

Analyzing the Spatial Accessibility of Public Healthcare Services in Djibouti

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ABSTRACT

Ensuring access to healthcare for all, regardless of demographic, geographic, or socio-economic status, is essential for achieving universal health coverage. In Sub-Saharan Africa, where populations are often dispersed and healthcare services are limited, reducing distances or travel time to healthcare facilities is crucial for ensuring equitable access. This study examines the geographical access to public health services in Djibouti, highlighting the inequality in the distribution of medical infrastructure, especially for rural populations. The primary objective is to analyze spatial disparities in accessibility to public health facilities, identifying the least-served districts and proposing solutions to reduce these inequalities. Using the enhanced two-step floating catchment area (E2SFCA) method, the research evaluates spatial access. Data collected from the Ministry of Health of Djibouti show a high concentration of health services in the city of Djibouti, where more than 50% of the population resides. In contrast, inland districts such as Galafi and Moussa Ali display limited access, with travel times often exceeding 60 minutes, indicating an inequitable distribution of tertiary care facilities. Strengthening healthcare infrastructure in inland districts and deploying innovative solutions like mobile clinics and telemedicine are essential to reducing access inequalities and ensuring more equitable universal health coverage in Djibouti. Future research should assess the effectiveness of these interventions in sustainably improving healthcare access in the most vulnerable areas.

1. Introduction

Access to healthcare is a crucial pillar of universal health coverage. It refers to individuals' ability to obtain necessary health services efficiently, equitably, and promptly, overcoming geographical, economic, sociocultural, and demographic barriers. Moreover, evaluating the variability of this access is essential for optimizing the allocation of national health resources (1). Healthcare access is a complex concept that encompasses several critical dimensions such as availability, acceptability, adaptability, affordability, and geographical accessibility (2,3). Availability pertains to the sufficient presence of health services and professionals to meet the population's needs. Acceptability relates to the alignment of health services with patients' cultural and social expectations, ensuring that care is provided respectfully and without discrimination. Adaptability means that health services must be flexible and capable of responding to the specific needs of different populations. Affordability is the ability of individuals to pay for care without experiencing financial hardship, requiring adequate social protection mechanisms. Finally, geographical accessibility refers to individuals' ability to reach health services in a timely manner, considering distance and transportation infrastructure (4,5). Many countries, including Djibouti, face geographical inequalities in the distribution of medical infrastructure, which hinders access to healthcare for vulnerable populations, particularly those living in rural or isolated areas. As a result, these populations, especially children, pregnant women, and the elderly, are vulnerable and succumb to diseases and conditions that are treatable in healthcare facilities (7,8). Therefore, examining geographical disparities in access to healthcare is essential not only to assess the robustness of the health system but also to identify the most vulnerable populations exposed to preventable diseases. In the Djiboutian healthcare system, understanding the dynamics of healthcare accessibility and the geographical disparities in public sector health facilities is crucial. This sector is the only one that covers the entire national territory, representing 71.19% of healthcare facilities nationwide, surpassing the parastatal (11.23%) and private (16.80%) sectors, according to the 2022 Health Statistical Yearbook (6).

In Djibouti, the dispersion of rural populations and their isolation, exacerbated by the transhumance of a portion of the population and the immobility of health teams, accentuate the weakness of health coverage. According to the Djibouti Ministry of Health's report on maternal and child health from 2013 to 2015, national healthcare accessibility is at 80%. In the capital, Djibouti City, access reaches 100%. However, significant disparities persist in the interior regions. For example, only 73.91% of the population in the Ali Sabieh region has access to basic healthcare, while this figure drops to 36.29% in the Tadjoura region. Access to healthcare is particularly challenging in isolated areas, and the implementation of mobile teams is often limited by financial constraints.

