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An Experimental Study of Hospital Capacity in Chennai during the COVID-19 Pandemic

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ABSTRACT: The Coronavirus disease 2019 (COVID-19) outbreak has been designated as a public health emergency of international concern. To prepare for a pandemic, hospitals need a strategy to manage their space, staff, and supplies so that optimum care is provided to patients. Preparation for a pandemic involves considering the different levels in the hierarchy of controls as well as the different phases of the pandemic. These containment measures are necessary to optimize the quality of care provided to COVID-19 patients and to reduce the risk of viral transmission to other patients or healthcare workers. Since hospitals are not planned based on population density, the number of hospitals in the same neighbourhood. Given these factors, the goal was to find out if we have hospitals sufficient in and around the highly populated areas/wards, at what distance the first hospital is available, and in case there are no beds in that hospital, what are the list of other hospitals that can be explored. This data would help guide an impacted person, quickly and effectively in case of an emergency.

KEYWORDS: COVID-19, Data science, Data mining, Chennai, Hospitals.

I. INTRODUCTION

Chennai is India's 4th largest city and 6th most populated. Chennai city is divided into wards, and population is measured at the ward level. The objective was to find the highly populated areas/wards in Chennai. Some of these wards can be in the centre of the city and while the others are on the outskirts of the city. Hospitals are not planned based on population density, number of hospitals in the same neighbourhood. Given these factors, the goal was to find out if we have hospitals sufficient in and around the highly populated areas/wards, at what distance the first hospital is available, and in case there are no beds in that hospital, what are the list of other hospitals that can be explored. This data would help guide an impacted person, quickly and effectively in case of an emergency.

II. METHODOLOGY

To analyse the availability of hospitals in a given ward, first I collected population distribution statistics from a number of different sources. Then, using FourSquare API I located the hospitals in each neighbourhood/ ward. With this data, I mapped the population related statistics and the hospital details, and performed various functions to analyse the data.

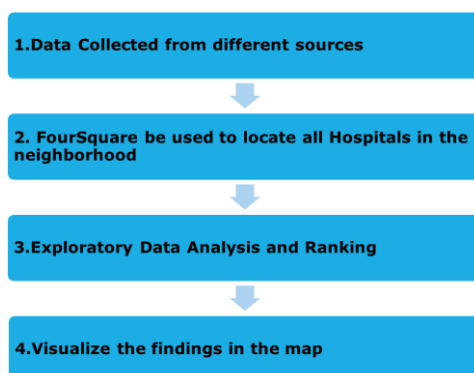


Figure 1: Process Framework



1. Data Collection

Chennai Corporation absorbed seven municipalities, three town panchayats and 13 panchayat unions in Tiruvallur district and two municipalities, five town panchayats and 12 panchayat unions in Kanchipuram district. In Chennai, population details are only available at the ward level. The expanded city contains 4.41 million voters and was re-organised into 15 zones consisting of 200 wards.

I collected data about the different areas and wards in Chennai, and their corresponding population demographics. I used various sources for the data collection process such as central and state government websites and Wikipedia.[1]

Ward No.	Ward Name
1	Kodungaiyur (West)
2	Kodungaiyur (East)
3	Dr.Radhakrishnan Nagar (North)
4	Cheriyar Nagar (North)
5	Jeeva Nagar (North)

Figure 2: Different wards in Chennai with their Ward number [2]

Population for each ward was extracted as an excel file titled Population.xls. [3]

State Code	District Code	Tahsil/ Sub-District Code	Town/ Village Code	Ward Code	Enumeration Block Code	Level	Name	Total/ Rural/ Urban	Total - Persons	Total - Males	Total - Females	Scheduled Caste - Persons	Scheduled Caste - Males	Scheduled Caste - Females	Scheduled Tribe - Persons
33	2	0	0	0	0	DISTRICT	Chennai	Total	4343645	2219539	2124106	598110	301835	296275	6728
33	2	0	0	0	0	DISTRICT	Chennai	Rural	0	0	0	0	0	0	0
33	2	0	0	0	0	DISTRICT	Chennai	Urban	4343645	2219539	2124106	598110	301835	296275	6728
33	2	0	40201000	0	0	TOWN	Chennai (M Corp.)	Urban	4343645	2219539	2124106	598110	301835	296275	6728
33	2	0	40201000	1	0	WARD	Chennai (M Corp.) - Ward No.1	Urban	57723	29449	28274	4477	2271	2206	46

