ГОРОДСКИЕ ОБЩЕСТВЕННЫЕ ПРОСТРАНСТВА

Research Article

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SPATIAL PLANNING STRATEGIES FOR MEDICAL FACILITIES IN IRAQI CITIES: THE CASE OF KARBALA

Abstract. This study aims to analyses the reality of health services in the city of Karbala in light of the rapid urban transformations and the continuous population increase witnessed by the city. The study focuses on the use of geographic information systems (GIS) techniques as an analytical tool to assess the distribution and spatial efficiency of health institutions within the general urban framework. The problem arises in the geographical imbalance between areas of health service availability and areas with clear health deprivation, which leads to imbalances in accessibility and increases pressure on functioning institutions. The study addresses identifying gaps in health service coverage, revealing disparities between regions in terms of population density versus availability of health facilities, and proposing strategies for better distribution. It also seeks to provide a planning vision that enhances spatial justice and supports the efficiency of the health system, in line with the requirements of

sustainable development in Iraqi cities. The expected results of this study are an important input for the reformulation of health policies and urban planning on a scientific basis that considers population distribution and existing infrastructure.

Key words: geographic information systems (GIS), health services, urban planning, health planning, spatial analysis, Karbala city, planning standards.

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Introduction

Health services are one of the most prominent indicators of well-being and quality of life in cities, as they are closely related to the ability of society to achieve sustainable development (Rao, Bairwa, Mehta et al., 2024). This sector is becoming increasingly important in Iraqi cities that are witnessing rapid urban transformation and a continuous increase in population, which is putting growing pressure on public services, especially health services (Al-Jubouri, 2021). This uncontrolled urbanization, coupled with the absence of comprehensive planning visions, has contributed to clear imbalances in the distribution of health institutions between regions, especially between urban and rural areas, and between northern and southern governorates (Abdoun, Al-Abbadi, 2025). The governorates of southern Iraq are among the areas most affected by these imbalances, where health deprivation is evident despite the concentration of non-governmental activities in some areas, without being matched by equitable distribution or sustainable planning of health centers and hospitals (Hasan, Webb, Quayyum, Ensor, 2024).

The city of Karbala faces complex challenges as a result of its religious location and the increasing population density, which calls for the need to analyze the reality of health services in it accurately, based on modern scientific tools, most notably geographic information systems (GIS), which allow the possibility of analyzing the spatial distribution of health institutions and measuring their efficiency based on quantitative and spatial criteria (Shakarchi, Shakarchi, Al-Abayachi et al., 2025). This analysis aims not only to provide a descriptive image, but also to reveal gaps in coverage, identify areas of deficit or congestion, and propose alternative locations that contribute to improving spatial justice and reducing disparities in access to health services (Liao, Chang, Yang, 2012). The importance of this study lies in the need to direct public policies towards adopting integrated planning for health services, in line with urban growth, and taking into account the population and social structure, and the functional dimension of services (Rahim, Toguzbaeva, Aidaraliev, Dzhusupov, 2025).

The reality of health services in Karbala, as in many Iraqi cities, reflects the lack of proactive planning, which has led to the concentration of health institutions in specific areas and the deprivation of entire neighborhoods of basic care services (Al-Janabi, 2023). These gaps are not limited to quantity but extend to quality, weakening the efficiency of the sector and increasing pressure on operating centers (Ding, Chen, Yu et al., 2021). To achieve comprehensive urban development, the distribution of health institutions must be proportional to the population distribution, considering demographic and urban changes; otherwise the continued popula-

tion increase will generate mounting pressure that will make these services ineffective (Shih, Yang, Chia et al., 2023).

The aim of the research is analysis the health institutions spatial distribution in Karbala using GIS-technologies, evaluation of spatial distribution efficiency and development of practical recommendations in urbanized areas. The study also seeks to contribute to the formulation of an integrated future vision for health services, considering social and spatial justice, and pushing towards achieving sustainable development goals in Iraqi cities.

Classification of levels of health services

Within the organizational structure of the national health system, health services are classified into four main levels, varying among themselves in terms of geographical scope, number of population served, and type of services provided, with the aim of achieving universal health coverage and more equitable and efficient distribution of resources.