In addition to physical and financial challenges, the quality of services is affected by staff mobility (7). The analysis of geographical accessibility, often referred to as spatial accessibility, is commonly employed because it constitutes an easily quantifiable and interpretable metric to guide policy decisions and strategies for health authorities. The most widely used method is the two-step floating catchment area (2SFCA), a multimodal approach to evaluating relative spatial access (8). This method has been refined to become a suitable tool for measuring spatial accessibility, significantly taking into account both supply and demand (9). The primary advantage of this method lies in its ability to provide a measure of accessibility at both the spatial and functional levels (10). The spatial level considers threshold distances between healthcare demand and the location of health facilities, while the functional level is based on ratios (11,12). The main objective of this article is to analyze the geographical accessibility of public health facilities in Djibouti, while addressing the following key questions: Which districts are the least served due to low spatial accessibility? Which populations benefit from the best geographical accessibility? Is it possible to reduce spatial inequalities, and what are the solutions to address this disparity? Additionally, it proposes recommendations to improve equity in access to health services. The results of this study are important for policymakers, health professionals, and development actors in Djibouti, providing vital information on the geographical areas requiring special attention.

2. Materials and Methods

Description of the study area

The Republic of Djibouti, a small country in the Horn of Africa, covers an area of 23,200 km² and is distinguished by its geographical and cultural diversity despite its modest size. In 2021, Djibouti had a population of 1,139,607, with a demographic growth rate of 2.8% (13). The Djiboutian population comprises three main components: the urban population, the rural population, and the nomadic population. Additionally, there is a significant proportion of the foreign population, with refugees representing approximately 3.2% of the country's total population. Nearly 71% of the population lives in urban areas, with 57.32% residing in the Djibouti region, while the rest is divided between a sedentary rural population and nomads (14). In 2017, Djibouti was classified among the lower-middle-income countries by the International Monetary Fund (IMF) and the World Bank. The country ranks 171st out of 191 in the latest Human Development Report of 2021/2022, with a Human Development Index (HDI) of 0.509(15). Despite recorded economic progress, poverty and unemployment levels remain high(16). Administratively, the Republic of Djibouti is divided into five decentralized regions: Ali Sabieh, Dikhil, Tadjourah, Obock, and Arta. These regions have legal personality, public law status, and financial autonomy. They are administered by Regional Councillors elected by direct universal suffrage. Furthermore, these regions are subdivided into nineteen administrative districts (17). The city of Djibouti, with a special status according to Law No. 122/AN/05/5thL, is governed by a Municipal Council comprising a deliberative Assembly, a President, and a Vice-President. The city is divided into three communes: Ras-Dika, Boulaos, and Balbala (18).

Data collection and analytical approach

The healthcare system of Djibouti is based on the principles of primary health care (PHC) and the district health system approach, in accordance with the Alma Ata Declaration of 1978. The delivery of health services is organized in a pyramidal manner, with three sectors: public, semi-public, and private.

