Spatial Distribution of Primary Government Healthcare Centers in Hail City Using Geographic Information Systems

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Abstract

This study aims to identify the spatial distribution of primary government healthcare centres in Hail City and analyse the accessibility to these centres. The research seeks to understand the pattern of distribution of healthcare services using spatial analysis tools, evaluating whether the locations can serve a larger number of service seekers or those within their basic service range. The study also investigates the ease of access to healthcare services, considering spatial access as a crucial factor in human health. The primary objective is to uncover the current situation of government primary healthcare centres in Hail City, assessing the existing conditions and proposing appropriate alternatives to achieve maximum fairness and social justice in accessing government healthcare facilities in the city. The study reveals some results, including a deficiency in the spatial distribution of primary healthcare services and variations in accessibility to healthcare centres in Hail City. The primary healthcare centres are distributed among the city's municipalities as follows: 15% in the north (3 centres), 70% in the central area (14 centres), and 15% in the south (3 centres). The central neighbourhoods exhibit higher accessibility points than the rest of the city, while most neighbourhoods lacking access to healthcare centres are situated in the city's peripheral areas. The findings can assist local health planners in improving spatial equality in accessing healthcare centres by prioritizing services for neighbourhoods with lower accessibility when allocating future healthcare centres in Hail City.

First: The Theoretical Framework of the Study

1-1 Introduction to the Study

Health is one of the most fundamental requirements for human life, and improving the overall health of the population by ensuring equality in access to healthcare is one of the core objectives of sustainable development. Therefore, primary healthcare is one of the essential pillars that governments seek to provide, finance, and manage to preserve the public health of communities. The healthcare system is a significant indicator of development and civilization in societies, ensuring equal access to services with minimal cost, time, and effort.

Primary healthcare centres are crucial service sectors for enhancing the quality of life in the Kingdom of Saudi Arabia. Providing various healthcare services is a cornerstone of sustainable development, serving as a vital service in the healthcare sector system. It contributes to

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achieving the health safety of citizens and protecting the community from diseases and epidemics in general. Improving infrastructure, facility management, healthcare facility safety, and enhancing the quality of life in Saudi cities are key goals of the Kingdom's Vision 2030.

One of the key strategic goals of Saudi Vision 2030 is to facilitate access to primary healthcare centres at the right time and place. Providing primary healthcare centres with equitable access to all individuals is a crucial matter for the Saudi Ministry of Health and relevant decision-makers. Therefore, the results of this study can benefit local health planners in Hail City by prioritizing underserved neighbourhoods when allocating future healthcare centres. This, in turn, is expected to improve equality in accessing primary healthcare centres.

Geographic Information Systems (GIS) play a significant role in making spatial decisions related to public health. GIS can efficiently address healthcare planning issues by applying statistical and analytical methods. Geographic information systems can enhance spatial accessibility measurements to healthcare by using various scales and models based on geographic and non-geographic factors to assess spatial disparities and identify areas lacking primary healthcare centres.

Previous studies on the spatial distribution of healthcare services in the Kingdom of Saudi Arabia and other Arab and foreign countries are rich and diverse. Initially, studies focused on theoretical statistical methods, emphasizing the efficiency of healthcare services concerning population densities. Over time, these studies evolved to produce more effective maps, especially with the emergence of Geographic Information Systems technologies, allowing various spatial and statistical analyses, here are some examples of previous studies:

A study by (Al-Qahtani,1994) found that healthcare development in the Ahad Rafidah region in the Aseer province grew slowly. The spatial distribution of healthcare centres exhibited clear variations between different parts of the region. Regarding healthcare capabilities in primary healthcare centres, a severe deficiency was identified. The study emphasized the importance of analyzing the spatial development of primary healthcare centers, and evaluating their services and usage, to enable proper future planning for this crucial service, ensuring easy and accessible provision for all residents. The study relied on a quantitative descriptive approach to analyze the spatial development of healthcare centres and understand their spatial distribution. Continuation:

The study conducted by (Al-Zahrani ,2006) revealed that the distribution of various elements of healthcare services in Jeddah is generally random, except for a few limited elements, as per certain analytical methods. The study utilized simple descriptive statistical methods for the spatial self-correlation of healthcare services distribution. This study relied on the ArcView 3.2 and ArcMap 8.3 Geographic Information Systems programs.

Additionally, a study by (Susan E. Chen and others ,2007) focused on population health and access to healthcare services, considering them crucial factors influencing economic development. The study examined the workforce in healthcare centres in the state of Indiana, USA, the population distribution in Indiana, and the ease of access to healthcare locations based on population concentrations in all counties in Indiana. The results highlighted sharp disparities in healthcare accessibility, especially in impoverished areas in rural and peripheral regions.

(Al-Anzi ,2013) conducted a study on the spatial distribution of public services in Hail City

using Geographic Information Systems (GIS). The study concluded that Hail City suffers from a deficiency in public services, with most services concentrated in the heart of the city within its central neighbourhoods. The distribution did not follow the planning standards adopted in Saudi cities, negatively affecting the spatial distribution efficiency of services in the city's neighbourhoods.

A study by (Usman Ado Kibon and others ,2013) focused on the distribution of primary healthcare facilities in Kano City using Geographic Information Systems. The study also examined related research on GIS to support healthcare planners in small regions. The study created a geographic database and used it to analyze the spatial distribution type of primary healthcare facilities in the study area. One of the most significant findings was that most healthcare facilities clustered within the municipality of Kano, indicating the existence of areas deprived of these services.

(Nuriinnisa Usul and others ,2013) addressed the policies of providing healthcare in Yola and its spatial distribution, using GIS to analyze the spatial distribution of healthcare centres in Yola. The study collected various digital and non-digital datasets and transformed them into geographic data using GIS. Spatial analysis tools were employed, leading the study to conclude the inadequacy of healthcare facilities in the study area, recommending improvements in the healthcare delivery system, including the construction of new facilities, upgrading existing ones, increasing medical staff, and advocating the use of GIS by healthcare planners and policymakers to enhance planning and resource allocation in the study area.

Furthermore, a study by (Minutha and others ,2014) addressed primary healthcare as one of the most crucial health needs for individuals. The study emphasized the necessity of providing primary healthcare centres, in addition to optimizing the distribution of healthcare facilities, ensuring easy access, and sustaining their provision. The findings indicated unequal distribution and limited accessibility of primary healthcare centres for the population. The study recommended the identification of new facility locations in the study area to contribute to achieving balanced regional development in terms of healthcare facilities.

