

Spatial Analysis of Health and Medical Infrastructure in Ajmer City with a Viewpoint of Smart city

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ABSTRACT

This study is about analyzing medical infrastructure of Ajmer city through GIS. GIS and related spatial analysis methods provided set of tools to describe and understand the spatial organization of health care and examining its relationship to health access and how it can be improved. Short –path analysis has been used on ward boundary of the city and accident hotspots to examine the spatial arrangement and accessibility in extreme circumstances, also use of HTML to create a webpage which manifest the spatial arrangement and utilities related to health infrastructure. **Keywords:** GIS; Medical infrastructure; accessibility; Short path analysis; HTML

INTRODUCTION

Health Information System is a term describing the acquiring, storing, retrieving and using of healthcare information to foster better collaboration among a patient's various healthcare providers. Health Informatics plays a critical role in the push toward healthcare reform. Health informatics is an evolving specialization that links information technology, communications and healthcare to improve the quality and safety of patient care [1].

In our country Health is a primary human right and has been accorded due importance by the Constitution through Article 21.Though Article 21 stresses upon state governments to safeguard the health and nutritional wellbeing of the people, the central government also plays an active role in the sector [2].

Recognizing the critical role played by the Health Industry, the industry has been conferred with the infrastructure status under section 10(23G) of the Income Act [3].

The healthcare sector is one of the most challenging and fastest growing sectors in India. Revenues from the healthcare sector account for 5.2 per cent of the GDP, making it the third largest growth segment in India [4].

The Indian Health sector consists of:

- Medical care providers like physicians, specialist clinics, nursing homes, hospitals.
- Diagnostic service centres and pathology laboratories.
- Medical equipment manufacturers.
- Contract research organizations (CRO's), pharmaceutical manufacturers.
- Third party support service providers (catering, laundry).

The healthcare industry in the country, which comprises hospital and allied sectors, is projected to grow 23 per cent per annum. The Indian healthcare sector, including

Pharmaceutical, diagnostics and hospital services, is expected to more than double its revenues to Rs 2000 billion by 2010. Expenditure on healthcare services, including diagnostics, hospital occupancy and outpatient consulting, the largest component of this spend is expected to grow more than 125% to Rs 1560 billion by 2012 from Rs 690 billion now [5].

Healthcare facilities, inclusive of public and private hospitals, the core sector, around which the healthcare sector is cantered, would continue to contribute over 70 per cent of the total sector and touch a figure of US\$ 54.7 billion by 2012. Adds a FICCI-Ernst and Young report, India needs an investment of US\$ 14.4 billion in the healthcare sector by 2025, to increase its bed density to at least two per thousand populations [6].

Technological advances achieved by Medicare globally in the recent years have been phenomenal. The Indian scenario has not

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remained immune to these changes. While IT (information technology) has come to the aid of the breakthroughs, the progress recorded in the Medicare area is as impressive as it is in the IT sector itself. The changes are in concepts, forms and content, as well as applications. These are both, quantitative and qualitative [7].

The transformation is pervasive and has penetrated almost all specialties, from diagnostics to physiotherapy, from cardiology to oncology, from non-invasive surgery to transplants. In India, the emergence of private Medicare services, especially through commercialization and corporatization, has contributed to the transformation. The rapid commercialization of the medical practices with the establishment of multi-million rupee hospitals, nursing homes and diagnostic centers, specialized and general, the demand has registered a very high growth rate in the recent years [8].

Types of Healthcare Service Providers:

- Hospital
- Government Hospitals
- Private Hospitals
- General hospitals
- Specialised hospitals
- Dispensaries
- Clinics
- Nursing homes
- Diagnostics centres
- Blood banks
- Ambulance services.

Shortest Path Analysis

The best route or the route of least impedance between two or more points, taking into account connectivity and travel restrictions such as one-way streets and rush-hour traffic [9].

According to the network being analyzed, the shortest path has a variety of measurements, such as time, to find the path. The problem with determining the shortest path, however, is to find both the fastest and the shortest path. Thus, research in the shortest path always has been a point of interest in graph theory.

