

Medical Tourism: Clustering hospitals based on the neighborhood characteristics

Background/Problem Definition

The push for international standardization of hospitals has enabled quality healthcare facilities across the globe. The rising healthcare costs is pushing people across the globe to look for cheaper alternatives for medical treatment without compromise on the healthcare service quality. This need has created a new tourism market known as medical tourism. In many cases, patient has to go to different countries for availing medical treatment. In such scenario, they may be accompanied by a carer or attendant when traveling across the country.

The length of stay in the hospital could vary from few days to few weeks based on the medical requirements. In case of long stay, it may be important for patient and carer to select hospital which may be present in the neighborhood that may more closely reflect their native place facilities. However, no such facility is available that could cluster the relevant hospitals based on their neighborhood. Hence, this study focuses on developing algorithm to cluster the hospital based on their neighborhood characteristics. Such geographical characterisation of medically at par hospitals would allow more customized healthcare facility options to patients and would help in providing better services to the patient.

Data

In order to solve the above problem of clustering the hospitals based on their neighborhood characteristics. The following data is needed:

1. Name of the Hospital
2. Address of the Hospital
3. Popular venues in the hospital locality

This study focused only on Indian hospitals. The data regarding the name and address of the hospital is obtained from the following website:

- <https://www.treatmenttraveller.com/top-hospitals-in-India-2018>

This website is selected because it maintains the list of top hospitals in India that are suitable for medical tourism. The study extracts the following information namely name of hospital and address of the hospital from the website using the web scraping facility provided by the *Beautifulsoup* package in Python. The data is processed and formatted to provide a sample dataframe as shown below:

Hospital_Name	Address
Medanta Hospital	Sector 38, Gurugram, Haryana
Apollo Hospital	Jubilee Hills, Hyderabad, Telangana
Rabindranath Tagore International Institute of Cardiac Sciences	Mukundapur, Kolkata, West Bengal
Narayana Health	Hsr Layout, Bengaluru, Karnataka
Continental Hospital	Gachibowli, Hyderabad, Telangana

The abovementioned dataframe containing hospitals is used for extracting the data regarding the popular venues. The major characteristics extracted regarding popular venues are namely name of venue, latitude and longitude of venue and category of venue. The Foursquare is one of the websites that maintains such data regarding the venues or facilities present in an area. Their API could extract the popular facilities in the area with its characteristics. Hence in study, the data regarding popular venues in an area with its desired characteristics is obtained from following website:

- <https://www.foursquare.com>

The foursquare API needs the latitude and longitude of the point around which the venues are searched. Hence, the latitude and longitude of the area in which the hospitals were present was extracted using the *geopy* package available in the Python. The resulting sample dataframe is as shown below:

	Hospital_Name	Address	Latitude	Longitude
0	Medanta Hospital	Sector 38, Gurugram, Haryana	28.4351	77.0404
1	Apollo Hospital	Jubilee Hills, Hyderabad, Telangana	17.4308	78.4103
2	Rabindranath Tagore International Institute of Cardiac Sciences	Mukundapur, Kolkata, West Bengal	22.4956	88.3984
3	Narayana Health	Hsr Layout, Bengaluru, Karnataka	12.9127	77.638
4	Continental Hospital	Gachibowli, Hyderabad, Telangana	17.4436	78.352

The extracted data of venues in the hospital locality is used to segment and cluster the hospitals in India. This will help in identifying the similarities and dissimilarities between different localities. These clusters will help any potential patient to select hospital based on its preferred locality characteristics.