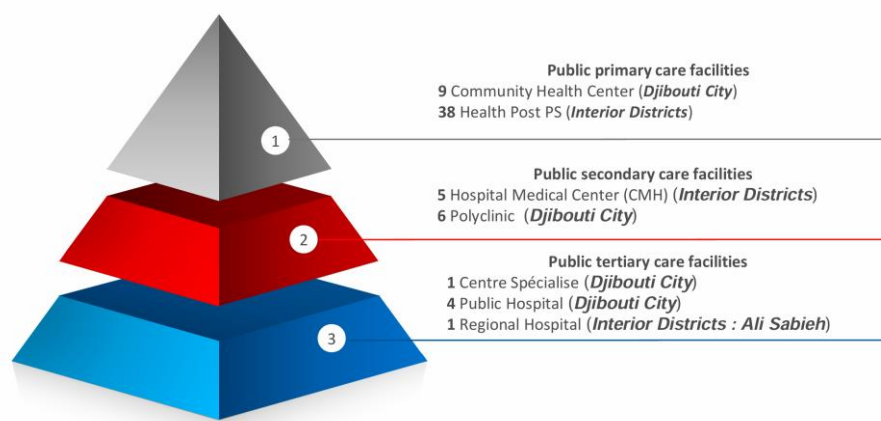


Figure 1. Structure of Public Healthcare Systems in Djibouti in 2022

The organization of public health care is divided into three levels based on the type of health facility and the complexity of services and care provided to the population. Health posts located in the districts and community health centers in Djibouti City represent the first-level facilities. These structures serve as the first points of contact for the population, providing primary health care, preventive activities, as well as prenatal and postnatal consultations. Their services include general consultations, vaccination, treatment of common diseases such as malaria, and health education. Polyclinics and medical-hospital centers (CMH) provide secondary health care. They handle cases referred by first-level facilities and offer specialized consultations, hospitalization services, radiology, laboratory services, and basic surgical interventions. Finally, third-level structures, such as specialized referral centers, regional and national hospitals like the National Reference Center for Reproductive Health (CNRSR-Housseina), the Regional Hospital Dr. Absieh in Ali-Sabieh, and the General Hospital Peltier, offer specialized tertiary care. They manage complex cases and perform advanced surgical interventions, specialized treatments, and sophisticated diagnostics.

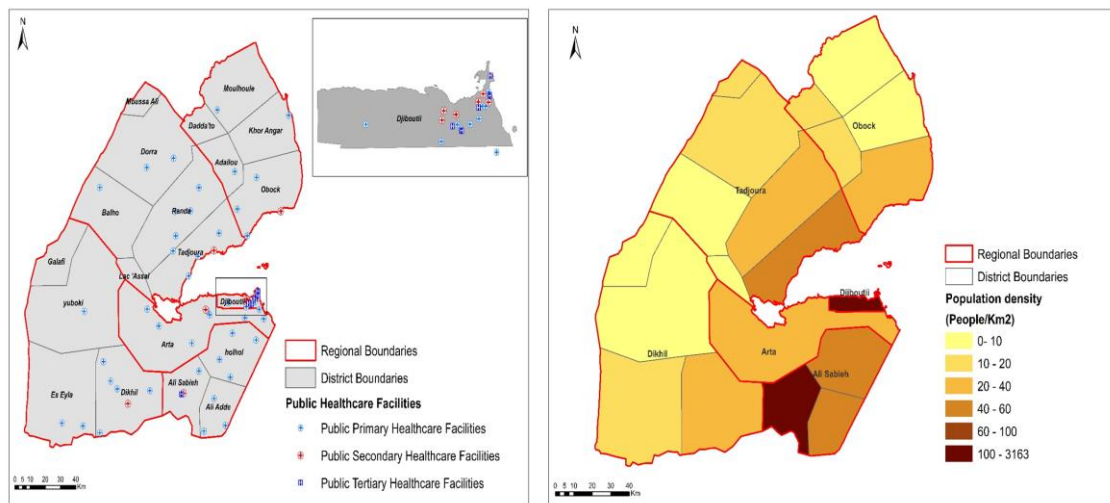


Figure 2A: Geographical Distribution of Public Healthcare Facilities in Djibouti: 2022

Figure 2B: Population Density Map of Djibouti by Region and District: 2021

Figure 2: Public Healthcare Facilities and Population Density in Djibouti

Source: WorldPop. "Demographic Data, 2020." <https://hub.worldpop.org/geodata/summary?id=49688>

Sources : Health Statistical Yearbook 2022, Ministry of Health: <https://sante.gouv.dj/publications>

Spatial databases sources

In the course of our research, we gathered comprehensive data on public health facilities from the 2022 health statistical directory provided by the Ministry of Health of Djibouti. This dataset included detailed information on the type of health facility, their bed capacity, the number of qualified professionals (numbers Doctor.), and the services offered to the population (6).

