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Spatial Distribution and Inequalities in Pediatric Healthcare Services in Kinshasa: A GIS-Based Assessment of Health Equity

Jean Pierre Kambondji Bukaya[1*], Patrick Ngoie Mululu[1],
Jean Claude Kamanda wa Kamanda[1], Kabamba Kabata[1], Aketi Loukia[2]
[1]Université Pédagogique Nationale,
BP 8815 Kinshasa I, Democratic Republic of Congo (DRC)
[2]University of Kinshasa, Faculty of Medicine,
B.P. 127 Kinshasa XI, Democratic Republic of Congo (DRC)

ABSTRACT

Rapid urban growth in many African cities has intensified spatial inequalities in access to healthcare services, particularly for vulnerable populations such as children. This study analyzes the spatial distribution and territorial disparities of pediatric healthcare services in Kinshasa, Democratic Republic of Congo, using Geographic Information Systems (GIS) and spatial statistical methods.

Data were collected from health facilities providing pediatric services across 11 sampled health zones out of the 35 existing zones in Kinshasa. Spatial datasets and demographic information were integrated into a GIS environment to assess healthcare distribution, facility density, and accessibility. Spatial analyses included density mapping, buffer-based accessibility analysis (500 m, 1 km and 2 km), and spatial autocorrelation using Moran's I.

The results reveal a strong spatial concentration of pediatric healthcare facilities in central and peri-central communes, particularly in Gombe, Lingwala and Kasa-Vubu. These areas show the highest facility densities, exceeding 2.5 structures per km² and more than 4 facilities per 10,000 inhabitants. In contrast, peripheral communes such as Kimbanseke, Mont-Ngafula and Kisenso display significantly lower service densities, often below 0.5 facilities per km² and fewer than 1 facility per 10,000 inhabitants.

Spatial analysis also indicates a significant clustering pattern of healthcare facilities (Global Moran's I = 0.34, z-score = 3.21, $p < 0.01$), confirming a polarized spatial structure of pediatric healthcare provision. Large peripheral areas remain underserved, with populations located more than 2 km from the nearest pediatric facility.

These findings highlight substantial territorial inequalities in pediatric healthcare accessibility in Kinshasa. Integrating spatial analysis into urban health planning could help identify priority areas for infrastructure development and improve equitable access to child healthcare services.

Keywords: Health geography, Pediatric healthcare, Spatial accessibility, Geographic Information Systems, Urban health inequalities, Kinshasa

1. INTRODUCTION

Access to healthcare services is widely recognized as a fundamental determinant of population health and a key component of equitable health systems. In urban environments, the spatial organization of healthcare infrastructure plays a critical role in shaping both the accessibility and the utilization of medical services. From the perspective of health geography, examining the spatial distribution of healthcare facilities provides essential insights into territorial inequalities in service provision and helps identify areas where populations may experience deficits in healthcare coverage (Cromley & McLafferty, 2012; Guagliardo, 2004).

[*] Corresponding Author

These challenges are particularly pronounced in many rapidly growing cities in Sub-Saharan Africa. Accelerated urbanization, often occurring in contexts of limited spatial planning and constrained public investment in infrastructure, frequently results in uneven patterns of healthcare provision. In such environments, healthcare facilities tend to concentrate in economically advantaged and centrally located areas, while peripheral neighborhoods remain comparatively underserved. This spatial imbalance contributes to disparities in healthcare accessibility and reinforces broader socio-economic inequalities within urban systems (UN-Habitat, 2020).

Among the populations most affected by these inequalities are children, whose health outcomes depend heavily on timely access to appropriate healthcare services. Pediatric healthcare systems require not only adequate numbers of facilities but also an equitable spatial distribution capable of ensuring that vulnerable populations can access care without excessive travel distances or delays. Limited spatial accessibility to pediatric services may result in delayed diagnosis, reduced use of preventive care, and increased vulnerability to avoidable childhood illnesses (Penchansky & Thomas, 1981; Guagliardo, 2004).

Kinshasa, the capital of the Democratic Republic of Congo, provides a particularly relevant context for examining these spatial inequalities. As one of the largest and fastest-growing urban agglomerations in Sub-Saharan Africa, the city has experienced rapid demographic expansion accompanied by largely unplanned urban development. Although Kinshasa concentrates a substantial share of the country's healthcare infrastructure, the spatial distribution of health facilities across its communes and health zones remains uneven. These disparities may significantly affect the accessibility of pediatric healthcare services, particularly for populations living in peripheral and socio-economically disadvantaged areas.

Recent advances in spatial analysis and Geographic Information Systems (GIS) have provided powerful tools for investigating the territorial organization of healthcare systems. By integrating spatial datasets with demographic information, GIS-based approaches allow researchers to map healthcare infrastructure, measure spatial accessibility, and detect spatial clustering patterns in service provision. Such analyses are increasingly used to identify underserved populations and to inform evidence-based health planning strategies (Cromley & McLafferty, 2012; Longley et al., 2015).

Despite the growing use of spatial analytical approaches in health geography, empirical studies examining the spatial organization of pediatric healthcare services in large African metropolitan areas remain relatively limited. In the case of Kinshasa, existing research has rarely combined spatial accessibility analysis, clustering methods, and multicriteria spatial evaluation to provide a comprehensive assessment of territorial inequalities in pediatric healthcare provision.

Against this background, the objective of this study is to analyze the spatial distribution and territorial disparities of pediatric healthcare services in Kinshasa using Geographic Information Systems (GIS) and spatial analytical techniques. Specifically, the study aims to (i) examine the spatial distribution and typology of pediatric healthcare facilities, (ii) evaluate spatial accessibility to healthcare services using density and buffer-based approaches, and (iii) identify spatial clusters and priority areas for improving equitable access to pediatric healthcare within the metropolitan area.