Level I: Community Health Post. This level is the foundation of the health service pyramid and usually arises in small villages with less than 1,000 inhabitants. This point is managed by a "health guide" selected from the residents of the same village, who is responsible for health education, first aid, and maternal health services. This unit is an effective link between the local community and government health institutions, and this level is supported on a weekly basis with periodic visits by a general practitioner and health technicians to provide basic treatment services. This model is effective in Promote health awareness and reduces pressure on higher centers.

Level II: Health Clinic. This level represents an evolution in the volume of services and the number of beneficiaries, as it is allocated to areas with a population between 1,000 and 3,000 people. These clinics provide basic preventive and curative services daily by a specialized medical team that includes a general practitioner and a qualified nursing staff. These clinics are relatively advanced health units that cover the basic needs of the population and are an important pillar in primary health networks.

Level III: Primary Health Center. This level provides an expanded package of services, including, in addition to basic services, oral and dental health services, and laboratory tests, and is established in areas with a population of between 3,000 and 10,000 people. These centers are managed by multidisciplinary medical staff, serve as a reference point between health clinics and hospitals, and contribute to reducing the burden on senior levels by providing integrated quality care at the local level.

Level IV: Comprehensive Primary Health Center. This is the highest level of primary health care and is reserved for areas with a population of more than 10,000 people. It is known as the "Comprehensive Health Center", as it provides an integrated range of preventive and curative services, including specialized clinics, radiology services, physiotherapy, and emergency services around the clock. These centers are also designed to be able act as a link between primary and secondary health care, enhancing the efficiency of the public health system and the effectiveness of urban infrastructure.

Level V: Hospital Services (Secondary and Tertiary Care). Hospitals represent the final and most specialized level within the health service hierarchy.

They are established in urban and regional centers to serve large population groups, often exceeding 50,000 people per facility. Hospitals offer a wide spectrum of advanced diagnostic, therapeutic, and surgical services that go beyond the scope of primary care. This includes inpatient care, specialized surgical units, intensive care, and a full range of diagnostic laboratories and imaging services. Hospitals are divided into general and specialized types, forming the backbone of the secondary and tertiary care system and playing a central role in the national referral network by managing complex cases and medical emergencies.

Urban planning strategies for the development of health services in cities

A. Spatial Integration Strategy

- It is based on the distribution of health institutions within the urban plan so that they are integrated with the rest of the uses (such as housing, transportation, education).
- Enhances accessibility and reduces health marginalization in the limbs.
- It relies on analysing "unserved urban spaces" and directing investment to them.

B. Accessibility-Oriented Planning

- The time distance criterion (such as 800 meters or 15 minutes on foot) is used to determine health service coverage.
- It is applied by cities such as London and Barcelona.
- The GIS is used to map physical access and measure coverage.

C. Hierarchical Health Network Planning

- Ensure the existence of all levels of service (health point > health center > hospital) with a thoughtful hierarchical distribution.
- It creates a balanced network between primary, secondary and tertiary care, and limits the momentum on central hospitals.

D. Infill Development Strategy

- It is based on the development of health centers within spaces within the existing urban fabric rather than external expansion.
- Reduces the cost of infrastructure and promotes spatial justice.
- Especially important in Iraq's cities, which are suffering from uncontrolled horizontal expansion.

E. Demand-Based Planning

- It links indicators of population density, age groups, and disease pattern in different regions.
- This data is used to determine the type and size of health service required in each area.
- Example: establishment of maternity care centers in areas with a high percentage of pregnant women.

F. Integrating the health dimension into land use planning (Health in All Planning Policies)

- A multisectoral approach that integrates health into all urban planning decisions.
- It includes the design of streets, parks, play areas, and public transportation to promote public health.

- Supported by the WHO Framework (WHO: Urban Health Equity Assessment and Response Tool).

G. Restructuring health networks in cities with random growth

- In cities with urban sprawl, mobile or combined health units are being developed.
- A healthy urban resilience approach is used to ensure response in crises and congestion.

The proposed strategies for developing the health sector in Karbala are grounded in a comprehensive assessment of both service availability and spatial adequacy. Tables 1 and 2 provide critical insights into the current and projected deficits in health facilities and land allocation relative to national planning standards. These findings highlight the urgent need for strategic interventions to bridge service gaps and ensure equitable access to healthcare in line with future population growth.

