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# Analyzing the Spatial Population Density and Available Health Facilities in Lahore, Pakistan

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**ABSTRACT**
*Lahore is one of the largest a very densely populated urban center in Pakistan and is grappling with the challenge of equitable access to health care services due to rapid urbanization. In this study spatial distribution of population density, accessibility and sufficiency of healthcare facilities has been analyzed in five tehsils of Lahore by using GIS techniques. The information regarding 97 hospitals were collected from Punjab Health Information Management Centre (PHIMC) while population data was collected from Pakistan Bureau of Statistics (PBS) 2023 census. Google Earth Engine and ArcMap 10.8 were used for the spatial analysis and visualization. The results show distinct spatial differences between population density and health care. Lahore City and Shalimar have the highest population density, but also have lower levels of health care accessibility (0.51 and 0.26 hospitals per 100,000 people). Raiwind demonstrates relatively better per-capita accessibility (1.85 per 100,000) but remains heavily dependent on private facilities (>90%), raising equity concerns. Spatial accessibility modeling further indicates that central Lahore areas generally fall within 15-minute travel times, while peripheral tehsils such as Raiwind and Shalimar exceed 22.5 minutes. Overall, hospitals are unevenly clustered in central zones, with general hospitals dominating and specialized services concentrated in Model Town. The study concludes that healthcare infrastructure in Lahore is misaligned with population demand, driven by spatial imbalance and institutional concentration. It is recommended that GIS-based planning and targeted public investment should be addressed to improve equitable healthcare access, particularly in high-density urban cores and underserved peripheral regions.*

***Keywords:*** *Healthcare Accessibility, Spatial Analysis, Population Density, GIS, Healthcare Equity, Hospital Distribution, Urban Planning.*

## Introduction

Spatial distribution of health care facilities in relation to population density is an important issue in urban planning and public health particularly in fast growing cities of developing countries (Adair-Rohani et al., 2013; Guagliardo, 2004). Healthcare access is a crucial component to improving overall wellbeing, as health is not just defined as the absence of disease, but physical, mental and social health (World Health Organization, n.d.). Healthcare adequacy is defined as the healthcare system's capacity to provide standardized, timely, and appropriate medical care

to satisfy patient needs and expectations (Mohammad et al., 2025). Healthcare provision is associated with social and economic development as healthcare institutions are important in preventing diseases, treating illness and delivering health education (Dejen et al., 2019).

Equitable provision of health care is a big challenge in the developing countries such as Pakistan because of overcrowding and inadequate resources (Gulzar, 1999). One of the main goals of healthcare systems is to provide equitable and timely access to health care (Murad, 2004). There is still, however, differences among the regions in terms of access to healthcare, with more limited and expensive availability of specialized care in low-income regions (Riaz et al., 2019). Research has highlighted the need to consider population distribution as well as the location of healthcare facilities, to understand the gaps in access to services and to enhance urban health planning (Nadeem et al., 2021).

Spatial analysis has been extensively adopted using GIS in the evaluation of accessibility to healthcare and the detection of inequalities in the distribution of these services. For instance, research in Wuhan, China, found that hospitals were concentrated in urban areas but lacking in suburban areas, which also showed that the spatial allocation of hospitals could be balanced by adopting methods such as kernel density estimation and buffer analysis (Wang and Wu, 2021).

The city of Lahore is the second largest city of Pakistan, and the rapid urbanization has caused considerable changes in land use and an increased population size (Shirazi, 2012). It has led to a rise in private vehicle usage, causing not only pollution and congestion but also to the inequalities in access to basic services, such as healthcare (Iram et al., 2012). This leads to a high concentration of health care facilities in central areas and leaves the peripheral areas underserved, which further narrows health care gaps.

**Study Area**

Lahore is the second largest city in the country and the capital of Punjab, and it has an area of 1,772 km² with a population of more than 13 million people (Pakistan Bureau of Statistics, 2023). From administrative point of view, it is divided into tehsils, towns, union councils of varying densities, and level of infrastructure (Planning & Development Board, Punjab, n.d.). The city consists of residential, commercial and growing up suburban areas (LDA, n.d.). Hospitals, Basic Health Units (BHUs), and dispensaries are included in the healthcare facilities, albeit services are not evenly distributed with overcrowding in central areas and limited services in peripheral areas (Sharif, Sughra, & Butt, 2016). Geographically, Lahore is located between 31°15′–31°45′ N and 74°01′–74°39′ E, surrounded by Sheikhupura in northern region, Wagah (India border) in eastern region and Kasur in southern region (Ghouri et al., 2022).