2. STUDY AREA

This study was conducted in Kinshasa, the capital city of the Democratic Republic of Congo (DRC) and the country's main political, economic, and demographic center. Kinshasa is one of the largest and fastest-growing urban agglomerations in Sub-Saharan Africa, characterized by rapid population growth and significant spatial expansion. The city concentrates a large share of the national healthcare infrastructure, yet important socio-spatial inequalities persist in access to healthcare services (UN-Habitat, 2020).

Geographically, Kinshasa is located on the left bank of the Congo River, between approximately 4°–5° South latitude and 15°–16° East longitude. The city covers an area of about 9,965 km² (INS, 2019). Its urban landscape is characterized by a strong contrast between densely populated central communes and rapidly expanding peripheral areas where infrastructure and public services are often insufficient.

Administratively, Kinshasa has the status of a city-province and is subdivided into 24 communes. Within the national health system, these communes are further organized into 35 health zones, which constitute the operational units for healthcare planning and service delivery. These health zones play a key role in the territorial organization of healthcare services, including pediatric care.

The demographic structure of Kinshasa is characterized by a relatively young population. Children represent a significant proportion of the urban population, which increases the demand for pediatric healthcare services. In this context, spatial inequalities in the distribution of healthcare infrastructure may have important implications for access to child healthcare and overall health outcomes in the metropolitan area (WHO & UNICEF, 2019).

Figure 1 presents the spatial distribution of the health zones within the city-province of Kinshasa, which constitute the territorial framework for healthcare planning and management.

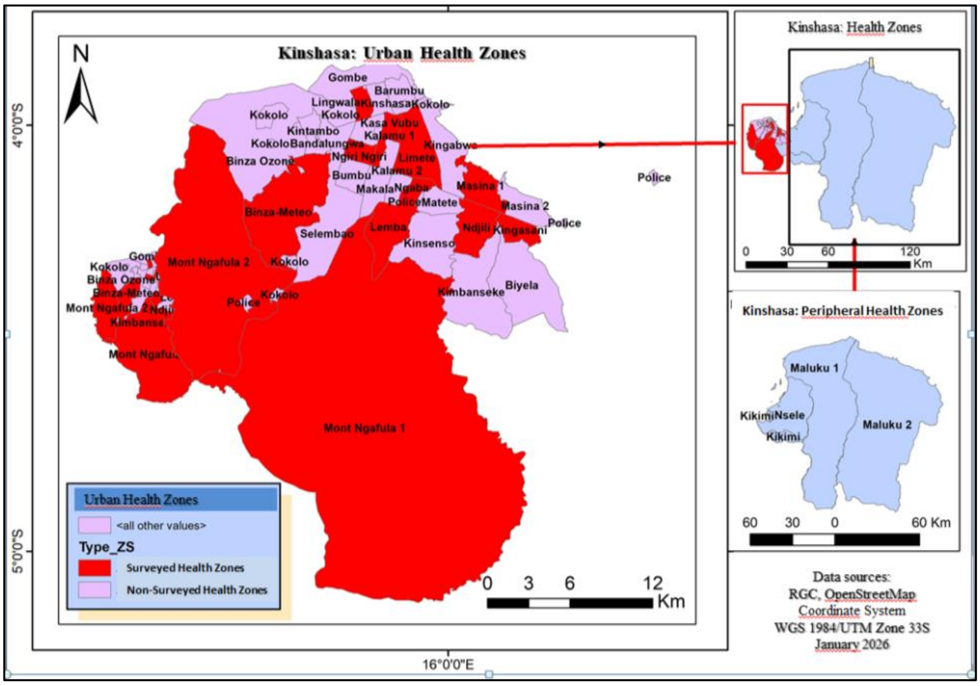

Figure 1. Kinshasa: Health Zones

3. MATERIALS AND METHODS

3.1 Data Sources

This study relies on both primary and secondary datasets to analyze the spatial distribution of pediatric healthcare services in Kinshasa.

Health data were collected from healthcare facilities providing functional pediatric services within the selected health zones. These data included information on the location of healthcare facilities, the type of facility, and the availability of pediatric healthcare services.

Demographic data were obtained from national statistical sources, including the National Institute of Statistics (INS), population census reports, and Demographic and Health Surveys (DHS). These datasets provided population estimates necessary for calculating healthcare service ratios and accessibility indicators.

Spatial datasets were obtained from several institutional and open geographic sources, including the Ministry of Land Affairs, OpenStreetMap, Natural Earth, and GADM. These spatial data were integrated into a Geographic Information System (GIS) environment in order to conduct multi-scale spatial analyses of healthcare infrastructure distribution (Longley et al., 2015).

All spatial data were projected in the WGS 84 / UTM Zone 33S coordinate system to ensure spatial consistency and analytical accuracy. Cartographic processing and spatial analyses were performed using ArcGIS 10.8, which enabled the mapping of healthcare facility distribution, the calculation of infrastructure density, and the identification of underserved areas within the metropolitan region.

3.2 Study Design

The research adopts a mixed-methods approach combining documentary analysis and field-based data collection. The documentary component included the review of reports and statistical publications from international and national institutions such as the World Health Organization (WHO), UNICEF, the World Bank, the Ministry of Public Health, and the National Institute of Statistics.

This documentary analysis provided contextual information on healthcare infrastructure distribution, demographic trends, and health system organization in Kinshasa.

Field data were collected in order to complement these secondary datasets and obtain updated information on the availability and spatial distribution of pediatric healthcare services.

3.3 Sampling Strategy

A proportionate stratified random sampling approach was used to select the health zones included in the study. The sampling design was based on the three health districts of Kinshasa, namely Kinshasa Centre, Kinshasa West, and Kinshasa East.