Methodology

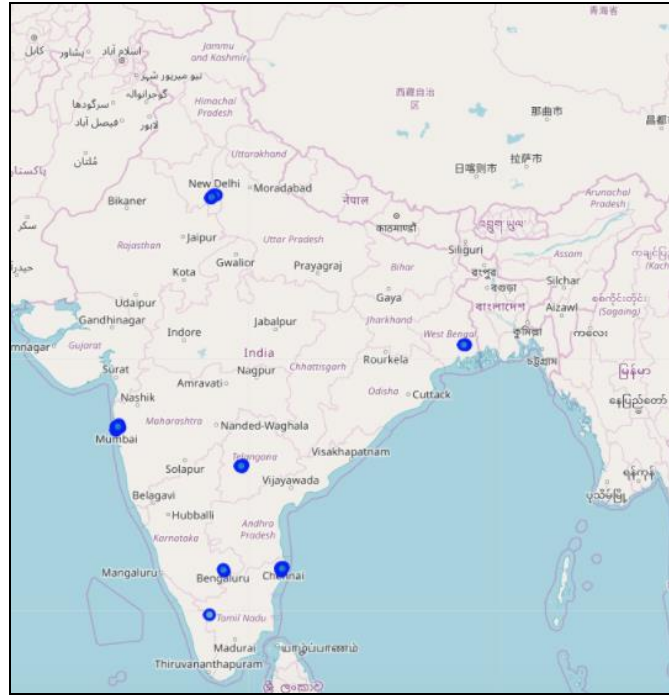
The hospital data collected from website (<https://www.treatmenttraveller.com/top-hospitals-in-India-2018>) with latitudes and longitudes obtained using the geopy package from Open Street Map is used for the analysis. The list initially consisted of 67 hospitals from which 32 hospitals are used for final analysis. The selection criteria adopted was:

1. Multispeciality hospitals
2. Locality latitude and longitudes were available from Open Street Map

The sample of final dataframe used for the study is as follows:

	Hospital_Name	Address	Latitude	Longitude
0	Medanta Hospital	Sector 38, Gurugram, Haryana	28.4351	77.0404
1	Apollo Hospital	Jubilee Hills, Hyderabad, Telangana	17.4308	78.4103
2	Rabindranath Tagore International Institute of Cardiac Sciences	Mukundapur, Kolkata, West Bengal	22.4956	88.3984
3	Narayana Health	Hsr Layout, Bengaluru, Karnataka	12.9127	77.638
4	Continental Hospital	Gachibowli, Hyderabad, Telangana	17.4436	78.352

The *folium* package is used to visualize the position of these hospitals in the country.



The foursquare API is used to call and search for 100 most popular venues within the radius of 10 km for each hospital locality and venues result is extracted and converted into dataframe. A sample of final dataframe is shown below.

The unique categories representing these venues were found to be 181. Then, for each hospital, 10 most popular categories are determined and prepared into dataframe as shown below.

	Neighborhood	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue	10th Most Common Venue
0	Apollo Hospital, Chennai, Tamil Nadu	Indian Restaurant	Hotel	Ice Cream Shop	Juice Bar	Café	Sandwich Place	BBQ Joint	Multiplex	Coffee Shop	Vegetarian / Vegan Restaurant
1	Apollo Hospital, Hyderabad, Telangana	Indian Restaurant	Bakery	Ice Cream Shop	Hotel	Café	Restaurant	Italian Restaurant	Lounge	BBQ Joint	Coffee Shop
2	Artemis Hospital, Gurugram, Haryana	Indian Restaurant	Hotel	Brewery	Café	Coffee Shop	Bakery	Bar	American Restaurant	Restaurant	Sandwich Place
3	Bombay Hospital, Mumbai, Maharashtra	Indian Restaurant	Café	Ice Cream Shop	Fast Food Restaurant	Hotel	Scenic Lookout	History Museum	Japanese Restaurant	Juice Bar	Diner
4	Continental Hospital, Hyderabad, Telangana	Hotel	Indian Restaurant	Restaurant	Ice Cream Shop	Italian Restaurant	Lounge	Coffee Shop	Café	BBQ Joint	Bakery
5	Dr. Balabhai Nanavati Hospital, Mumbai, Maharashtra	Indian Restaurant	Hotel	Café	Coffee Shop	Ice Cream Shop	Dessert Shop	Bar	Seafood Restaurant	Pub	Lounge
6	Dr. L H Hiranandani Hospital, Mumbai, Maharashtra	Indian Restaurant	Hotel	Coffee Shop	Ice Cream Shop	Dessert Shop	Bakery	Seafood Restaurant	Restaurant	Asian Restaurant	Italian Restaurant
7	Fortis Flt. Lt. Rajan Dhall Hospital, New Delhi, Delhi	Hotel	Indian Restaurant	Italian Restaurant	Coffee Shop	Shopping Mall	Café	American Restaurant	Chinese Restaurant	Asian Restaurant	Thai Restaurant
8	Fortis Hospital, Kolkata, West Bengal	Hotel	Café	Mughlai Restaurant	Chinese Restaurant	Shopping Mall	Indian Restaurant	Italian Restaurant	Dhaba	Multiplex	Indian Sweet Shop
9	Fortis Hospital, Mumbai, Maharashtra	Indian Restaurant	Multiplex	Dessert Shop	Pub	Coffee Shop	Café	Donut Shop	Shopping Mall	Snack Place	Department Store