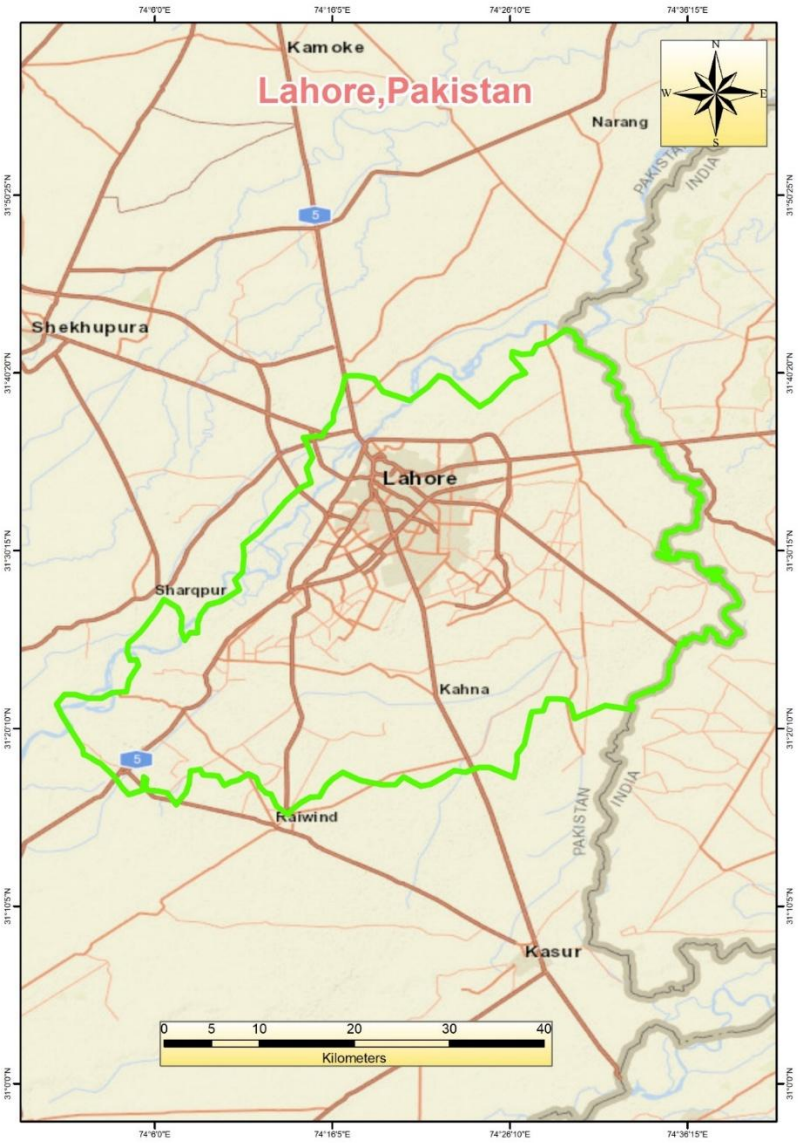


**Figure 1 Study Area**

Lahore is in the midst of rapid urbanization and population growth, leading to significant changes in land use patterns and exacerbating healthcare access inequalities. Healthcare facilities are mostly clustered in central urban areas, while suburban and peripheral areas have less capacity and inadequate access to essential health services, leading to overcrowding in areas of good access and under-served areas in disadvantaged areas. Furthermore, it is evident that there is a gap in research related to the effect of population density on spatial distribution and accessibility of healthcare facilities in Lahore. Thus, the objectives of the study are to map and analyze the population density in tehsils of Lahore, assess the spatial accessibility of health care facilities in terms of high-density areas, and analyze the overall distribution and adequacy of healthcare facilities in relation to population density.

**Methodology**

The present study employed a quantitative spatial analysis approach to examine the relationship between population density and healthcare accessibility in Lahore District. Locations of

healthcare facilities, service adequacy and population distribution were analyzed using Geographic Information Systems (GIS) and statistical techniques in five tehsils of Lahore namely Model Town, Lahore Cantonment, Raiwind, Shalimar and Lahore City.

The research utilized a descriptive and cross-sectional research design. Spatial and statistical indicators were calculated and visualized in order to assess patterns of healthcare accessibility. Data on 97 hospitals were obtained from the Punjab Health Information Management Centre (PHIMC) and population and area data were obtained from the Pakistan Bureau of Statistics (PBS) 2023 Digital Census.

