

Geospatial Analysis of Dental Services in Jaipur, Rajasthan, India: A Retrospective Observational Study

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ABSTRACT

Introduction: Geographic Information Systems (GIS) are tools used to integrate spatial and non spatial attribute information, providing a foundation for mapping and understanding geographic context and aiding the allocation and redistribution of dental services, thereby making dental services accessible to underserved populations.

Aim: To analyse the distribution of dental services in Jaipur district using geospatial analysis, an evidence-based reorganisation tool.

Materials and Methods: This retrospective observational study was conducted over nine months from October 2019 to July 2020 in the Department of Public Health Dentistry of NIMS Dental College and Hospital, Jaipur, Rajasthan, India. Data collection was carried out from October 2019 to February 2020 and data analysis was performed from March 2020 to July 2020. GIS applications used included QGIS, ArcGIS Desktop, ArcGIS Online, Google Earth Pro and Google Maps to perform geospatial analyses. All public and private dental services in Jaipur district were mapped using GIS software and overlaid with population data from the 2011 Census.

Results: Jaipur district comprises 13 subdivisions with a total population of 9,847,662. The majority of dental services 1,117 (95.14%) were in the private sector, with relatively few 57 (4.85%) in the public sector. Accessibility analysis showed that dental services located in Jamwa Ramgarh, Shahpura and Bassi were highly inaccessible within 5, 10 and 15 km, respectively. The average nearest-neighbour analysis indicated a clustered distribution of dental services in Jaipur district ($z = -35.28$), suggesting less than a 1% probability that the observed clustering occurred by chance.

Conclusion: Geospatial analysis provides insights into the population and dental services, highlighting underserved areas and guiding policymakers. A spatial join analysis of the entire Jaipur district indicated that the concentration of dental services is highest in the Jaipur subdivision compared with other subdivisions. Therefore, local health planners in Jaipur should allocate dental services to the less-served districts identified by the present study.

Keywords: Accessibility, Geographic information system, Oral health, Population, Spatial analysis

INTRODUCTION

Oral health is a critical component of general health. Dental services provide a basis for relief from discomfort, pain and suffering, as well as improving people's quality of life. Despite being largely preventable, these diseases continue to pose a significant health risk [1]. Recent studies suggest that lack of dental care may also correlate with systemic diseases such as cardiovascular disease and low birth weight [2-4]. Prevention of oral diseases and maintenance of good oral health largely depend on a person's ability to access dental care. Thus, the issue of inaccessibility to dental care services needs to be critically addressed to improve dental service utilisation [5].

There is an unequal distribution of dentists between rural and urban areas of the country. Since about 70% of the population lives in villages and the greatest numbers of dentists practice in urban agglomerations, awareness of dental diseases and the affordability and accessibility of dental treatment are limited [6,7]. According to Census 2011, only 25% of dentists operate in rural areas, yielding a rural dentist-to-population ratio of around 1:30,000. In addition, the urban dentist-to-population ratio is around 1:4,000 [8-10]. Urban polarisation of private dental practitioners has made access to dental services limited and unaffordable for rural people, which leads to various obstacles in the utilisation of dental services for the rural population in India [11].

The introduction of GIS and spatial analysis has aided in improving the accessibility of spatial data within a geographical context. The term "spatial analysis" refers to the analysis of problems

with a geographical dimension [2]. GIS is a computer-based tool that aids in the mapping and analysis of geographical data. It is an analytical tool that has been used in a number of healthcare fields and sectors, but its application in dentistry remains under-explored [12].

However, to date there have been relatively few applications of GIS in examining spatial patterns in dental health, such as investigating differences in the spatial connection between dental caries and obesity [13], correlating dental caries with areas of social deprivation [14], studying geographical incidences of oral cancer [15], identifying the spatial distribution of dental fluorosis among school children [16,17], improving clinical decision-making by dental practitioners [18] and investigating patterns of geographical access to dental services for different sectors of the community [19].

Although accessibility to dental services and their geographic location is a prime concern for people in need of dental treatment, virtually no geographic analyses of dental services have been undertaken in Jaipur district to assess dental care access. Jaipur district is located in Rajasthan, India's northernmost state and the authors conducted the present study with the aim of analysing the distribution of dental services in Jaipur district, which ranks first among all state districts in population density [20].

The primary objective of the present study was the reorganisation of existing dental services and addressing issues of maldistribution of dental services. Additionally, the secondary objectives of the present study were to propose a methodology for addressing geographical accessibility that identifies locations with no dental facilities and to

indicate the most appropriate locations for new dental facilities. The present study would also help researchers, planners and policymakers explore service and geographical accessibility issues in dentistry.

MATERIALS AND METHODS

The present retrospective observational study was conducted over nine months from October 2019 to July 2020 in the Department of Public Health Dentistry of NIMS Dental College and Hospital, Jaipur, Rajasthan, India. Prior to the start of the study, a protocol was submitted to the Ethical Review Committee, NIMS University, Jaipur, and ethical clearance was obtained (Ref no NIMSUR/IEC/2019/003).

Inclusion and Exclusion criteria: All dental services in Jaipur district (public and private) formed the study population; inclusion criteria were all dental services in Jaipur district. Mobile dental services and school dental services were excluded.

Study Procedure

A pilot study was conducted on 10% of the desired sample population of dental services to assess feasibility. A total of 15 dental services were identified on Google Earth and saved as a Keyhole Markup Language (KML) file. These dental services were transferred into QGIS v3.10.2 and overlaid with the Jaipur shapefile. All data were secondary and collected from open-access sources.