Table 1. Comparison of the Current Number of Health Facilities with Standards and Deficits

Type of Facility	Existing Number	Standard per Population	Number Required Currently	Current Deficit	Number Required by Target Year 2035	Deficit by Target Year
Hospital	9	1 per 50,000 people	14	–5	18	–9
Primary Health Center	29	1 per 10,000 people	49	–20	88	–59

Table 2. Area and Per Capita Share of Health Services

Category	Planned Area (ha)	Actual Area (ha)	Planned Per Capita (m²)	Actual Per Capita (m²)	Standard (m²/person)	Difference from Standard (Planned)	Difference from Standard (Actual)
Health	23.69	23.36	0.49	0.48	0.86	–0.37	–0.38
Total Land Uses	4147.23	2957.98	84.73	60.35	113.085	–28.36	–52.74

Spatial Analysis of Health Services in Karbala City

Health services are among the most important indicators of quality of life and urban well-being, and their balanced spatial distribution is a key outcome of sustainable urban planning. The need to analyze the spatial distribution of such services increases in cities with demographic and religious particularities, such as Karbala. Growth of cities puts great pressure on the health infrastructure.

Two core spatial analysis indicators were used:

- Global Moran's I: to measure the degree of spatial autocorrelation among the locations of health institutions.

- Getis — Ord General G: to detect the presence of high- or low-value spatial clusters (High/Low Clustering).

Moran's I Analysis Results. To assess the degree of spatial autocorrelation in the distribution of health services in Karbala City, the Global Moran's I statistic was applied to two categories: hospitals and primary healthcare centers (Table 3).

Table 3. Moran's Index Results

Facility Type	Moran's I	Z-score	P-value
Hospitals	0.0054	0.0445	0.9644
Primary Healthcare Centers	0.0739	1.7092	0.0874

The analysis of spatial distribution using Moran's Index reveals that hospitals in Karbala are distributed in a random pattern, that indicate a lack of spatial planning or alignment with population needs. Although primary healthcare centers show a slight tendency toward clustering, the result is not statistically significant. These findings underscore the urgent need to ensure equitable distribution of health services across urban areas.

Getis — Ord General G Analysis Results. To examine the presence of spatial clustering of health institutions in Karbala, the Getis — Ord General G statistic was applied to hospitals and primary healthcare centers. This analysis helps detect whether high-value or low-value clusters exist in the spatial arrangement of the features (Table 4).

Table 4. General G Results Table

Facility Type	General G	Z-score	P-value
Hospitals	0.1255	0.0449	0.9641
Primary Healthcare Centers	0.07388	1.7092	0.0874

The General G analysis supports the findings of the Moran's I statistic. Hospitals in Karbala are randomly distributed with no evidence of spatial clustering. Although primary healthcare centers show a slight inclination toward forming high-value clusters, the result lacks statistical significance. These outcomes emphasize the need for proactive spatial planning to ensure equitable access and reduce potential service gaps in underserved areas.

Evaluating Health Service Distribution against Planning Standards

When comparing the results of Moran's I and Getis — Ord General G spatial statistics with the standard service ranges for health facilities, it becomes clear that Karbala City exhibits significant spatial disparities in the distribution of health services. Although primary healthcare centers are expected to serve areas within a 1,000-meter radius and populations up to 10,000 people, the spatial analysis reveals a weak tendency toward clustering (Moran's I = 0.0739), yet the result is not statistically significant. This indicates insufficient coverage density or poor distribution across the urban fabric. In the case of hospitals, which should serve broader areas ranging from 3 to 5 km and populations up to 100,000, the results show a com-

pletely random spatial pattern (Moran's I = 0.0054) and no evidence of spatial clustering (General G = 0.1255). This reflects a lack of prior strategic planning to ensure balanced spatial coverage of hospital services (Table 5).

Table 5. Standard Geographic and Population Coverage Ranges for Health Facilities

Health Facility Type	Standard Geographic Range	Standard Population Coverage
Primary Health Care Center	500—1000 meters	8,000—10,000 persons
General/Specialized Hospital	3—5 km	50,000—100,000 persons

These findings confirm the mismatch between the actual distributions of health facilities and recommended planning standards, highlighting the urgent need to reallocate services and optimize their locations using GIS-based spatial analysis to improve spatial equity in access to healthcare (Fig. 1, 2).