From the total 35 health zones in Kinshasa, a sample of 11 health zones (31.4%) was selected using proportionate allocation. The number of health zones selected within each district was determined according to the following formula:

$$n_i = \frac{N_i}{N} \times n$$

where:

- (ni) = number of sampled health zones in district *i*
- (Ni) = total number of health zones in district *i*
- (N) = total number of health zones in Kinshasa
- (n) = total sample size

Random selection of the sampled health zones was performed using R statistical software, ensuring the representativeness of the sample across the three health districts (Cochran, 1977; Kish, 1965; Lohr, 2010).

Table 1. Distribution of sampled health zones by health district

Health District	Total Health Zones	Sampled Zones (%)	Selected Health Zones
Kinshasa Centre	12	4 (33.3%)	Ngiri-Ngiri, Kalamu I, Lemba, Limete
Kinshasa West	12	4 (33.3%)	Lingwala, Mont-Ngafula II, Binza Météo, Mont-Ngafula I
Kinshasa East	11	3 (27.3%)	N'djili, Kingasani, Masina I
Total	**35**	**11 (31.4%)**	

3.4 Field Data Collection

Primary data collection was conducted using the KoboCollect mobile data collection application, which allowed the design and administration of digital questionnaires during field surveys.

This tool enabled the collection of georeferenced information related to pediatric healthcare services, healthcare infrastructure characteristics, and users' perceptions of healthcare accessibility. The use of digital forms facilitated data validation, improved accuracy in geolocation recording, and reduced potential data entry errors.

The integration of field survey data with spatial datasets within a GIS environment enabled a comprehensive analysis of the spatial organization of pediatric healthcare services and the identification of areas experiencing deficits in healthcare accessibility.

3.5 Spatial Analysis

Spatial analysis was conducted using ArcGIS 10.8 to examine the spatial organization and territorial disparities of pediatric healthcare services across the city-province of Kinshasa. Geographic Information Systems (GIS) were used to integrate spatial datasets, produce thematic maps, and perform spatial analytical procedures aimed at identifying patterns of healthcare infrastructure distribution and accessibility.

The analytical framework combined several complementary spatial approaches commonly used in health geography and spatial epidemiology, including facility typology, density analysis, accessibility analysis, spatial autocorrelation, and multicriteria spatial evaluation**.** These methods allowed the identification of spatial inequalities in healthcare provision and the detection of areas experiencing insufficient healthcare coverage.

3.5.1 Typology of Healthcare Facilities

A typology of healthcare facilities providing pediatric services was established in order to characterize the structure of the healthcare system and its spatial organization within the urban territory of Kinshasa.

Facilities were classified according to two principal criteria:

• Type of healthcare facility (hospital, health center, clinic, and other healthcare structures)

• Institutional status (public, private, or faith-based)

This typological classification allowed the identification of spatial differences in the organization of pediatric healthcare services across communes. The mapping of facility types made it possible to highlight areas where specific categories of healthcare providers dominate the pediatric healthcare supply, as well as areas where higher-level healthcare institutions remain scarce.

This approach provides a more comprehensive understanding of healthcare accessibility by considering not only the number of facilities but also their functional roles within the healthcare system (Cromley & McLafferty, 2012).

3.5.2 Density Analysis of Healthcare Facilities

In order to quantify spatial disparities in healthcare provision, the distribution of pediatric healthcare facilities was analyzed using spatial density indicators.

Two complementary density measures were calculated:

• Surface density: number of healthcare facilities per square kilometer (facilities/km²)
• Population-based density: number of healthcare facilities per 10,000 inhabitants

Surface density allows the identification of areas where healthcare infrastructure is spatially concentrated, while population-based density provides a more realistic indicator of the balance between healthcare supply and potential demand.

In addition to these indicators, Kernel Density Estimation (KDE) was applied to generate continuous density surfaces representing areas of high and low healthcare facility concentration across the urban space. Kernel density analysis helps reveal spatial concentration patterns that may not be visible when using administrative boundaries alone (Longley et al., 2015).

3.5.3 Buffer-Based Accessibility Analysis

Spatial accessibility to pediatric healthcare services was evaluated using buffer analysis, a commonly used method in health geography for measuring theoretical proximity to healthcare facilities.

Buffer zones of 500 meters, 1 kilometer, and 2 kilometers were generated around healthcare facilities. These thresholds represent progressively broader levels of spatial accessibility commonly used in urban accessibility studies.

The buffer analysis enabled the estimation of:

• the proportion of urban territory covered by healthcare services, and
• the distribution of population located within different accessibility distances from pediatric healthcare facilities.

This method provides an approximation of spatial coverage and allows the identification of areas where populations may experience limited geographic access to healthcare services (Luo & Wang, 2003).

3.5.4 Spatial Autocorrelation Analysis

To determine whether the spatial distribution of healthcare facilities follows a random or structured pattern, spatial autocorrelation analysis was performed using Moran’s I statistic (Moran, 1950).

The global Moran’s I index measures the degree of similarity between spatial units by evaluating whether areas with similar values tend to cluster in space. Positive Moran’s I values indicate spatial clustering of similar values, while values close to zero suggest a random spatial distribution.

To further explore the spatial structure of healthcare facility distribution, Local Indicators of Spatial Association (LISA) were used to detect local clusters of high and low healthcare facility density. LISA analysis allows the identification of spatial clusters such as high-density clusters (hotspots) and low-density clusters (coldspots), as well as spatial outliers (Anselin, 1995).

In addition, the Getis-Ord Gi* statistic was applied to identify statistically significant hotspots and coldspots of healthcare facility concentration. This method provides a complementary perspective by detecting areas where the intensity of healthcare infrastructure concentration is significantly higher or lower than expected.

Together, these spatial autocorrelation techniques provide robust evidence for identifying spatial inequalities and concentration patterns in the distribution of pediatric healthcare services.

3.5.5 Multicriteria Spatial Analysis for Healthcare Infrastructure Planning

To support spatial decision-making in healthcare planning, a multicriteria spatial analysis (MCDA) was conducted to identify priority areas for the future development of pediatric healthcare infrastructure.