Population data: The current population data for the present study were extracted from the website of the Office of the Registrar General and Census Commissioner, India, Ministry of Home Affairs, Government of India and related to the urban and rural population of Jaipur district. The 2011 census data were extracted from the District Census Handbook [8].

Dental practice locations:

- A) Public dental practice locations:** The database of dental services was collected from the public health sector {Primary Health Centres (PHCs), Community Health Centre (CHCs), rural hospitals, paramilitary hospitals, Employees' State Insurance Corporation (ESIC) hospitals, district hospitals and government dental colleges}. The addresses of each were obtained from government websites (eDantSeva) and government offices [21].
- B) Private dental practice locations:** The addresses for each private sector (private hospitals, private dental colleges and dental clinics) in Jaipur district were obtained from various sources {e.g., phone books, dental distributors, professional lists, Google Earth, Google Maps, web searches and the Indian Dental Association (IDA)} [22,23].

Data from Google Maps and Google Earth were downloaded and saved as a KML file. The downloaded file was then input into Quantum GIS (QGIS) and Aeronautical Reconnaissance Coverage Geographic Information System (ArcGIS) for further analysis. All public dental services were identified from the government website eDantSeva and through Google search. Data for private dental services were collected from official websites such as Just Dial [24], Sulekha [25], TopRanker [26], KiviHealth [27], Practo [28], Lybrate [29], Yellow Pages [30] and Google Earth [22].

Administrative boundary data and health facilities point data:

The geographic administrative area of Jaipur district was retrieved from Diversity Map Geographic Information System (DIVA-GIS), publicly available on the website [31]. DIVA-GIS is an official site developed by Robert Hijmans; free spatial data for any country is available there. The road network was used in the present study as it takes into consideration the natural and built environment of the study area and can therefore accurately simulate how dental services can be located using straight-line distance and overlaying with population characteristics. For health facilities point data,

geospatial analytical techniques were used. A grid tool was employed to create a standard square spatial layer that was geo-referenced and connected to the Jaipur district administrative boundary.

Geocoding approach: An important issue related to healthcare planning is to identify the location of healthcare needs. GIS can be used in this regard because it has tools for converting address data into point coverage through geocoding. Geocoding of the dental locations was completed using a free-access geocoding website—ArcGIS Online—by which geographic coordinates (longitudes and latitudes) were assigned to the physical addresses of the locations [32]. The geocodes were then cross-checked for accuracy by overlaying the coordinates on a world street map available from Google Maps.

All recorded and cleaned database files were then moved into QGIS (version 3.10.2) for analysis [33]. Using the GIS software, based on centroid locations, various buffers were constructed around the dental services [32,34]. These extracted datasets were then moved into Excel (Version 2016) for further analysis.

Spatial analysis: Various spatial analyses were performed, including overlay analysis, spatial join analysis, network analysis, closest facility search, hotspot analysis, buffer analysis and the average nearest neighbour summary.

General approach and technical support: At the beginning, the shapefile of Jaipur district was generated using QGIS Desktop v3.10.2. The shapefile was available on the official website of the Indian Space Research Organisation (ISRO) 'Bhuvan'—the Indian Geoplatom of ISRO. This shapefile contained only the outline of Jaipur district. The urban and rural components were obtained from research conducted by Bedi P et al., [35]. The extracted image was superimposed on the Jaipur district shapefile. Thus, the final shapefile of Jaipur district containing both the urban and rural components was created in QGIS Desktop v3.10.2.

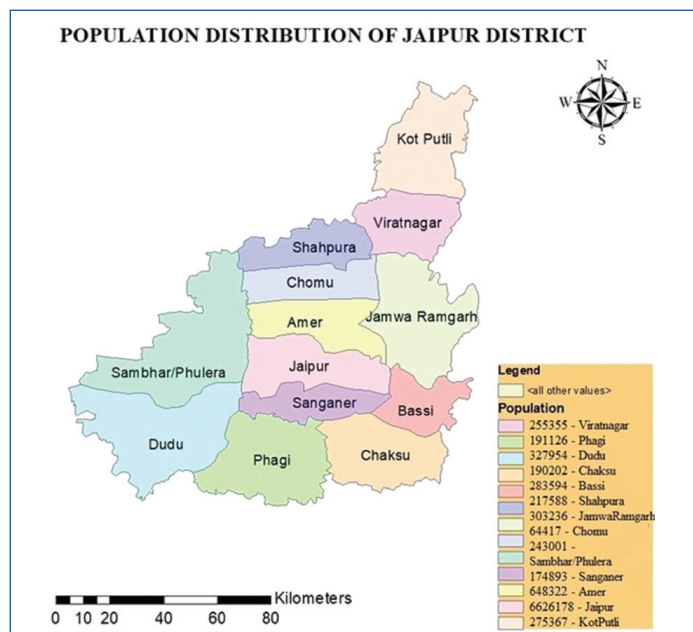
A database and model were created with the aim of verifying the appropriate distribution of dental services in Jaipur district. To do this, data about dental services were gathered from Google Maps, Google Earth and various search engines and web pages. The list of collected dental services was grouped together and then imported into Microsoft Excel 2016. These practice addresses were cross-checked with databases. Further cross-checks involved telephoning 50 dental services at random to confirm their location and to obtain local practitioner verification of list accuracy. The final list included 57 dental services in the public sector and 1,117 dental services in the private sector. This final list was then converted into public-and private-sector .csv files, respectively. These .csv files were then entered into ArcGIS and QGIS for analysis. All dental services with names and locations were plotted in QGIS v3.10.2 as a point feature map. The longitude and latitude of each practice address were obtained through a free and easily accessible geocoding website—ArcGIS Online.