10	Fortis Malar Hospital, Chennai, Tamil Nadu	Hotel	Indian Restaurant	Café	Beach	Ice Cream Shop	Juice Bar	Italian Restaurant	Vegetarian / Vegan Restaurant	Burger Joint	Restaurant
11	Fortis Memorial Research Institute, Gurugram, Haryana	Indian Restaurant	Hotel	Brewery	Café	Coffee Shop	Bakery	Bar	American Restaurant	Restaurant	Sandwich Place
12	GEM Hospital, Coimbatore, Tamil Nadu	Indian Restaurant	Ice Cream Shop	Fast Food Restaurant	Café	Burger Joint	Shopping Mall	Hotel	Restaurant	South Indian Restaurant	Italian Restaurant
13	Global Hospital, Chennai, Tamil Nadu	Indian Restaurant	Pizza Place	Multiplex	Fast Food Restaurant	Coffee Shop	Sandwich Place	Hotel	Café	Clothing Store	Donut Shop
14	Global Hospital, Hyderabad, Telangana	Indian Restaurant	Bakery	Hotel	Ice Cream Shop	Coffee Shop	Multiplex	Café	Diner	Restaurant	Asian Restaurant
15	HCG Hospital, Bengaluru, Karnataka	Indian Restaurant	Hotel	Pub	Bakery	Brewery	Ice Cream Shop	Lounge	Burger Joint	Italian Restaurant	Dessert Shop
16	Indraprastha Apollo Hospital, New Delhi, Delhi	Indian Restaurant	Coffee Shop	Café	Hotel	Restaurant	Market	Shopping Mall	Italian Restaurant	Bakery	Stadium
17	Kohinoor Hospital, Mumbai, Maharashtra	Indian Restaurant	Hotel	Dessert Shop	Bar	Deli / Bodega	Coffee Shop	Bakery	Café	Seafood Restaurant	Snack Place
18	Kokilaben Dhirubhai Ambani Hospital, Mumbai, Maharashtra	Indian Restaurant	Café	Hotel	Ice Cream Shop	Bakery	Coffee Shop	Chinese Restaurant	Pub	Multiplex	Beach
19	LivLife Hospital, Hyderabad, Telangana	Indian Restaurant	Bakery	Ice Cream Shop	Hotel	Café	Restaurant	Italian Restaurant	Lounge	BBQ Joint	Coffee Shop
20	MGM Hospital, Navi Mumbai, Maharashtra	Indian Restaurant	Fast Food Restaurant	Café	Restaurant	Coffee Shop	Chinese Restaurant	Ice Cream Shop	Shopping Mall	Dessert Shop	Lounge
21	Madras Institute of	Indian	Hotel	Clothing	Ice Cream	Sandwich	Café	South	Italian	Coffee Shop	Chinese

