REVIEW ARTICLE

Underutilization of GIS in health research in Pakistan: A literature review of Pakistani medline indexed journals

Masood Ali Shaikh[1], Syed Muhammad Mubeen[2]

Abstract

Understanding the spatial dimension of place, alongside time and personal characteristics, is essential in epidemiology. The current narrative review was planned to analyse articles from all three Medline-indexed general medical journals in Pakistan that reported on the use of Geographic Information System or the Global Positioning System. From 2011 till October 2024, a total of 20 studies were published; 18(90%) of them in the *Journal of Pakistan Medical Association*, including the first article in July 2011. Most studies focussed on health risk assessment 12(60%), while 3(15%) examined health disparities and 2(10%) analysed spatial distribution and hospital accessibility. Geographic Information Systems facilitate spatial visualisation and analysis of health data, enabling a more nuanced understanding of disease patterns, hotspots and trends. This spatial intelligence is important for Pakistan, where geographical diversity, population density and socioeconomic disparities create complex health challenges.

Keywords: Geographic information systems, Spatial, Pakistan.

DOI: https://doi.org/10.47391/JPMA.23297

Introduction

Healthcare events and specific geographical locations have a critical association. The spatial dimension is an important aspect of epidemiology, complementing the focus on time and personal characteristics of individuals in understanding disease patterns as well the burden of morbidity and mortality. Spatial epidemiology is a branch of epidemiology that examines the geographical distribution of health outcomes, and explores how environmental, demographic and social factors influence these patterns. It is defined as "the description and analysis of geographically indexed health data with respect to demographic, environmental, behavioural, socioeconomic, genetic and infectious risk factors".[1] The Geographic Information System (GIS) is defined as "an integrated collection of computer software and data used to view and manage information about geographic places, analyse spatial relationships, and model spatial processes. GIS provides a framework for gathering and organising spatial data and related information so that it can be displayed and analysed".[2] Hence, by supporting the integration of various data layers — such as demographic information, environmental exposures, and health service locations — GIS enables complex and comprehensive analyses, including visualisations and dashboards for better decision-making. A dashboard is a visual display presenting important information using charts, graphs and maps to help understand status, and monitor trends for informed decision-making in various fields, including health. This includes spatial analysis and mapping techniques that identify clusters, hotspots and trends in disease occurrence across different administrative subdivisions, like districts and provinces. This approach helps understand how location affects the occurrence, presence and spread of diseases and health conditions; enabling the design of targetted interventions, efficient resource allocation, and addressing health disparities more effectively by uncovering the underlying correlates and causes of diseases and identifying high-risk areas.

GIS has been extensively utilised in a wide range of health-related applications to enhance the understanding of disease morbidity and mortality burden, and to improve population health outcomes. These myriad applications range from spatial analysis of the effectiveness of coronavirus disease-2019 (COVID-19) vaccine coverage among the elderly[3] to studying disparities in prostate cancer incidence using GIS tools.[4] GIS is also playing a pivotal role in supporting polio eradication efforts by mapping cases and identifying high-risk areas.[5] It has also been utilised in assessing health disparities in spatial accessibility to maternal and child health services.[6] Moreover, GIS has been employed in mapping vulnerability to crisis events, aiding in emergency preparedness and response strategies.[7] It has been used to evaluate the effects of COVID-19 lockdowns on survival rates, providing

[1]Department of Medicine, College of Medicine, Korea University, Seoul, South Korea; [2]Department of Community Health Sciences, Hamdard University, Karachi, Pakistan.

Correspondence: Syed Muhammad Mubeen.
e-mail: syed.mubeen@hamdard.edu.pk
ORCID ID: 0000-0002-4542-5905

Submission completed: 20-03-2025 **1st Revision received:** 30-04-2025
Acceptance: 13-08-2025 **Last Revision received:** 12-08-2025

insights into the pandemic's impact on different regions.[8] In the realm of mental health, GIS has facilitated the mapping of eating disorder prevalence and access to care facilities, highlighting areas in need of enhanced services.[9] Additionally, GIS has been crucial in enhancing healthcare services during large-scale events, like the Hajj pilgrimage, optimising resource allocation and crowd management to ensure the wellbeing of millions of participants.[10] These varied examples show the huge potential of GIS in addressing diverse health challenges by integrating spatial analysis into public health planning and research to improve population health.