In a study conducted by (Al-Zeer ,2017), the current distribution of primary healthcare centres in western Riyadh was found to be inconsistent with the geographical distribution of variables. The study suggested the need for approximately 25-33 new healthcare centres in the study area. The methodology involved a descriptive-analytical review and the application of Geographic Information Systems (GIS).

Additionally, the study by (Al-Khalifa and Al-Shuwaish ,2019) demonstrated that optimal centre locations vary with the distance to them. The study employed a spatial analytical approach using GIS and remote sensing techniques. Spatial survey techniques and location-allocation models were utilized to reveal the spatial distribution of residents within neighbourhoods, assess the service range of primary healthcare centres, and determine their accessibility in the city of Arar.

Furthermore, a study by (Al-Qahtani ,2019) highlighted the importance of the topic and its impact on a significant segment of society. The study aimed to assess the satisfaction of beneficiaries regarding the quality of services provided in primary healthcare centres. Recognizing the significance of the services offered by these centres, the study adopted a social survey methodology with a sample of healthcare beneficiaries in Riyadh.

A study by (Al-Shammari ,2020) revealed the lack of qualitative and quantitative efficiency in

the preparation of healthcare centres. The study employed a geographical analytical approach to uncover the distribution pattern of primary healthcare centres. It focused on two aspects: the spatial distribution of primary healthcare centres and the levels of healthcare service efficiency in these centres in Al-Qadisiyah Governorate.

In another study by (Okasha ,2020), the educational services in Hail City were assessed in terms of efficiency, distribution, and alignment with urban distribution and population growth. The study used spatial analysis tools provided in GIS, including proximity analysis, standard distance, distribution direction, and spatial ranges. The findings indicated a spatial distribution imbalance for all educational services, emphasizing the need for additional services in the city.

The study conducted by (Al-Rawashdeh, Tarawn, Al-Khasawneh, and Msarweh ,2020) addressed the inadequate distribution and shortage of healthcare centres in the Qasabat Al-Karak district concerning urban clusters. The spatial distribution of healthcare centres did not adhere to planning standards for accessibility distances, resulting in a dispersed random pattern. This negatively impacted the quality of healthcare services provided to the population, and the study utilized descriptive, historical, and analytical methodologies, incorporating statistical methods.

(Parvin and others,2020) focused on the accessibility and locational suitability of healthcare services in Madurai, India, using a GIS-based decision-making approach. The study aimed to develop a decision-making approach using GIS to integrate spatial and non-spatial data for a weighted result. It included three-level analyses to evaluate accessibility, choose suitable locations for healthcare facilities, and determine the shortest network path. Results revealed spatial disparities in accessing healthcare facilities, highlighting the need for equal access to healthcare.

The study by (Al-Shahri ,2021) found deficiencies in drug availability, electronic and construction services, and workforce development in primary healthcare centres in Riyadh. The study recommended the establishment of government buildings, improving workforce efficiency through training, and addressing shortages, especially in medications and other support services. The study utilized a descriptive-analytical approach to assess and analyze the satisfaction of primary healthcare centre visitors in Riyadh.

Moreover, the study by (Qatishat, Haddoush, Al-Zoubi, and Shbool ,2021) identified a random pattern in the distribution of healthcare centres in the study area. The study recommended developing hospital services to cover vital specialities lacking in Jerash Province and increasing the medical staff in primary healthcare centres. The study employed an inductive methodology, which starts with particulars and concludes with generalities. It also utilized geographic maps and statistical methods within GIS.

Lastly (Al-Olay ,2021) highlighted a quantitative shortage of hospitals compared to the served population in the Hail region. The study aimed to identify the spatial pattern of home healthcare hospitals in Hail and evaluate the efficiency of home healthcare services. It utilized a descriptive-analytical methodology and a spatial analysis approach. Field studies were conducted to measure patient satisfaction and identify challenges faced by home healthcare providers.

The rapid urban expansion of Hail City has not been accompanied by a corresponding re-distribution of primary healthcare centres in the neighbourhoods experiencing significant

population growth. These centres serve as the primary destination for residents seeking healthcare services, emphasizing the importance of aligning their distribution with the population size and ensuring the availability of essential services. Therefore, this study focuses on the spatial distribution of primary healthcare centres in Hail City, evaluating whether their current geographic locations can efficiently serve a growing number of service seekers and whether they align with the needs and demands of the population.

The study addresses the following questions to define its problem statement:

1. What is the current spatial distribution of primary healthcare centres in Hail City?
2. Does the growth of primary healthcare centres in Hail City align with the population size?
3. What are the spatial variations in accessibility to primary healthcare centres in Hail City?

The objectives of the study are:

1. To understand the current status of primary healthcare centres in Hail City across its residential neighbourhoods.
2. To assess the degree of alignment between the distribution of healthcare centres and the planning standards for healthcare services.
3. To generate results and recommendations that can guide decision-makers in enhancing the status of primary healthcare centres in the city.

The study aims to contribute valuable insights to decision-makers, providing a basis for improvements in the distribution and accessibility of primary healthcare services in response to the evolving needs of the population and the urban landscape of Hail City.

Secondly, the Study Methodology

The study adopted a descriptive and analytical approach to examine the distribution of primary healthcare centres and assess their functional efficiency. This was achieved by relying on bibliographic sources and relevant authorities related to the study topic. The study employed a spatial analysis method to illustrate the locations of primary healthcare centres in Hail City. Geographic maps, statistical methods, and tools within Geographic Information Systems (GIS) software were utilized to conduct spatial analysis and create appropriate models for spatial phenomena.

Several tools facilitated the completion of the research, including digital maps (Hail City Digital Map) and ArcGIS 10.8 software. The cartographic methods employed in the study involved the application of Geographic Information Systems (GIS) through five specific applications for spatial statistical analysis: Nearest Neighbor Analysis, Standard Distance Analysis, Mean Center Analysis, Directional Distribution Analysis, and the spatial impact range of the locations of primary healthcare centres based on accessibility distance in Hail City.