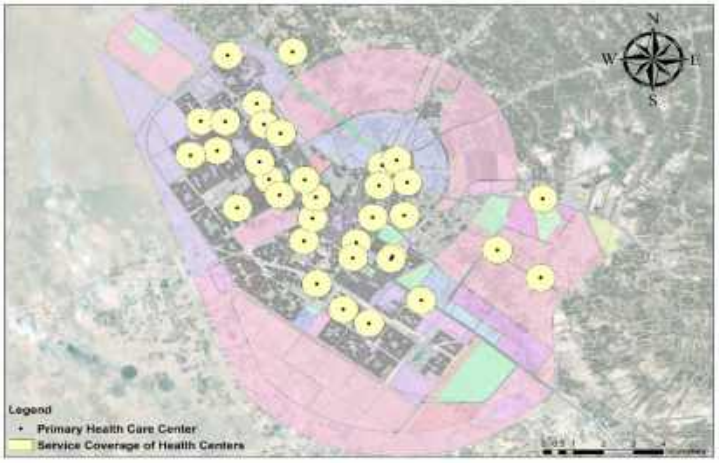

Fig. 1. Scheme illustrated the service coverage of primary health care centers in the city of Karbala

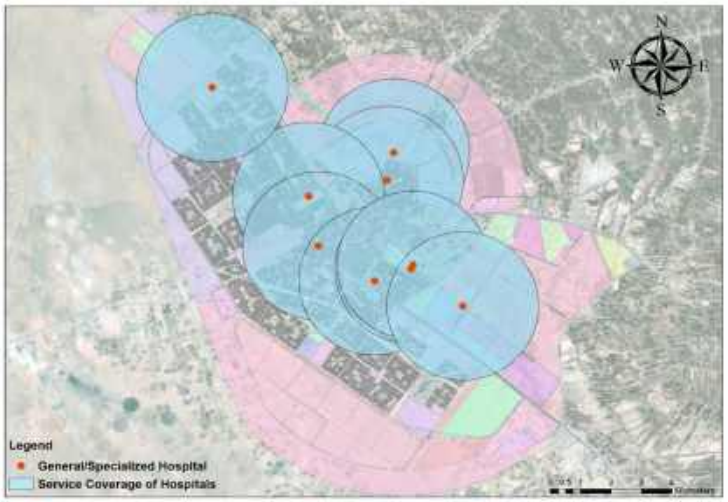

Fig. 2. Scheme illustrated the service coverage of general and specialized hospitals in the city of Karbala

Conclusions

1. The current spatial distribution of health institutions in Karbala reveals a lack of balance, resulting in significant disparities in access to healthcare services across neighborhoods.

2. The locations of hospitals and primary health centers do not align with established planning standards regarding both geographic coverage and population thresholds.

3. Certain areas are over-served with healthcare facilities, while others suffer from severe shortages, creating functional gaps that undermine overall system efficiency.

4. The existing health facilities were not planned based on scientific or quantitative criteria such as population density or demand indicators, but rather on historical or administrative factors.

5. The absence of accurate spatial databases and a GIS-based strategic health planning approach has weakened decision-makers' ability to implement effective service expansions or redistributions.

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СТРАТЕГИИ ПРОСТРАНСТВЕННОГО ПЛАНИРОВАНИЯ МЕДИЦИНСКИХ УЧРЕЖДЕНИЙ В ИРАКСКИХ ГОРОДАХ (НА ПРИМЕРЕ КЕРБЕЛЫ)

Целью данного исследования является анализ состояния медицинского обслуживания в городе Кербела в свете стремительных городских преобразований и непрерывного роста населения. Исследование основано на использовании методов географических информационных систем (ГИС) в качестве аналитического инструмента для оценки распределения и пространственной эффективности медицинских учреждений в рамках городской инфраструктуры. Проблема состоит в географическом дисбалансе между районами с доступным и недоступным медицинским обслуживанием, что приводит к увеличению нагрузки на эксплуатируемые медицинские учреждения. Исследование направлено на выявление пробелов в медицинском обслуживании, различий между регионами с точки зрения плотности населения и доступности медицинских учреждений, а также на разработку стратегий для более эффективного распределения медицинского обслуживания. Также оно направлено на разработку концепции планирования, поддерживающей эффективность системы здравоохранения в соответствии с требованиями устойчивого развития иракских городов. Ожидаемые результаты данного исследования являются важным вкладом в переосмысление политики здравоохранения и городского планирования на научной основе с учетом распределения населения и существующей инфраструктуры.

Ключевые слова: географические информационные системы (ГИС), здравоохранение, городское планирование, планирование здравоохранения, пространственный анализ, город Кербела, планировочные стандарты.

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