Pakistan, the world's fifth most populous country with over 220 million inhabitants in 2024,[11] faces a myriad of health challenges exacerbated by its diverse geography and socioeconomic disparities. Communicable diseases, such as malaria, tuberculosis (TB) and hepatitis, remain prevalent, while non-communicable diseases (NCDs), like cardiovascular ailments and diabetes mellitus (DM), are on the rise due to lifestyle changes. The country's vulnerability to natural disasters, like earthquakes and floods, further compounds these health issues by upending infrastructure and displacing communities.

The application of GIS in health research within Pakistan has gained momentum over the past two decades. The current narrative review was planned to provide an overview of the use of GIS for health research in Pakistan.

Materials and Methods

The narrative review was conducted in October 2024, comprising literature search from January 01, 2011 to October 22, 2024, on Pakistani Medline-indexed general medical journals, namely: the Journal of Pakistan Medical Association (JPMA), the Journal of the College of Physicians and Surgeons Pakistan (JCPSP), and the Journal of Ayub Medical College (JAMC). These journals maintain a regularly updated website where all published articles are freely available for search and download. The 'Search' function on the three websites was used to locate any type of published article containing specific words or terms, including Letters to the Editor. The specific search words/terms used were: GIS, Geographic Information System, Spatial, Remote

Table: Characteristics of the studies analysed.

Publication Year	Published In Journal	Article Type	Software Used	Analysis Type & Category
2011[12]	JPMA	Original Article	ArcView 3.1	Reported/collected GPS data and displayed road traffic injuries as points on the map. (Health risk assessment & Health services accessibility)
2016[13]	JPMA	Short Communication	ArcGIS 10.2	Collected hospital locations with GPS. Reported spatial buffers and hospital service areas. (Health services accessibility)
2016[14]	JPMA	Short Report	ArcGIS 10.4	Spatial distribution of being sick/injured (Health risk assessment)
2017[15]	JPMA	Short Report	ArcGIS 10.4	Spatial distribution of health consultations. (Health risk assessment)
2018[16]	JPMA	Short Communication	ArcGIS 10	Spatial distribution of road traffic crash fatalities. (Health risk assessment/Environmental health study)
2018[17]	JPMA	Original Article	ArcGIS	Used GPS for malaria larval spatial distribution. (Spatial distribution analysis/Tracking disease spread)
2018[18]	JPMA	Short Report	ArcGIS 10.4	Spatial distribution of being sick or injured. (Health Risk assessment)
2018[19]	JPMA	Short Report	ArcGIS 10.4 & GeoDa 1.8	Cluster analysis with Moran's I and Local Indicators of Spatial Association. (Identifying clusters & Health risk assessment)
2018[20]	JPMA	Short Report	ArcGIS 10.4 & GeoDa 1.8	Global & Local Indicators of Spatial Association, Spatial Lag Regression Model. (Identifying clusters & Health risk assessment)
2018[21]	JPMA	Short Report	ArcGIS 9.2	Time-Location comparison using GPS. (Health risk assessment)
2019[22]	JAMC	Short Communication	ArcGIS 10.5 & GeoDa 1.12	Cluster analysis of tuberculosis. (Identifying clusters & Health risk assessment)
2019[23]	JCPSP	Short Communication	ArcGIS 10.5	Buffers around hospitals & hospital service areas. (Health services accessibility)
2020[24]	JPMA	Narrative Review	GRASS	Health facilities density mapping. Use of Moderate Resolution Imaging Spectroradiometer (MODIS) land surface temperature (LST) data as raster layers. (Environmental health study)
2020[25]	JPMA	Research Article	ArcGIS 10	Ecological Mapping and Multi-Criteria Evaluation. Interpolated surfaces generated. The weighted sum function in ArcGIS 10's spatial analyst tool was used to assess the risk of asthma. Spatial distribution of clinics. Buffers of patient coverage by clinics. (Environmental health study)
2021[26]	JPMA	Special Communication	ArcGIS 10.6 & GeoDa 16.4	Cluster analysis with Moran's I and Local Indicators of Spatial Association. (Identifying clusters & Health risk assessment)
2022[27]	JPMA	Short Report	ArcGIS 10.7	Gender differentials in spatial distribution of immunisation status in children. (Health Disparities & Health Risk Assessment)
2022[28]	JPMA	Letter to Editor	ArcGIS 10.7	Urban rural differentials in the spatial distribution of pregnant women's choice of delivery place. (Health Disparities & Health services accessibility)
2022[29]	JPMA	Letter to Editor	ArcGIS 10.7	Urban-rural differentials in the spatial distribution of pregnant women having received Tetanus Toxoid injection. (Health Disparities & Health services accessibility)
2022[30]	JPMA	Original Article	ArcGIS 10.7 & GeoDa 1.14	Disease mapping, Global & Local Indicators of Spatial Association, Spatial Lag Regression Model. (Identifying clusters & Health risk assessment)
2023[31]	JPMA	Short Communication	ArcGIS 10.7 & GeoDa 1.14	Spatial distribution and clustering of the proportion of disabled individuals, Global & Local Indicators of Spatial Association. (Identifying disease clusters & Health Disparities)