Study Boundaries

Hail City is situated as the capital of the Hail Region, with a rich history and a strategically important location in the centre of the northern part of the Kingdom. It is one of the most significant geographic locations in the region, serving as a hub for commercial activities and a focal point for transportation and communication. The city is located at a latitude of 27° 31' 13" north and a longitude of 41° 41' 25" east (Saudi Geographical Society, 2001). Hail City is bordered to the east by the provinces of Qassim and Shanan, to the south by the provinces of Samirah and Al Ghazalah, and to the west and north by the province of Hail. It is an urban city without administratively affiliated villages. The region is overseen by the municipality, which

also extends its services to other sub-municipalities in the area (Okasha, 2020, p. 5).

Figure (1-1)

The study focused on the primary healthcare centres in Hail City, encompassing all the entities in the study community, totalling 20 health centres as of the year 2023, as illustrated in Figure (1-2) , The study population included the residents of Hail City, numbering approximately 475,000 individuals, with around 21% being non-Saudi citizens. The average population density in the city is 3,212 individuals per square kilometre, and the average household size is estimated at 6 persons per family (City Prosperity Report, Ministry of Municipal and Rural Affairs, 2018).

Figure (1-2)

Third,Results and Discussions

3-1 Factors Influencing Primary Healthcare Centers Distribution:

3-1-1 Natural Factors

The distribution of primary healthcare centres in the city is influenced by various natural factors, including climate, elevation, and topography. Additionally, the presence of green spaces plays a crucial role, as each of these factors acts as an attractor or deterrent for the location of healthcare services. Generally, moderate climates and green landscapes are known to attract healthcare services. Hail, situated within an elevation range of 825 to 1050 meters above sea level, exhibits characteristics such as a scarcity of groundwater beneath the surface due to the Arabian Shield's geological structure, deep clayey soil, and geological formations from the fourth era. The eastern part of the city consists of indistinct granite rocks, while the western areas are characterized by the Aja Mountains, reaching up to 1490 meters above sea level. To the east and southeast, there are the Red Mountains ranges and their passages and the city itself is located in a spacious valley, the Wadi Al-Adir and its branches (High Authority for the Development of Hail, 2017).

3-1-2 Population Distribution

The study of population distribution involves examining how populations are distributed across spatial units and understanding the processes or factors influencing the distribution pattern. This can be studied in absolute or relative numbers, such as population density, and other measures like concentration indices and Lorenz curves that reveal the nature and pattern of distribution. The use of cartographic representation for population distribution, whether relative or numerical, is one of the oldest methods employed in studying population distribution, especially with advancements in digital (computerized) maps and Geographic Information Systems (GIS) technology (Al-Kharif, 2008, p. 142).

Furthermore, the significance of services is measured by their ability to meet the population's needs with minimal effort and cost, necessitating their proximity to population centres in the city. Typically, old neighbourhoods in the city centre have high population densities and are fully serviced with various essential facilities. As one moves away from the city centre towards the peripheries, population density decreases, and the distribution of service locations becomes less widespread (Al-Sharai, 1999, p. 28).

3-1-3 Population Density

The concept of population density first emerged in maps created for planning Irish railroad lines in 1837. Population density is measured using various methods, including arithmetic density, agricultural density, and physiological density. Arithmetic density, also known as crude density, is the most commonly used and widely understood measure. It is often referred to simply as population density. The calculation is straightforward:

$$\text{Arithmetic Density} = \frac{\text{Population of an Area, Country, or Residential Area}}{\text{Area of the Region, Country, or Residential Area}}$$

In Hail, with a population of 344,111 individuals and an average population density of 19.63 people per hectare within the current built-up area, the total built-up area of the city is 7,634 hectares. Only 4% of this area has a density exceeding 50 people per hectare, accommodating 13% of the population. Additionally, 3.7% of the total built-up area has a population density ranging from 30 to 50 people per hectare, hosting 9% of the population. The remaining 78% of the population resides in low-density areas with fewer than 30 people per hectare. The highest concentration of residents is observed in the city centre, gradually decreasing towards the outskirts. Density significantly decreases in the south, north, and beyond the ring road (Ministry of Municipal and Rural Affairs and the UN Human Settlements Program, 1440 AH).

Expected Population and Urban Planning

The anticipated population according to the land-use plan is 586,152, covering an estimated area of around 89,000 hectares, with a built-up area of 63,000 hectares. Based on the UN-recommended density of 150 people per hectare, the region could accommodate over 9 million people. Notably, the proposed new areas will have abundant open spaces with low-density residential neighbourhoods resulting from urban sprawl.

A comparison of Hail's urban land area in 1435/1450 with that of various global capitals reveals that the land utilized by Hail for its 344,111 residents exceeds that of Prague, a city with over 2.5 million inhabitants. This indicates that the infrastructure, facilities, and services for Hail's population are considerably more costly for the Saudi government and society than those of other successful cities worldwide, which often have larger populations. Moreover, the expected future population of 586,152 by 2030 remains significantly lower than Prague's population of over 2.5 million (Ministry of Municipal and Rural Affairs and the UN Human Settlements Program, 1440 AH).

Analyzing the density of point phenomena allows the creation of a surface map illustrating variations in the distribution density across the study area. By utilizing specific non-spatial values, the map represents changes in the density of these values around the locations of the phenomena. For instance, knowing the population of certain cities allows the derivation of a map depicting the spatial changes in population numbers across the study area containing these cities (Dawood, 2012).

Applying Kernel Density analysis to understand the geographic distribution density of the population in the geographical area covered by Hail, by calculating the point density around the centre, reveals surface trends and geographic dispersion of these urban centers. The results show circular density rings reflecting the population density of urban centres in each range. High-density areas are depicted in dark red, gradually decreasing in density as one moves away from the centre, noticeably diminishing in the south, north, and beyond the ring road.

In terms of population distribution, Al-Wusayta comes first with 32,118 residents, followed by Al-Naqra with 22,959 residents. Al-Aziziyah ranks third with 22,525 residents. Regarding population density, Al-Ulaya tops the list with 11,915 residents/km², followed by A'irf with 11,545 residents/km², and the third is Burzan with 10,908 residents/km². These neighbourhoods, characterized by small areas, are among the earliest residential areas in Hail and stand out for their cultural heritage, contributing to their distinctive status in Hail's history.

Figure (1-3)

3-1-4 Ease of Access

Spatial importance for any service is measured by the time required for access. The effort exerted by individuals and the time taken to reflect the functional significance of service locations. This is closely linked to road networks and their various types within and outside the city. Consequently, a well-planned and distributed road network that allows individuals to reach service locations with minimal effort, cost, and time achieves the highest benefit.

