

Spatial distribution and accessibility to public sector tertiary care teaching hospitals in Karachi: A Geographic Information Systems application

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Abstract

Optimal utilization of specialized curative healthcare services is contingent on spatial access to tertiary-care hospitals by the targeted population. The objectives of this study were to determine the spatial distribution of public sector tertiary-care teaching hospitals in Karachi, and to use GIS and network analysis for modeling the accessibility to these hospitals for Karachi residents. Maps of three, six, and nine kilometer buffers were created around the five selected hospitals to determine which towns of Karachi are either entirely or partially covered/accessible. Most of the towns in Karachi were covered either partially or completely by the three buffers and service areas of 3,6, and 9 kilometers around the five selected hospitals. This study highlights the limitations of using publicly available data for road network, and the need for creating and making available in public domain, comprehensive road network vector dataset in conjunction with population breakdowns by administrative subdivisions.

Keywords: Hospitals, Accessibility, Pakistan.

Introduction

Public sector provision of healthcare is an important determinant of population health status and morbidity and mortality burden in developing countries like Pakistan.¹ It is the least expensive source of curative care to the majority of residents in Pakistani cities for low and middle income families. Optimal utilization of specialized curative healthcare services is contingent on spatial access to tertiary care hospitals by the targeted population. Patients requiring these specialized services and hospitals catering to their needs are almost never uniformly distributed; hence, resulting in variable physical accessibility across a defined geographic space.²

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Utilization of healthcare facilities is influenced by multitude of factors ranging from individual characteristics entailing income, race, availability, affordability and acceptability of services to physical accessibility and distances that need to be traversed by the care seekers.³⁻⁵ Geographic Information Systems (GIS) are being used in both developing and developed world to study the distribution and access to healthcare services.^{2,5}

The financial hub of Pakistan and maritime metropolis of Karachi is the largest city of Pakistan in terms of population, with an estimated population of over 23.5 million in 2013.⁵ There are no studies on spatial accessibility to tertiary care public sector hospitals in Pakistan, using GIS and network analysis. The objectives of this study were to determine the spatial distribution of public sector tertiary care teaching hospitals in Karachi, and to use GIS and network analysis for modeling the accessibility to these hospitals for residents of Karachi; using a simple method of GIS data collection in conjunction with freely available GIS data.

Methods and Results

The five public sector teaching hospitals in Karachi: Civil hospital, Abbasi Shaheed hospital, Jinnah Postgraduate Medical Center, Dow University (Ojha) hospital, and Lyari General Hospital were selected for accessibility analysis. All geographic data were created, processed, analyzed, and mapped in the GIS software programme ArcMap 10.2. The latitude and longitude (X and Y) coordinates of these hospitals were obtained from a Global Positioning System (GPS) enabled mobile phone using World Geodetic System 1984 (WGS 1984) coordinate system, and a GIS vector (point) shape file was created in the ArcMap 10.2. The accuracy of these readings was checked using an aerial image from Google Earth. All five selected hospitals are located in the south central part of Karachi.

The vector road network file for Pakistan was downloaded from website Open Street Map;⁶ a free to use website that operates under open license and

