19]. Such spatial inequalities potentially exacerbate health disparities, as accessibility is strongly linked to service utilization and health outcomes [1].

The findings align with prior research emphasizing that the location and accessibility of health infrastructure remain critical determinants for healthcare equity in emerging urban settings [16] [9]. The identified clustering of clinics could indicate concentration in more populated or commercially active areas, leaving outlying neighborhoods underserved. This spatial mismatch highlights the need for strategic planning and targeted infrastructure development to reduce accessibility gaps.

Furthermore, the small number of primary health centers and hospitals within the LGA suggests limited availability of comprehensive and emergency care, which is pivotal for improving public health standards. Primary health centers, often the first point of contact in the healthcare system, were notably insufficient relative to the population distribution, supporting calls for increased investment in grassroots health infrastructure. This shortfall in adequately distributed health services could have repercussions on addressing public health goals such as Universal Health Coverage (UHC) and Sustainable Development Goal 3 [20].

The study validates Geographic Information System (GIS) as an effective tool for elucidating spatial health service disparities, enabling health planners and policymakers to visualize service deficits and devise data-driven interventions. The creation of an up-datable geo-database facilitates continuous monitoring and responsive planning, which are essential in fast-growing urban areas like Abakaliki [11].

5. Conclusion

This research confirms that GIS-based spatial analysis is invaluable for diagnosing health infrastructure disparities and guiding equitable distribution of health services. The establishment of a detailed geo-database and mapped assessment of health care facilities in Abakaliki LGA provides foundational data critical for future healthcare planning and policy implementation.

6. Recommendations

Expansion of primary health centers, particularly in underserved neighborhoods, to improve local access to essential health services and promotion of health facilities offering 24-hour services to address emergency care needs within the metropolis. Implementing these recommendations will address identified spatial inequities and bolster the capacity of Ebonyi State's health system to provide accessible, timely, and quality healthcare to all residents.

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