Medical Tourism: Clustering hospitals based on the neighborhood characteristics

Background/Problem Definition

The push for international standardization of hospitals across the globe 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 toursim market known as medical tourism. In many cases, patient has to go to different countries for availing medical treatment. In such scenario, they may 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 neighboorhood. 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 neighboorhood 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.
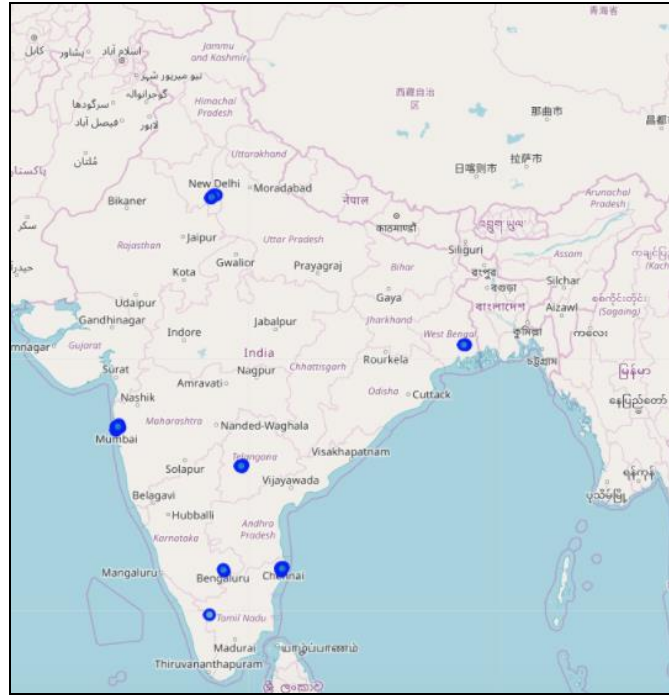
Methodology

The hospital data collected from website (https://www.treatmenttraveller.com/top-hospitals-in-India-2018) with latitudes and longitudes obtained using the geopy packgage from Open Street Map is used for the analysis. The list initially consisted of 67 hospital from which 33 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	Jaslok Hospital, Mumbai, Maharashtra	Indian Restaurant	Hotel	Bar	Scenic Lookout	Café	Ice Cream Shop	Restaurant	Fast Food Restaurant	Juice Bar	Lounge
18	Kohinoor Hospital, Mumbai, Maharashtra	Indian Restaurant	Hotel	Dessert Shop	Bar	Deli / Bodega	Coffee Shop	Bakery	Café	Seafood Restaurant	Snack Place
19	Kokilaben Dhirubhai Ambani Hospital, Mumbai, Maharashtra	Indian Restaurant	Café	Hotel	Ice Cream Shop	Bakery	Coffee Shop	Chinese Restaurant	Pub	Multiplex	Beach
20	LivLife Hospital, Hyderabad, Telangana	Indian Restaurant	Bakery	Ice Cream Shop	Hotel	Café	Restaurant	Italian Restaurant	Lounge	BBQ Joint	Coffee Shop
21	MGM Hospital, Navi	Indian	Fast Food	Café	Restaurant	Coffee Shop	Chinese	Ice Cream	Shopping	Dessert	Lounge

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

| 32 | 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 three hospitals locality, Cluster 1 consisted of 24 hospitals locality and Cluster 2 consisted of six hospitals locality.