Additionally, important information was added, such as the Jaipur road network and city-district boundaries with appropriate population details. The road network and other administrative boundaries were retrieved from the official website of DIVA-GIS. The population data from the 2011 Census were overlaid in GIS and various maps were generated. All spatial analyses were performed. An average nearest-neighbour analysis was also generated to interpret the data, which indicated a clustered distribution of dental services in Jaipur district. Underserved geographic areas in urban and rural settings were identified, indicating potential new development of dental services in areas of need.

RESULTS

Exploration of population data: To establish where people are generally concentrated, the population was spatially distributed using a gridding approach and visualised with a choropleth map.

The gridded dataset was used to visualise the spatial distribution of population in Jaipur district before relating it to the provision of dental services. A choropleth map that contains the shapefile of Jaipur district along with its 13 subdivisions is indicated in [Table/Fig-1]. The population was projected onto the Jaipur shapefile and the map was generated. The population of Jaipur district is 9,847,662. Exploration of population distribution in Jaipur indicates concentration in areas such as Jaipur, followed by Amer and Dudu.



[Table/Fig-1]: Choropleth map of population distribution of Jaipur district in GIS.

Distribution of urban and rural population of Jaipur district: The subdivisions with only rural population, including Chomu, Kotputli, Viratnagar, Sambhar/Phulera, Phagi, Sanganeer and Chaksu is shown in [Table/Fig-2]. Subdivisions such as Jaipur, Shahpura, Dudu, Amer, Jamwa Ramgarh and Bassi have both rural and urban components. The majority of subdivisions have a rural component.

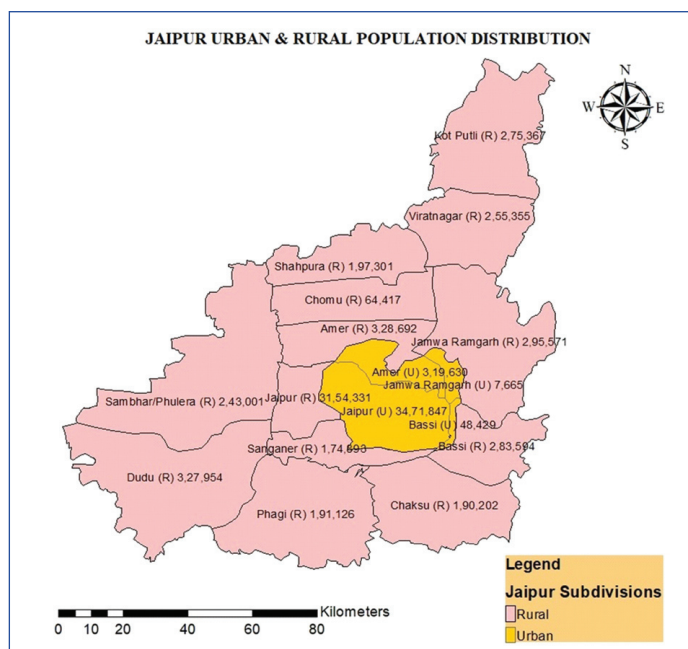
Subdivisions	Urban	Rural
Jaipur	34,71,847	31,54,331
Amer	3,19,630	3,28,692
Jamwa Ramgarh	7,665	2,95,571
Bassi	46,429	2,83,594
Shahpura	20,287	1,97,301
Dudu	0	3,27,954
Phagi	0	1,91,126
Kotputli	0	2,75,367
Sanganeer	0	1,74,893
Sambhar/Pulera	0	2,43,001
Chomu	0	64,417
Chaksu	0	1,90,202
Viratnagar	0	2,55,355

[Table/Fig-2]: Distribution of urban and rural population of Jaipur district.

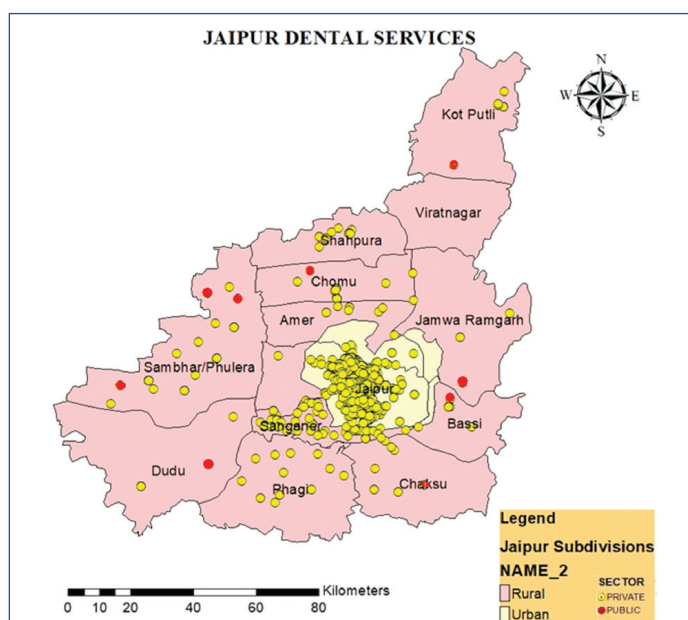
Spatial distribution of urban and rural population of Jaipur district: The map in [Table/Fig-3] indicates the spatial distribution of urban and rural populations in Jaipur district in ArcGIS. As shown, yellow indicates urban areas, while pink indicates rural areas.

The spatial distribution of all dental services in Jaipur district, suggesting a maximum concentration of dental services in the Jaipur subdivision [Table/Fig-4].