Figure 3: Ward number and ward name mapped to population distribution data

2. Using FourSquare API[4] to collect information about Hospitals

Using geographical coordinates and data concerning the most highly populated ward as input for the Foursquare API, a list of hospitals was obtained.

name	categories	referralId	hasPerk	location.lat	location.lng	location.labeledLatLngs	location.distance	location.postalCode	location.cc	location.c
Parms Laboratory	[[{"id": "4f4531b14b9074f6e4fb0103", "name": "H..."}]]	V-1592507526	False	13.104899	80.207886	[[{"label": "display", "lat": 13.104899, "lng":...}]]	1438	600049	IN	Chen
Madras Medical Mission (MMM Hospital)	[[{"id": "4bf58dd8d48988d196941735", "name": "H..."}]]	V-1592507526	False	13.085986	80.187398	[[{"label": "display", "lat": 13.08598577011605...}]]	4401	600037	IN	Chen
MaxiVision Eye Hospital	[[{"id": "4bf58dd8d48988d196941735", "name": "H..."}]]	V-1592507526	False	13.092917	80.218327	[[{"label": "display", "lat": 13.09291696556728...}]]	2749	NaN	IN	Chen
Damien Foundation	[[{"id": "4bf58dd8d48988d196941735", "name": "H..."}]]	V-1592507526	False	13.072128	80.201814	[[{"label": "display", "lat": ...}]]	5199	NaN	IN	Chen

Figure 4: Using FourSquare API, details regarding different hospitals are obtained

Data Cleaning and Feature Selection

To make the Data analysis more accurate, features which had null values as entries were removed.



State Code	District Code	Tahsil/ Sub-District Code	Town/ Village Code	Ward Code	Enumeration Block Code	Level	Name	Total/ Rural/ Urban	Total - Persons	Total - Males	Total - Females	Scheduled Caste - Persons	Scheduled Caste - Males	Scheduled Caste - Females	Scheduled Tribe - Persons
33	2	0	0	0	0	DISTRICT	Chennai	Total	4343645	2219539	2124106	598110	301835	296275	6728
33	2	0	0	0	0	DISTRICT	Chennai	Rural	0	0	0	0	0	0	0
33	2	0	0	0	0	DISTRICT	Chennai	Urban	4343645	2219539	2124106	598110	301835	296275	6728
33	2	0	40201000	0	0	TOWN	Chennai (M Corp.)	Urban	4343645	2219539	2124106	598110	301835	296275	6728
33	2	0	40201000	1	0	WARD	Chennai (M Corp.) - Ward No.1	Urban	57723	29449	28274	4477	2271	2206	46

Figure 5: Population of each ward after deleting unnecessary features

Kept Features	Dropped Features	Reason for dropping Features
Ward Code, Ward Name, Total-Persons	State Code, District code	State Code, District code: Same for all rows
	Village Code	Village Code: Not applicable
	Gender based or Religion / community based	Gender based or Religion / community based – Not Applicable

Table 1: Table of Feature which have been retained and removed

Figure 6 shows the tabular column after alteration and deletions of features, mapping the Ward Code and its population alone.

State Code	Ward Code	Total - Persons
33	0	4343645
33	0	0
33	0	4343645
33	0	4343645
33	1	57723
...
33	151	38366
33	152	24555
33	153	95818
33	154	41627
33	155	78007

159 rows × 2 columns

Figure 6: Table with ward code mapped to population alone

Obtaining list of all Hospitals in the neighbourhood from FourSquare API

Step 1: Use FourSquare API to fetch only details of Venue category type of “Hospital”

Kept Features	Dropped Features	Reason for dropping Features
Venue Category of type Hospital	All other Venue Categories are dropped	Hospitals is the focus area

Table 2: Details about retained and removed features



Step 2: There are different sub-categories such as Dentist’s Office, Emergency Room, Eye Doctor, etc under “hospital”. For the sake of this experiment, we only require regular hospitals. So, the list of hospitals is further filtered.