	Orthopedics and Traumatology, Chennai, Tamil Nadu	Restaurant		Store	Shop	Place		Indian Restaurant	Restaurant		Restaurant
22	Max Hospital, New Delhi, Delhi	Coffee Shop	Café	Italian Restaurant	Indian Restaurant	Asian Restaurant	Shopping Mall	Market	Lounge	Clothing Store	Thai Restaurant
23	Medanta Hospital, Gurugram, Haryana	Indian Restaurant	Hotel	Brewery	Café	Coffee Shop	Bar	Bakery	Shopping Mall	American Restaurant	Sandwich Place
24	Narayana Health, Bengaluru, Karnataka	Ice Cream Shop	Indian Restaurant	Brewery	Café	Hotel	Pub	Burger Joint	Lounge	Breakfast Spot	Dessert Shop
25	Omega Hospital, Hyderabad, Telangana	Indian Restaurant	Bakery	Hotel	Ice Cream Shop	Coffee Shop	Café	Multiplex	Restaurant	Lounge	BBQ Joint
26	P.D. Hinduja National Hospital, Mumbai, Maharashtra	Indian Restaurant	Café	Bakery	Dessert Shop	Seafood Restaurant	Bar	Scenic Lookout	Lounge	Coffee Shop	Hotel
27	Rabindranath Tagore International Institute of Cardiac Sciences, Kolkata, West Bengal	Hotel	Café	Mughlai Restaurant	Chinese Restaurant	Multiplex	Coffee Shop	Shopping Mall	Italian Restaurant	Indian Sweet Shop	Indian Restaurant
28	S.L. Raheja (A fortis Associate) Hospital, Mumbai, Maharashtra	Indian Restaurant	Café	Bakery	Dessert Shop	Seafood Restaurant	Bar	Scenic Lookout	Lounge	Coffee Shop	Hotel
29	SIMS Hospital, Chennai, Tamil Nadu	Indian Restaurant	Hotel	Ice Cream Shop	Sandwich Place	Multiplex	Clothing Store	Café	BBQ Joint	Chinese Restaurant	Restaurant
30	The Calcutta Medical Research Institute, Kolkata, West Bengal	Café	Hotel	Mughlai Restaurant	Indian Restaurant	Chinese Restaurant	Multiplex	Indian Sweet Shop	Shopping Mall	Italian Restaurant	Dhaba
31	Yashoda Hospital, Hyderabad, Telangana	Indian Restaurant	Hotel	Bakery	Multiplex	Restaurant	Ice Cream Shop	Fast Food Restaurant	Café	Coffee Shop	BBQ Joint

These hospitals are now clustered using K-mean algorithm on the basis of their locality shared characteristics and features. The number of clusters chosen for the study is 3, which is derived by performing k optimization. The package used for the clustering is *sklearn.cluster* package from sci-kit library. The cluster labels are added into the dataframe and final dataframe obtained.

Results

The three clusters are derived from the analysis are shown in dataframe below. Cluster 0 consisted of 13 hospitals locality, Cluster 1 consisted of 12 hospitals locality and Cluster 2 consisted of seven hospitals locality.

	Hospital	latitude	longitude	Cluster Labels	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue	10th Most Common Venue
0	Medanta Hospital, Gurugram, Haryana	28.4351423	77.0403538	0	Indian Restaurant	Hotel	Brewery	Café	Coffee Shop	Bar	Bakery	Shopping Mall	American Restaurant	Sandwich Place
1	Apollo Hospital, Hyderabad, Telangana	17.4308362	78.4102882	0	Indian Restaurant	Bakery	Ice Cream Shop	Hotel	Café	Italian Restaurant	Restaurant	BBQ Joint	Lounge	Coffee Shop
2	Rabindranath Tagore International Institute of Cardiac Sciences, Kolkata, West Bengal	22.49562345	88.3984405	2	Hotel	Chinese Restaurant	Café	Mughlai Restaurant	Dhaba	Coffee Shop	Shopping Mall	Italian Restaurant	Indian Sweet Shop	Indian Restaurant
3	Narayana Health, Bengaluru, Karnataka	12.9127356	77.6380054	1	Ice Cream Shop	Indian Restaurant	Brewery	Café	Hotel	Pub	Burger Joint	Lounge	Breakfast Spot	Dessert Shop
4	Continental Hospital, Hyderabad, Telangana	17.4436222	78.3519638	1	Indian Restaurant	Hotel	Restaurant	Ice Cream Shop	Lounge	Coffee Shop	Café	Italian Restaurant	BBQ Joint	Bakery
5	Max Hospital,	28.5244107	77.2137253	1	Coffee Shop	Café	Italian Restaurant	Indian Restaurant	Asian Restaurant	Shopping Mall	Market	Lounge	Clothing Store	Thai Restaurant