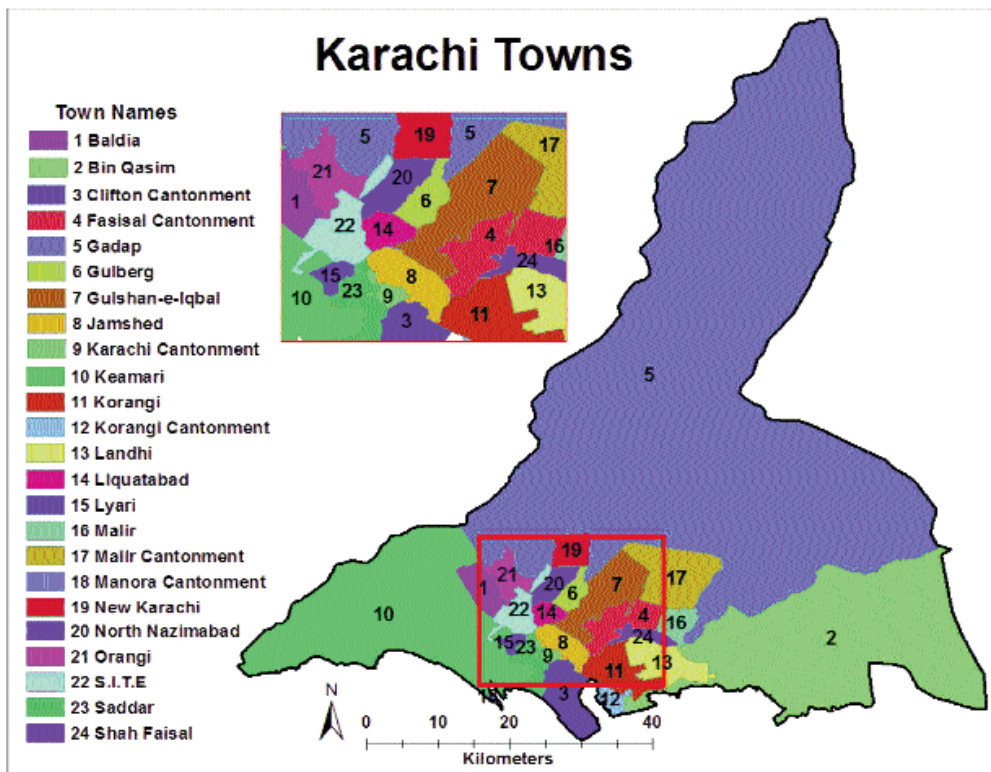


Figure-1: Karachi city towns.

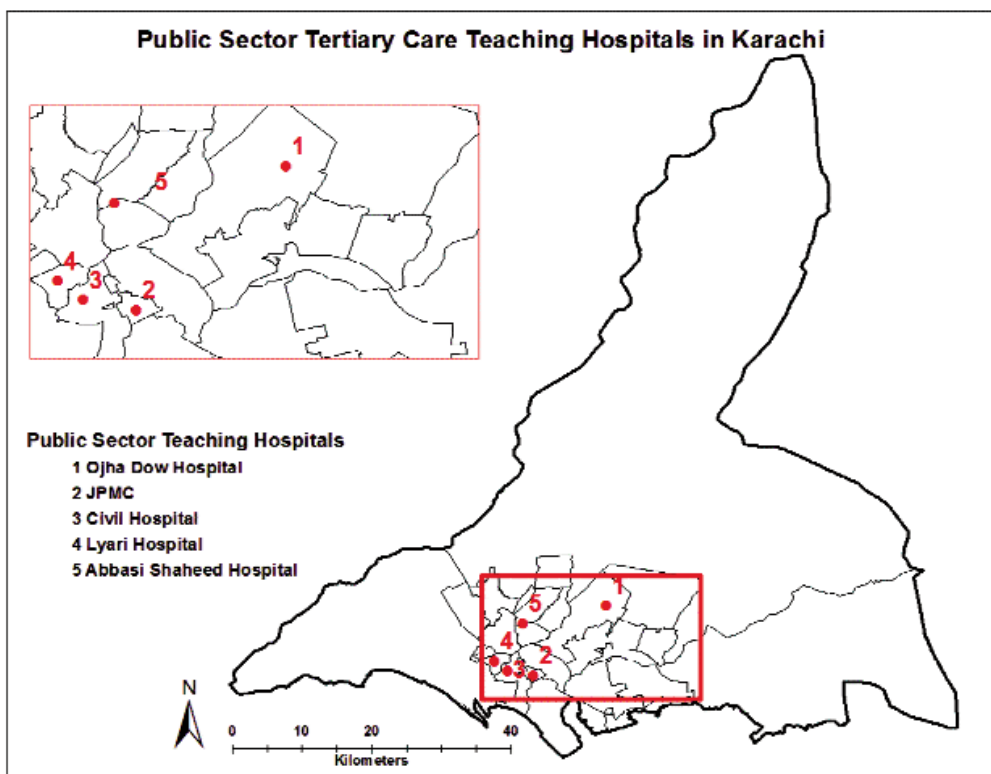


Figure-2: Locations of public sector teaching hospitals in the Karachi city.