Table 1: Analysis of Healthcare Facility Distribution and Resource Allocation in Djibouti: A Multi-Level Assessment

Level	The types of facilities	Area	The number of beds	The number of doctors
Level 1 (Primary Care)	Health Post	Districts	149	2
	Community Health Center	Djibouti City	0	13
Level 2 (Secondary Care)	Polyclinics	Djibouti City	171	24
	Medical-Hospital Center (MHC)	Districts	112	15
Level 3 (Tertiary Care)	Regional Hospital (Ali Sabieh District)	Districts	100	15
	Balbala Hospital 'Cheiko	Djibouti City	195	55
	General Hospital Peltier		332	84
	Dar Al Hanan Hospital		141	32
	Dr. Chakib Hospital		117	7
	Housseina CNRSR Health Center		0	2

Sources : Health Statistical Yearbook 2022, Ministry of Health: <https://sante.gouv.dj/publications>

We mapped and geolocated the public health facilities to model their spatial analysis. Their coordinates were

derived using google earth (19). Travel to services is mainly via road networks. Therefore, the road network data were downloaded from OpenStreetMap, offering detailed and current information on the transportation network (20). In addition, the administrative boundary data were acquired from the Humanitarian Data Exchange website. To model spatial accessibility to services, it is essential to have a reliable understanding of the distribution and density of the populations served. However, the last census in Djibouti dates back to 2009, and although a new census began in 2024, results will not be available until 2025, with currently limited data at the regional level. To compensate for this low resolution of demographic data, WorldPop has developed spatial disaggregation techniques that allow for redistributing populations at finer resolutions (21). We used these demographic data to refine our analysis and fully leverage the detailed information from other sources.

Table 2 : Regional Population Distribution and Density by District in Djibouti in 2020

ADM1_PCODE	Regions/Cities	district	Pop Régional	pop Distric	surface (Km2)	pop_densit District hab/Km ²	Percentage of the region %
DJ01	Obock	Moulhoule	66966	8862	1282	7	5,83%
		Obock		41133	1225	34	
		Adailou		6045	502	12	
		Dadda'to		5449	349	16	
		Khor Angar		5477	983	6	
DJ02	Tadjourah	Randa	164706	56155	1698	33	14,34%
		Balho		8237	1327	6	
		Moussa Ali		4328	228	19	
		Dorra		28220	2024	14	
		Lac 'Assal		413	228	2	
		Tadjourah		67353	1160	58	
DJ03	Dikhil	yuboki	111398	18269	2556	7	9,70%
		Dikhil		57544	1531	38	
		Es Eylal		31548	1991	16	
		Galafi		4037	624	6	
DJ04	Djibouti -Ville	Djibouti	598580	598580	189	3163	52%
DJ05	Ali Sabieh	Ali Sabieh	151628	78569	747	105	13,20%
		holhol		39708	980	41	
		Ali Adde		33351	603	55	
DJ06	Arta	Arta	55512	55512	2161	26	4,83%
Total			1148790	1148790	22388	3662	100,00%

Source: WorldPop. "Demographic Data, 2020." <https://hub.worldpop.org/geodata/summary?id=49688>

The 2SFCA method

This study employs the Enhanced Two-Step Floating Catchment Area (E2SFCA) method, which is implemented in two distinct steps. First, the method calculates the provider-to-population ratio within specified drive time zones. For each healthcare provider, multiple drive time zones (e.g., 0-10 minutes, 10-30 minutes, and 30-60 minutes) are established. We assigned weights to each service area ring based on a distance decay function using a Gaussian curve, resulting in weights of 0.945, 0.403, and 0.01 for the three zones, respectively. The total population within each zone is then summed. The provider-to-population ratio for each zone is computed by dividing the capacity of the healthcare providers by the total population within the respective zone using the formula:

$$R_j = \frac{S_j}{\sum_{r=1}^3 \sum_{k \in \{Distance(k,j) \leq d_0\}} P_k W_r}$$

where S_j is the capacity of healthcare provider j , P_k is the population at location k , W_r is the weight assigned to each drive time zone, and d_0 is the travel threshold. For second and tertiary health facilities, capacity is measured by the number of beds. In contrast, for primary health facilities, capacity is represented by the number of doctors and nurses. Discussing bed capacity for primary health facilities is usually irrelevant because these facilities primarily offer outpatient services and preventive care. They may have a small number of observation beds for short-term use, but their focus is on providing services without the need for significant inpatient accommodation. Therefore, the number of doctors and nurses is a more relevant measure of capacity for these facilities. Second, for each population center, the healthcare providers within each drive time zone are identified, and their provider-to-population ratios are summed to calculate an accessibility index using the formula:

$$A_i^F = \sum_{j \in \{\text{Distance}(i,j) \leq d_0\}} \sum_{r=1}^3 R_j W_r$$

This index represents the cumulative access to healthcare services for the population center, taking into account the distance decay effect by weighting the influence of providers based on their distance from the population center. By incorporating distance decay, the E2SFCA method provides a more refined measure of healthcare accessibility, reflecting the varying travel times and preferences of the population (Figure 3).

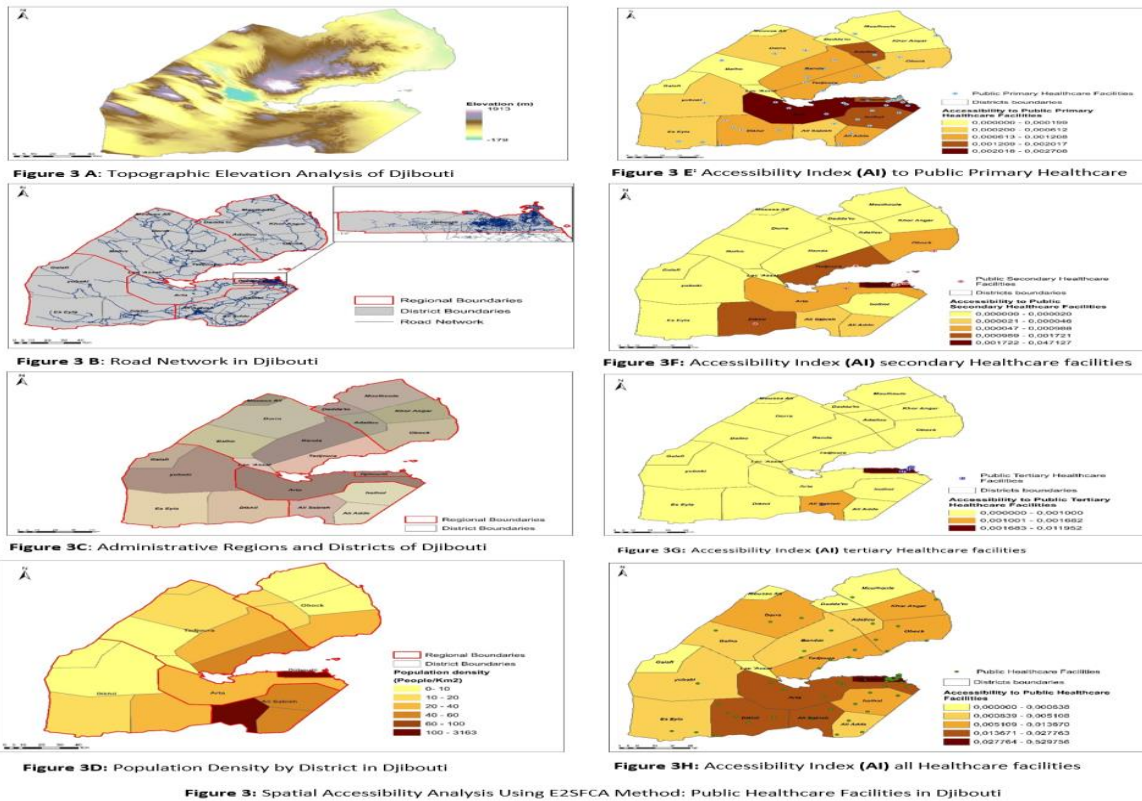
3. Results

Distribution of public health facilities and population density

Djibouti City is home to approximately 52% of the country's total population, with an extremely high density of over 3,163 inhabitants per square kilometer. This demographic concentration necessitates a robust healthcare infrastructure to meet the population's needs. In terms of the distribution of public health facilities, Djibouti City contains about 19.5% of primary healthcare facilities, 54.55% of secondary healthcare facilities, and over 83.33% of tertiary healthcare facilities (Table 3). In contrast, the interior districts, which house nearly the other half of the country's population, exhibit varied population densities depending on the district. The capital districts and three other districts, namely Ali Sabieh, Tadjourah, Arta, Obock, Dikhil, Randa, Hol-Hol, and Ali Adde, have more or less moderate densities, ranging from 33 to 105 inhabitants per square kilometer. Conversely, other districts such as Es Eyla, Yuboki, Galafi, Balho, Dorra, Moussa Ali, Khor Angar, Dadda'to, and Adailou have lower population densities. It is noteworthy that tertiary healthcare facilities in the interior districts represent only 16.67% of the total tertiary facilities in the country. Regarding healthcare facilities offering secondary care in the interior districts, they account for 45.45% of the total, while primary healthcare facilities are predominantly located in these districts, making up 80.85% (Figure 2).