The road network serving the study area comprises regional, main, sub, local, and commercial roads. The 20 health centres in the study area are strategically located on various types of roads. Some centres are situated on two types of roads. From tracking the distribution of health care centres on the road network, it is evident that all health centres are located on sub-roads, local roads, and commercial roads. In general, all centres are situated on roads that facilitate easy access, ensuring connectivity between them and residential neighbourhoods Distribution of Primary Health Care Centers.

Figure (1-4)

A study of the distribution of primary health care centres on main roads in Hail City and Figure (1-4) reveals that these centres are distributed along local, sub, local commercial, and sub-commercial roads. There are 10 health centres along local roads, including Aja, Zahra, North Airport, Airport, Al-Wusayta, Sharaf, Samra, Al-Jamiyeen, Television, and Naqra. Additionally, three health centres are along local commercial roads: Western Park, Eastern Park, and Qaffar

Two health centres are situated on sub-roads: Lubda and Al-Wudi. Furthermore, five health centres are located on sub-commercial roads: Al-Nisayyah, Al-Aziziyah, Al-Badia, Sababah, and Al-Khamashiyah.

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3-2 Planning Criteria for Primary Health Care Centers

Primary health care centres serve as the core of medical services, providing primary care at the neighbourhood, residential, and village levels. These centres create health records for all families within their service area, monitor the health status of each family member, provide treatment and preventive services, and facilitate referrals to specialized medical centres when necessary. The centre may include examination rooms, waiting areas for males and females, an emergency room, a laboratory, and a pharmacy. It may also have an ambulance unit along with associated facilities such as health facilities, storage rooms, and maternal and child care offices (Ministry of Municipal and Rural Affairs, 2005).

Planning criteria for health centres are outlined by the Ministry of Municipal and Rural Affairs, focusing on the population served, service area in square meters, and per capita space. The

rates vary based on the level of residential proximity, and the criteria are summarized in Table (1-1).

Table (1-1): Planning Standards for Primary Health Care Centers.

Planning Criteria	Minimum	Maximum	Notes
Population Served	-	15000	One or more adjacent residential areas or neighbourhoods
Service Area (in square meters)	-	800	-
Per Capita Space (square meters)	0.12	0.15	-

Source: Planning Standards Guide for Services, Ministry of Municipal and Rural Affairs, 1426 H.

Several requirements for the location of primary health care centres are outlined in the Planning Standards Guide for Public Services (Ministry of Municipal and Rural Affairs, 2005), as follows:

1. The centre's location should be carefully chosen, ideally situated in the middle of a residential neighbourhood, adjacent residential areas, or between residential neighbourhoods.
2. The site should be characterized by tranquillity and, therefore, should be distant from schools and commercial markets.
3. The chosen location should be away from noise, pollution, smoke, dust, and other environmental hazards.
4. Consideration should be given to having the centre situated along collector or main roads.

Additionally, some fundamental considerations for primary health care centres are highlighted in the Planning Standards Guide for Public Services (Ministry of Municipal and Rural Affairs, 2005) , as follows:

1. Clinics, in addition to primary health care centres, may perform certain functions.
2. The centre's location should ideally facilitate easy access by car from the main roads.
3. The site should allow for multiple secondary entrances to the building.
4. Provision should be made for parking spaces outside the health centre. According to the Parking Standards Guide, 6 parking spaces per 100 square meters of floor area should be provided.

These planning standards aim to ensure that primary health care centres are strategically located and designed to meet the needs of the community while considering factors such as accessibility, tranquillity, and environmental considerations.

3-3 Geographic Distribution of Primary Health Care Centers in Hail City

Healthcare is an integral part of any thriving nation. The Kingdom of Saudi Arabia has dedicated efforts to provide comprehensive healthcare services to all members of society in an easy and accessible manner. This includes healthcare legislation, patient rights and responsibilities, healthcare facility systems, the Kingdom's efforts during the COVID-19 pandemic, precautionary measures to be taken, available vaccine types, healthcare services during the Hajj pilgrimage, services for the elderly, mental health, chronic diseases, telemedicine, health insurance, and healthcare for non-Saudis (Unified National Platform

GOV.SA, 2023).

The primary healthcare centres in Hail City are divided into three sections: North, Central, and South. The city has a total of 20 health centres as of 2023, distributed as follows: 3 in the North, 14 in the Central, and 3 in the South, as shown in Figure (1-2). The central area, being the heart and central business district, has the highest population and generally receives more healthcare services. This is due to it encompassing the oldest neighbourhoods in Hail City.

3-4 Geographic Distribution of Primary Health Care Centers According to Residential Neighborhoods

The study area includes 20 primary healthcare centres, and upon examining their distribution, it's noted that these centres are spread across 20 neighbourhoods. Most centres are named after the neighbourhoods they are located in, except for a few exceptions like the "North Airport Health Center" in the Station neighbourhood, "Sababah Health Center" in the Salahuddin Al Gharbi neighbourhood, and "Television Health Center" in Al Mujama neighbourhood. The health centres are evenly distributed, with one health centre serving each neighbourhood.

3-5 Geographic Distribution of Primary Health Care Centers and Their Stakeholders in Hail City for 2023

As of 2023, 20 primary healthcare centres were serving 20 residential neighbourhoods, employing a total of 87 doctors and approximately 230 healthcare nurses. The total number of visitors to these centres in 2021 was 262,749, distributed unevenly among the health centres.

Some centres serve a low number of visitors, such as the "Nisba Health Center," which caters to approximately 1.07% of the total visitors to healthcare centres in Hail City, with less than 3,000 inhabitants.

Centers Serving Moderate Numbers of Visitors (3,000 to less than 6,000 residents), There are two centres, Al-Wadi Health Center and Sababah Health Center, serving moderate numbers of visitors, constituting approximately 3.47% of the total visitors to healthcare centres in Hail City.

Centers Serving High Numbers of Visitors (6,000 to 9,000 residents), Seven centres, namely Sababah Health Center, Television Health Center, Lubdah Health Center, Sharaf Health Center, Al-Jamaiyeen Health Center, Al-Khamashia Health Center, and Al-Azizia Health Center, serve high numbers of visitors, making up around 19.95% of the total visitors to healthcare centres in Hail City.