DATA AND METHODOLOGY

Study Area

Ajmer city is the part of Ajmer district. The Ajmer district is situated between 25°38' & 25°58'North latitudes and 73°54' & 75°22' East longitudes. It is covering a geographical area of 8,481 sq km. Ajmer division which is further sub-divided into 4 sub-divisions namely Ajmer, Beawar, Kekri & Kishangarh & comprise of six tehsils and eight blocks. Population of Ajmer District is around 25, 83,035.Population growth rate of the district is 16.40% since 2011 [10,11].

The Ajmer city has got a good accessibility by road. It is well connected by National Highways NH-8 or NH-79 and State Highways making all the important places of the district easily accessible. The main railway station is Ajmer junction which is spread over an area of 8,481 sq. Km's and is bounded by Nagaur

district to the north, Jaipur and Tonk district to the east, Bhilwara district to the south and Pali district to the east [12].

A part, from the National highway and State highway, the study area has a good road and rail network which connects the city to the all major cities of the country and the capital of the state and the country as well. Ajmer city has specialized hospitals as Cardiology, Cancer, TB etc [13].



Data used

To delineate the healthcare facilities of Ajmer city, some materials and methodology are prepared utilizing Remote sensing, field studies, Google Earth imagery, Survey of India Toposheet (SOI), and Geographical Information System (GIS).

Transportation network was digitized using Google Earth imagery and field data was collected using GPS (global positioning system). Various reference data /Primary data such as demographic data and healthcare infrastructure details, accident hotspots was collected from respective administrative offices.

Every application success or its completion is depends on well programmed and integrated approach of the reliable methodology for data collection, carrying out field survey, identification, selection and evaluation of results. In this particular project it has been completed in five phases [14].

- Data Collection
- Digital image processing
- Data integration with GIS
- Date interpretation and analysis
- Results.



Integration with GIS: After preprocessing, combining data of the different type and from different sources is the pinnacle of data integration and analysis.

In a digital environment, where all the data sources are geometrically registered to a common geographic base, the potential for information extraction is extremely wide.

The integration with GIS allows a synergistic processing of multisource spatial data [15].

The integration of the two technologies creates a synergy in which the GIS improves the ability to extract information from remotely sensed data, and remote sensing in turn keeps the GIS up-to-date with actual environment information.

As a result, large amount of spatial data can now be integrated and analysis. This is allowing for better understanding of environmental process and better insight into the effect of human activities.

Land cover" is distinct from "land use", despite the two terms often being used interchangeably. Land use is a description of how people utilize the land and of socio-economic activity.

Urban and agricultural land uses are two of the most commonly known land use classes.

At any one point or place, there may be multiple and alternate land uses, the specification of which may have a political dimension [16].



Figure 2: LULC Map of Ajmer City

Ward Map - "Ward is a division of the city, as for administrative or political purpose." A ward map shows the ward boundary of the city and there location. Award map can be used in many purposes according to the need of the study [17].

There are total 60 wards under the aimer municipality. At the time of 2011 census there were only 55 wards.

Population Density Map Population density is the number of people living per unit of an area (e.g. per square kilometer.

A population density map shows the density of population in the specific area.

We were calculating the population density of the ajmer city with census data of year 2011.

For this we used the ward boundary of 55 wards of ajmer city because 60 wards were formed in 2015 and there were no census data available for year 2015 or 2016 [18].

- Total area under Ajmer municipality is 81.70427²km.
- Total population of Ajmer city is 54231 people.

Ward wise population density can be studied in shown map.





Figure 3: Ward Wise population of Ajmer City

ANALYSIS & RESULT

Healthcare Facility Centers

Healthcare facility centers are crucial in the study of health and medical facilities.

For analyzing the health care facilities of Ajmer city we need to look the number of centers available in the city.

