Study to Identify the Geographic Source of Inpatients Using Geotagging and Visual Maps at Manipal Hospitals, Jaipur

By

Prabhav Sharma

Dissertation submitted in partial fulfillment of the requirements of the degree

MBA Hospital and Health Management

Academic year, 2018-2020

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ManipalHospitals
LIFE'S ON

15-June-2020

TO WHOMSOEVER IT MAY CONCERN

This is to certify that, Prithvi Sharma a student of IIHMR, Jaipur has undergone his internship project with us from 10-Feb-2020 to 09-May-2020.

During this period, he was involved in projects pertaining to Quality at Manipal Hospital Jaipur (A unit of Manipal Health Enterprises Pvt. Ltd.).

His performance on the projects assigned and his conduct was found to be good.

We wish him success in his future endeavors.

For Manipal Hospital Jaipur
(A unit of Manipal Health Enterprises Pvt. Ltd.)

Partha Das
VP& Head - Human Resources

CERTIFICATE BY SCHOLAR

This is to certify that the dissertation titled **A Study to Identify the Geographic Source of Inpatients Using Geotagging and Visual Maps at Manipal Hospitals, Jaipur** and submitted by **Prabhav Sharma**, Enrolment No**. IIHMR-U/01/2018-20/0798** under the supervision of **Dr. S.D Gupta** for award of MBA in Hospital and Health carried out during the period from _____ embodies my original work and has not formed the basis for the award of any degree, diploma associate ship, fellowship, titles in this or any other institute or other similar institution of higher learning.

Signature

ABSTRACT

A Study to Identify the Geographic Source of Inpatients Using Geotagging and Visual Maps at Manipal Hospitals, Jaipur

Introduction: Identification and understanding of geographic patterns from patient origin data may guide a sound healthcare planning process. Analysing healthcare services availed by patients belonging to a specific area may further assist in determining trends and success of these services. Like most multi-speciality tertiary care hospitals, Manipal Hospital Jaipur (MHJ) serves a population beyond city limits. In order to better understand the service area of the hospital, Geotagging and Visual Maps have the potential to act as valuable tools. This study is aimed at learning the extent and nature of the hospital's service area using these tools.

Methods: This retrospective study extracted discharge data of inpatients over a 6-month period from the HIS, including patient origin data. Zoning/Clustering of patient residence was performed for all nonscheme patients on the basis of distance from the hospital and consequently, service areas were derived. Results were visualized in a geographic information system using Geotagging and Visual Maps.

Results: All discharged nonscheme inpatients (n=3482) were considered and zone-specific clusters of patients were identified, centred at Jaipur city and consisted of adjacent districts such as Jhunjhunu, Nagaur, Sikar, etc. Highest number of patients were served from Vidhyadhar Nagar (34%), Jhotwara (25%) and Chomu (32%) in Zone A, B and C respectively. Males of the age group 18-64, requiring medical admission constituted the major share of inpatient services availed in each zone. Oncology and Internal Medicine services were mostly availed for inpatient care in all zones.

Conclusion: Geographical information systems consisting of tools such as Geotagging and Visual maps provides interesting insights regarding patient characteristics and service areas of the hospital. Although Manipal hospitals, Jaipur primarily focuses on serving its immediate communities, the study suggests the population served by the hospital is actually more extensive and varies by patient characteristics and type of services availed.

Keywords: Geographic source, patient origin, geotagging, visual maps

ACKNOWLEDGMENT

I would initially like to thank my institute, Indian Institute of Health Management Research (IIHMR), Jaipur for providing me this chance in the form of dissertation, which helped me understand the workings of a hospital and its processes.

My sincere regards go to **Mr. Karthihaivelan (Hospital Director, Manipal Hospital, Jaipur)** and **Mr. Sudeep Singh (Head Operations, Manipal Hospital, Jaipur)** for providing me such a great platform to learn. I am also thankful to **Dr. Umesh Goswami (Head Quality, Manipal Hospital, Jaipur)** for his consent and thoughts on my project, giving me confidence to go ahead with my project.

I would like to thank my hospital mentor, **Dr. Shivani Arora (Assistant Manager, Quality & Non- Medical Ops., Manipal Hospital, Jaipur)** for helping me at each step of my journey and for being willing to give valuable insights for my project, allowing me to keep improving the quality of my project. My immense gratitude also go to **Dr. Archana Singh (Assistant Manager, Medical Operations, Manipal Hospital, Jaipur)** for being cooperative and helpful throughout my time at Manipal Hospital, Jaipur.

Special thanks to the staff of Manipal Hospital, Jaipur for always being available and treating me as a functional part of the organization. They have played a big role in letting me complete my dissertation on time.

My regards extend to my university mentor at IIHMR, **Dr. S.D Gupta (Chairman, IIHMR University)** for supporting my ideas throughout this project as well as adding his precious views.