Centers Serving Very High Numbers of Visitors (More than 9,000 residents),The majority of the health centres, including North Airport Health Center, Al-Wusayta Health Center, Al-Zahra Health Center, Aja Health Center, Airport Health Center, Al-Badia Health Center, Qaffar Health Center, Al-Muntazah Al-Gharbi Health Center, Al-Nuqra Health Center, Al-Muntazah Al-Sharqi Health Center, and Al-Samra Health Center, serve very high numbers of visitors, constituting around 77.76% of the total visitors to healthcare centres in Hail City.

3-6 Spatial Analysis of Primary Health Care Centers in Hail City

3-6-1 Nearest Neighbor Analysis

The Nearest Neighbor Analysis was employed to discern the spatial distribution pattern of primary healthcare centres in Hail City. This analysis reveals the geographic spread or clustering of the phenomenon under study, comparing the actual distribution with a theoretical one

(Dawood, 2012). The results of the analysis indicate a dispersed distribution pattern for primary health care centres in Hail City, with a Nearest Neighbor Index value of 1.236309. The calculated z-score of 2.021741, which is greater than the expected p-value of 0.043203, supports the conclusion of a dispersed distribution.
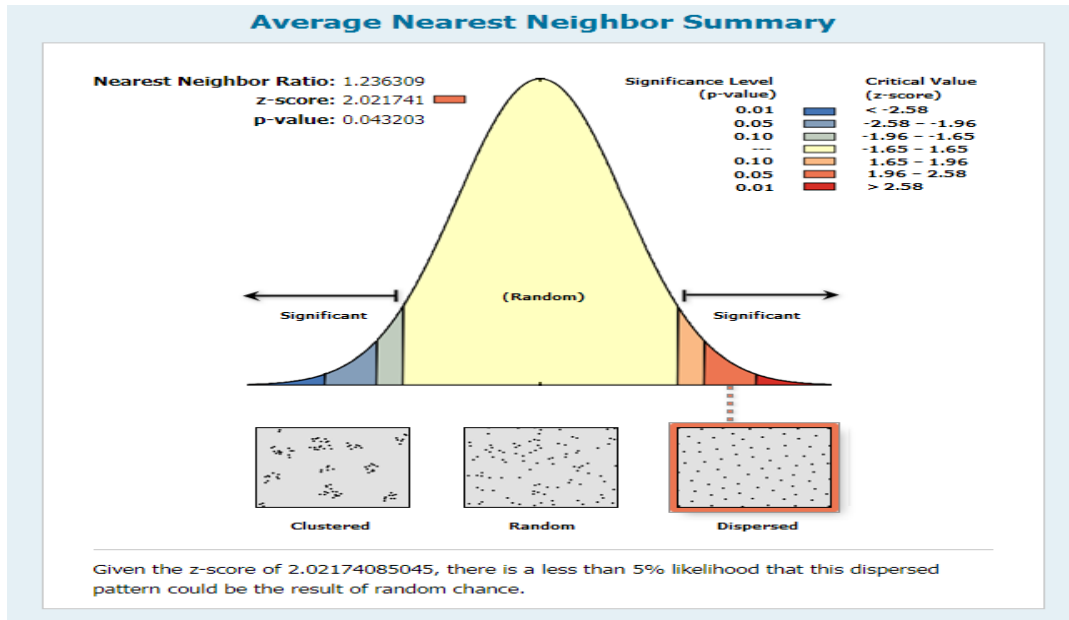

Figure (1-5): Nearest Neighbor Analysis result.

Source: Prepared by the researcher based on ArcGIS tools.

The results indicate that as the value of Z increases beyond one, the distribution tends towards dispersion, and if it decreases below one, the distribution tends towards clustering. The previous findings demonstrate that the ratio of the observed average distance to the expected average distance is 1.23, indicating a dispersed distribution pattern. This is further affirmed by the standard deviation value (Z-Score) of 2.021741, which is greater than the expected p-value of 0.043203.

Average Nearest Neighbor Summary

Observed Mean Distance:	2387.8612 Meters
Expected Mean Distance:	1931.4443 Meters
Nearest Neighbor Ratio:	1.236309
z-score:	2.021741
p-value:	0.043203

Dataset Information

Input Feature Class:	Export_Output
Distance Method:	EUCLIDEAN
Study Area:	298438152.609840
Selection Set:	False

Figure (1-6): Results of the Nearest Neighbor Analysis.
Source: Prepared by the Researcher Based on Arcgis Tools.

The value of the nearest neighbour analysis coefficient ranges between zero and 2.15. As the value approaches zero, the distribution tends to be clustered, while approaching the maximum indicates a more regular distribution. A value of 1 signifies complete spatial randomness (Daoud, 2012, p. 51).

3-6-2 Standard Distance Analysis

The standard distance is used in spatial analysis as an equivalent to the spatial standard deviation indicator employed in non-spatial data analysis. It serves as a measure to assess the extent of dispersion or concentration of primary healthcare centres in Hail City spatially. The standard distance value is often used to draw a standard circle, providing insights into the spatial concentration or dispersion of primary healthcare centres in Hail, as depicted in Figure (1-7).

Standard Distance

Measures the degree to which features are concentrated or dispersed around the geometric mean center.
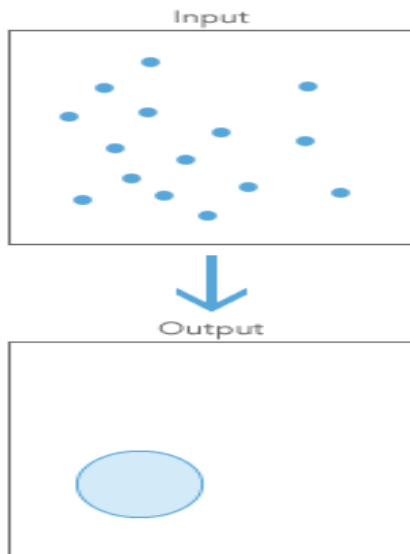

Figure (1-7) Standard Distance Analysis Result.

The centre of this standard distance circle corresponds to the coordinates of the mean centre. The larger the standard distance value and the size of the standard circle, the greater the spatial dispersion, indicating an increase in the spatial spread of the phenomenon, and vice versa (Daoud, 2012, p. 44).