Table 1: List of Healthcare facilities in Ajmer city

	Categories	Total
1	Government Hospitals	11
2	Dispensaries	13
3	Private hospitals	47
4	E, N, T & Dental hospitals	11
5	Clinics &Nursing homes	12
6	Diagnostic Centres	16
7	Blood Banks	4

Government Hospitals: 11 hospitals are the main government hospitals in which specialized hospitals are included. Government hospitals with their categories are shown in the following table.

	Name	
1	Jawahar lal Nehru Hospital	
2	Janana Hospital	
3	Cancer Hospital	
4	JLN Cardiology Hospital	
5	Govt. T.B. Hospital	
6	РМО	
7	New Satellite Hospital	
8	ESI Hospital	
9	North Western Divisional Railway Hospital	
10	Railway Hospital	
11	Composite Hospital CRPF	

Table 2: List of Government Hospitals in Ajmer city

Dispensaries: The administration of the has tried to provide health care facilities in different areas of the city for that they setup some dispensaries with basic facilities and at least 1 MBBS doctor in every dispensary. Dispensaries of Ajmer city are listed below.

Table 3: List of Dispensaries in Ajmer city

	Name
1	Ajay Nagar
2	Anderkot
3	Diggi Bazar
4	Gulab bari
5	Gadi Maliyan
6	Kasturba
7	Police Line
8	Ramganj
9	Ram Nagar
10	Shrinagar Road
11	Panchsheel
12	Pahadganj
13	Vaishali Nagar

Private Hospitals: Everywhere in the world private sector is covering more than 65% of the health care facilities so it is also an important part of this study. There are total 46 private hospitals in the city which are the following.

Table 4: List of Private Hospitals in Ajmer city

	Name	
1	K S Hospital	
2	Ajmer Hospital	
3	Anita Children Hospital	
4	Bachpan Hospital	
5	Bharat Hospital	
6	Chandak Hospital	
7	Chaudhary Hospital	
8	Choelerry Hospital	
9	City Hospital	
10	Deepmala Pagarani Hospital	
11	Deevya Hospital	
12	DR. Ashok Mehrada Skin Care Clinic	
13	Gattani Hospital	
14	Getwell Hospital and Maternity Home	
15	Hada Hospital	
16	Holy Family Hospital	
17	Jeevan jyoti Hospital	
18	Kamla Nehru Demonstration Hospital	
19	Kamlesh Memorial	
20	Kshetrapal Hospital Multispeciality & Research Centre	
21	Longia Ayurvedic Hospital	
22	Malik Hospital	
23	MAVEN'S Hospital	
24	Mewar Hospital	

25	Mittal Hospital & research Centre	
26	Navjeevan Hospital & Research Centre	
27	Old Mittal Hospital	
28	Parihar Hospital & Fertility Centre	
29	Patanjali Chikitsalay	
30	Pratap memorial Hospital & Research Center	
31	R G hospital	
32	R.K. Hospital	
33	Rajasthan Hospital	
34	Rawal Hospital	
35	Sant Memorial Hospital	
36	Sant Sukharam Memorial Hospita (SRM)	
37	Sharma Hospital and Diagnostic Centre	
38	Shree Rana Hospital & Chartable Medical Institute	
39	Shubham Hospital	
40	Shulepan Hospital	
41	St. Francis Hospital	
42	Sushila Devi Hospital	
43	T J Mayani Hospital	
44	The Ayurvedic Hospital	
45	Vaishali Hospital	
46	Sewa Mandir Foundation(Homoeopathic Inst. & Research centre)	

ENT and Dental Hospitals: There are total 11 Eye, Nose, and Throat & Dental Specialized Hospitals in Ajmer city all of those are listed below.

Table 5: List of ENT & Dental Hospitals in Ajmer city

	Name
1	Balanis Eye Hospital

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2	Choudhary Dental Hospital & Orthodontic Centre	
3	Dr Gowd Eye Hospital	
4	Dubey Eye Hospital	
5	G K Dental clinic	
6	Khunger Eye Hospital	
7	Kothari Eye Hospital	
8	Kshetrapal Eye Hospital & Lasik Laser Centre	
9	Shri Eye Hospital	
10	Tela Dental Clinic	
11	Tooth Spot Dental Hospital and Orthodontic Centre	

Clinics & Nursing Homes: There are total 12 Clinics and Nursing Homes providing there facilities to the people of ajmer city. All the 12 Clinics & Nursing homes are following.