provides vector World map created by volunteers. The Karachi road network shape file was extracted from the Pakistan road network by clipping out with the Karachi city vector boundary outline shape file.

All vector shape files were assigned the Geographic Coordinate System i.e. WGS 1984, prior to subsequent spatial distribution and accessibility analyses. Figure-1 and 2, depict the Karachi city towns, and point locations of the five selected hospitals, respectively in maps. Maps of three, six, and nine kilometer straight line (Euclidean) buffers were created around the five selected hospitals to determine which towns of Karachi are either entirely or partially covered/accessible; as depicted in Figure-3.

Service areas around the five selected hospitals were created next; which are areas comprising of all accessible roads leading to the locations of five selected hospitals i.e. accessible by roads within specified distances. Service areas by distance were created using 'Any Vertex' connectivity policy, and by ignoring the direction of travel permitted on the roads i.e. whether roads were one way or allowed flow of traffic in both directions. Service areas of three, six, and nine kilometers were created using the ArcGIS 10.2

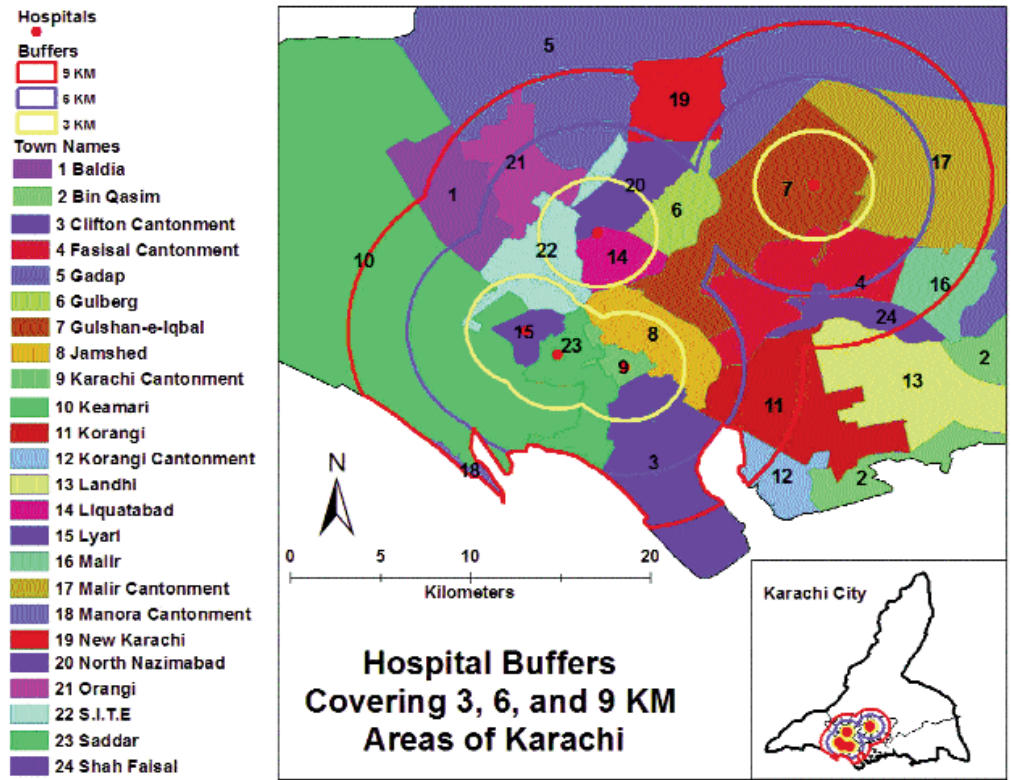


Figure-3: Coverage of various towns in Karachi, by 3, 6, and 9 kilometer hospital buffers.