The MCDA approach integrates several spatial indicators related to healthcare accessibility and population needs, including:

- population distribution and density.
- distance to existing healthcare facilities.
- spatial coverage of healthcare services.
- density of healthcare infrastructure.

These indicators were standardized and combined to generate a composite spatial suitability score, allowing the identification of areas where the mismatch between healthcare supply and population needs is greatest.

The resulting prioritization map provides a spatially explicit framework for identifying communes where the construction of new healthcare facilities could significantly improve territorial healthcare equity.

Multicriteria spatial analysis is widely used in geographic information science to support evidence-based territorial planning and infrastructure allocation (Malczewski, 1999).

4. RESULTS

4.1 Structure and Spatial Distribution of Pediatric Healthcare Services in Kinshasa

Pediatric healthcare services in Kinshasa are provided by a variety of healthcare institutions, including public and private hospitals, integrated health centers, private clinics, and faith-based facilities. While this diversity contributes to the overall availability of pediatric services, it also reflects significant spatial inequalities in healthcare provision.

Figure 2 presents the spatial distribution of healthcare facilities across Kinshasa, excluding the communes of Maluku and Nsele, whose territorial areas are substantially larger than those of the other communes. The distribution reveals a clear spatial differentiation within the metropolitan area.

Healthcare facilities are predominantly concentrated in central and peri-central communes, particularly within the area commonly referred to as *Kinshasa Centre* and in several communes of Kinshasa West. In these areas, the high density of facilities indicates a strong concentration of healthcare services.

In contrast, peripheral communes especially in parts of Kinshasa East and Kinshasa West display a more dispersed distribution of healthcare facilities. Facilities are fewer and more widely spaced, reflecting lower spatial density of healthcare infrastructure.

Overall, the spatial distribution highlights a center–periphery pattern, characterized by a concentration of healthcare facilities in central communes and a more limited presence in peripheral areas.

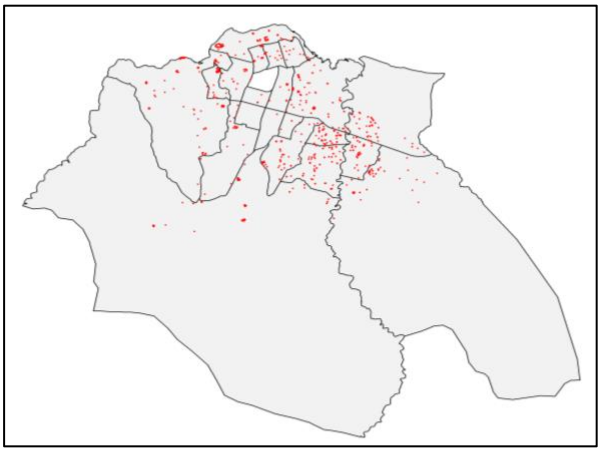

Figure 2. Spatial Distribution of Healthcare Facilities in the City of Kinshasa (excluding Maluku and Nsele)

4.1.1 Typology of Pediatric Healthcare Facilities

Healthcare facilities providing pediatric services in Kinshasa include hospitals, health centers, clinics, and other healthcare structures. These categories reflect the hierarchical organization of the urban healthcare system.

Health centers and clinics represent the most common forms of pediatric healthcare provision and are widely distributed across the city. Hospitals, which provide more specialized services, are fewer in number and tend to be concentrated in central communes.

The typological analysis also reveals differences according to institutional status. Private and specialized facilities are more frequently located in economically advantaged central communes, whereas peripheral areas rely more heavily on public health centers.

This spatial differentiation indicates that disparities in pediatric healthcare provision involve not only the number of facilities but also differences in the level and type of healthcare services available.

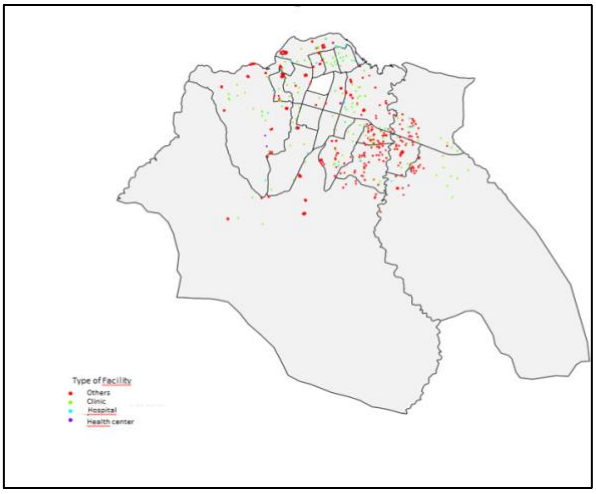

Figure 3. Healthcare Facilities by Type

4.2 Density and Accessibility of Healthcare Facilities

To quantify spatial disparities in healthcare provision, the distribution of healthcare facilities was analyzed using density indicators and spatial analytical methods. Two complementary approaches were applied:

- density measured by administrative units (communes)
- continuous density estimation using Kernel Density Estimation (KDE)

These methods allow a clearer identification of spatial concentration patterns in healthcare infrastructure.

4.2.1 Density by Commune

Communal density was calculated using two indicators:

• surface density: number of healthcare facilities per square kilometer (facilities/km²)
• population-based density: number of healthcare facilities per 10,000 inhabitants

Figures 4 and 5 illustrate these indicators.

The highest density values are observed in central communes, particularly Gombe. Relatively high densities are also present in Lingwala, Barumbu, Kinshasa, and Kasa-Vubu.

Intermediate density levels characterize peri-central communes such as Kalamu, Ngiri-Ngiri, Bandalungwa, Limete, and Lemba.

In contrast, peripheral communes including Mont-Ngafula, Selembao, Makala, Kisenso, Kimbanseke, Masina, and Ndjili display significantly lower facility densities and reduced accessibility.