	New Delhi, Delhi						nt	nt	nt					t
6	Fortis Flt. Lt. Rajan Dhall Hospital, New Delhi, Delhi	28.5292495	77.1541335	1	Hotel	Indian Restaurant	Italian Restaurant	Shopping Mall	Coffee Shop	Café	American Restaurant	Restaurant	Asian Restaurant	Thai Restaurant
7	Artemis Hospital, Gurugram, Haryana	28.4287011	77.0666877	2	Indian Restaurant	Hotel	Brewery	Café	Coffee Shop	Bar	Bakery	American Restaurant	Shopping Mall	Restaurant
8	Apollo Hospital, Chennai, Tamil Nadu	13.0884967	80.2783092	2	Indian Restaurant	Hotel	Ice Cream Shop	Juice Bar	Café	Sandwich Place	BBQ Joint	Multiplex	Coffee Shop	Vegetarian / Vegan Restaurant
9	Global Hospital, Chennai, Tamil Nadu	12.9050095	80.1968629	1	Indian Restaurant	Pizza Place	Multiplex	Fast Food Restaurant	Coffee Shop	Sandwich Place	Hotel	Café	Clothing Store	Donut Shop
10	Global Hospital, Hyderabad, Telangana	17.4038328	78.4635019	0	Indian Restaurant	Bakery	Hotel	Ice Cream Shop	Coffee Shop	Multiplex	Restaurant	Diner	Café	Asian Restaurant
11	Yashoda Hospital, Hyderabad, Telangana	17.4690889	78.5059176	2	Indian Restaurant	Hotel	Bakery	Multiplex	Ice Cream Shop	Restaurant	Hyderabad Restaurant	Coffee Shop	Chinese Restaurant	Fast Food Restaurant
12	Bombay Hospital, Mumbai, Maharashtra	18.9456157	72.8238162	0	Indian Restaurant	Café	Ice Cream Shop	Fast Food Restaurant	Hotel	Scenic Lookout	History Museum	Japanese Restaurant	Juice Bar	Lounge

1 3	S.L. Raheja (A fortis Associate) Hospital, Mumbai, Maharashtra	19.0423145	72.8398344	0	Indian Restaura nt	Café	Bakery	Dessert Shop	Seafood Restaura nt	Bar	Deli / Bodega	Lounge	Coffee Shop	Scenic Lookout
1 4	Dr. Balabhai Nanavati Hospital, Mumbai, Maharashtra	19.1038725	72.8402903	0	Indian Restaura nt	Hotel	Café	Coffee Shop	Ice Cream Shop	Dessert Shop	Bar	Lounge	Seafood Restauran t	Pub
1 5	P.D. Hinduja National Hospital, Mumbai, Maharashtra	19.0423145	72.8398344	0	Indian Restaura nt	Café	Bakery	Dessert Shop	Seafood Restaura nt	Bar	Deli / Bodega	Lounge	Coffee Shop	Scenic Lookout
1 6	MGM Hospital, Navi Mumbai, Maharashtra	19.075713	73.0003541	1	Indian Restaura nt	Fast Food Restaura nt	Restaura nt	Café	Coffee Shop	Chinese Restaura nt	Ice Cream Shop	Diner	Lounge	Asian Restauran t
1 7	Kohinoor Hospital, Mumbai, Maharashtra	19.0686026	72.876583	1	Indian Restaura nt	Hotel	Dessert Shop	Bar	Deli / Bodega	Coffee Shop	Bakery	Café	Seafood Restauran t	Snack Place
1 8	SIMS Hospital, Chennai, Tamil Nadu	13.0509293	80.212045	0	Indian Restaura nt	Hotel	Ice Cream Shop	Sandwich Place	Multiplex	Clothing Store	Café	Bar	Italian Restauran t	BBQ Joint
1 9	Madras Institute of	13.0147531	80.1744935	0	Indian Restaura	Hotel	Clothing Store	Ice Cream	Sandwich Place	Café	South Indian	Italian Restauran	Coffee Shop	Chinese Restauran

	Orthopedics and Traumatology, Chennai, Tamil Nadu				nt			Shop			Restaurant	t		t
20	Fortis Hospital, Kolkata, West Bengal	22.5142557	88.4098863046898	1	Hotel	Chinese Restaurant	Café	Mughlai Restaurant	Shopping Mall	Indian Restaurant	Multiplex	Coffee Shop	Dhaba	Italian Restaurant
21	Indraprastha Apollo Hospital, New Delhi, Delhi	28.5334785	77.2935232	0	Indian Restaurant	Café	Coffee Shop	Market	Restaurant	Hotel	Shopping Mall	Lounge	Bakery	Stadium
22	HCG Hospital, Bengaluru, Karnataka	12.97587815	77.5906011991715	1	Indian Restaurant	Hotel	Pub	Bakery	Brewery	Ice Cream Shop	Lounge	Burger Joint	Italian Restaurant	Dessert Shop
23	Omega Hospital, Hyderabad, Telangana	17.4177464	78.4399014	2	Indian Restaurant	Bakery	Hotel	Ice Cream Shop	Coffee Shop	Café	Multiplex	Lounge	BBQ Joint	Restaurant
24	The Calcutta Medical Research Institute, Kolkata, West Bengal	22.5325748	88.3210139	1	Café	Hotel	Mughlai Restaurant	Chinese Restaurant	Indian Restaurant	Shopping Mall	Multiplex	Indian Sweet Shop	Pub	Dhaba
25	Fortis Malar Hospital, Chennai,	13.00645	80.2577791	0	Hotel	Indian Restaurant	Café	Beach	Ice Cream Shop	Italian Restaurant	Juice Bar	Burger Joint	Vegetarian / Vegan Restaurant	Restaurant