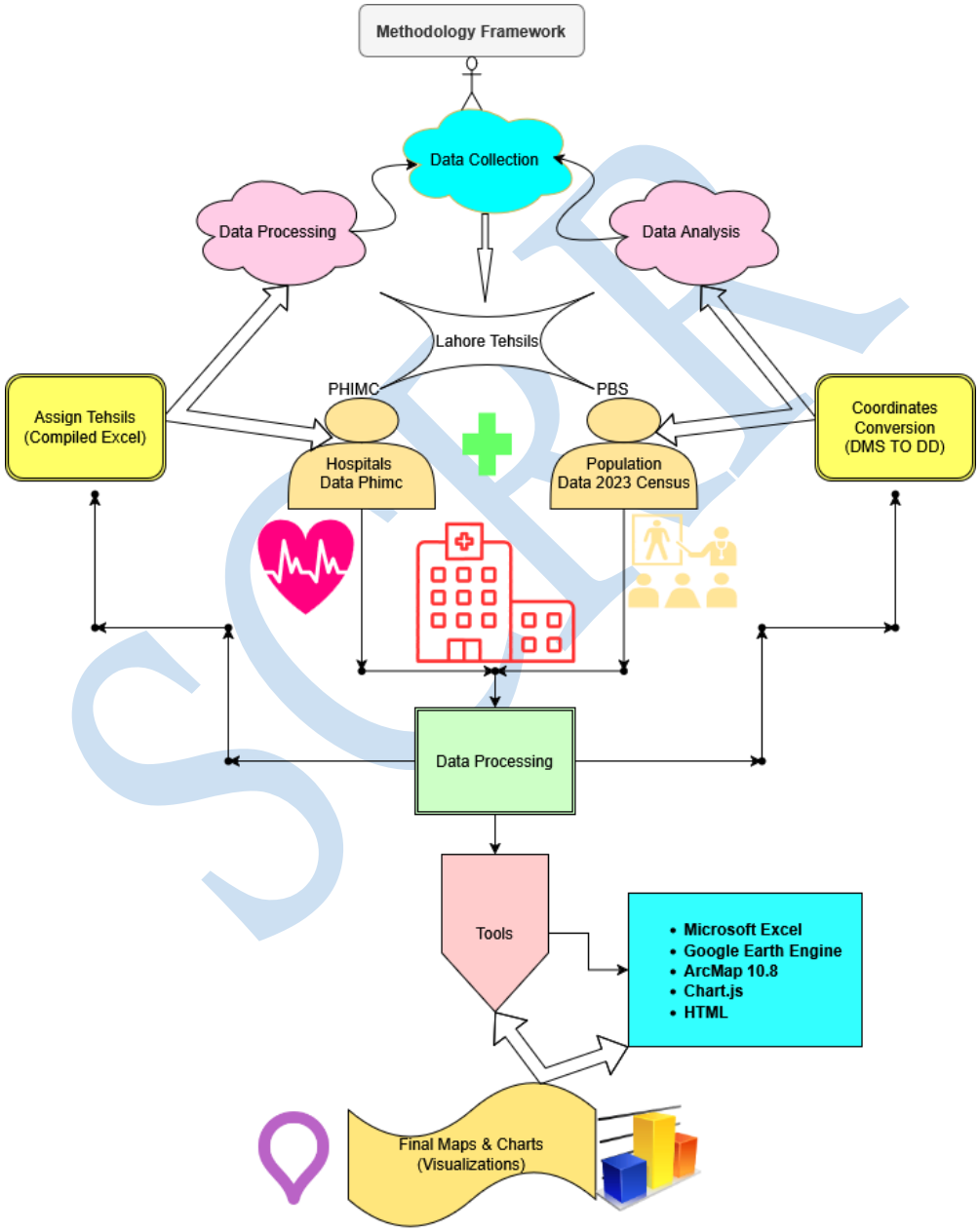


**Figure 2 Methodological Framework of the Study**

This figure provides an overall overview of the research process, including data collection, processing, GIS analysis, and output generation.

Data processing included compiling datasets in Excel, converting coordinates from degrees-minutes-seconds (DMS) to decimal degrees (DD) using:

$$\textbf{Decimal Degrees} = \textbf{Degrees} + \frac{\textbf{Minutes}}{60} + \frac{\textbf{Seconds}}{3600} \quad (1)$$

Hospital coordinates were mapped using Google Earth Engine, and spatial datasets were verified and analyzed in ArcMap 10.8. Each hospital was assigned to its respective tehsil based on geolocation and administrative boundaries.

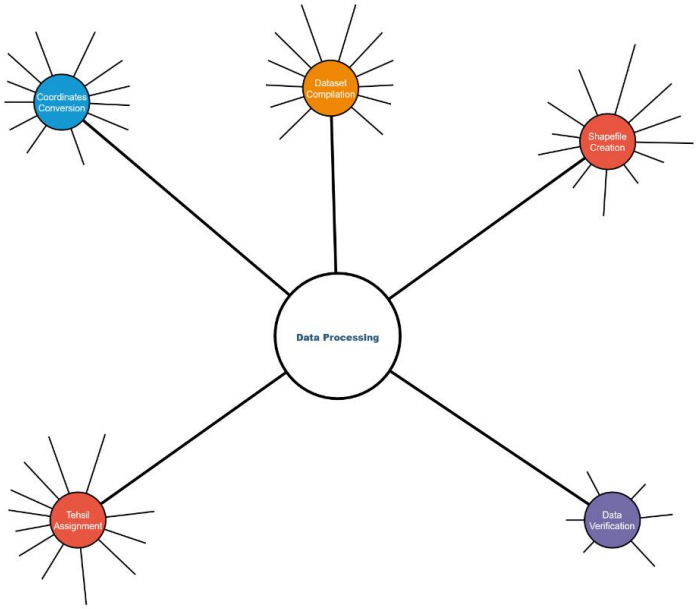


**Figure 3 Data Processing Framework**

This figure illustrates how raw hospital and population data were transformed into spatial datasets for GIS analysis. For spatial and statistical analysis, the following key indicators were computed:

Population Density:

$$\textbf{Population Density} = \frac{\textbf{Total Population}}{\textbf{Area (km}^2\textbf{)}} \quad (2)$$

Healthcare Accessibility (Hospitals per 100,000 population):

$$\textbf{Hospitals per 100,000} = \left(\frac{\textbf{Number of Hospitals}}{\textbf{Total Population}}\right) \times \mathbf{100,000} \quad (3)$$

Hospital Density:

$$\textbf{Hospital Density} = \frac{\textbf{Number of Hospitals}}{\textbf{Area (km}^2\textbf{)}} \quad (4)$$

These indicators were used to assess spatial inequalities in access and adequacy of healthcare services across tehsils.

The data were organized and calculated using Microsoft Excel. The spatial analysis and mapping were performed using ArcMap 10.8 and Google Earth Engine. Bar charts, scatter plots, bubble charts, and thematic maps were graphically visualized using Chart.js. Limitations are possible data currency issues, lack of hospital capacity information, and minor

uncertainties originating from manual data processing, although all datasets were thoroughly verified. Overall, the methodology provides a solid spatial-statistical framework to evaluate healthcare accessibility and population distribution patterns in Lahore.

**Results and Discussion**

The chapter is about the spatial analysis of population density, health care accessibility and hospital adequacy in five tehsils of Lahore i.e., Model Town, Lahore Cantonment, Raiwind, Shalimar and Lahore City. The results are based on GIS mapping and statistical indicators to measure disparities between population distribution and provision of health care. A summary of the availability of hospitals, population, area, population density and healthcare indicators show a clear spatial variation across tehsils. Model Town has the highest number of hospitals (39) and hospital density while Lahore City has the highest population (4.1 million) and population density (19,268 persons/km²). Shalimar has the highest population with the least number of hospitals which shows service imbalance.