Overall, the density analysis reveals a clear center–periphery gradient in healthcare infrastructure distribution.

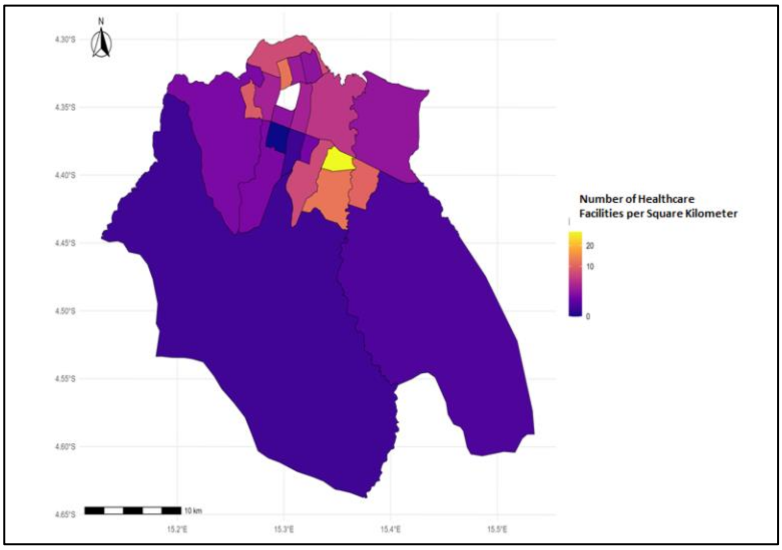

Figure 4. Raw Density of Healthcare Facilities in Kinshasa

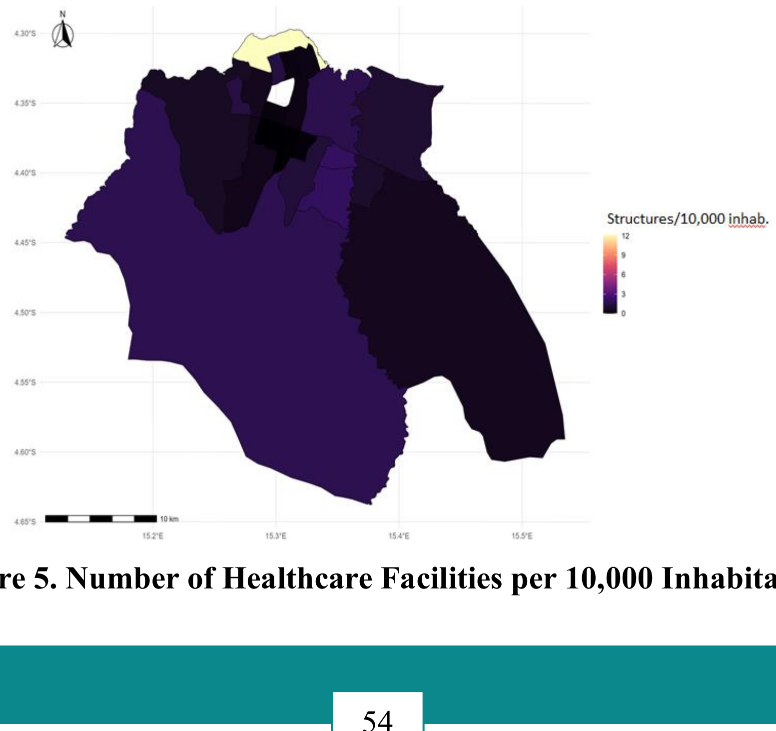

Figure 5. Number of Healthcare Facilities per 10,000 Inhabitants

4.2.2 Buffer-Based Accessibility and Uncovered Population

To assess spatial accessibility, buffer zones of 500 m, 1 km, and 2 km were generated around healthcare facilities.

The analysis indicates marked spatial differences in service coverage across Kinshasa. Central and peri-central communes display overlapping buffer zones, indicating relatively continuous spatial coverage of healthcare services.

In contrast, several peripheral communes remain only partially covered. Large areas fall outside the 2 km accessibility threshold, indicating limited spatial access to pediatric healthcare services.

The analysis of uncovered population confirms these disparities. Certain communes show large populations located more than 2 km from the nearest healthcare facility, highlighting significant spatial gaps in healthcare provision.