JPMA: Journal of Pakistan Medical Association, JCPSP: Journal of College of Physicians and Surgeons of Pakistan, JAMC: Journal of Ayub Medical College, GIS: Geographic information system, GPS: Global positioning system.

Sensing, Raster, Geo, GPS, Global Positioning System, Geostatistics, Cluster, Clustering, Autocorrelation, Hotspots, Hot-spots, Hot spots, Cold spots, and Cold-spots. Each listed word/term was searched individually. The identified articles were reviewed, and those that employed GIS technology, including the use of Global Positioning System (GPS) or any kind of spatial analysis, were selected. The inclusion criteria entailed analysis done on data from Pakistan, and articles that used any kind of spatial analysis using data from other countries were excluded.

The identified articles were downloaded for detailed review and categorisation. Data, including journal name, month and year of publication, article type, software used, and the type of analysis conducted and reported, was tabulated.

Results

Of the 20 articles analysed,[12-31] 18(90%) were published in JPMA, while 1(5%) each was published in JAMC and JCPSP. The very first article using GIS software was published in 2011.[12] This was followed by a four-year hiatus during which no articles were published. From 2016 to 2023, at least 1 article was published each year. In 2018, the publication peaked with 6(30%) articles, while no article was published again in 2024 till the cut-off date.

Of the total, 12(60%) were published as either Short Report or Short Communication. Only 3(15%) were published as Original article, while 2(10%) were published as Letter to Editor. GPS was used in 3(15%) of the studies. The ArcGIS software was used, either alone or in combination with other software, in 19(95%) articles, while GeoDa was used in conjunction with ArcGIS in 6(30%) studies (Table).

Regarding the types of analyses conducted and reported, 12(60%) studies focussed either exclusively or alongside other themes on health risk assessment.[12,14-16,18-22,26-27,30] Further, 2(10%) studies concentrated exclusively on the spatial distribution and accessibility of specified types of hospitals: one in Karachi[13] and the other covering Peshawar and Abbottabad.[23] Disparities were examined in 3(15%) studies, exploring gender differentials in immunisation status,[27] urban-rural differentials in delivery place choice by pregnant women[28] and urban-rural differentials in pregnant women receiving the Tetanus Toxoid vaccine.[29] There were 3(15%) studies pertaining to environmental health, investigating the spatial distribution of road crash fatalities,[16] land surface temperatures[24] and the relationship between environmental settings and asthma.[25] Only 2(10%) studies employed spatial regression models[20,30] and 4(20%) studies utilised GPS units for data collection.[12,13,17,21]