**Table 1 Summary of Hospital and Population Metrics by Tehsil**

| Tehsil | Hospitals | Population (2023) | Area (km²) | Pop Density (pers/km²) | Hosp per 100,000 | Hosp per km² |
|---|---|---|---|---|---|---|
| **Lahore Cantonment** | 10 | 1,885,098 | 466 | 4,047 | 0.53 | 0.021 |
| **Lahore City** | 21 | 4,123,354 | 214 | 19,268 | 0.51 | 0.098 |
| **Model Town** | 39 | 3,244,906 | 353 | 9,192 | 1.2 | 0.11 |
| **Raiwind** | 20 | 1,080,637 | 467 | 2,314 | 1.85 | 0.043 |
| **Shalimar** | 7 | 2,670,140 | 272 | 9,817 | 0.26 | 0.026 |
| **Total / Average** | 97 | 13,004,135 | 1,772 | 7,339 | 0.75 | 0.055 |

**Spatial Distribution of Population Density**

The analysis of population distribution shows a strong spatial inequality. Lahore City and Shalimar are very densely populated areas and Raiwind has the lowest population density. But health care provision does not correspondingly match population concentration.

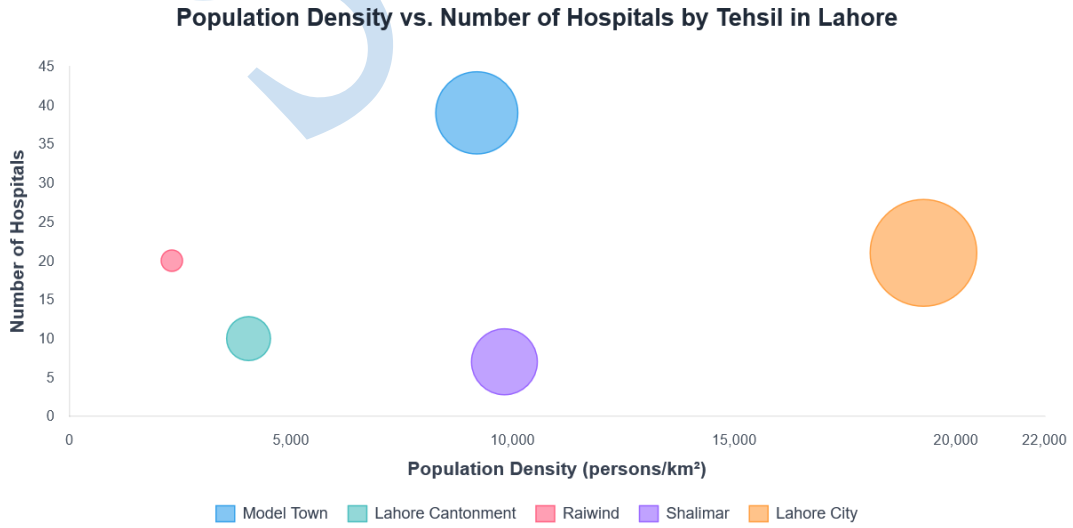


**Figure 4 Population Density and Number of Hospitals by Tehsil in Lahore**

**Spatial Accessibility of Health Facilities**

The availability of healthcare, measured by the number of hospitals per 100,000 people, shows some counter-intuitive patterns. The most accessible is Raiwind (1.85) and the least accessible are the most populated areas of Lahore City (0.51) and Shalimar (0.26). This indicates the pressure on the healthcare systems in the densely populated areas.

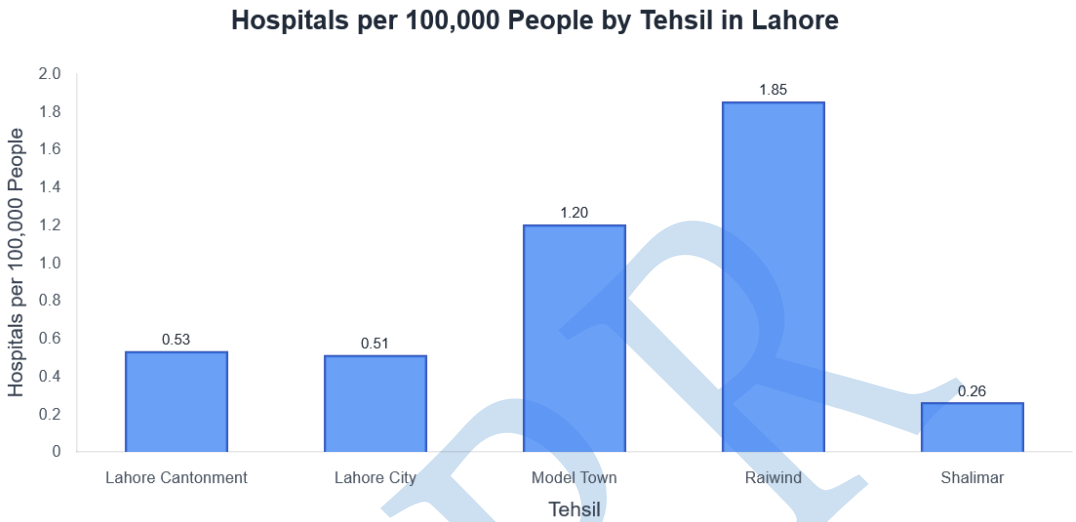


**Figure 5 Hospitals per 100,000 People by Tehsil in Lahore**

Spatial mapping shows hospitals are concentrated in Model Town and central Lahore with sparse facilities in peripheral areas. ArcMap visualization indicates uneven distribution, where population pressure and administrative boundaries mean proximity does not always equal real accessibility.