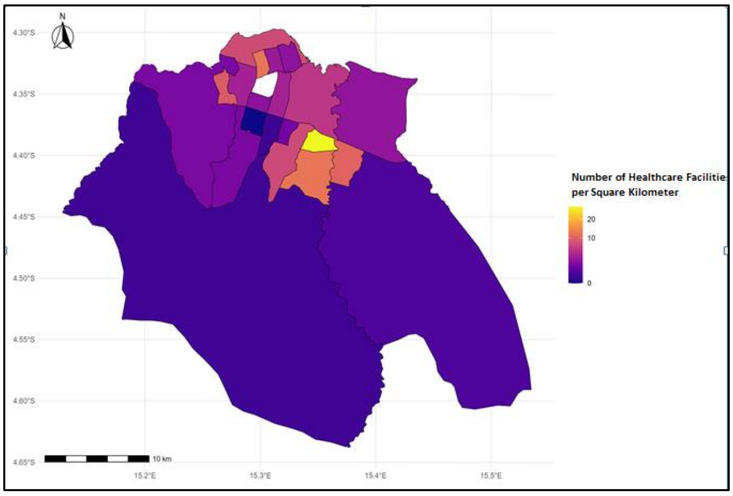

Figure 6. Density of Healthcare Facilities in Kinshasa

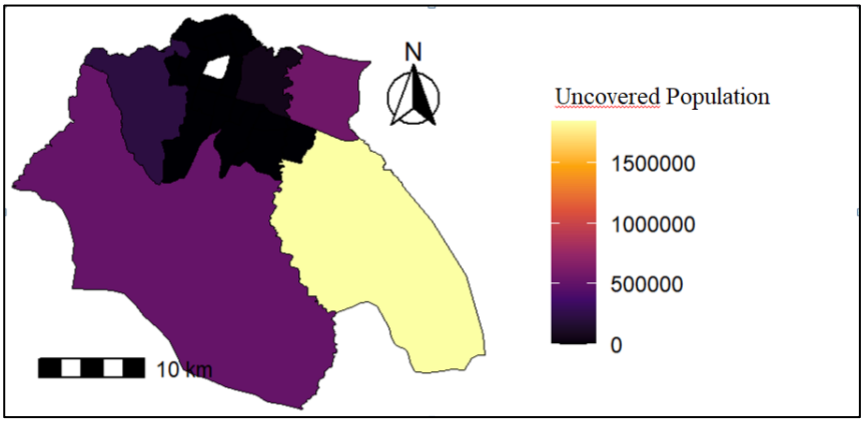

Figure 7. Population Living Beyond 2 km from Healthcare Facilities

4.2.3 Differential Accessibility by Type of Healthcare Facility

Accessibility also varies according to the type of healthcare facility. Different accessibility thresholds were applied to reflect the hierarchical organization of healthcare services:

- 2 km for health centers
- 5 km for hospitals

Health center coverage appears relatively localized around urban cores, whereas hospital buffers extend over broader areas due to their referral function.

This pattern highlights a hierarchical spatial structure in healthcare provision. Areas located within both accessibility thresholds benefit from more comprehensive healthcare coverage, while peripheral areas often depend primarily on hospitals located at greater distances.

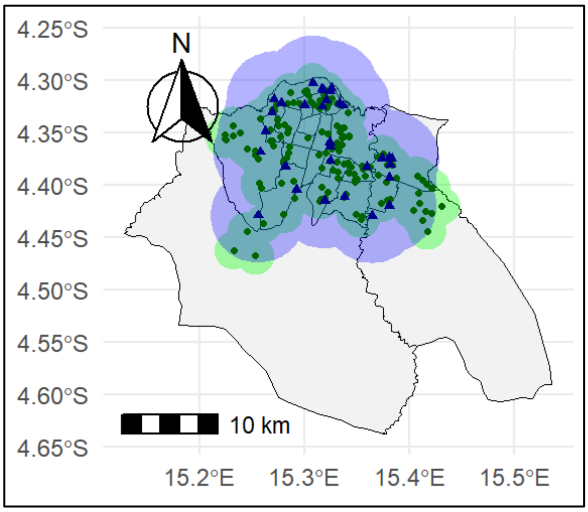

Figure 8. Differential Accessibility Zones to Healthcare Facilities (2 km for Health Centers and 5 km for Hospitals)

4.3 Territorial Disparities in Healthcare Provision

Territorial disparities in healthcare provision were evaluated using several indicators:

• number of facilities per commune
• facility density per km²
• facilities per 10,000 inhabitants
• average distance to the nearest healthcare facility.

These indicators reveal significant spatial inequalities in healthcare accessibility across communes.

4.3.1 Spatial Structuring of Inequalities

Spatial autocorrelation analysis was conducted to determine whether healthcare facilities are randomly distributed or spatially clustered.

Global Moran's I indicates positive spatial autocorrelation, suggesting that healthcare facilities tend to cluster spatially rather than being randomly distributed.

Local analysis using LISA identifies clusters of high facility density in central and peri-central communes, while peripheral areas generally correspond to lower-density clusters.

The Getis-Ord Gi* analysis further identifies statistically significant hotspots and coldspots of healthcare infrastructure distribution.

These results confirm a spatially polarized healthcare system, with central communes forming clusters of higher service availability and peripheral areas showing lower levels of healthcare provision.