categories	name	distance	lat	lng	id
Alternative Healer	1	1	1	1	1
Dentist’s Office	4	4	4	4	4
Doctor’s Office	5	5	5	5	5
Emergency Room	1	1	1	1	1
Eye Doctor	1	1	1	1	1
Hospital	22	22	22	22	22
Medical Center	9	9	9	9	9
Medical Lab	1	1	1	1	1
Veterinarian	1	1	1	1	1

Figure 7: Different kinds of hospitals available in a particular ward

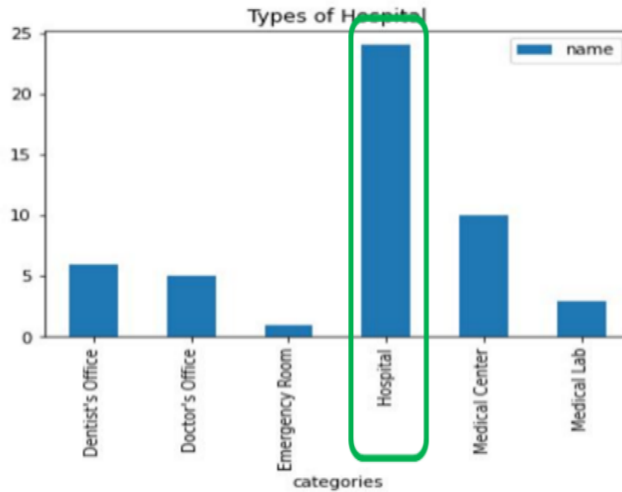


Figure 8: Bar Graph representing distribution of different kinds of hospitals

Kept Features	Dropped Features	Reason for dropping Features
Venue Category of type Hospital	All other Venue Categories such as Dentist’s office, Doctor’s office, labs are dropped	For Covid 19, information on hospitals are required. Dentist, Doctor’s office and labs are not of focus in this context

Table 3: Details about retained and removed features

Step 3: Feature Selection

name	categories	referralId	hasPerk	location.lat	location.lng	location.labeledLatLngs	location.distance	location.postalCode	location.cc	location.c
Parms Laboratory	'4f4531b14b9074f6e4fb0103', 'name': 'M...	1592507526	False	13.104899	80.207886	[[{"label": "display", "lat": 13.104899, "lng": ...	1438	600049	IN	Chen
Madras Medical Mission (MMM Hospital)	'4bf58dd8d48988d196941735', 'name': 'H...	1592507526	False	13.085986	80.187398	[[{"label": "display", "lat": 13.085986, "lng": ...	4401	600037	IN	Chen
MaxiVision Eye Hospital	'4bf58dd8d48988d196941735', 'name': 'H...	1592507526	False	13.092917	80.218327	[[{"label": "display", "lat": 13.092917, "lng": ...	2749	NaN	IN	Chen
Damien Education	'4bf58dd8d48988d196941735', 'name': 'H...	1592507526	False	13.077426	80.201844	[[{"label": "display", "lat": 13.077426, "lng": ...	5438	NaN	IN	Chen

Figure 9: Data before Feature selection process

To clean and organize the data for analysis, only the necessary features or columns are selected. Table 4 lists the different features that were retained and those that were deleted.

Kept Features	Dropped Features	Reason for dropping Features
Name, location.lat, location.lng, Id, distance	hasPerk, PostalCode, referralID, city	hasPerk, referralID, city: All rows have same value PostalCode: Many missing data entries

Table 4: Details about retained and removed features

3. Exploratory Data Analysis

Step 1: The first step was to visualize the population in different areas in Chennai to identify highly populated regions.

