

## Leveraging GIS for Empowering Health Research in Pakistan: A Path to Smarter Public Health Solutions

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Location is a fundamental feature for understanding the occurrence, spread of diseases and their associated risk factors. Understanding that "everything that happens, happens somewhere"<sup>1</sup> underscores the essential significance of geography in the analysis of health and disease morbidity and mortality burdens. Epidemiology is all about understanding the interaction of place with time and individual characteristics to fathom the distribution and determinants of diseases. This spatial standpoint is imperative for a nuanced understanding of how various social, economic, biological, and environmental factors intertwine to influence and confluence health outcomes. Spatial analysis offers insights into the distribution and clustering of diseases across space, hot and cold spot identification, and uncover spatial variations in health behaviours and outcomes. Providing pivotal context for the effective prevention, control, and management of diseases by providing spatial context for targeted interventions and policies to specific geographical areas. Contrary to cookie-cutter solutions based on the erroneous assumption of one-size-fits-all.

Geographic Information Systems (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. A GIS provides a framework for gathering and organizing spatial data and related information so that it can be displayed and analysed."<sup>2</sup> The myriad applications of GIS in epidemiology and public health include disease mapping,<sup>3</sup> disease surveillance and outbreak investigation,<sup>4</sup> disease risk assessment and prevention,<sup>5</sup> health services planning and evaluation,<sup>6</sup> environmental health assessment,<sup>7</sup> and emergency response and disaster management,<sup>8</sup> among many others.<sup>9</sup> Thus it offers a cost-effective and scalable solution for improving population health.

By integrating disease data with demographic and

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environmental information, GIS helps identify high-risk areas, enabling more effective resource allocation. When it comes to risk assessment and prevention, GIS aids in evaluating exposure risks to environmental hazards like air pollution, contaminated water, and toxic waste, thus informing preventive strategies and prioritizing support for vulnerable populations. For health services planning and evaluation, GIS complements the strategic placement of healthcare facilities, ensuring equitable access to healthcare facilities. In the context of environmental health, GIS helps study the effects of environmental factors on health, such as the link between air pollution and respiratory illnesses or the influence of climate change on the spread of infectious diseases. Additionally, GIS is indispensable in emergency response and disaster management by supporting the identification of potential hazards.

Pakistan has made significant progress in promoting GIS education, with many universities and institutions, both educational and non-educational across the country offering GIS training programmes, ranging from short courses to doctoral degrees in geospatial sciences. Institutions leading this initiative include the National University of Sciences and Technology, Lahore University of Management Sciences, University of Punjab, The University of Karachi, Mehran University, University of Peshawar, University of Baluchistan, Institute of Space Technology, and the Pakistan Space & Upper Atmosphere Research Commission equipping students with essential practical technical skills for the application of GIS across various fields. Numerous institutes provide complimentary GIS training online, readily accessible through a basic Google search that uncovers various websites offering free GIS courses.

Numerous training programmes have been available in the country for years, and occasional research publications utilising GIS for health are published in Pakistani medical journals, enhancing the understanding of the spatial dimension in the context of public health in the country. There is, nevertheless, a significant underutilisation of GIS in enhancing health outcomes. Significant unmet potential exists for employing GIS to enhance health outcomes.

We propose four targetted strategies to enhance the utilisation of GIS for health in Pakistan. First, universities and other educational institutions in the country needs to provide or customise courses and diplomas that focus on 'GIS for Health' specializations. This has been previously proposed as well.<sup>10</sup> Second, to encourage more research using GIS in health, the three Medline-indexed journals need to introduce 'Special Supplements' inviting submissions that leverage GIS applications to enhance population health. Third, incorporating GIS training as mandatory courses in medical and public health education programmes will enhance the understanding of spatial analysis in health promotion. Finally, offering funding opportunities for projects that employ GIS in health research will incentivise more researchers to investigate and apply GIS in the field of health. Collectively, these measures could substantially improve the application of GIS for better health outcomes in Pakistan.

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