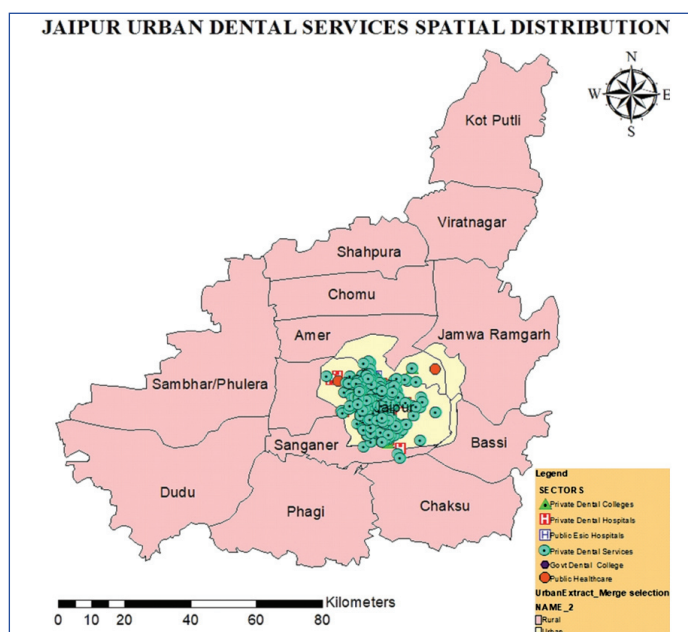
Distribution of dental services in Jaipur district urban: The spatial distribution of dental services in urban Jaipur district in the ArcGIS database is shown in [Table/Fig-5]. The distribution of dental services in urban Jaipur district is shown in [Table/Fig-6]. In the



[Table/Fig-3]: Spatial distribution of urban and rural population of Jaipur district.



[Table/Fig-4]: Spatial distribution of dental services in Jaipur district.



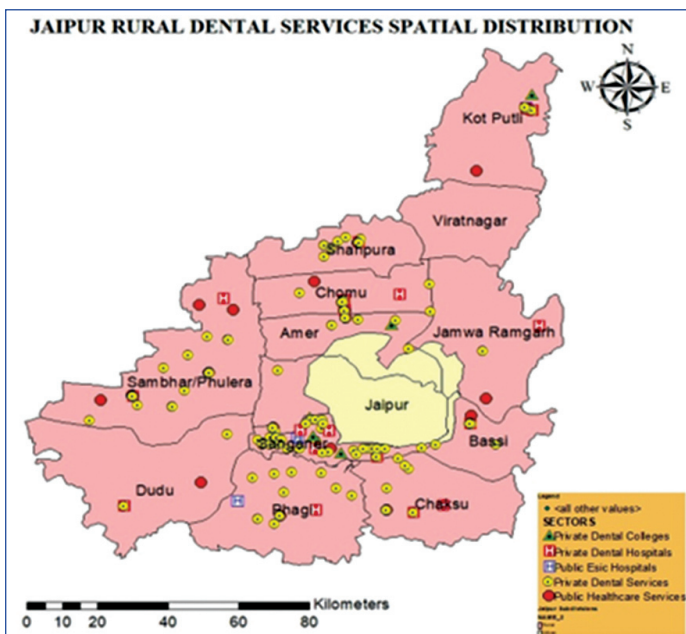
[Table/Fig-5]: Spatial distribution of dental services in Jaipur district.

Dental services	Urban dental services	Numbers
Public	Healthcare	12
	ESIC hospitals	23
	Dental college	1
Private	Dental hospitals	58
	Dental clinics	906
	Dental colleges	2

[Table/Fig-6]: Distribution of dental services in Jaipur district urban.

public sector, there are 12 healthcare facilities, 23 ESIC hospitals and one dental college. In the private sector, there are 58 dental hospitals, 906 dental clinics and two dental colleges.

Distribution of dental services in Jaipur district rural: The spatial distribution of dental services in rural Jaipur district in the ArcGIS database is shown in [Table/Fig-7]. [Table/Fig-8] shows Jaipur rural dental services distribution. In the public sector, there are 19 healthcare facilities, two ESIC hospitals and no dental college. In the private sector, there are 40 dental hospitals, 108 dental clinics and three dental colleges.



[Table/Fig-7] Spatial distribution of dental services in Jaipur district rural in ArcGIS database.

Dental services	Rural dental services	Numbers
Public	Healthcare	19
	ESIC Hospitals	2
	Dental College	0
Private	Dental Hospitals	40
	Dental Clinics	108
	Dental Colleges	3

[Table/Fig-8]: Distribution of rural dental services in Jaipur district.

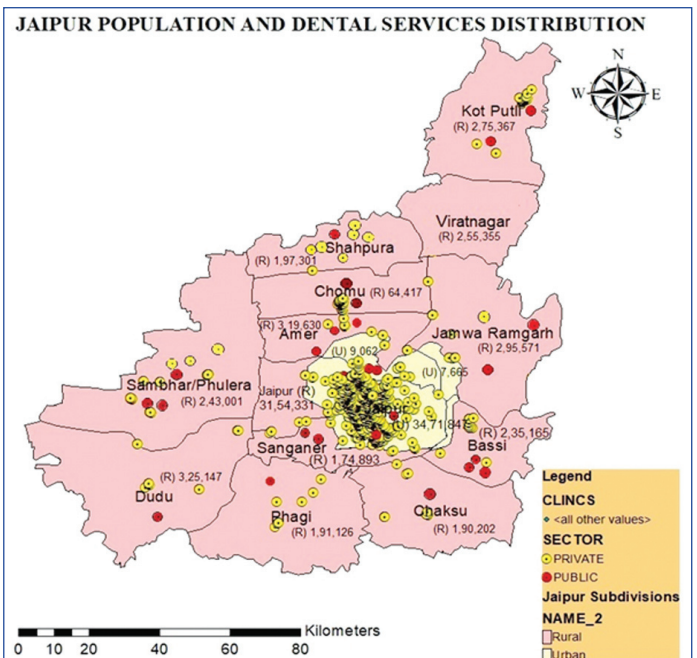
Thus, based on the findings in [Table/Fig-6] and [Table/Fig-8], the present study shows that the majority of dental services are in the private sector 1,117 (95.14%), with very few in the public sector 57 (4.85%).