Accessibility indices

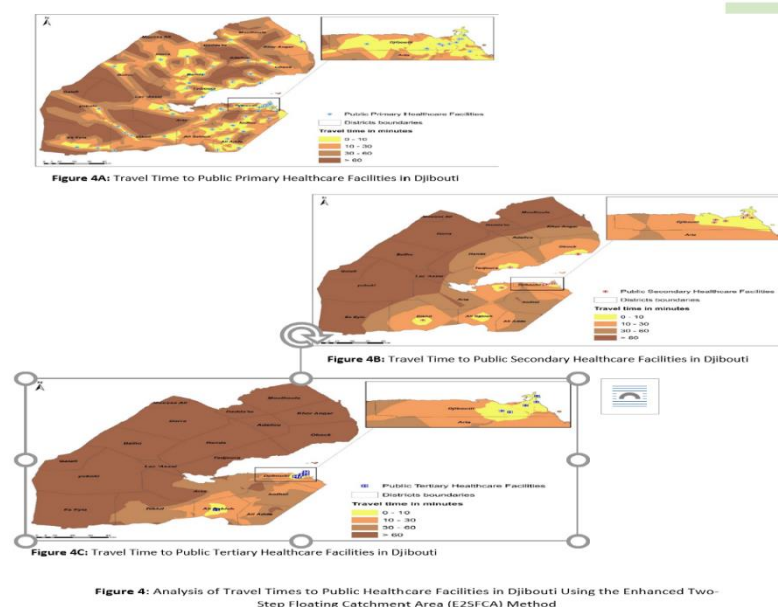
To calculate the accessibility index, we considered the human resource capacity (doctors and nurses) for primary public health facilities, as they are not intended for accommodating or hospitalizing patients but provide outpatient care. For secondary and tertiary facilities, we considered their bed capacity to ensure greater relevance in the assessment of accessibility. The results of the accessibility index calculation for public health facilities, across all levels, reveal significant spatial disparity. Djibouti City shows the highest accessibility index compared to other districts. The southeastern districts, such as Arta, Dikhil, and Ali Sabieh, have a good accessibility index. Regarding other districts, specifically Tadjourah, Obock, Hol-Hol, Dorra, Khor Angar, Aidoul, Yoboki, As Eyla, and Ali Adde, they show moderate accessibility indices, allowing their populations to access public health facilities. The most isolated districts, characterized by very low accessibility indices, are Galafi, Moussa Ali, Dadda, and Moulouhle. Examining the levels of care within the public sector, for tertiary health facilities, Ali Sabieh district stands out with a good accessibility index, second only to Djibouti City, which has the best accessibility to tertiary care. For secondary care, capital districts such as Arta, Ali Sabieh, Tadjourah, Obock, and Dikhil show a good accessibility index compared to other districts in the country. The districts with the lowest accessibility index for secondary care are Es-Eyla, Hol-Hol, Yoboki, Galafi, Balho, Randa, Aidoulou, Khor Angar, Mouloul, Dadda, Dorra, and Moussa Ali. In terms of primary care facilities, the districts with the lowest indices are Galafi, Balho, Moussa Ali, Dadda, Moulouhle, Khor Angar, and Lac Assal (Figure 3).