Table 6: List of Clinics & Nursing homes in Ajmer city

	Name
1	Chandak Nursing Home
2	City Dispensary
3	Dr. Nandlal Clinic
4	Garg Medicare Centre
5	Goor Mental Health Clinic
6	Kiran Nursing Home
7	Mehra Clinic & Dispensary
8	Parivar Seva Clinic
9	Porwal Clinic
10	Sharda Nursing Home
11	Shri Sai Clinic
12	St. Francis Nursing Home

Diagnostic Centers: Diagnostic centers anywhere can be finding in the supporting role of health care facilities. In the Ajmer city many healthcare centers have their diagnostic centers too but there are 16 separate diagnostic centers available for people of Ajmer.

Table 7: List of Diagnostic Centers

	Name	
1	Agarwal Clinic and Diagnostic Centre	
2	Baba Diagnostic Center	
3	Bhargava Sonography Centre	
4	Dayal Veena Charitable Diagnostic and Research Centre	
5	Diagnostic Centre	
6	Diwani Labs	
7	Dr. Manghani's Clinic and Diagnostic Centre	
8	Get Well X-Ray's and Diagnostics	
9	Goyal Sonography Centre	
10	Lifeline Diagnostic Centre	
11	Mediscan Sonography and Diagnostic Centre	
12	Patel Diagnostic Center	
13	Prabhu Diagnostic and Research Centre	
14	Shree Rana CT Scan & Diagnostic Centre	
15	Shri Diagnostic Centre	
16	Sigma Diagnostic and research Centre	

Blood banks:

Table 8: List of Blood Bank in Ajmer city

	Name
1	Jawahar lal Nehru Hospital
2	Janana Hospital
3	North Western Divisional Railway
4	Mittal Hospital & research Centre



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Figure 4: Maps of Health utilities and services in Ajmer- a) Government Hospitals, b) Private Hospitals, c) ENT and Dental Clinics, d) Nursing Homes, e) Diagnostic Centers, f) Blood Banks.

Healthcare Facilities Centers Ward Wise



Graph 1: Ward Wise Health Care Facilities Centers Table 9: Ward wise health facilities in Ajmer city

Ward No.	Private Sector	Government Sector
1	2	0
2	0	0
3	3	1
4	0	0
5	0	0
6	1	0
7	0	0
8	2	0
9	0	0
10	0	0
11	0	0
12	1	0
13	0	0
14	1	1
15	1	0
16	0	0
17	0	0
18	0	0

19	0	3
20	4	0
21	0	0
22	3	0
23	0	0
24	0	0
25	0	0
26	0	0
27	0	0
28	2	1
29	0	1
30	0	0
31	0	0
32	0	0
33	2	0
34	0	0
35	2	1
36	0	0
37	1	0
38	0	0
39	0	0
40	0	1
41	0	0
42	1	0
43	1	0
44	2	1
45	2	1
46	0	0
47	0	0
48	3	0
49	1	0
50	1	1

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51	5	3
52	2	3
53	0	0
54	9	2
55	2	1
56	3	0
57	7	0
58	2	1
59	0	0
60	0	0

In Ajmer city, there are 15 wards where Govt. HCC's are available and rest 45 wards are devoid of government facilities in healthcare sector.

Stats are little good in the case of private sector, covering 27 wards of the city.

The most important thing is that, there are 30 wards in the city which are completely devoid of healthcare facilities ,no Government or private healthcare facility is available , these 30 wards are as follows- Ward no. 2, 4, 5, 7, 9, 10, 11, 13, 16, 17, 18, 21, 23, 24, 25, 26, 27, 30, 31, 32, 34, 36, 38, 39, 41, 46, 47, 53, 59, 60.

After the analysis, it is concluded that facilities are not equally distributed throughout the city and covers only 50% administrative area of the city.