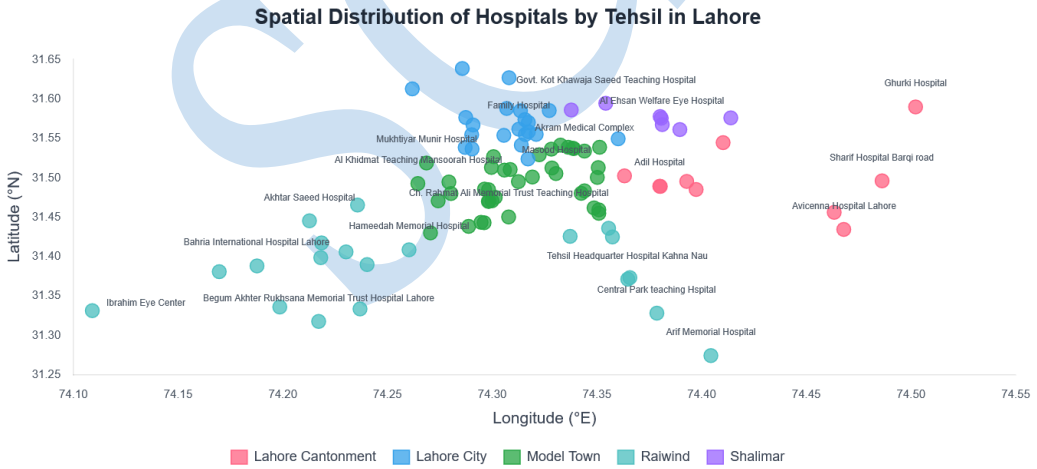


**Figure 6 Spatial Distribution of Hospitals by Tehsil**

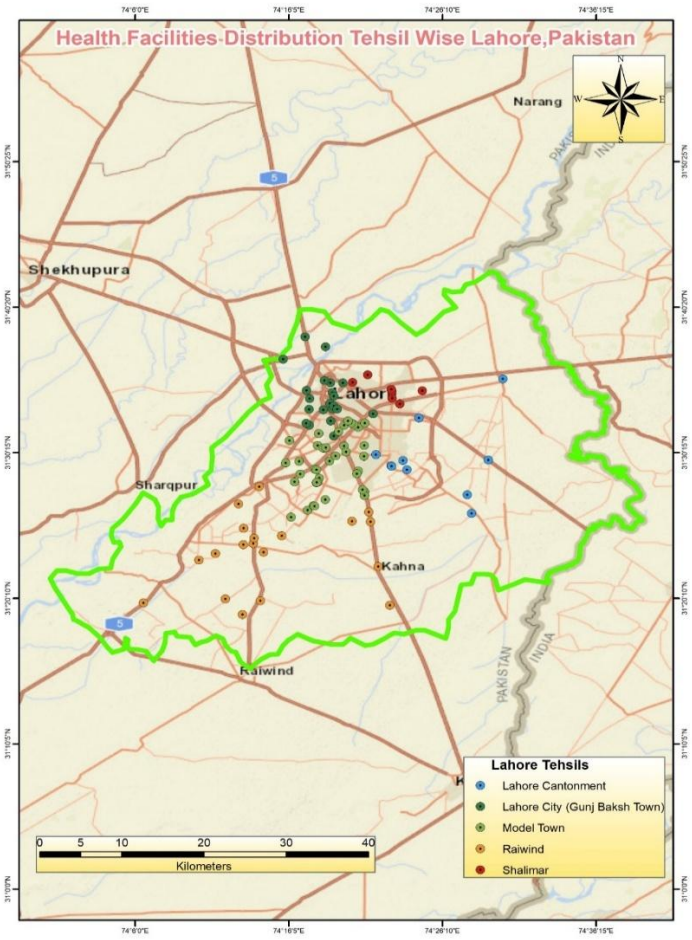


**Figure 7 ArcMap Distribution Map of Hospitals by Tehsil**

**Spatial Distribution and Adequacy of Health Facilities**

Hospital density analysis shows relatively better spatial distribution in Model Town (0.110 hospitals/km²) and Lahore City (0.098 hospitals/km²) and sparse distribution in Shalimar and Lahore Cantonment.

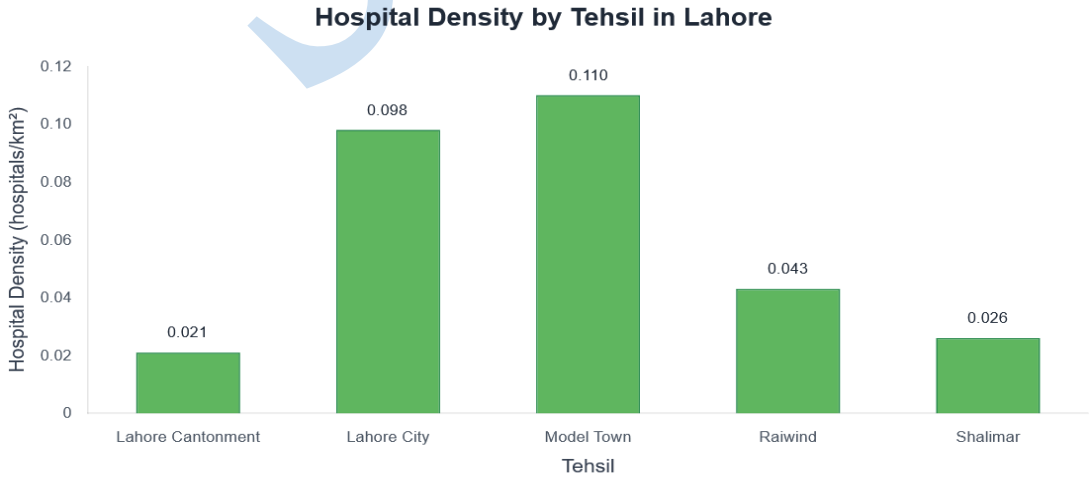


**Figure 8 Hospital Density by Tehsil**

The cost-distance accessibility model shows that the central Lahore (Model Town, Lahore City, Lahore Cantonment) has a high accessibility (less than 15 minutes travel time), whereas the peripheral areas, including Raiwind and Shalimar, have more than 22.5 minutes travel time.