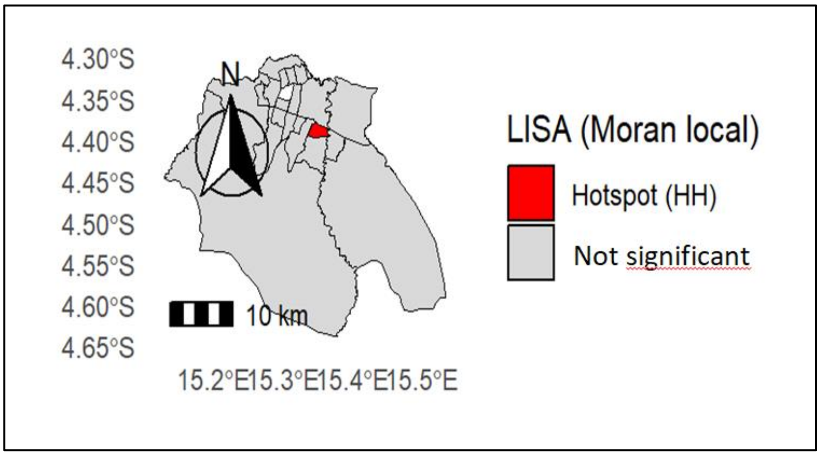

Figure 9. LISA and Multicriteria Score Overlay

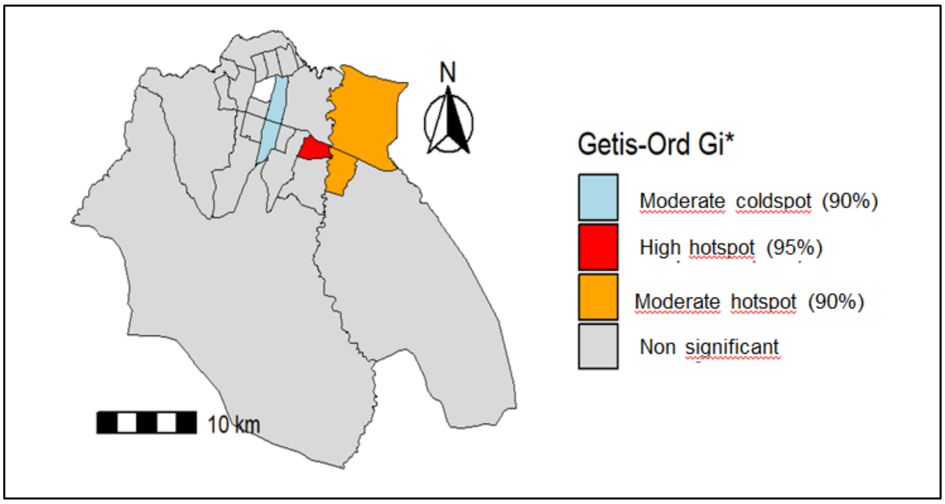

Figure 10. Getis-Ord Gi Hotspot Analysis of Pediatric Healthcare Facilities

4.4 Priority Areas for Healthcare Infrastructure Development

The spatial analysis also identifies priority areas for future healthcare infrastructure development.

By combining indicators of facility density, accessibility, and population distribution, the analysis highlights communes where healthcare services remain insufficient relative to population needs.

Priority areas are mainly located in peripheral communes characterized by low facility density and limited spatial accessibility. Targeted investment in these areas could significantly improve territorial equity in healthcare access.

4.4.1 Multicriteria Prioritization of Areas for Healthcare Infrastructure Development

A multicriteria spatial analysis was conducted to identify priority areas for the development of new healthcare facilities.

This analysis integrates several spatial indicators, including:

• healthcare facility density
• accessibility deficits
• population distribution

The resulting prioritization map highlights communes where the gap between healthcare demand and service availability is greatest.

Peripheral communes generally display the highest priority levels, while central communes show lower priority due to their higher concentration of healthcare facilities.

These results provide a spatial decision-support framework for guiding healthcare infrastructure planning.

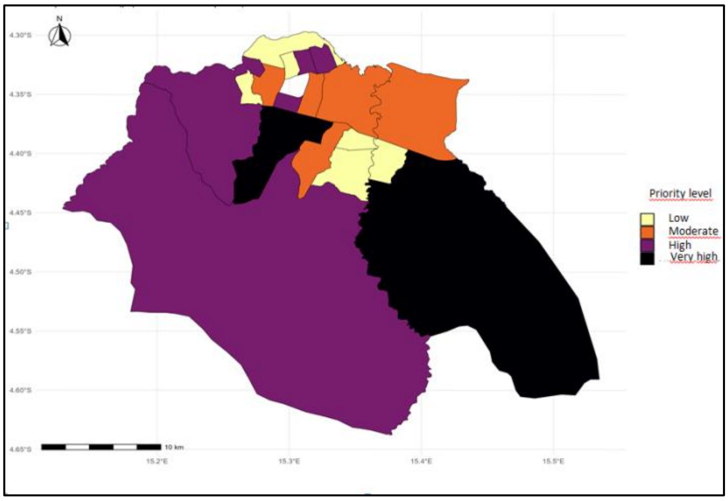

Figure 11. Prioritization of Healthcare Facility Construction

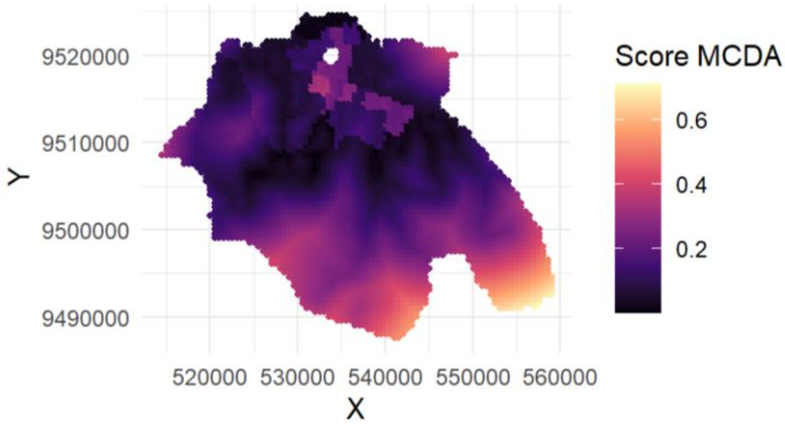

Figure 12. Multicriteria Decision Analysis (MCDA)

5. DISCUSSION

The results of this study reveal pronounced spatial inequalities in the distribution and accessibility of pediatric healthcare services across the city of Kinshasa. The spatial analysis highlights a clear center–periphery gradient, characterized by a strong concentration of healthcare facilities in central and peri-central communes and significantly lower availability in peripheral areas. This pattern is consistent with findings reported in many rapidly expanding cities in Sub-Saharan Africa, where healthcare infrastructure tends to concentrate in economically advantaged urban cores while peripheral neighborhoods remain relatively underserved (Fafa, 2007; UN-Habitat, 2020; Noor et al., 2006).

The high concentration of pediatric healthcare facilities observed in communes such as Gombe, Lingwala, and Kasa-Vubu reflects broader urban socio-economic dynamics that influence the spatial organization of healthcare systems. In many urban contexts, private and specialized healthcare providers tend to locate their services in areas characterized by higher population density, better infrastructure, and stronger purchasing power (Kruk et al., 2018; Talen, 1997). This process contributes to the formation of spatial clusters of healthcare infrastructure, reinforcing inequalities between central and peripheral areas.

The spatial clustering identified through Moran's I analysis confirms that the distribution of pediatric healthcare services in Kinshasa is not random but rather spatially structured. The positive spatial autocorrelation observed in this study (Moran's I = 0.34, z-score = 3.21, $p < 0.01$) indicates the presence of statistically significant clusters of healthcare facilities in specific parts of the urban space. At the same time, large peripheral areas remain underserved, with substantial segments of the population located more than 2 km from the nearest pediatric healthcare facility. Similar clustering patterns have been documented in studies examining healthcare accessibility in other urban environments, where healthcare infrastructure often follows cumulative spatial dynamics in which well-served areas tend to attract additional services (Anselin, 1995; Cromley & McLafferty, 2012; Guagliardo, 2004).