Overlay analysis:

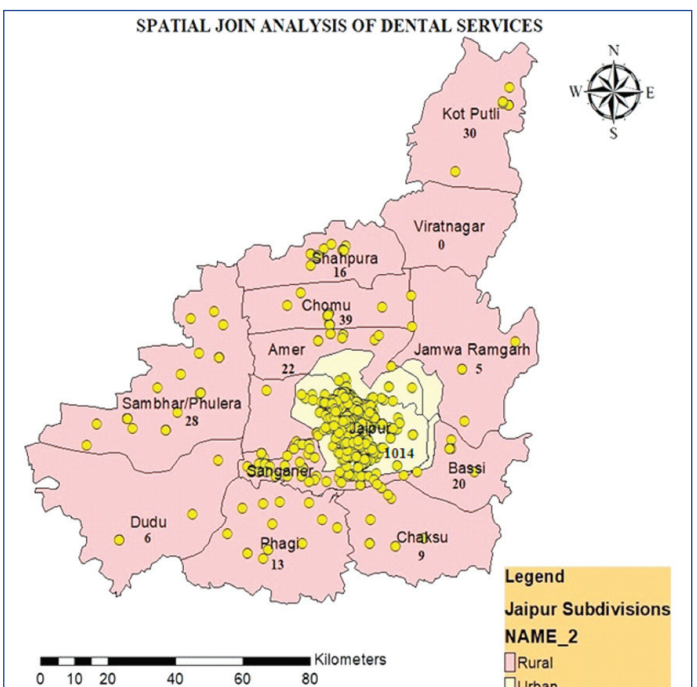
Distribution of population and dental services in Jaipur district:

The map shown in [Table/Fig-9] indicates an overlay analysis. Urban and rural populations were overlaid with dental services. Private dental services are shown in yellow and public dental services in red.

Spatial join analysis of dental services in Jaipur district: As shown in [Table/Fig-10], a spatial join analysis was performed to determine the total number of dental services in each subdivision of Jaipur



[Table/Fig-9]: Spatial distribution of population and dental service in Jaipur district.

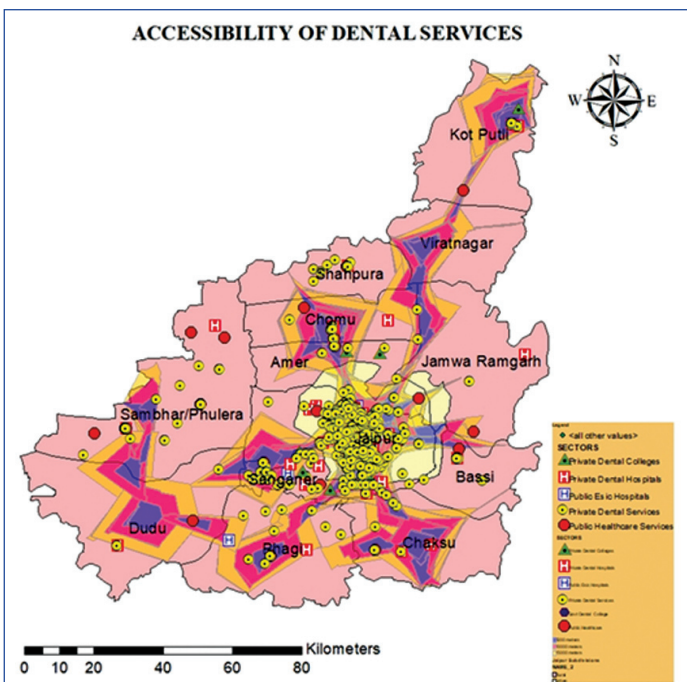


[Table/Fig-10]: Spatial join analysis dental service in Jaipur district.

district. The dental clinics in Jaipur district urban and rural areas were 906 and 108, respectively. This indicates that the maximum number of dental clinics were concentrated in Jaipur district (1014), followed by Sanganeer (56) and Chomu (39). Conversely, very few dental clinics were found in Dudu (6) and Jamwa Ramgarh (5), while none were present in Viratnagar (0).

Accessibility of dental services in Jaipur district: Accessibility was categorised as 5 km, 10 km and 15 km. Since road-network distance is a better predictor than straight-line distance, it is used to measure spatial accessibility. The Origin-destination (OD) cost-distance analysis in ArcGIS was used to calculate the distance between each centroid (subdivision) and the dental service sites. The road network was extracted from DIVA-GIS. The origin is set to the centroid and the destination to the dental service sites and the OD-Matrix is computed accordingly.