Hospital	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
Medanta Hospital, Gurugram, Haryana	1	Indian Restaurant	Hotel	Brewery	Café	Coffee Shop	Bar	Bakery	Shopping Mall	American Restaurant	Sandwich Place
Apollo Hospital, Hyderabad, Telangana	1	Indian Restaurant	Bakery	Ice Cream Shop	Hotel	Café	Restaurant	Italian Restaurant	Lounge	BBQ Joint	Coffee Shop
Rabindranath Tagore International Institute of Cardiac Sciences, Kolkata, West Bengal	2	Hotel	Café	Mughlai Restaurant	Chinese Restaurant	Multiplex	Coffee Shop	Shopping Mall	Italian Restaurant	Indian Sweet Shop	Indian Restaurant
Narayana Health, Bengaluru, Karnataka	1	Ice Cream Shop	Indian Restaurant	Brewery	Café	Hotel	Pub	Burger Joint	Lounge	Breakfast Spot	Dessert Shop
Continental Hospital, Hyderabad, Telangana	1	Hotel	Indian Restaurant	Restaurant	Ice Cream Shop	Italian Restaurant	Lounge	Coffee Shop	Café	BBQ Joint	Bakery
Max Hospital, New Delhi, Delhi	1	Coffee Shop	Café	Italian Restaurant	Indian Restaurant	Asian Restaurant	Shopping Mall	Market	Lounge	Clothing Store	Thai Restaurant
Jaslok Hospital, Mumbai, Maharashtra	1	Indian Restaurant	Hotel	Bar	Scenic Lookout	Café	Ice Cream Shop	Restaurant	Fast Food Restaurant	Juice Bar	Lounge
Fortis Flt. Lt. Rajan Dhall Hospital, New Delhi, Delhi	2	Hotel	Indian Restaurant	Italian Restaurant	Coffee Shop	Shopping Mall	Café	American Restaurant	Chinese Restaurant	Asian Restaurant	Thai Restaurant
Artemis Hospital, Gurugram, Haryana	0	Indian Restaurant	Hotel	Brewery	Café	Coffee Shop	Bakery	Bar	American Restaurant	Restaurant	Sandwich Place
Apollo Hospital, Chennai, Tamil Nadu	1	Indian Restaurant	Hotel	Ice Cream Shop	Juice Bar	Café	Sandwich Place	BBQ Joint	Multiplex	Coffee Shop	Vegetarian / Vegan Restaurant

Global Hospital, Chennai, Tamil Nadu	1	Indian Restaurant	Pizza Place	Multiplex	Fast Food Restaurant	Coffee Shop	Sandwich Place	Hotel	Café	Clothing Store	Donut Shop
Global Hospital, Hyderabad, Telangana	2	Indian Restaurant	Bakery	Hotel	Ice Cream Shop	Coffee Shop	Multiplex	Café	Diner	Restaurant	Asian Restaurant
Yashoda Hospital, Hyderabad, Telangana	1	Indian Restaurant	Hotel	Bakery	Multiplex	Restaurant	Ice Cream Shop	Fast Food Restaurant	Café	Coffee Shop	BBQ Joint
Bombay Hospital, Mumbai, Maharashtra	1	Indian Restaurant	Café	Ice Cream Shop	Fast Food Restaurant	Hotel	Scenic Lookout	History Museum	Japanese Restaurant	Juice Bar	Diner
S.L. Raheja (A fortis Associate) Hospital, Mumbai, Maharashtra	1	Indian Restaurant	Café	Bakery	Dessert Shop	Seafood Restaurant	Bar	Scenic Lookout	Lounge	Coffee Shop	Hotel
Dr. Balabhai Nanavati Hospital, Mumbai, Maharashtra	1	Indian Restaurant	Hotel	Café	Coffee Shop	Ice Cream Shop	Dessert Shop	Bar	Seafood Restaurant	Pub	Lounge
P.D. Hinduja National Hospital, Mumbai, Maharashtra	2	Indian Restaurant	Café	Bakery	Dessert Shop	Seafood Restaurant	Bar	Scenic Lookout	Lounge	Coffee Shop	Hotel
MGM Hospital, Navi Mumbai, Maharashtra	1	Indian Restaurant	Fast Food Restaurant	Café	Restaurant	Coffee Shop	Chinese Restaurant	Ice Cream Shop	Shopping Mall	Dessert Shop	Lounge
Kohinoor Hospital, Mumbai, Maharashtra	1	Indian Restaurant	Hotel	Dessert Shop	Bar	Deli / Bodega	Coffee Shop	Bakery	Café	Seafood Restaurant	Snack Place
SIMS Hospital, Chennai, Tamil Nadu	1	Indian Restaurant	Hotel	Ice Cream Shop	Sandwich Place	Multiplex	Clothing Store	Café	BBQ Joint	Chinese Restaurant	Restaurant
Madras Institute of Orthopedics and Traumatology, Chennai, Tamil Nadu	1	Indian Restaurant	Hotel	Clothing Store	Ice Cream Shop	Sandwich Place	Café	South Indian Restaurant	Italian Restaurant	Coffee Shop	Chinese Restaurant
Fortis Hospital,	1	Hotel	Café	Mughlai	Chinese	Shopping	Indian	Italian	Dhaba	Multiplex	Indian Sweet