Travel time

City of Djibouti

In Djibouti City, travel times to primary care facilities are very short, with the majority of the population able to access these services within less than 10 minutes, thanks to a dense network of care centers and a well-developed road infrastructure. For secondary care facilities, travel times are also favorable, with access ranging from 10 to 30 minutes for most residents, due to the presence of several well-distributed secondary hospitals. Accessibility to tertiary care facilities is excellent, with travel times of less than 30 minutes for the majority of the population, owing to the presence of several well-equipped and strategically located tertiary hospitals.



Interior Districts

Outside Djibouti City, the interior districts show significant variations. For primary care facilities, about 70% of the population in the district capitals of Tadjourah, Ali Sabieh, and Dikhil can access services within 30 minutes.

In the districts of Arta, Holhol, and Ali Adde, about 60% of the population takes between 10 and 30 minutes to reach these services. In contrast, in the districts of Es Eyla, Yuboki, Galafi, Lac 'Assal, Randa, Adailou, and Obock, about 50% of the population has travel times of 30 to 60 minutes, while in Balho, Dorra, Moussa Ali, Khor Angar, Dadda'to, and Moulhoule, more than 70% of residents take more than 60 minutes to access primary care. For secondary care facilities, about 65% of the population in the district capitals of Ali Sabieh and Dikhil can access services within 30 minutes. In Tadjourah, Obock, and Arta, about 50% of the inhabitants take between 30 and 60 minutes to reach these facilities. The other districts, such as Randa, Adailou, Balho, Dorra, Moussa Ali, Yuboki, Galafi, Es Eyla, Holhol, Ali Adde, Lac 'Assal, Khor Angar, Dadda'to, and Moulhoule, see more than 75% of their population requiring more than 60 minutes of travel to access secondary care. Accessibility to tertiary care facilities is particularly limited in the interior districts. Only the districts of Ali Sabieh and Arta allow about 60% of their population to access services within 30 minutes. In Dikhil, Holhol, Ali Adde, Tadjourah, and Obock, about 55% of residents take between 30 and 60 minutes to reach these services. The other districts, such as Randa, Adailou, Balho, Dorra, Moussa Ali, Yuboki, Galafi, Es Eyla, Lac 'Assal, Khor Angar, Dadda'to, and Moulhoule, have more than 80% of their population requiring more than 60 minutes to access tertiary care (Figure 4).

4. Discussion

This study reveals disparities in the distribution and accessibility of public health facilities between Djibouti City and the other interior districts, using GIS tools and the Two-Step Floating Catchment Area (2SFCA) method. It is understandable that Djibouti City requires a robust and well-equipped healthcare infrastructure to meet the needs of its local population, as it houses more than half of the country's population, with a high urban and cosmopolitan density. Nonetheless, it is crucial to highlight that there is an inequality in the distribution of public sector facilities, especially for tertiary care facilities. Only the Ali Sabieh district has a tertiary care facility. According to the 2022 Health Statistical Yearbook of the Ministry of Health, Djibouti City has approximately 208 doctors, while the other interior districts have only 32. This translates to a ratio of about 3.5 doctors per 10,000 inhabitants in Djibouti City, compared to only 0.058 doctors per 10,000 inhabitants in the interior districts (6). Djibouti City accounts for 83.33% of public tertiary care facilities and 54.55% of secondary care facilities. For the populations of the interior districts, this has a significant impact on accessibility to highly specialized care in advanced medical fields such as cardiology, oncology, neurosurgery, and orthopedic surgery. These facilities are equipped with state-of-the-art medical technologies, including high-precision imaging diagnostic equipment (MRI, CT scans), biomedical research laboratories, and sophisticated surgical facilities. To address this disparity, it is recommended to increase the number of tertiary care facilities and deploy more qualified medical personnel in the interior districts to provide more accessible advanced medical services to these populations (22,23).