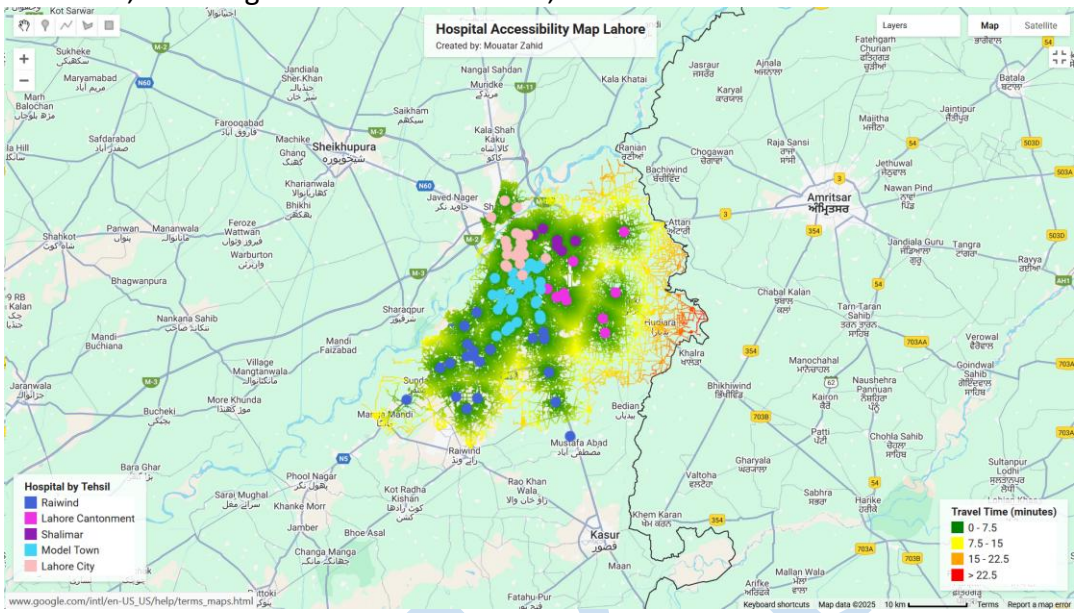


**Figure 9 Hospital Accessibility in Lahore**

Analysis of hospital classification reveals that general hospitals are prevalent in all tehsils, while Model Town hosts the largest concentration of specialized facilities (cardiac, pediatric, orthopedic). This indicates a centralized advance healthcare service.

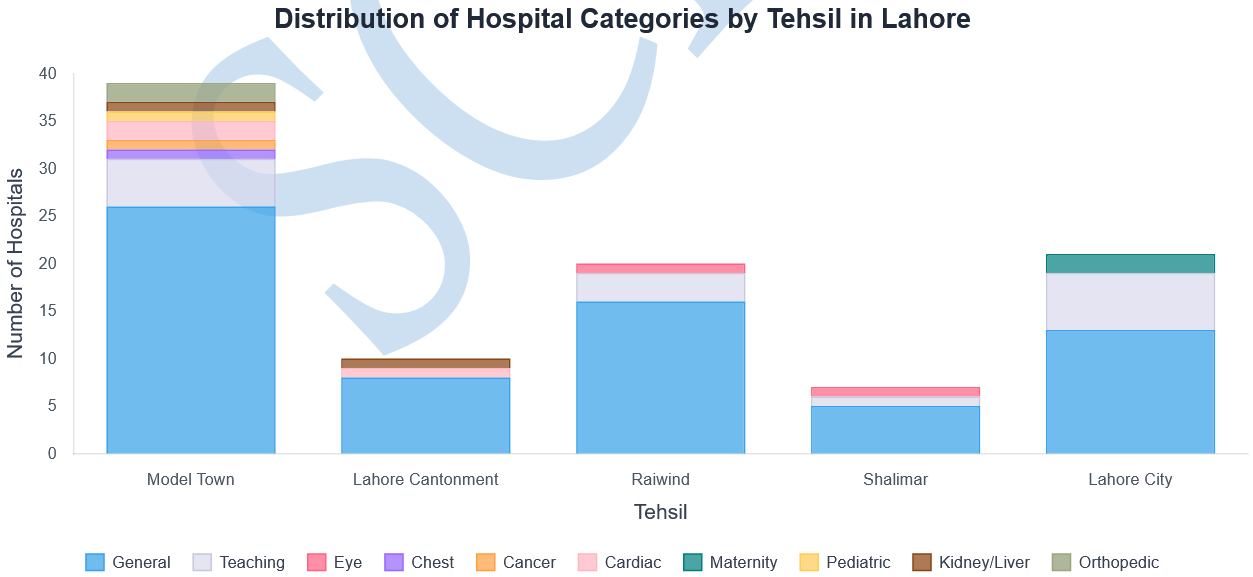


**Figure 10 Hospital Categories by Tehsil**

Public-private distribution shows a strong dominance of the private sector in most of the tehsils, particularly in Raiwind and Lahore Cantonment (>90% private). The only city with a higher share of public hospitals is Lahore City, which is the main public healthcare hub.