Kolkata, West Bengal				Restaurant	Restaurant	Mall	Restaurant	Restaurant			Shop
Indraprastha Apollo Hospital, New Delhi, Delhi	1	Indian Restaurant	Coffee Shop	Café	Hotel	Restaurant	Market	Shopping Mall	Italian Restaurant	Bakery	Stadium
HCG Hospital, Bengaluru, Karnataka	2	Indian Restaurant	Hotel	Pub	Bakery	Brewery	Ice Cream Shop	Lounge	Burger Joint	Italian Restaurant	Dessert Shop
Omega Hospital, Hyderabad, Telangana	2	Indian Restaurant	Bakery	Hotel	Ice Cream Shop	Coffee Shop	Café	Multiplex	Restaurant	Lounge	BBQ Joint
The Calcutta Medical Research Institute, Kolkata, West Bengal	1	Café	Hotel	Mughlai Restaurant	Indian Restaurant	Chinese Restaurant	Multiplex	Indian Sweet Shop	Shopping Mall	Italian Restaurant	Dhaba
Fortis Malar Hospital, Chennai, Tamil Nadu	1	Hotel	Indian Restaurant	Café	Beach	Ice Cream Shop	Juice Bar	Italian Restaurant	Vegetarian / Vegan Restaurant	Burger Joint	Restaurant
Fortis Hospital, Mumbai, Maharashtra	1	Indian Restaurant	Multiplex	Dessert Shop	Pub	Coffee Shop	Café	Donut Shop	Shopping Mall	Snack Place	Department Store
Kokilaben Dhirubhai Ambani Hospital, Mumbai, Maharashtra	0	Indian Restaurant	Café	Hotel	Ice Cream Shop	Bakery	Coffee Shop	Chinese Restaurant	Pub	Multiplex	Beach
LivLife Hospital, Hyderabad, Telangana	1	Indian Restaurant	Bakery	Ice Cream Shop	Hotel	Café	Restaurant	Italian Restaurant	Lounge	BBQ Joint	Coffee Shop
GEM Hospital, Coimbatore, Tamil Nadu	1	Indian Restaurant	Ice Cream Shop	Fast Food Restaurant	Café	Burger Joint	Shopping Mall	Hotel	Restaurant	South Indian Restaurant	Italian Restaurant
Fortis Memorial Research Institute, Gurugram, Haryana	0	Indian Restaurant	Hotel	Brewery	Café	Coffee Shop	Bakery	Bar	American Restaurant	Restaurant	Sandwich Place
Dr. L H Hiranandani	1	Indian	Hotel	Coffee	Ice Cream	Dessert	Bakery	Seafood	Restaurant	Asian	Italian

Hospital, Mumbai, Maharashtra		Restaurant		Shop	Shop	Shop		Restaurant		Restaurant	Restaurant

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 shopping and entertainment (Malls and Multiplexes) venues are also popular. Cluster 1 represents locality where entertainment and relaxation (Multiplexes and Lounges) venues are also popular. Cluster 2 represents locality where shopping and alcohol 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	Hotel	Café	Mughlai Restaurant	Chinese Restaurant	Indian Restaurant	Shopping Mall	Indian Sweet Shop	Multiplex	Italian Restaurant	Coffee Shop
1	1	Indian Restaurant	Hotel	Café	Ice Cream Shop	Bakery	Coffee Shop	Restaurant	Multiplex	Italian Restaurant	Lounge
2	2	Indian Restaurant	Hotel	Café	Coffee Shop	Brewery	Shopping Mall	Italian Restaurant	Restaurant	Bakery	Bar

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.