These results also highlight significant disparities in spatial accessibility to pediatric healthcare services. The buffer analysis indicates that several peripheral communes remain partially or entirely outside the 2 km accessibility threshold. Previous research in health geography has emphasized that geographic distance represents a major barrier to healthcare utilization, particularly for vulnerable populations such as children (Penchansky & Thomas, 1981; Luo & Wang, 2003). When healthcare facilities are located at excessive distances, populations may delay or forgo medical care, which can contribute to adverse health outcomes.

The hierarchical accessibility analysis further reveals important differences between primary healthcare services and hospital-level services. While hospitals generally serve broader catchment areas, access to primary healthcare services remains more spatially fragmented. This finding supports the argument that the organization of healthcare systems should prioritize strong primary healthcare networks capable of providing geographically accessible services for the population (World Health Organization & UNICEF, 2019). In many developing urban contexts, insufficient distribution of primary healthcare facilities places additional pressure on hospitals and contributes to inefficiencies within the healthcare system.

The spatial patterns observed in Kinshasa also reflect broader processes of urban spatial inequality. Rapid demographic growth and largely unplanned urban expansion have produced strong contrasts between well-served central areas and rapidly growing peripheral neighborhoods. Similar patterns have been documented in other large African cities such as Nairobi, Lagos, and Accra, where healthcare infrastructure development has often lagged behind urban population growth (Noor et al., 2006; Ouma et al., 2018; Tatem et al., 2012). In such contexts, spatial accessibility becomes a critical dimension of health equity.

From a methodological perspective, this study demonstrates the usefulness of Geographic Information Systems (GIS) and spatial analytical techniques for assessing territorial inequalities in healthcare provision. The integration of density analysis, buffer-based accessibility measures, and spatial autocorrelation techniques provides a comprehensive framework for examining the spatial organization of healthcare systems. Previous studies have highlighted the growing importance of GIS-based approaches for identifying underserved areas and supporting evidence-based health planning (Cromley & McLafferty, 2012; Longley et al., 2015; Malczewski, 1999).

The multicriteria spatial analysis conducted in this study further contributes to the identification of priority areas for healthcare infrastructure development. By combining indicators related to facility density, accessibility deficits, and population distribution, the analysis highlights peripheral communes where the mismatch between healthcare demand and service availability is greatest. Such spatial decision-support approaches are increasingly used in urban planning and public health to guide the allocation of limited resources and improve spatial equity in service provision (Malczewski, 1999; Talen & Anselin, 1998).

Despite these contributions, this study has several limitations. First, the accessibility analysis is primarily based on spatial proximity indicators and does not fully account for transportation networks, travel time variability, or socio-economic barriers to healthcare utilization. Previous research has shown that factors such as transportation availability, household income, and cultural perceptions of healthcare services may significantly influence healthcare access (Guagliardo, 2004; Penchansky & Thomas, 1981). Future research could therefore integrate network-based accessibility models and travel-time analysis to provide a more comprehensive evaluation of healthcare accessibility.

Second, the analysis focuses primarily on the spatial distribution of healthcare facilities and does not directly evaluate the quality or functional capacity of pediatric healthcare services. Differences in staffing levels, equipment availability, and service quality may also contribute to inequalities in healthcare utilization and health outcomes (Kruk et al., 2018). Integrating health service quality indicators into future spatial analyses would provide a more complete understanding of healthcare accessibility in Kinshasa.

Overall, the findings of this study highlight the importance of incorporating spatial analysis into urban health planning and policy-making. Identifying areas characterized by low healthcare accessibility allows decision-makers to prioritize investments in healthcare infrastructure and to promote more equitable distribution of services across the urban territory. In rapidly growing cities such as Kinshasa, addressing spatial inequalities in pediatric healthcare provision is essential for strengthening health systems and improving child health outcomes.

6. CONCLUSION

This study analyzed the spatial distribution and territorial disparities of pediatric healthcare services in Kinshasa using Geographic Information Systems (GIS) and spatial statistical methods. The results reveal a clearly uneven spatial organization of pediatric healthcare infrastructure**,** characterized by a strong concentration of healthcare facilities in central and peri-central communes and significantly lower availability in peripheral areas.

The spatial analysis highlights a pronounced center–periphery gradient in healthcare accessibility. Central communes such as Gombe, Lingwala, and Kasa-Vubu exhibit the highest levels of healthcare facility density and accessibility, while peripheral communes including Kimbanseke, Mont-Ngafula, Kisenso, and Masina show significantly lower service availability. These disparities are further reinforced by the predominance of private healthcare providers in economically advantaged areas and the greater dependence of peripheral populations on public health centers with more limited resources.

The application of spatial analytical tools, including density mapping, buffer-based accessibility analysis, and spatial autocorrelation**,** demonstrates the value of Geographic Information Systems in identifying underserved areas and revealing territorial inequalities in healthcare provision. The detection of spatial clustering patterns confirms that pediatric healthcare services are not randomly distributed but rather follow a structured spatial pattern influenced by urban socio-economic dynamics.

From a public health planning perspective, these findings emphasize the importance of integrating spatial analysis into urban health system planning and infrastructure allocation**.** Identifying areas with limited healthcare coverage provides critical evidence for prioritizing investments in pediatric healthcare facilities and improving equitable access to healthcare services for children.

In rapidly growing metropolitan contexts such as Kinshasa, addressing spatial inequalities in healthcare provision is essential for strengthening urban health systems and improving child health outcomes. Future research could further explore the relationship between healthcare accessibility, socio-economic conditions, and health outcomes in order to support more targeted and evidence-based health planning strategies.

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