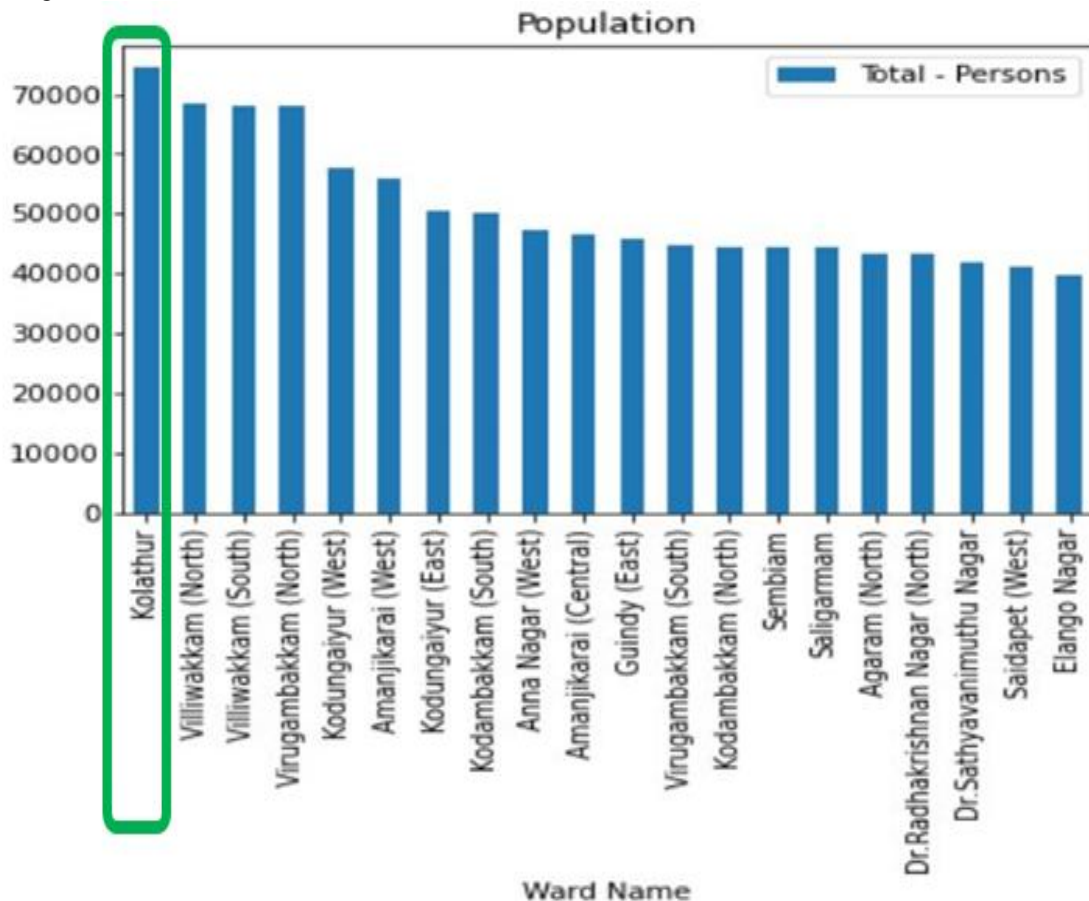


Figure 10: Bar graph of population of different wards in Chennai



From Figure 10, we can observe that “Kolathur” is the area with the highest population.

Step 2: List of hospitals after data cleansing in the dataframe.

Next step is to rank the hospitals based on their distance from Kolathur (the starting coordinates are taken as the centre of the ward).

	distance_rank		name	categories	distance	lat	lng	id
0	3.0		Sridevi Hospitals	Hospital	3508	13.088418	80.198918	4d5769fdafe4b60cb0934461
1	4.0		soundarapandian	Hospital	3715	13.083676	80.214851	4ff6938fe4b058e164cf8dd9
2	5.0		Apollo Medical Centre	Hospital	3744	13.084527	80.221720	58a11a11fc73d453c2995729
3	6.0		Ashwin Clinic	Hospital	3875	13.082277	80.215457	5604e217498e96c19e4ae389
4	7.0		Sundaram Medical Foundation OP Services	Hospital	3938	13.081995	80.207172	4f06ef92e4b0ad9c23935a9c
5	8.0		km hospital	Hospital	4298	13.088939	80.239872	528e21cc11d2871318e3852b
6	9.5		Madras Medical Mission (MMM Hospital)	Hospital	4401	13.085986	80.187398	4ccc3d8ba79a1cdf6c83ecb
7	9.5		physiotherapy clinic	Hospital	4401	13.089308	80.241615	528e1a2511d279f7d736786f
8	11.0		Frontier Lifeline Hospital	Hospital	4448	13.087158	80.185292	519b1365498e484c03997d3a

Figure 11: Tabular data of Hospitals in Kolathur sorted by distance

We can see that the first hospital is found at the distance of 3.5 km from Kolathur’s central coordinates.