Discussion

The spatial dimension is a fundamental aspect of epidemiology. Using GIS in health research offers significant potential in enhancing public health outcomes by providing spatial insights into disease patterns, improving accessibility to health services, optimal resource allocation, and reducing environmental health risks. Despite this promise, the current review reveals significant underutilisation of GIS in health research in Pakistan. Since the publication of the first article on the use of GIS in health in JPMA in 2011, only 19 more articles have been published in the three Medline-indexed journals of Pakistan.[12-31] This small body of work stands in sharp contrast to the numerous institutes and universities in the country offering GIS short courses, graduate and postgraduate programmes, and even doctorates; indicating a substantial gap between academic GIS training and its practical application in the health sector. Universities and other educational institutes need to incorporate health applications into their GIS curricula. Offering specialised courses on the use of GIS in health can equip graduates with the skills to apply spatial analysis in public health contexts. Integrating GIS education into medical schools has been reported as an effective way to promote and instill the importance of GIS, thereby widening students' perspectives on improving population health.[32]

The limited number of publications over 14 years underscores a missed opportunity to leverage GIS for advancing population health in Pakistan. Several factors may contribute to this underutilisation, including limited awareness, insufficient interdisciplinary collaboration, against the backdrop of technological and infrastructure barriers. Collectively, these factors might have led to missed opportunities in health research, as inadequate use of GIS in health research in the country limits the generation of local evidence needed for informed decision-making.

The JPMA has been spearheading the promotion of GIS for health research publications in the country by publishing 90% of such articles. The other two Medline-indexed journals have published one article each over the course of 14 years. This calls for greater encouragement for the use of GIS in health research and its publication in Pakistan, particularly by incentivising researchers to contribute to special supplements dedicated to this subject by these three prestigious and globally recognised Medline-indexed journals.

The low number of merely 20 publications over 14 years needs to be interpreted against the current review's limitations. The major limitation is the fact that only three — albeit the most notable Pakistani general medical

journals — were included. There are many health and medical journals published in Pakistan, and they sometimes publish articles utilising GIS and spatial analysis.[33] Secondly, several Pakistani researchers have conducted research using GIS for health in Pakistan, and published their findings in foreign/international medical and health journals.[34-36]

There were no studies published in the three Medline-indexed journals of Pakistan on the use of Unmanned/ Uncrewed Aerial Vehicles (UAVs), commonly referred to as drones. It is a promising area for increasing access and delivery of health services in developed and developing countries.[37,38] Future studies in Pakistan need to explore the use of drones for promoting population health, and publication of findings in Pakistani journals for wider accessibility and visibility within the country.

Conclusion

In developing countries, like Pakistan, where health challenges are complex and resources are perennially limited, the broader application of GIS holds significant promise for enhancing public health outcomes. Leveraging GIS technology and spatial analysis can lead to more effective health interventions, better resource management, and improved population health.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