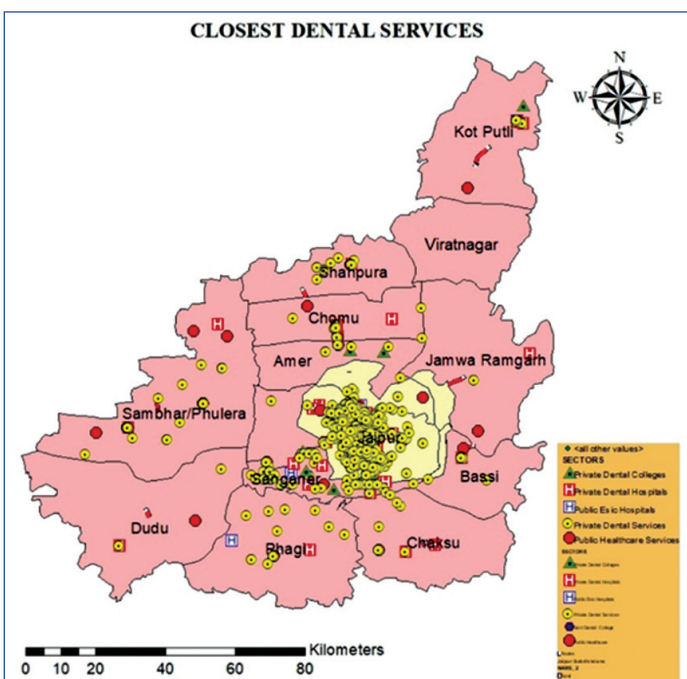
The [Table/Fig-11] indicates that dental services located in Jamwa Ramgarh, Shahpura and Basli were highly inaccessible up to 5, 10 and 15 km, indicating that it was challenging to access dental services in these districts within those distances. There were also



[Table/Fig-11]: Accessibility of dental service in Jaipur district.

no hotspot analyses of dental services in the Viratnagar subdivision. Closest dental services for all subdivisions of Jaipur district: The Closest Facility Solver calculates the travel cost between incidents and facilities to determine which facilities are the closest. The closest facilities in each subdivision of Jaipur district is indicated in [Table/Fig-12]. The closest dental services were calculated from the centroids of each Jaipur subdivision. The closest routes were found and mapped in ArcGIS using the Network Analyst feature. A total of 13 routes were identified:

1. Amer - Rudrakshi Dental and General Clinic
2. Bassi - Dental Care and Implant Hospital
3. Chaksu - Shree Krishna Hospital
4. Chomu - Sarkar Hospital
5. Dudu - ABS Hospital
6. Jaipur - Dr. Dorwal's Dental Hospital
7. Jamwa Ramgarh - CHC
8. Kotputli - Shyam Dental Clinic

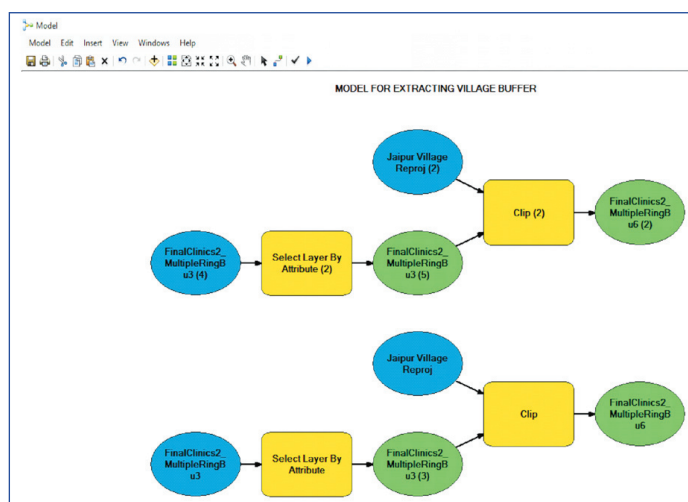


[Table/Fig-12]: Closest dental service of all subdivision of Jaipur district.

9. Shahpura - CHC
10. Phagi - Arvind Dental Clinic
11. Sambhar/Phulera - Dr. Jai Prakash Kumawat
12. Sangarner - Medi Dental Clinic
13. Viratnagar - Shriya Hospital

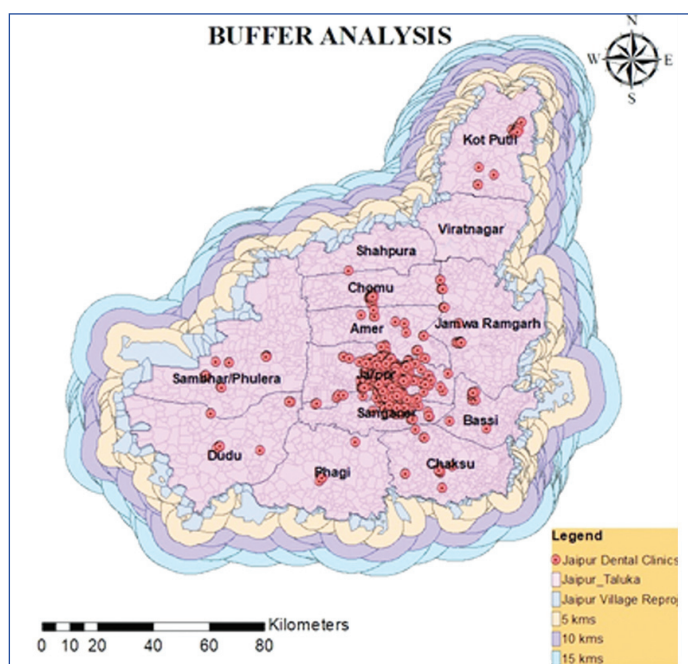
Buffer analysis:

Buffer analysis framework: As shown in [Table/Fig-13], the model was created in ArcGIS using ModelBuilder from the Toolbox. Next, the route layer within the model was created. The procedure for using Network Analyst in a model is identical to that for using Network Analyst in ArcMap. The first step involved building a route layer and giving it attributes. The route layer was therefore updated to include the "Jaipur Village reprojected file." The network locations (stops) used as inputs were then included. Thus, network locations for 5, 10 and 15 kilometers were added and calculated. The buffer analysis was completed in the final stage and the outcomes are provided below.