Except for the main districts such as Dikhil, Tadjourah, Obock, Arta, Ali Sabieh, and the district of Ali Adde, which exhibit an acceptable accessibility index, other districts like Hol-Hol, Es-Eyla, Yuboki, Galafi, Balho, Lac-Assal, Randa, Adailou, Dorra, Moussa Ali, Dadda'to, Moulhoul, Moussa Ali, and Khor Angar, characterized by more dispersed and predominantly rural populations, display a very low accessibility index to secondary healthcare facilities. This implies that the populations in these districts, which still represent one-third of the country's population, have limited access to basic specialty services such as pediatrics, gynecology, dermatology, cardiology, and other common medical specialties. Furthermore, diagnostic services, such as medical analysis laboratories, radiology services, and basic equipment for examinations like ultrasounds, X-rays, and electrocardiograms (ECGs), are not equally available to them. This situation is due to several factors: the lack of establishment of these facilities in these districts, inadequate road infrastructure that complicates access to healthcare facilities in neighboring districts, and the mountainous topography of these regions. The insufficient road infrastructure exacerbates this situation by increasing travel times and making some facilities practically inaccessible, especially in medical emergencies. These conditions complicate the delivery of medical equipment and the mobility of healthcare professionals, thereby reducing the quality and availability of care for local populations. To improve healthcare accessibility in rural districts of Djibouti, several solutions can be considered to address these disparities. Firstly, the reinforcement of mobile clinic deployments and the use of telemedicine would allow the provision of specialized healthcare without requiring long and costly travel (24). Secondly, the use of drones for the rapid delivery of essential medicines and medical equipment in hard-to-reach areas would reduce delays and improve the availability of medical resources (25). However, the most vulnerable and isolated populations identified in our study are the inhabitants of the districts of Galafi, Moussa Ali, Dadda'to, Moulhoul, and Lac Assal, who exhibit an extremely low accessibility index to public health services. These populations represent 2% (23,089) of the country's total population and require special attention (Table

3). It is urgent to establish health posts or community health centers in these districts to reduce healthcare access inequalities and improve the health status of these vulnerable populations.

Like any research, our study presents certain limitations. The results should, however, be interpreted in the context of these limitations. Other factors such as the cost of transportation, level of education, cultural factors, and service acceptability are among the elements that influence geographical access (26). Therefore, including these variables is likely to provide a more comprehensive picture of access to healthcare services. The fact that our study focuses solely on public sector facilities may limit our understanding of the role of other sectors in healthcare access. Additionally, detailed information on the modes of transportation used by populations to access healthcare facilities is lacking, with these modes varying from one district to another, as well as the precise number of transportation means available. Finally, the travel time models assume that people use the nearest healthcare facility, without considering other factors influencing the choice of service provider. Among the factors rarely accounted for in these models are competition between facilities, especially in urban areas where patients have multiple options for care. Although these factors are often integrated into gravity models, their reliance on precise data on service capacity and detailed demographic data makes their application difficult in African contexts (27).

5. Conclusion

The study on the spatial accessibility of public healthcare services in Djibouti reveals significant disparities between the city of Djibouti and the interior districts. The concentration of healthcare facilities in the capital caters to the needs of a dense urban population but creates inequalities for rural and remote regions. The interior districts suffer from limited access to specialized care, exacerbated by inadequate road infrastructure and an inequitable distribution of healthcare professionals. To address these disparities, it is essential to strengthen healthcare infrastructure in the interior districts by increasing the number of tertiary care facilities and deploying more qualified medical personnel. The introduction of innovative solutions such as mobile clinics and telemedicine can also improve access to care. These measures will help reduce access inequalities and ensure more equitable universal health coverage across the country. The results of this study are crucial for policymakers, healthcare professionals, and development actors, providing valuable insights to guide public health policies and improve equity in healthcare access in Djibouti.

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