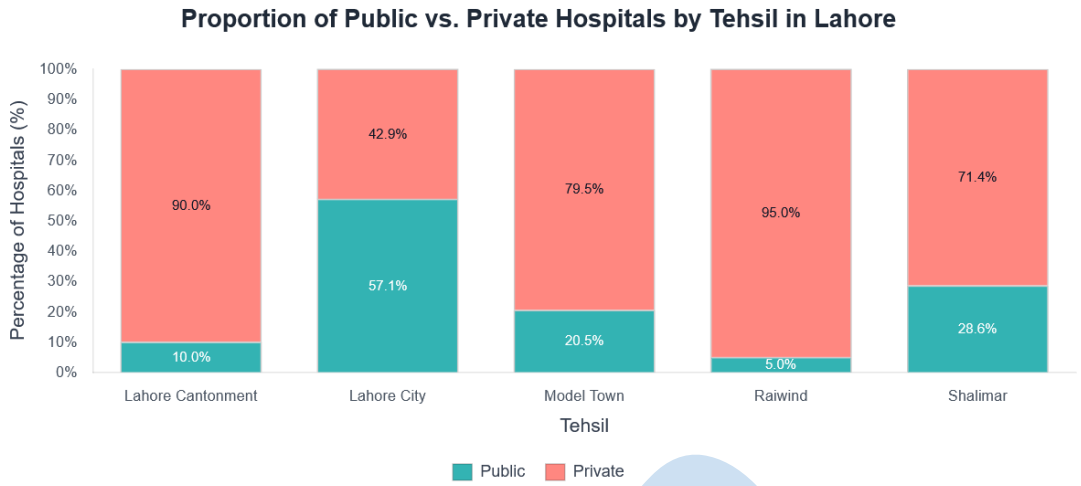


**Figure 11 Public vs. Private Hospitals by Tehsil**

Overall, the analysis reveals a distinct mismatch between population density and healthcare provision.

Lahore City and Shalimar are at the brink of major health care shortages against population demand. Model Town is the health care hub despite lower population density. Raiwind & Lahore Cantonment have better per-capita accessibility but are highly dependent on private healthcare which raises questions of affordability and equity. Thus, accessibility is a function of geography and economic and institutional factors, indicating a significant spatial inequality in the health care system of Lahore.

**Limitations**

The study is limited by the use of secondary data from PHIMC and PBS which may not fully reflect recent changes in the population or health care infrastructure. The analysis is also constrained by the absence of hospital capacity indicators such as bed availability, staffing levels and service quality that are relevant to evaluate true adequacy of healthcare. Furthermore, the aggregation at tehsil level may obscure intra-urban differences at the neighborhood or community level, and may miss localized differences in terms of access to healthcare.

**Conclusion**

Using GIS-based spatial and statistical analysis, this study investigated the geographical link between population density and healthcare facility distribution throughout Lahore's five tehsils. The results show notable differences in the availability and quality of healthcare. While Model Town functions as a significant healthcare hub despite less population pressure, high population density places like Lahore City and Shalimar face very poor healthcare supply. According to accessibility study, Shalimar and Lahore City have the most service deficiencies, while Raiwind and Model Town have comparatively higher per-capita availability. Additionally, general and private hospitals dominate the healthcare system, with few public and specialized institutions available in the majority of tehsils. Overall, the analysis shows that there is significant healthcare disparity throughout Lahore due to a glaring spatial mismatch between population distribution and healthcare facilities.

**Recommendations**

Targeted initiatives are needed to alleviate these discrepancies. First, more healthcare facilities should be built in underdeveloped and densely populated tehsils like Shalimar and Lahore City,

with smart placement in high-demand and periphery areas. Second, in order to lessen the burden of patient travel, specialty healthcare services (such as cardiac, pediatric, maternity, and oncology) must be expanded, especially outside of Model Town. Third, to increase affordability and equity, public healthcare facilities in private-dominated places like Raiwind and Lahore Cantonment must be strengthened. Fourth, to guarantee evidence-based placement of new facilities in line with population growth trends, urban health planning should incorporate GIS-based spatial analysis. Lastly, to enhance short-term healthcare coverage, telemedicine services and mobile health units should be encouraged in less accessible places.

**References:**

Adair-Rohani, H., Zukor, K., Bonjour, S., Wilburn, S., Kuesel, A. C., Hebert, R., & Fletcher, E. R. (2013). Limited electricity access in health facilities of sub-Saharan Africa: A systematic review of data on electricity access, sources, and reliability. *Global Health Science and Practice, 1*(2), 249–261. https://doi.org/10.9745/ghsp-d-13-00037

Afzal, U., & Yusuf, A. (2013). The state of health in Pakistan: An overview. *The Lahore Journal of Economics, 18*(Special Edition), 233–247. https://doi.org/10.35536/lje.2013.v18.isp.a10

Ajeel, F. S., & Kadhim, R. J. (2024). Using artificial intelligence to analyze population density in Iraq with Google Earth Engine and QGIS. In *Lecture Notes in Networks and Systems* (pp. 589–598). https://doi.org/10.1007/978-981-97-3591-4_44

Das, M., Dutta, B., Roy, U., Das, S., & Rath, S. (2023). Spatial accessibility modeling to healthcare facilities in the case of health shocks of Midnapore municipality, India. *GeoJournal*. https://doi.org/10.1007/s10708-023-10838-1

Das-Munshi, J., Bécares, L., Dewey, M. E., Stansfeld, S. A., & Prince, M. J. (2010). Understanding the effect of ethnic density on mental health: Multi-level investigation of survey data from England. *BMJ, 341*, c5367. https://doi.org/10.1136/bmj.c5367

Egeru, A., Mwesigwa, G. Y., Siya, A., Serwajja, E., & Bamutaze, Y. (2024). Spatial distribution and clustering of COVID-19 cases reveal the effect of urbanization and population density in Uganda. *SN Social Sciences, 4*(9). https://doi.org/10.1007/s43545-024-00970-1

George, A., & Sharma, P. (2023). Spatial disparities in health status and access to health-related interventions in Madhya Pradesh. *Asia-Pacific Journal of Regional Science, 7*(3), 865–902. https://doi.org/10.1007/s41685-023-00284-9

Ghouri, Y., Ghouri, A. Y., Rasheed, F., & Yousaf, M. A. (2022). Availability of heavy metals in soil of Lahore City, Pakistan and mapping by using GIS techniques. *Journal of Earth Science & Climatic Change, 13*(629), 2.