References

1. Elliott P, Wartenberg D. Spatial epidemiology: current approaches and future challenges. Environ Health Perspect 2004;112:998-1006. doi:10.1289/ehp.6735
2. ESRI. GIS dictionary – gis [Online] [Cited 2024 November 11]. Available from: URL: https://support.esri.com/en-us/gis-dictionary/search?q=gis
3. Wulan WR, Widianawati E, Wahyuni AT. COVID-19 vaccine coverage effectiveness among elderly with geographical information system mapping: what about Indonesia? Ther Adv Vaccines Immunother. 2024;12:25151355241285379. doi:10.1177/25151355241285379
4. El Khoury CJ. Application of geographic information systems (GIS) in the study of prostate cancer disparities: a systematic review. Cancers. 2024;16:2715. doi:10.3390/cancers16152715
5. Kipterer JK, Touray K, Godwin AU, Cisse A, Aimee BNM, Busisiwe N, et al. Geographic information system and information visualization capacity building: successful polio eradication and current and future challenges in the COVID-19 era for the World Health Organization's African region. PLoS One. 2024;19:e0307001. doi:10.1371/journal.pone.0307001
6. Qin Q, Xu B, Hu X, Wei X, Su Y, Tang X. Spatiotemporal trends and geographic disparities in spatial accessibility to maternal and child health services in Nanning, China: impact of two-child policies. BMC Health Serv Res. 2024;24:934. doi:10.1186/s12913-024-11415-z
7. Jarghon AEM, Damayanti NA, Dhamanti I, Notobroto HB, Hidajah AC, Awad AMM. Mapping vulnerability to potential crisis events in Surabaya city: a GIS-based approach. F1000Res. 2024;13:465. doi:10.12688/f1000research.145182.2
8. Jalali R, Etemadfard H. Spatio-temporal analysis of COVID-19 lockdown effect to survive in the US counties using ANN. Sci Rep 2024;14:19608. doi:10.1038/s41598-024-70415-5
9. Pang N, Nagata JM, Testa A, Ganson KT. Mapping eating disorders in adolescents and young adults: an investigation of geographic distribution and access to care in Ontario, Canada. J Eat Disord. 2024;12:136. doi:10.1186/s40337-024-01098-6
10. AlJahdali IA, Adly HM, Alshahrani AY. Strategic enhancement of healthcare services during the Hajj season in Makkah: a comprehensive geographic information system (GIS) analysis. Cureus. 2024;16:e68030. doi:10.7759/cureus.68030
11. Population Pyramid.net. List of countries ordered by their population. Accessed on November 11, 2024. Available from https://www.populationpyramid.net/population-size-per-country/2024/
12. Razzak JA, Khan UR, Jalal S. Application of geographical information system (GIS) for mapping road traffic injuries using existing source of data in Karachi, Pakistan — a pilot study. J Pak Med Assoc. 2011;61:640-3.
13. Shaikh MA, Ali MS. Spatial distribution and accessibility to public sector tertiary care teaching hospitals in Karachi: a geographic information systems application. J Pak Med Assoc. 2016;66:889-92.
14. Shaikh MA. Spatial distribution of being sick or injured in the past two weeks by district in Pakistan. J Pak Med Assoc. 2016;66:1648-51.
15. Shaikh MA. Spatial distribution of health consultations in the past two weeks by provider type and district: Pakistan social and living standards measurement survey 2014-15. J Pak Med Assoc. 2017; 67:1270-4.
16. Jooma R, Ali MS, Shaikh MA. Spatial distribution of road traffic crash fatalities in Karachi: perspective from 2008-2012. J Pak Med Assoc. 2018;68:105-8.
17. Khan SU, Khan RA. Characterisation of breeding sites of anopheline mosquitoes in District Bannu, KPK, Pakistan. J Pak Med Assoc. 2018;68:175-86.
18. Shaikh MA. Spatial distribution of under five-year-olds being sick or injured in the past two weeks by district in Pakistan. J Pak Med Assoc. 2018 Aug;68(8):1248-1253.
19. Shaikh MA. Spatial distribution of contraceptive usage by district in Pakistan: Percent change in a couple years of protection in 2015-16 compared to 2014-15. J Pak Med Assoc. 2018 Jul;68(7):1090-1094.
20. Shaikh MA. Correlates of being sick or injured in under five-year old children by district in Pakistan: A spatial analysis case study. J Pak Med Assoc. 2018 Apr;68(4):633-638.
21. Jamali T, Khan AA, Nafees AA, Ahmed M, Azam I, Kadir MM, Lee K. Application of the GPS technology to assess time-location pattern of undergraduate students at a private medical university in Karachi, Pakistan: A pilot study. J Pak Med Assoc. 2018 Jul;68(7):1094-1096.
22. Shaikh MA, Malik NA. Spatial Cluster Analysis Of New And Relapsed Cases Of Pulmonary Tuberculosis By District: Pakistan 2015. J Ayub Med Coll Abbottabad. 2019 Apr-Jun;31(2):293-295.
23. Shaikh MA, Malik NA. Spatial distribution and accessibility to public sector tertiary care teaching general hospitals: tale of two Khyber Pakhtunkhwa districts Peshawar and Abbottabad. J Coll Physicians Surg Pak. 2019;29:87-9. doi:10.29271/jcpsp.2019.01.87.
24. Atif S, Hussain E, Khan JA. Surface urban heat islands in the mega city of Karachi, their spatial distribution and health emergency response infrastructure. J Pak Med Assoc. 2020;70:705-12. doi:10.5455/JPMA.5478.