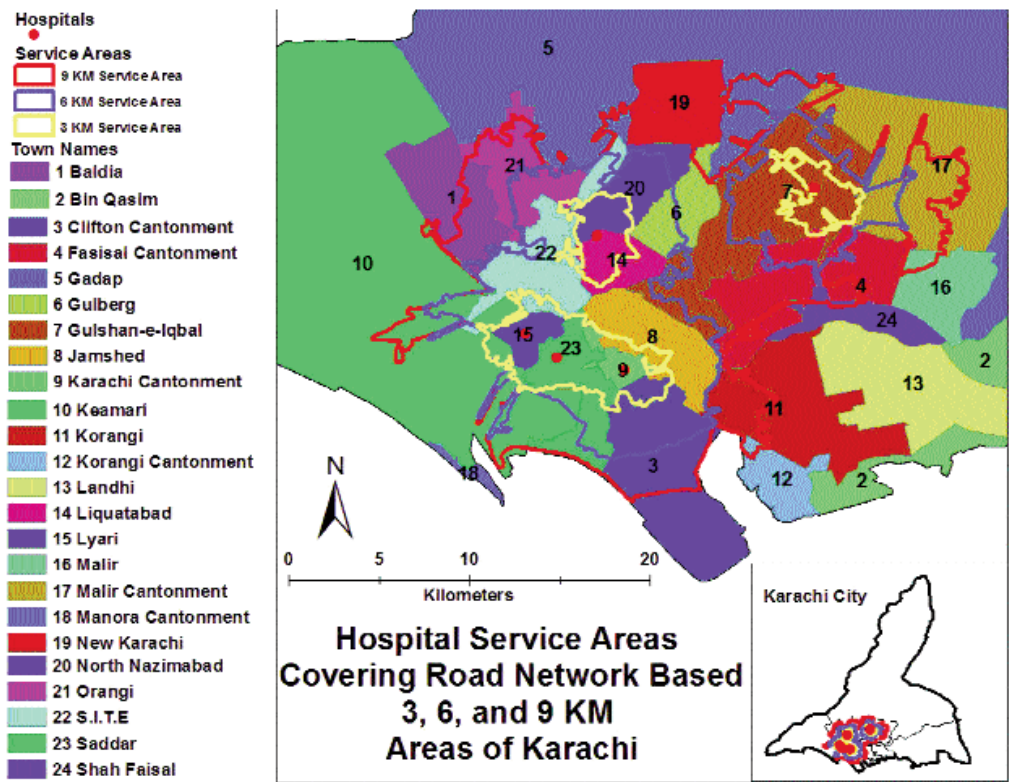


Figure-4: Coverage of various towns in Karachi, by 3, 6, and 9 kilometer service areas around hospitals.

extension 'Network Analyst' and depicted in a map as shown in Figure 4.

Discussion

This is the first study of its kind in Pakistan analyzing the spatial distribution of public sector tertiary care teaching hospitals and modeling the accessibility to these hospitals for the residents of a city. One previous study reported on the spatial distribution of both public and private health facilities in Islamabad, and concluded that most of the clinics were located within one kilometer of a hospital.⁸

Results show that the five hospitals are located in the south central part of Karachi. Most of the towns in Karachi were covered either partially or completely by the three buffers as well as three service areas of 3, 6, and 9 kilometers around the five selected hospitals. With the exception of Gadap, Kemari, and Bin Qasim towns, most other towns are either completely, or sizable parts of their areas, were covered by the nine kilometer buffer as well as service area. The towns of Bin Qasim is entirely missed by the nine kilometer buffer as well as service area, while small portions of Gadap, and Kemari are covered by this buffer and service area.