[Table/Fig-13]: Model for extracting buffer.

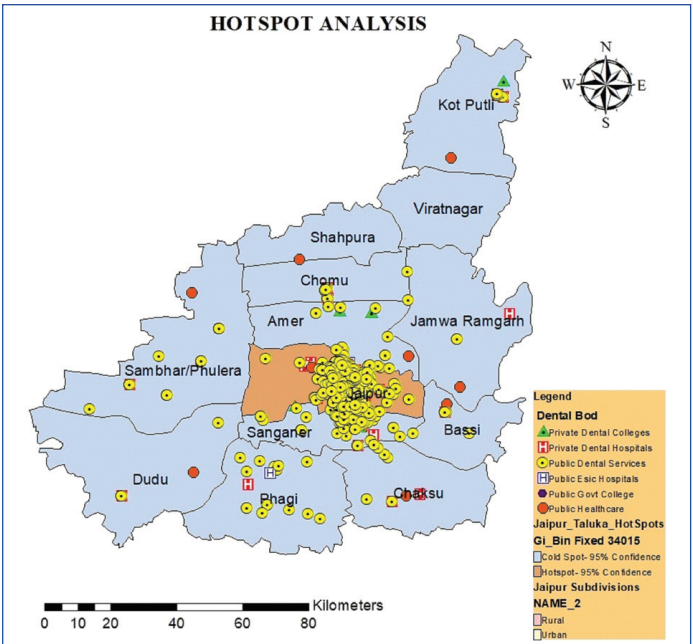
Buffer zones of Jaipur district: Buffers are circular zones of concentric circles constructed around each subdivision for locating the nearest and farthest dental services. The buffers were created for 5 km, 10 km and 15 km in [Table/Fig-14].



[Table/Fig-14]: Buffer zones of Jaipur district.

Hotspot analysis of dental services in Jaipur district: Hotspot analysis in [Table/Fig-15] indicates that the Jaipur subdivision has

more dental services compared to other subdivisions. Hotspots and coldspots were generated using the hotspot analysis feature of ArcGIS and were based on a 95% confidence interval. The hotspot area identified is in brown color as shown in the figure. It shows the maximum concentration of dental services, whereas blue areas indicate very few concentrations of dental services and are identified as cold spots.



[Table/Fig-15]: Hotspot analysis of dental services in Jaipur district.

Average nearest neighbour summary of dental services in Jaipur district: The average nearest neighbour summary report was generated using the average nearest neighbour tool in ArcGIS. This tool, as shown in [Table/Fig-16], calculates the distance between each feature’s centroid and that of its closest neighbour. It then sums all of these distances between closest neighbours. The summary generated indicates a clustered distribution of dental services in Jaipur district. It shows a z-score of -35.28, which indicates less than 1% probability that the clustered pattern is due to random chance.

Average nearest neighbour summary	
Metric	Value
Observed mean distance	308.2690 metres
Expected mean distance	2029.5866 metres
Nearest neighbour ratio	0.151888
z-score	-35.287011
p-value	0.000000
Dataset information	
Attribute	Value
Input feature class	Closest facility\facilities
Distance method	Euclidean
Study area	7793567596.888791
Selection set	False

[Table/Fig-16]: Average nearest neighbour summary report generated using the average nearest neighbour tool of ArcGIS.

DISCUSSION

The GIS is a tool that integrates spatial and non spatial attribute information and is a useful planning tool for matching available dental services with population characteristics. However, providing oral healthcare can be challenging, especially when dental services are unevenly distributed and do not align with population distribution [15].

Thus, the present study was conducted with the aim of analysing the variability, availability and accessibility in the distribution of public

and private dental services throughout Jaipur district. The present study is the first of its kind to incorporate various geospatial analysis tools to map dental service locations by first identifying geographical inequities in dental provider locations. To date, very few national studies have applied such an extensive methodology to address the urban-rural disparity in dental services [17-19].

The present study identified both public and private dental services and by using an overlay analysis tool, urban and rural population distributions were overlaid with the dental services of Jaipur district. Studies conducted by Langford M et al., in the UK [36], Horner MW and Mascarenhas AK in Ohio [2], Willie-Stephens J et al., in Australia [37], Shiikha Y et al., in Australia [38] and Almado H et al., in Australia [39] were similar to the present study. They examined the distribution of both public and private dental services and overlaid it with population data. However, the present study’s findings are contrary to those of Perera I et al., in Sri Lanka [40] and Nayak PP et al., in India [41], where they overlaid both population and socioeconomic data with identified dental services.

Population distribution is also an important factor in planning the location of health services. The spatial distribution of the population and the location of healthcare services are related to key variables that generate information vital for decision-making in health-service planning. Thus, the authors performed a spatial join analysis to determine the total number of dental services in each subdivision of the district and they found that the maximum concentration of dental clinics was in Jaipur district, followed by Sangarner and Chomu. This suggests a maldistribution of dental services between urban and rural areas. Similar findings were reported in a 2019 study by Md Bohari NF et al., in Malaysia, which showed that dental services were unevenly distributed across the country, with people living in rural areas and on isolated islands of Malaysian Borneo lacking access to dental services despite high population density [42]. The present findings were also consistent with the study by Nayak PP et al., (2022) in Karnataka, which found that areas with higher per capita income, greater urbanisation and denser populations have more dental health services [41].