Thanking You,
Prabhav Sharma

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LIST OF ACRONYMS

GIS - Geographic Information System
CA - Catchment Area
EHR - Electronic Health Record
ATD - Average Travel Distance
IPD - Inpatient Department
OPD - Outpatient Department
HIS - Hospital Information System
HMIS - Hospital Management Information System
MS - Microsoft
SEO - Search Engine Optimization

A Study to Identify the Geographic Source of Inpatients Using Geotagging and Visual Maps at Manipal Hospitals, Jaipur

1. INTRODUCTION

Geographic, spatial and visual methods have been widely used to study and understand healthcare utilization patterns and health service availability [1]. Several complex approaches have reportedly been embraced for the identification of clusters [2,3], which consequently confirms and quantifies the mere existence of stable service areas that may well be explained by the density of episodes occurring proximal to the service provider. At the same time, inpatient data collected in a hospital contains crude but extremely substantial information about various characteristics of patients, who contribute majorly to hospital revenue.

Identification of geographical patterns [4] provides interesting and meaningful insights into the service population and could be of major use in other fields of the health industry. With their ability to represent disparities in the demographic and health characteristics of a population [5], and to exhibit physical structures such as health facilities, roads and other links, a great opportunity lies in their everyday use in various health facilities. Therefore, Medical service providers, such as a hospitals or standalone medical care groups, etc., could benefit greatly from an ability to analyse trends regarding origination of business, acting as tools to assist providers in calculating catchment areas as well as measuring the effectiveness and success of medical service offerings such as inpatient care. Additionally, map-based could act as a visual representation regarding from where health services groups are targeting/getting their patients and how this trends overtime.

Studies focusing on Catchment area to date have majorly concentrated on market penetration and accessibility [6,7], where different methods to defining catchment areas have been proposed and developed. One of the simpler ways of establishing the boundaries of a particular catchment area is to use distance from the service facility – either the direct straight-line distance, the distance patients have to travel or the actual distance travelled by patients in a given period of time [8]. On the basis of this approach, it is assumed that people would prefer visiting the closest facility, which further implies that in fact, distance is the overriding factor influencing participation. However, studies have shown that distance is only one of the many factors influencing the choice of health-care facility; with other factors also plating a role [9].

A functional and maintained Geographic information system (GIS) that uses Geotagging and Visual Mapping can be utilized to detect geographic segments or clusters within a market area

from which varying proportion of businesses are obtained as well as planning for service deployment. Such a GIS would effectively give information regarding a health-care institution's actual catchment area, which would aid in performing further important analyses.

The suggested study has been carried out to explore the source of the inpatient population which are directly seeking inpatient care at Manipal hospital in Jaipur, Rajasthan, which has been described as a geographic clustering phenomenon. Essential information about the densest areas of patient recruitment will be obtained and various demographics will highlight geographic area differences for patients within subpopulations.

Catchment Area

A Catchment Area (CA) is the geographical area and population through which a health facility draws its maximum patients. Defining a CA permits a health centre to describe and understand its primary patient population and eventually evaluate how well it meets the needs and demands of patients within the CA. A CA is supposed to capture a significant portion of the hospital's activity and rightfully exclude areas whose general contribution to hospital activity perhaps represents random variation. It is also supposed to reflect demographic and geographical influences on hospital activity, including the physical barriers to competition and access, and is ought to be proportional in geographic size in comparison to hospital size.

Fig.1: Manipal Hospital Map Location

Zones

For clustering of inpatients which would represent a unique geographical area, zoning could be performed on the basis of distance of patient residence (in km.) from the hospital.

Zone	Distance from Hospital
Zone A	Within 5 Kms.
Zone B	5-15 Kms.
Zone C	15-25 Kms
Outside	Beyond 25 Kms

Table 1: Zoning Considerations

Background

The availability of somewhat inexpensive as well as user-friendly geographical information systems (GISs), with an improved range of analytic and other facilities, provides a powerful and potentially game-changing tool for the analysis and virtual display of the increasing number of health-related data sets and figures. To fully utilize the capabilities of geographic maps, there is a need to first collect, analyze and understand the data that consists of their demographics as well as origin.

Rationale

The inpatient care services provided by a hospital brings in a huge chunk of the hospital revenue. Hospital Managers are required to continuously look for opportunities for growth and expansion. Keeping that in mind, the geographic dispersion of inpatients was examined to get a better idea with regards to the service area of Manipal Hospital, a tertiary care hospital situated in an urban center. Similar to most other multispecialty corporate hospitals, the hospital provides for a population beyond city boundaries. Urban tertiary care hospitals are rightfully expected to serve their immediate neighborhoods/vicinity and to address the various disparities in access to specialty care and services. Our main purpose of the study was to learn the extent and nature of the hospital service area for inpatient care.