III. EXPERIMENTAL RESULTS

In the exploratory analysis of the different wards of Chennai, their populations, and hospital availability, the following questions were answered:

Problem 1: Do we have hospitals in and around the highly populated areas/wards that are identified?

There are 20 hospitals around Kolathur each of them is at different distance and located in different locations

Problem 2: What is the radius in which the first hospital is available?

First hospital is available at 3.5KM distance from Kolathur

Problem 3: In case there are no beds in that hospital what are the list of other hospitals that can be explored?

Here is the list of other hospitals that can be explored.

	distance_rank		name	categories	distance	lat	lng	id
0	3.0		Sridevi Hospitals	Hospital	3508	13.088418	80.198918	4d5769fdafe4b60cb0934461
1	4.0		soundarapandian	Hospital	3715	13.083676	80.214851	4ff6938fe4b058e164cf8dd9
2	5.0		Apollo Medical Centre	Hospital	3744	13.084527	80.221720	58a11a11fc73d453c2995729
3	6.0		Ashwin Clinic	Hospital	3875	13.082277	80.215457	5604e217498e96c19e4ae389
4	7.0		Sundaram Medical Foundation OP Services	Hospital	3938	13.081995	80.207172	4f06ef92e4b0ad9c23935a9c
5	8.0		km hospital	Hospital	4298	13.088939	80.239872	528e21cc11d2871318e3852b
6	9.5		Madras Medical Mission (MMM Hospital)	Hospital	4401	13.085986	80.187398	4ccc3d8ba79a1cdf6c83ecb
7	9.5		physiotherapy clinic	Hospital	4401	13.089308	80.241615	528e1a2511d279f7d736786f
8	11.0		Frontier Lifeline Hospital	Hospital	4448	13.087158	80.185292	519b1365498e484c03997d3a

Figure 12: A list of hospitals in the Kolathur area

Details for each hospital can also be extracted from the dataset (however, some values may not be present). This can be used to evaluate hospital capacity and availability.

```

Address ['Chennai', 'Tamil Nadu', 'India']
Likes 0
Tips 0
Hospital Name soundarapandian
Contact {}
Address ['India']
Likes 0
Tips 0
Hospital Name Apollo Medical Centre
Contact {}
Address ['India']
Likes 1
Tips 0
Hospital Name Ashwin Clinic
Contact {}
Address ['India']
Likes 0
Tips 0
Hospital Name Sundaram Medical Foundation OP Services
Contact {}
Address ['Chennai', 'Tamil Nadu', 'India']
Likes 0
Tips 1
Hospital Name km hospital
Contact {}
Address ['India']
Likes 0
Tips 0
Hospital Name Madras Medical Mission (MMM Hospital)
Contact {'phone': '+914426565961', 'formattedPhone': '+91 44 2656 5961'}
Address ['4-A, Dr. J. Jayalalitha Nagar, (Mogappair)', 'Chennai 600037', 'Tamil Nadu', 'India']
Likes 2
Tips 4
Hospital Name physiotherapy clinic
Contact {}
Address ['India']
Likes 0
Tips 0
Hospital Name Frontier Lifeline Hospital
Contact {}
Address ['India']

```

Figure 13: Hospitals with data

From figure 13, we can observe that we do not have sufficient data at many hospitals, thus it becomes a challenge for citizens to make decisions as to which hospital might be available.

IV. CONCLUSION

The COVID-19 pandemic continues to create extraordinary challenges for hospital leaders. Identifying and reviewing surge capacity planning models that handle both caseload projection and hospital capacity management for this novel pandemic disease has become evidently crucial. Further, it is evident that hospital data must be surveyed and updated periodically, especially in the case of a global emergency. An enhanced understanding of hospital locations, availability, and transportation facilities can help physicians, hospital administrators, emergency response personnel, and public health agencies meet the requirements to treat patients during a pandemic. The crucial problem now facing health systems worldwide is to determine how to construct and operate the complex supply chain needed to create the required resources.



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- [3] Population for each ward in Chennai:
https://data.gov.in/catalog/area-wise-population-within-corporations-and-municipalities-tamil-nadu?filters%5Bfield_catalog_reference%5D=85975&format=json&offset=0&limit=6&sort%5Bcreated%5D=desc
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