The current study demonstrates relatively straightforward methods to calculate accessibility and proximity measures in GIS as metrics for geographic access to dental services. Euclidean distance was used as a measure of accessibility to the dental services. A previous study by Chong S et al., (2015) in Australia used simple density metrics to capture variables of interest [43]. The findings suggest that travel time/distance is as important as geographical location in accessing healthcare centres. A similar study by Meeral P and Meignana Arumugham I (2023) in India also utilised a straight-line distance matrix to measure accessibility of dental services, wherein they found that most dental services were located in urban areas and that individuals in need of dental services had to travel long distances to receive treatment [44].

A study by Lwasa S (2008) in Uganda stated that health infrastructure for rural and urban populations should be built in various administrative units within a 2-km radius [45]. Nayak PP et al., (2022) conducted a similar study in Karnataka to identify accessibility to oral healthcare, wherein circular buffers were created around dental services using heat maps/density maps. Thus, the authors adopted a similar study design and created circular zones/buffers around the dental services to assess accessibility up to 5, 10 and 15 km [41]. Using network analysis with origin-destination cost functions in ArcGIS indicated that dental services located in Jamwa Ramgarh, Shahpura and Bassi were highly inaccessible within 5, 10 and 15 km. These findings were similar to Shiikha Y et al., who created similar buffer zones around dental services to assess accessibility [38]. Another study by Okumu BA et al., in Kenya identified this urban-rural disparity using buffer analysis and found that the majority of the population did not have access to dental services within a 20-km radius [46]. However, the findings of Huang

Z et al., were contrary to the present study, as they used spatial autocorrelation analysis rather than buffer analysis to determine geographic accessibility of dental services around the municipal areas of Tokyo, Osaka and Nagoya [47].

Lastly, to determine whether the clustered pattern of dental services was due to random chance, an average nearest neighbour summary report was generated. If the average distance is less than that for a hypothetical random distribution, the distribution of the features being analysed is considered clustered. If the average distance is greater than that for a hypothetical random distribution, the features are considered dispersed. Thus, the present study indicates a clustered distribution of dental services in the Jaipur district. It shows a z-score of -35.28, indicating less than 1% probability that the clustered pattern is the result of random chance.

A study by Bostanci B et al., (2024) also supported these findings, wherein they used the average nearest neighbour summary report to assess periodontal disease prevalence in a community and found clustering in patient distribution [48]. These findings suggest maldistribution of the dental workforce, particularly in less urbanised and poorly inhabited regions, ultimately leading to an increase in the prevalence of oral diseases in inaccessible areas. Thus, local health planners in Jaipur should prioritise these areas in future dental health-service expansion plans.

Using GIS, health planners can identify areas of the city with poor accessibility to hospitals and accordingly, decisions regarding improving hospital accessibility can be made easily and quickly. Based on the analysis results, this study recommends increasing health services in subdivisions such as Jamwa Ramgarh, Shahpura, Dudu, Phagi, Chaksu and Viratnagar to cover existing underserved areas, because this can support health planners in evaluating and monitoring changes in health supply and demand and help define the spatial impacts of any proposed health policy. Specific services and provisions should be made for dentists willing to serve in rural areas.

A strength of the present study is that the spatial analysis was conducted at the smallest unit of statistical data available, making the findings more relevant to the local area. Geographic access to general practices was measured using Euclidean distance, providing an overview of the study area while disregarding actual road travel distances. Such analyses are increasingly feasible as travel-route applications are developed and refined within GIS software. In sum, the present study contributes to building bridges among health policy, dentistry and medical geography and among communities and this approach might be considered in future examinations of dental access.

Limitation(s)

However, there are some limitations regarding the methods of the present research. The present study was retrospective in nature, so the authors were limited in terms of data collection. A large amount of time was spent geocoding the records due to errors and inconsistencies in the dental service addresses. Some records could not be geocoded, as they either did not have a dental service address or had incomplete addresses and were thus excluded from the analysis. The present study undertook extensive efforts to compile a database of all dental services in Jaipur district up to 2019; however, this database may be inadequate for the present year, as many clinics have been established since then. Also, population data from the 2011 census were not available due to the Coronavirus Disease-2019 (COVID-19) outbreak, so the 2021 census data were used. This may overestimate dental services relative to the overlay population. Future research could incorporate additional variables such as socioeconomic status, number of dentists, dentist-to-population ratios, dental diseases (e.g., dental caries or periodontal diseases) and school or mobile dental services, along with population needs.

CONCLUSION(S)

There was a strong rural-urban difference in population distribution and in the location of dental services. This demonstrates wide variation in the supply of dentists across communities in Jaipur subdivision. In the present study, the majority of dental services were provided by the private sector (95.14%), with only a small number in the public sector (4.85%). Population distribution indicates concentration in areas such as Jaipur subdivision, followed by Amer and Dudu. Spatial join analysis indicated that the maximum density of dental clinics was in Jaipur district, followed by Sanganer and Chomu, while very few clinics were found in Dudu and Jamwa Ramgarh. No dental services were present in Viratnagar. Network analysis indicated that dental services located in Jamwa Ramgarh, Shahpura and Bassi were highly inaccessible within 5, 10 and 15 km. The average nearest neighbour summary indicates a clustered distribution of dental services in the Jaipur district, with a z-score of -35.28, indicating less than 1% probability that the pattern is due to random chance. Therefore, local health planners in the Jaipur district should allocate dental services to the underserved areas identified by the present study.

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