(ArcGIS Desktop Help)

The results of the standard distance analysis on the locations of primary healthcare centres in Hail City, as shown on Figure (1-7), reveal that the standard distance circle extends over 35 neighbourhoods, constituting approximately 53.8% of the total neighbourhoods in the city. These neighbourhoods include Darat Mashar, Aja, Gharb Aja, Al Zahra, Al Montazah Al Shamali, Al Salam, Al Montazah Al Gharbi, Al Montazah Al Sharqi, Al Maza'ber, Al Tareefi, Al Ward, Al Badia, Al Azizia, Mughaydah, Al Na'am, Lubdah, Samah, A'irif, Al Mahatta, Salahuddin, Sibabah, Al Wusaytai, Al Zabarah, Al Matar, Al Samra, Sharaf, Hail King Abdullah District, Al Jamiyin, Al Khumashiyah, Al Buhairah, Qaryat Aja, Al Television, Al Mujamma, Corniche Hail, and Al Nuqra. By examining the database in the Attribute Table, the coordinates of the centre of this circle, denoted in the Center X and Center Y columns, are identified. The standard distance value from the Std Dist column is 162 kilometres, accounting for 85% of the total area of Hail City, which is 710 square kilometres.

Figure (1-8)

This indicates a concentration of primary healthcare centre locations in the older neighbourhoods of Hail, especially in the heart of the city. The total number of primary healthcare centres within this circle is 17, representing 85% of the total primary healthcare

centres, including Aja Health Center, Zahra Health Center, Al Montazah Al Gharbi Health Center, Al Montazah Al Sharqi Health Center, Al Azizia Health Center, Al Badia Health Center, Sibabah Health Center, Lubdah Health Center, North Airport Health Center, Airport Health Center, Al Wusaytai Health Center, Sharaf Health Center, Al Samra Health Center, Khumashiyah Health Center, Al Jamiyin Health Center, Television Health Center, and Nuqra Health Center.

3-6-3 Spatial Analysis of the Mean Center:

The mean centre is the location (or point) that represents the average geographical coordinates of the studied geographical phenomenon (Daoud, 2012, p. 41). The coordinates of the mean centre are calculated by obtaining the arithmetic mean of the latitude and longitude coordinates for the primary healthcare centre locations in Hail City, as per Equation 1 (ArcGIS Desktop 10.8 Help).

The spatial analysis of the mean centre (Mean Center) is instrumental in determining the geographical average of the spatial distribution of primary healthcare centres in Hail. This analysis is crucial for geographers as it helps assess changes in the geographical distribution of phenomena over time. The Mean Center for primary healthcare centres in Hail was determined to be in the Al Azizia neighbourhood, which is one of the older neighbourhoods in Hail City.

Figure (1-9)

3-6-4 Directional Distribution (Standard Deviational Ellipse)

Directional Distribution analysis, also known as Standard Deviational Ellipse, assesses whether the spatial distribution of primary healthcare centres in Hail has a specific orientation. This analysis provides an elliptical shape that represents the directional characteristics of the distribution. The centre of the ellipse is aligned with the Mean Center point, and its major axis measures the primary direction taken by most features of the phenomenon (Daoud, 2012, p. 46).

On Figure (1-10), representing the directional distribution of primary healthcare centres in Hail, it is evident that the spread follows the northeast-to-southwest direction, deviating by an angle of 32 degrees. The ellipse contains 15 centres, constituting 75% of the total primary healthcare centres in Hail. Additionally, the elliptical shape intersects approximately 39 residential neighbourhoods out of a total of 65 in Hail, representing around 60% of the city's neighbourhoods.

Figure (1-10)

3-6-5 Accessibility Distance to Primary Healthcare Centers in Hail:

Distance is a crucial element in geographic distribution analysis of services, serving as the basis for understanding spatial organization. Accessibility distance analysis involves using buffer distances to draw circles around the service locations. The buffer distance is a specific radius or range defining proximity to specific locations. In this study, a buffer distance of 800 meters was used to represent the accessibility distance to primary healthcare centres in Hail, based on the standards for accessibility distance to primary healthcare centres (Ministry of Municipal and Rural Affairs, 1426 AH).

The spatial analysis tools available in Geographic Information Systems (GIS) software can be used to draw the spatial range to determine the accessibility distance or service impact area.

The study employed a buffer distance of 800 meters, and the GIS tools help assess the proximity of spatial features to one another.

The spatial buffer tool creates a polygon around a specified (fixed or variable) distance, defining the spatial range of the phenomenon, which could be points, lines, or polygons (Daoud, 2012, p. 201).

The service impact range was employed based on the Planning Standards Guide for Services in the year 1426 AH. Utilizing the standard rates for primary healthcare centres, an 800-meter service impact range was applied to the primary healthcare centres in Hail.

Cartographic analysis of Figure (1-11) reveals the overlapping service ranges for primary healthcare centres in the older neighbourhoods of the city with smaller areas. Particularly, intersections occur within the standard distance circle, which anchors seven centres, representing 35% of the total number of primary healthcare centres in the city.

Figure (1-11)

The service impact range of 800 meters overlaps in the Al-Matar neighbourhood, where the Airport Healthcare Center is located, as well as in the Northern Al-Matar neighbourhood, the Waseeta neighbourhood, the University neighbourhood, the Sharaf neighbourhood, the Al-Azizia neighbourhood, the Badiyah neighbourhood.

3-6-6 Distribution of Served and Unserved Neighborhoods:

Primary healthcare centres concentrate in the internal neighbourhoods of the city, while marginalized neighbourhoods such as Al-Musayif, Mushar, Al-Nafal, Al-Khuzama, Al-Yasmeen, Al-Mamlaka, Al-Suwifla, Al-Muzahir, Al-Khraimi, Al-Iskan, Al-Warood, Al-Salam, Al-Zubara, Al-Shubaily, Al-Madain, Al-Shifa, Al-Rusaf, Al-Wadi, Al-Rusaf, Marifq, Hail Regional Airport, and others remain underserved, as shown in Figure (1-12)

Figure (1-12)