Guagliardo, M. F. (2004). Spatial accessibility of primary care: Concepts, methods and challenges. *International Journal of Health Geographics, 3*(1). https://doi.org/10.1186/1476-072X-3-3

Gulzar, L. (1999). Access to health care. *Image: The Journal of Nursing Scholarship, 31*(1), 13–19. https://doi.org/10.1111/j.1547-5069.1999.tb00414.x

Iram, A., Rasool, L., Shahzad, F., & Saeed, Y. (2012). Impact of urban sprawl on public health: An analysis of Lahore, Pakistan. *World Applied Sciences Journal, 20*(1), 80–86.

Katta, S., & Srinagesh, B. (2022). GIS-based healthcare accessibility analysis: A case study of selected municipalities of Hyderabad. In *Advances in Geographical and Environmental Sciences* (pp. 389–406). https://doi.org/10.1007/978-981-16-7310-8_19

Khan, S. U., & Hussain, I. (2020). Inequalities in health and health-related indicators: A spatial geographic analysis of Pakistan. *BMC Public Health, 20*(1). https://doi.org/10.1186/s12889-020-09870-4

Lahmar, B., Dridi, H., & Akakba, A. (2020). Territorial health approach outputs of geo-governance of health facilities: Case study of Batna, Algeria. *GeoJournal, 86*(5), 2305–2319. https://doi.org/10.1007/s10708-020-10189-1

Lahore Development Authority. (n.d.). *Urban structure and planning of Lahore*. Government of Punjab. https://lda.gop.pk

Mohammad, A. S., Alolayyan, M. N., Mohammad, S. I. S., Daoud, K. I. A., Oraini, B. A., Vasudevan, A., & Hunitie, M. F. A. (2025). Healthcare demand and adequacy: Impact on patient satisfaction and quality outcomes. *Journal of Posthumanism, 5*(1), 1171–1187. https://doi.org/10.63332/joph.v5i1.654

Munir, B. A., Hafeez, S., Rashid, S., Iqbal, R., & Javed, M. A. (2019). Geospatial assessment of physical accessibility of healthcare and agent-based modeling. *GeoJournal, 85*(3), 665–680. https://doi.org/10.1007/s10708-019-09987-z

Murad, A. A. (2004). Creating a GIS application for local health care planning in Saudi Arabia. *International Journal of Environmental Health Research, 14*(3), 185–199. https://doi.org/10.1080/0960312042000218606

Nadeem, M., Aziz, A., Al-Rashid, M. A., Tesoriere, G., Asim, M., & Campisi, T. (2021). Scaling the potential of compact city development: The case of Lahore, Pakistan. *Sustainability, 13*(9), 5257. https://doi.org/10.3390/su13095257

Pakistan Bureau of Statistics. (2023). *District-wise results of 2023 digital census: Lahore tehsils population and density*. https://www.pbs.gov.pk

Parvin, F., Ali, S. A., Hashmi, S. N. I., & Khatoon, A. (2020). Accessibility and site suitability for healthcare services using GIS-based hybrid decision-making approach. *Spatial Information Research, 29*(1), 1–18. https://doi.org/10.1007/s41324-020-00330-0

Planning & Development Board, Punjab. (n.d.). *Administrative divisions and population distribution*. Government of Punjab. https://pnd.punjab.gov.pk

Punjab Health Information Management Centre. (n.d.). *List of hospitals in Lahore Division*. https://phimc.punjab.gov.pk/lhrdiv

Riaz, M., Tiller, J., Ajmal, M., Azam, M., Qamar, R., & Lacaze, P. (2019). Implementation of public health genomics in Pakistan. *European Journal of Human Genetics, 27*(10), 1485–1492. https://doi.org/10.1038/s41431-019-0428-z

Robertson, A. (2023). Population and public health. In *Textbook of Medical Administration and Leadership* (pp. 349–363). Springer.

Saikia, A., & Kar, B. K. (2024). Evaluating geographical accessibility to healthcare centres using GIS. *GeoJournal, 89*(4). https://doi.org/10.1007/s10708-024-11147-x

Sarwar, A. (2021). Mapping regional disparities of reproductive health care services in Pakistan. *Asia-Pacific Journal of Regional Science, 5*(3), 825–849. https://doi.org/10.1007/s41685-021-00207-6

Shahid, S. U. I., Iqbal, J., Abbasi, N. A., & Tahir, A. (2023). GIS-based hotspot analysis of groundwater arsenic in Lahore. *Environmental Geochemistry and Health, 45*(8), 6053–6068. https://doi.org/10.1007/s10653-023-01612-w

Sharif, H., Sughra, U., & Butt, Z. (2016). Challenges and opportunities for primary healthcare systems in Pakistan. *Journal of Ayub Medical College Abbottabad, 28*(3), 550–554.

Shirazi, S. A. (2012). Spatial analysis of NDVI and population density: A case study of Lahore, Pakistan. *South Asian Studies, 29*(1), 269.

Ullah, S., Ullah, N., Tariq, A., Panezai, S., Tahir, P., & Khan, B. (2025). Spatial assessment of healthcare facilities in Balochistan using GIS. *Spatial Information Research, 33*(2). https://doi.org/10.1007/s41324-025-00602-7

Veldhuizen, E. M., Ikram, U. Z., De Vos, S., & Kunst, A. E. (2017). Ethnic composition and self-reported health. *International Journal of Health Geographics, 16*(1). https://doi.org/10.1186/s12942-017-0084-x

Wang, Y., & Wu, C. (2021). Spatial distribution and accessibility of medical institutions in Wuhan. *IOP Conference Series: Earth and Environmental Science, 825*(1), 012028. https://doi.org/10.1088/1755-1315/825/1/012028

World Health Organization. (n.d.). *Health and well-being*. https://www.who.int

You, H., Zhou, D., Wu, S., Hu, X., & Bie, C. (2019). Social deprivation and rural public health in China. *Social Indicators Research, 147*(3), 843–864. https://doi.org/10.1007/s11205-019-02183z