Small portions of Gadap, and Kemari towns are covered by the nine kilometer buffer and service area, while the

entire town of Bin Qasim is missed. These three towns are less densely populated compared to other towns in Karachi. Hence results show that majority of the towns and their residents fall within the three buffers and service areas analyzed in this study.

However these results need to be interpreted with several caveats and limitations of this study. There wasn't enough data in road network file and associated table to get the results based on time, as opposed to distance; no needed data was available on speeds for every road segment. As only with speed and distance one could create a time field in order to solve the using time as impedance, in addition to distance.

The data also does not model elevation well. For instance, there was an area where there are two roads marked with a value of 1 for bridge, and the road that crosses them is also marked as 1 for bridge. This was not modeled correctly; hence, cannot be used to accurately build a network data set using elevations. Therefore, I had to build the data set without elevations. This may give a fairly good idea about service areas, but if there are overpasses/underpasses within those service areas, they may not be entirely correct. The same goes for the one-way data. The values are simply 1 or 0 but this doesn't provide any information about the actual direction. If 1 means the segment is one-way, one doesn't know which direction is one-way. The correct way to model one-way data needs to include values that correctly indicate whether it is one-way in the from/to direction that the line is digitized or in the to/from. Without this, one-way travel can't be modeled so again it somewhat weakens the results. The service areas may be close, but one needs to appreciate that without accurately modeling one-way and elevation, there are weaknesses in the dataset. Finally data on residents by towns was not available that would have more clearly indicated the number of people having access to the selected hospitals.

Remedying these deficiencies in the road network data would be resource intensive in terms of financial,

technical, logistical, and human. This study highlights the limitations of using publicly available data for road network, and the need for creating and making available in public domain, comprehensive road network vector dataset in conjunction with population breakdowns by administrative subdivisions like towns and union councils. Engineering and Geography departments of universities would be ideally suited to embark on such undertakings in the city of Karachi. It would be interesting and of more practical value for health policy makers to estimate the total population served by these hospitals. How many people live in the 3,6, and 9 kilometer buffers and service areas, by hospital; future studies need to incorporate actual or estimated populations served by hospitals.

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Conflict of Interest: None.

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References

1. Basu S, Andrews J, Kishore S, Panjabi R, Stuckler D. Comparative performance of private and public healthcare systems in low- and middle-income countries: a systematic review. *PLoS Med* 2012; 9: e1001244.
2. Masoodi M, Rahimzadeh M. Measuring access to urban health services using Geographical Information System (GIS): a case study of health service management in Bandar Abbas, Iran. *Int J Health Policy Manag* 2015; 4: 439-45.
3. Lasser KE, Himmelstein DU, Woolhandler S. Access to care, health status, and health disparities in the United States and Canada: results of a cross-national population-based survey. *Am J Public Health*. 2006; 96: 1300-7.
4. Goudge J, Gilson L, Russell S, Gumede T, Mills A. Affordability, availability and acceptability barriers to health care for the chronically ill: longitudinal case studies from South Africa. *BMC Health Serv Res* 2009; 9: 75.
5. Comber AJ, Brunsdon C, Radburn R. A spatial analysis of variations in health access: linking geography, socio-economic status and access perceptions. *Int J Health Geogr* 2011; 10: 44.
6. Karachi. [online]. [cited 2015 August 2]. Available from: URL: <https://en.wikipedia.org/wiki/Karachi>
7. Open Street Map. [online]. [cited 2015 July 11]. Available from: URL: <https://www.openstreetmap.org/#map=18/24.85653/67.07582&layers=Q>
8. Shaikh MA. Spatial distribution of health facilities in Islamabad, Pakistan. *East Mediterr Health J* 2014; 19 Suppl 3: S213-5.