Many of these wards which don't have any healthcare facility available are situated at the periphery of the city, either along the National Highways or another busy routes / risk zones; they don't even have primary healthcare facility.

Ward no. 1, 2, 23, 25, 26, 27, 39, 41, 42, 46, 47, 59, 60 need more proximate facilities.

There are many wards which does not have any health care center but have closer accessibility to the wards with such utilities but in order to make it a smart city, the administration need to develop centers and facilities covering all the wards.



Figure 5: Maps of Health utilities and services in Ajmer- a) Government Hospitals, b) Private Hospitals, c) ENT and Dental Clinics, d) Nursing Homes, e) Diagnostic Centers, f) Blood Banks.

Role of govt. & private sector in health care facilities

As we see before there is major role of private sector in providing health care facilities to the public which is more than 65% according to the World Health Organization. In Ajmer city it is 9% more than the average figure for the world. 75% HCC's are under private sector and only 26% participation of the Government sector. Which tells the different story of Health Care facilities Centers in Ajmer city?

As we see the 50% wards are not have the Healthcare centers here the major reason behind that is exposed that is the only 26% participation of the government sector in health sector.

We analyzed the role of private sector in providing health care facilities but this sector is working with their primary aim of earning so we cannot blame this sector for the unequal distribution of the HCFC's. So basically role of government sector is main thing.



Chart 1: Role of Government & Private Sector in Health Care Facilities

The government sector has only 24 Hospitals and Dispensaries in different wards but it doesn't mean it covers 24 wards of the city these all 24 centers are situated in only 15 wards.

It means government sector is covering only 15 wards.

Know the question is all these 24 govt. Centers are located at appropriate place or not.

All major hospitals like JLN & its specialized units are closer to each other like JLN hospital, JLN Cardiology, JLN Cancer Hospital, TB hospital, & there is ESI dispensary is also there in the same location. All of these are located in ward no. 51 & 54. But these center's covers the whole city, district & nearby districts.

Let's see the ward wise locations of the all 13 dispensaries.

	Table 11:	Ward	Wise	dispe	ensaries	in A	Ajmer	city
--	-----------	------	------	-------	----------	------	-------	------

Sr. No.	Name	Ward No.
1	Ajay Nagar	19
2	Anderkot	52
3	Diggi Bazar	52
4	Gadi Maliyan	29
5	Gulab bari	40
6	Kasturba	52
7	Pahadganj	14
8	Panchsheel	58
9	Police Line	50
10	Ram Nagar	3
11	Ramganj	19
12	Shrinagar Road	44

13	Vaishali Nagar	56	

Out of these 13 dispensaries 3 are in ward no. 52 and 2 dispensaries are situated in ward no. 19 which is closer enough. So this analysis says the exact story which is lack of management by government.

Population V/S Health Care Facility Centre's

According to the 2011 census total population of the city is 5, 42, and 321. Total 93 HCC's are providing facilities to the people of the city.

The ratio of people and HCC's is 5, 42, and 321: 93

That means 1 HCC is serving 5831 people of the city



Figure 6: Map of Ward wise health care facilities.

Accidental Zones

The Police department marked 29accidental zones in the aimer urban area out of those 25 zones are in the aimer municipal boundary.

All accidental zones, there location addresses and their nearest 108 ambulance locations are the shown in the following table.

Table 12: Accidental zones of Ajmer city

Sr. No.	Name	Location	Nearest Ambulance
1	9 No. Petrol Pump	Nasirabad Road,ajmer	Alwargate
2	AgraGate Circle	Agragate	Kotwali