25. Khan IA, Arsalan MH, Mehdi MR, Kazmi JH, Seong JC, Han D. Assessment of asthma-prone environment in Karachi, Pakistan using GIS modeling. J Pak Med Assoc. 2020;70:636-49. doi:10.5455/ JPMA. 11828.

26. Shaikh MA. Spatial analysis of 'couple years of protection' by district in Punjab: percent change from 2015-2016 to 2016-2017. J Pak Med Assoc. 2021;71:2415-9.

27. Shaikh MA. Gender differentials in spatial distribution of immunisation status in children aged 12-23 months by district in Punjab: results from Pakistan social and living standards measurements survey 2014-15. J Pak Med Assoc. 2022;72:747-51.

28. Shaikh MA. Urban rural differentials in spatial distribution of pregnant women's choice of delivery place by district in Punjab - results from Pakistan Social and Living Standards Measurements Survey 2014-15. J Pak Med Assoc. 2022;72:366-8. doi:10.47391/ JPMA.22-35.

29. Shaikh MA. Urban rural differentials in spatial distribution of pregnant women having received tetanus toxoid injection by district in Punjab: results from Pakistan Social and Living Standards Measurements Survey 2014-15. J Pak Med Assoc. 2022;72:206. doi:10.47391/JPMA.22-008.

30. Shaikh MA. Spatiotemporal analysis of having been sick or injured and having sought health consultation by district in Punjab province of Pakistan-2010-2015. J Pak Med Assoc. 2022;72:1913-20. doi:10.47391/JPMA.22-99.

31. Shaikh MA. Spatial distribution and clustering of the proportion of disabled individuals by districts in Punjab. J Pak Med Assoc 2023;73:2077-82. doi:10.47391/JPMA.23-71.

32. Shrivastava SR, Bobhate P, Umate R. Geographical information system: strengthening the delivery of medical education. J Pharm Bioallied Sci 2024;16(Suppl 3):S2955-7. doi:10.4103/ jpbs.jpbs_1270_ 23.

33. Rashid M, Chand S. Spatial analysis and modeling of infant mortality rate using conditional autoregressive model: a case study of Punjab, Pakistan. Pak J Med Res 2016;55:75-83.

34. Malik NA, Shaikh MA. Spatial distribution and accessibility to public sector tertiary care teaching hospitals: case study from Pakistan. East Mediterr Health J. 2019;25:431-4. doi:10.26719/emhj.18.049.

35. Muhammad FS, Shahabudin SM, Talib MBA. Measuring spatial inequalities in maternal and child mortalities in Pakistan: evidence from geographically weighted regression. BMC Public Health. 2024;24:2229. doi:10.1186/s12889-024-20046-1.

36. Lu C, Khan K, Khan F, Shah SU, Jamal M, Badshah N. Epidemiology of cutaneous leishmaniasis in children of Khyber Pakhtunkhwa, Pakistan. Trop Med Int Health. 2024;29:633-46. doi:10.1111/ tmi. 14095.

37. Flemons K, Baylis B, Khan AZ, Kirkpatrick AW, Whitehead K, Moeini S, et al. The use of drones for the delivery of diagnostic test kits and medical supplies to remote First Nations communities during Covid-19. Am J Infect Control. 2022;50:849-56. doi:10.1016/j.ajic.2022. 03.004.

38. Sharma S, Sharma H. Drone a technological leap in health care delivery in distant and remote inaccessible areas: a narrative review. Saudi J Anaesth. 2024;18:95-9. doi:10.4103/sja.sja_506_23.

Author Contribution:
MAS: Concept, Literature review, writing, data analysis and final revision.
SMM: Literature review, writing, data analysis and final version review.