Recommendations

1. Conduct a study on urban development trends and population growth rates to select optimal locations for new primary healthcare centres and identify new service locations in deprived marginalized neighbourhoods, especially in emerging modern neighbourhoods. This ensures long-term utilization based on city land use maps, distance criteria, accessibility, and population density. The study reveals a deficit in healthcare services in some neighbourhoods (underserved neighbourhoods) on the outskirts of the city.
2. Utilize modern technologies such as Geographic Information Systems (GIS) in spatial planning for healthcare service locations and support decisions related to their selection.
3. It is essential to consider the application of the Ministry of Municipal and Rural Affairs standards for future primary healthcare centres in Hail City and other cities in the Kingdom.
4. Encourage private sector participation in supporting healthcare infrastructure and human healthcare resources by establishing hospitals and clinics, equipping and operating them in neighbourhoods lacking healthcare services. This would benefit both the private sector and the community.
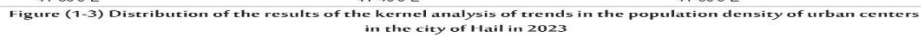
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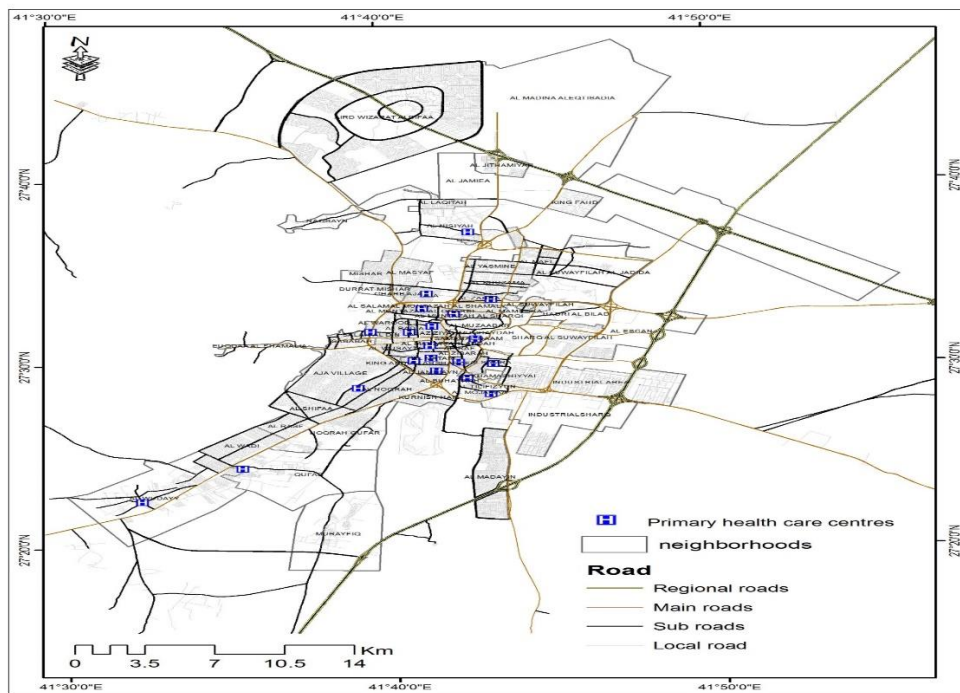4- Kibon, U.A.,&Ahmed, M. (2013). Distribution of Primary Health Care Facilities in Kano

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Figure (1-1) Administrative division of neighborhoods for the city of Hail in 2023

Figure (1-2) Distribution of primary health care centers in the city of Hail in 2023

Figure (1-3) Distribution of the results of the kernel analysis of trends in the population density of urban centers in the city of Hail in 2023

Figure (1-4) Geographical distribution of primary health care centers and the main road network in the city of Hail in 2023
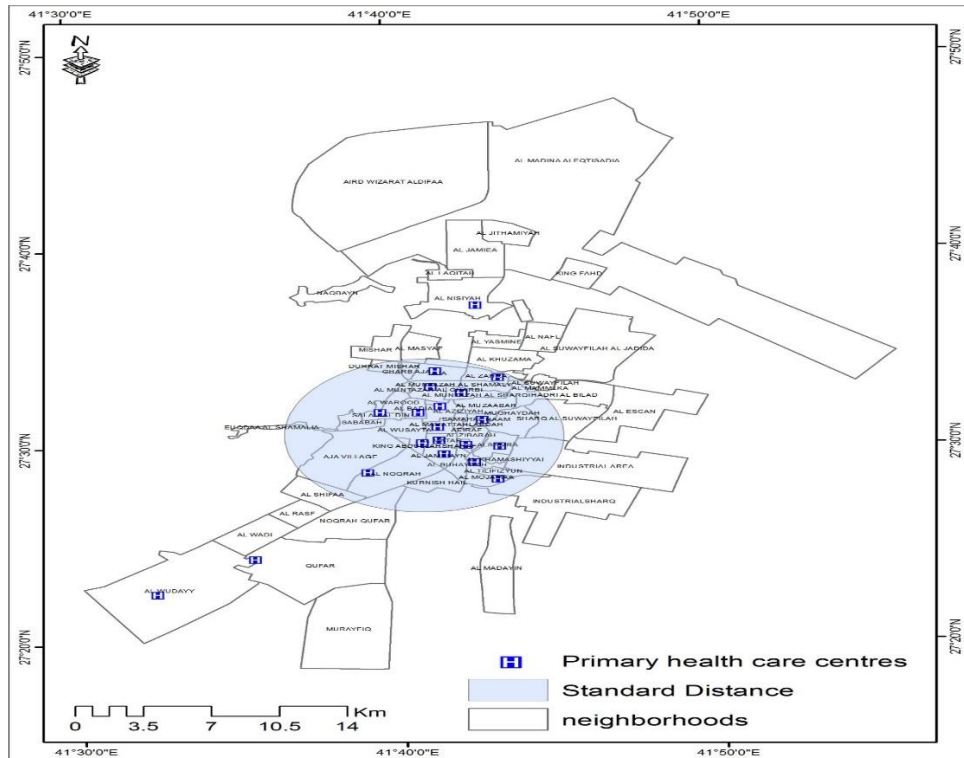
Figure (1-8) The standard distance for the distribution of primary health care centers in the city of Hail in 2023
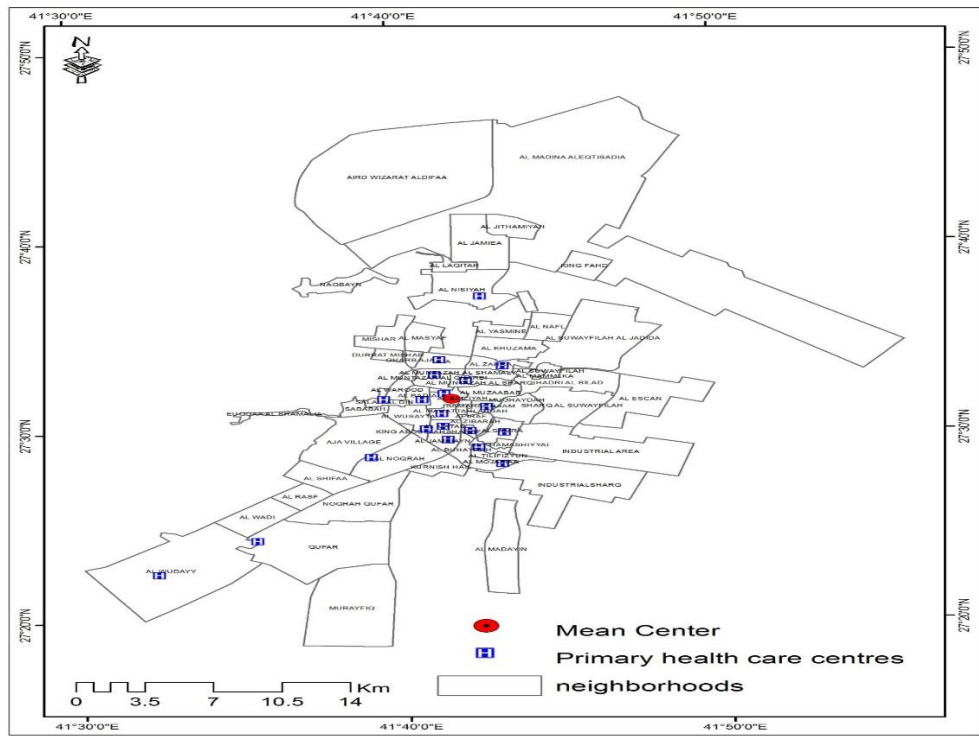
Figure (1-9) Spatial analysis of the average location of primary health care centers in the city of Hail in 2023