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3	Badlya Circle	Shrinagar Road,ajmer	Adarshnagar
4	BajrangGarh Circle	Near Daulat Bagh,ajmer	Kotwali
5	Bata Showroom	Kaiserganj,ajme r	Clock Tower
6	C.R.P.F. Bridge	Bus stand Road,ajmer	Alwargate
7	Central Jail Circle	Near Central Jail,ajmer	Civillines
8	Churi Bazar Tiraha	ChuriBazar,ajm er	Kotwali
9	G.C.A Circle	Near Govt. College Ajmer	Clock Tower
10	Gandhi Bhawan Circle	Gandhi Bhawan Circle,ajmer	Kotwali
11	Ghughra Ghati	Ghughra Ghati,ajmer	Civillines
12	India Motor Circle	Topdara,ajmer	Topdara,ajmer
13	Johnsganj Circle	Beawer Road,ajmer	Ramganj
14	Kaiserganj Circle	Kaiserganj,Ajm er	Clock Tower
15	King Edward Memorial	Railway Station Road,Ajmer	Clock Tower
16	Makadwali Road Tiraha	Vaishali Nagar,ajmer	ChirstianGanj
17	Martinal Bridge	Martinal Bridge,Ajmer	Clock Tower
18	Nagra	Nasirabaad Road,ajmer	Alwargate
19	Nareli Byepass	Jaipur Road, ajmer	Alwargate
20	Palra Tiraha	Palra,ajmer	Adarshnagar
21	Parbatpura Circle	Parbatpura,ajm er	Adarshnagar
22	Police Superintendent Office	Karkriya,ajmer	Civillines
23	Purani ChungiChoki	Beawer Road,ajmer	Ramganj

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24	Ramganj Bazar	Beawer Road,ajmer	Ramganj
25	Regional College Tiraha	Near Regional College	ChirstianGanj
26	Rodways Bus Stand Circle	Rodways Bus Stand Circle	Civillines
27	Savitri College Tiraha	Near Savitri College	ChirstianGanj
28	Session Court Tiraha	Session Court,ajmer	Civillines
29	University Tiraha	University Road,ajmer	Civillines

Out of these 29 accidental zones only 3 (Palra tiraha, Badlya Choraha, & Nareli Bypass) are outside of the ajmer city area. But these all 3 zones gets the 108 ambulance service in any emergency case from the city. Palra tiraha & Badlya Choraha gets the ambulance from Adarsh Nagar police station and Nareli bypass gets 108 services from Alwar gate police station.

Here we generate the shortest path from every accidental zone to the Jawahar lal Nehru hospital. For this we given speed limit attribute to every Road of the city rest of streets according to their location, size and quality.



Figure 7: Map of Accidentl zones in Ajmer City

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Figure 8: Map of Ambulane Locations in Ajmer City

Shortest path analysis for ambulances from accidental zones to JLN hospital

This analysis gives the shortest path between two points. There is two types of this analysis first is according to the shortest length of the route and the second is according to the shortest time. We prefer the shortest time algorithm in our analysis because we have to perform this for any one's life.





Figure 9: Map of Ambulance Locations in Ajmer City

RECOMMENDATIONS

After analyzing the health care facilities of Ajmer city we have some recommendations for its improvement, better planning.

- Need more participation from Government sector in the health sector mainly in that area which are situated at periphery of the city.
- City needs more dispensaries in outer wards and for making it a Smart City it needs more and more healthcare centres in proximity.
- Administration has to control the clustering of health care centres mainly of private sector which is concentrated mainly at 3 points of the city and at major roads.
- The city is spreading out so with the spread of the city administration have to develop the health care facilities in the newly develop areas.
- With developing of the infrastructure there is the basic need that is hygiene.
- Government needs to check infrastructure of all the health care centres is it according to their norms or not. At least height of the ramp, receptions in the basement, doctors and rooms are in the basement, waiting rooms are not enough which is intolerable.
- Easy approach is also a requirement for a smart city so the city administration has to invite private sector in transportation services and develop their own too.
- For a smart city public health figures are very important to make plans and for the health of the city & quality of life too. So government should form a department to monitor all health care facilities centres, or bound all the government and private health care centres to report at the appropriate department.
- Off course CMHO is there in the city but all the HCFC's are not reporting them even they are covering limited government hospitals.
- City needs appropriate plans for developing healthcare sector an.
- Ajmer city needs a place where people can get all the information about the city officially. For this city administration should develop a Web page & an Android app with all the information.
- We hope for the batter planned development of the Ajmer city as a Smart City by government organisations.

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