	Tamil Nadu												t	
26	Fortis Hospital, Mumbai, Maharashtra	19.1719717	72.9511956	1	Indian Restaurant	Multiplex	Dessert Shop	Café	Pub	Coffee Shop	Donut Shop	Shopping Mall	Lounge	Snack Place
27	Kokilaben Dhirubhai Ambani Hospital, Mumbai, Maharashtra	19.1172495	72.833968	2	Indian Restaurant	Café	Hotel	Ice Cream Shop	Bakery	Coffee Shop	Chinese Restaurant	Pub	Multiplex	Beach
28	LivLife Hospital, Hyderabad, Telangana	17.4308362	78.4102882	1	Indian Restaurant	Bakery	Ice Cream Shop	Hotel	Café	Italian Restaurant	Restaurant	BBQ Joint	Lounge	Coffee Shop
29	GEM Hospital, Coimbatore, Tamil Nadu	10.9947773	76.99213	0	Indian Restaurant	Hotel	Café	Fast Food Restaurant	Shopping Mall	Ice Cream Shop	Burger Joint	Vegetarian / Vegan Restaurant	South Indian Restaurant	Multiplex
30	Fortis Memorial Research Institute, Gurugram, Haryana	28.4507064	77.0738281	2	Indian Restaurant	Hotel	Brewery	Café	Coffee Shop	Bar	Bakery	American Restaurant	Shopping Mall	Restaurant
31	Dr. L H Hiranandani Hospital, Mumbai, Maharashtra	19.1187195	72.9073476	0	Indian Restaurant	Hotel	Coffee Shop	Ice Cream Shop	Bakery	Dessert Shop	Asian Restaurant	Seafood Restaurant	Restaurant	Café

Further, the cluster center for each cluster is derived and its 10 most popular venue categories are identified as shown below. On the basis of the venue categories for each cluster center, it is found that food is common among all the localities. However, these clusters could be differentiated by other characteristics. Cluster 0 represents locality where entertainment (Multiplexes) venues are also popular. Cluster 1 represents locality where relaxation (Multipl Lounges) venues are also popular. Cluster 2 represents locality where shopping and alcoholic beverages (Malls and Brewery) venues are also popular.

	Cluster center	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue	10th Most Common Venue
0	0	Indian Restaurant	Hotel	Ice Cream Shop	Café	Bakery	Multiplex	Coffee Shop	Italian Restaurant	Restaurant	Chinese Restaurant
1	1	Indian Restaurant	Café	Hotel	Coffee Shop	Ice Cream Shop	Bakery	Dessert Shop	Lounge	Restaurant	Italian Restaurant
2	2	Hotel	Indian Restaurant	Café	Coffee Shop	Brewery	Shopping Mall	Chinese Restaurant	Italian Restaurant	Bakery	Mughlai Restaurant

Discussion

The clustering analysis performed to categorize the localities of the hospitals is successful. It provided three different types of localities in India in which the hospitals are present. The categorization of localities may not be perfect as various factors like radius and socio-economic features could play an important role in determining locality characteristics. Further, venue popularity is based on individual user experience, but the experience is unique for an individual so results may vary with individuals visiting the area.

Conclusion

In conclusion, the study aimed to provide a more customized options for making better decisions regarding the choice of hospital for the potential patient. The study was able to categorize the hospitals based on its locality. This could enable the patient and its carer to choose hospitals based on the type of locality they would want to stay.

This study could be replicated for all the hospitals around the globe. Further, more datasets and parameters could be incorporated to create more accurate categorization of the localities.