Figure (1-10) Distribution of the general trend for the distribution of primary health care centers in the city of Hail in 2023
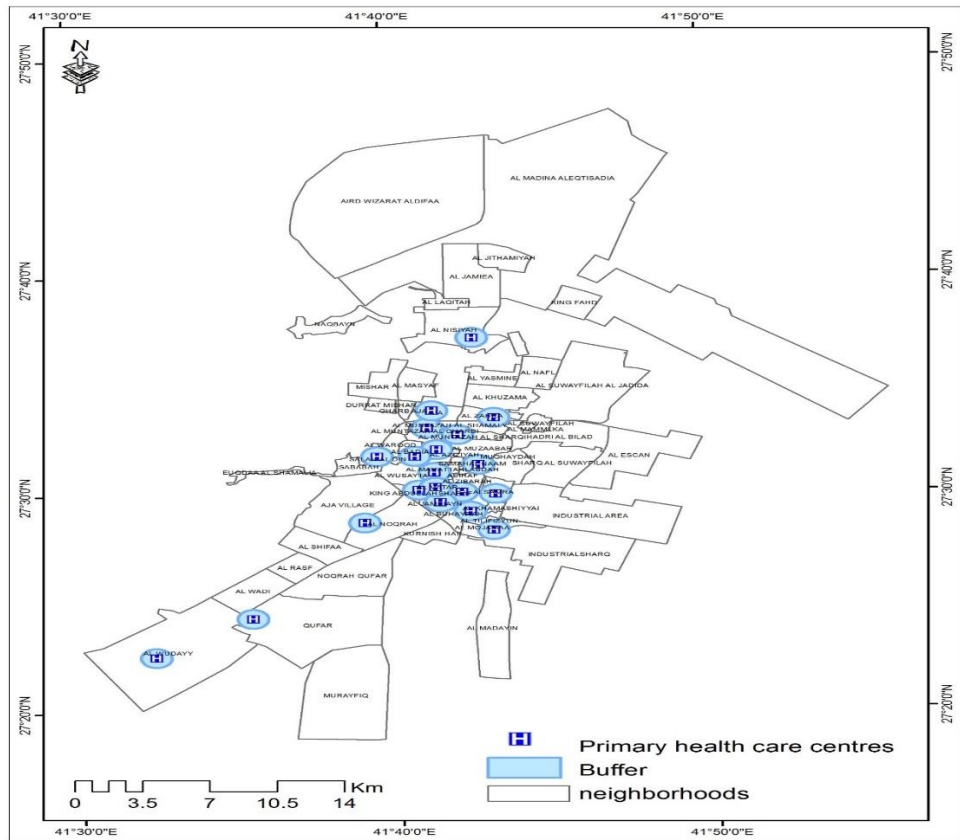
Figure (1-11) Distribution of the spatial influence of primary health care centers in the city of Hail for the year 2023
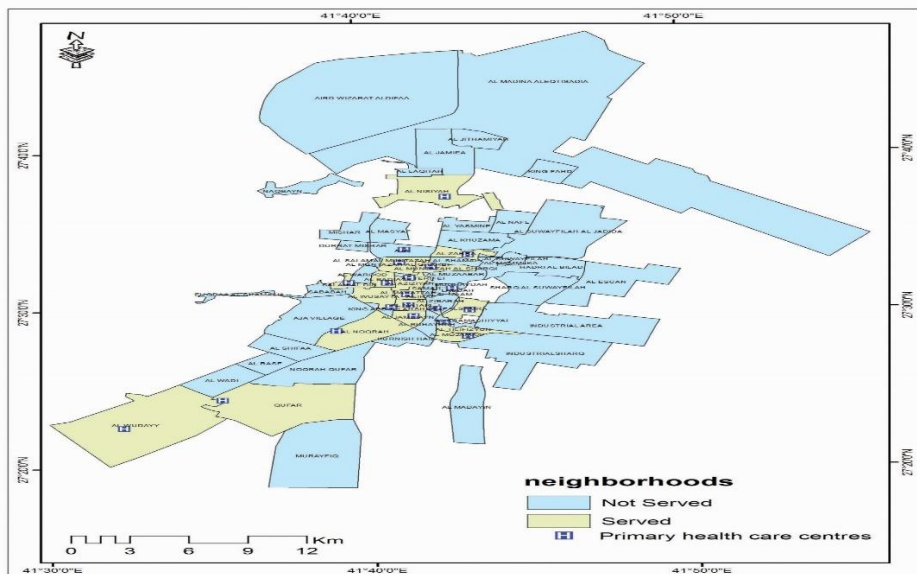

Figure (1-12) Distribution of neighborhoods served and unserved by primary health care centers in the city of Hail in 2023