Research Question

- What is the geographic source of patients undergoing inpatient care at Manipal Hospitals, Jaipur?

Research Problem

Although all the hospitals that come under Manipal Group serve a rather significantly large area because of their various offerings of specialized services throughout the country, a consistent definition and clarity of the population from which each hospital draws its inpatients has not yet been described. Further, default service areas are envisaged as being either very small, as in the immediate city and its neighboring districts, or a large but very well-defined area, such as the surrounding state(s). Therefore, the problem statement for this study is the lack of current knowledge regarding the hospital's service area for inpatient care.

Aim

The aim of the study is to determine the extent and nature of the hospital service area for inpatient care at Manipal Hospitals, Jaipur.

Research Objectives

- To determine zone-wise geographic distribution of inpatients at Manipal Hospitals, Jaipur.
- To determine the distribution of inpatient specialties served in each zone at Manipal Hospitals, Jaipur.
- To analyze overall trend of inpatient footfall at Manipal Hospitals, Jaipur.
- To illustrate the use and significance of Geotagging and Visual Maps for identifying highly served and underserved regions for inpatient care at Manipal Hospitals, Jaipur.
- To provide recommendations for increasing inpatient footfall in the future on the basis of geographical data at Manipal Hospitals, Jaipur.

2. REVIEW OF LITERATURE

Current Status

Analyzing and interpreting geographic origin data of patients and visitors has increasingly become an essential part of the day-to-day working and functioning of health centers around the world. It seems rather foolish that more health facilities haven't taken advantage of this opportunity to understand their services more visibly and clearly. Geographic data in the current context is being utilized widely in timely understanding of a new disease source, dynamics and epidemiology, and in shaping our effective response to it.

Indeed, health professionals have long considered conventional mapping, and more recently geographic information systems (GIS), as critical tools in tracking and combating contagion. Maged N Kamel Boulos and Estella M. Gerathy in their study [10] showcased how 21st century GIS technologies are supporting the global fight against outbreaks and epidemics with special focus on geographical tracking and mapping of coronavirus disease COVID-19/severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) epidemic.

Another study on COVID-19 performed in China [11] analyzed the characteristics of suspected or laboratory-confirmed COVID-19 patients who asked for help on Sina Weibo. Among the characteristics, one of the determinants was patient geographical origin, which determined locations from where patients were seeking help.

Some of the studies this year [12,13] have analyzed the possibility of identifying any correlation between the patient geographic data and prevalence of disease. Geographic origin was also used as a parameter in predicting mortality in patients suffering from fibrosing pulmonary sarcoidosis [14]. F Vilchez Sanchez et al. classified patients by geographical origin for assessing differences in allergic sensitization and clinical characteristics in a foreign-born population [15].

The use of Mapping and patient origin data is on the rise and with the COVID-19 pandemic proving to be catalyst in innovation of new and improved geographic information systems, one cannot help but think about the potential of these tools in today's modern world as well as the future.

Scholar Articles

- **Monk EJM, Yee KP, Allan R, Gayton IB in 2019 [16]** conducted a study detailing a new and reliable method for determining the true patient origin in the rural residence of Sierra Leone. Possible villages were detected within an area of 7800 km^2 from the health facility catchment area from a satellite imagery, which were duly accessed by a motorcycle and surveyed individually, which included capturing of the village name and section/district defined by the community. The final proof of concept of the study reported a substantial and huge record of correct and actual patient origin.

- **Doll D, Orlik A, Maier K, Kauf P, Schmid M, Diekmann M, Vogt AP, Stauffer VK, Luedi MM in 2019 [17]** studied the effect pf geographical distribution of surgical methods for treatment of PSD and eventual geo-specific rates. Relevant databases were looked out for and rates for recurrence were then linked with reported follow up time and geographical origin. Final analysis showed that recurrence rates in PSD does not only depend on therapeutic approaches and follow-up time but on geography as well.

- **Reimer A, Bruckner-Tuderman L, Ott H. in 2018 [18]** conducted a study to Map prevalence of Epidermolysis Bullosa in Germany. The study included a survey (online) of all dermatological department and paediatric departments. Observations revealed large variations between frequency, time frame and consultation, then the recommended check-ups and diagnostics which are used to establish a particular diagnosis. The results of the survey duly showed that health care for individuals with the ailment in the country is provided multidisciplinary. Innovative and functioning political structures are direly needed to improve upon networking and strengthening specialised centres to meet the needs of individuals with EB as well as other diseases.

- **Sjetne IS, Iversen HH in 2017 [19]** conducted a national survey to determine the standard of women's experiences with birthing, pregnancy and postnatal care in Norway. The main aim of this analysis was to examine potential differences in the experiences of women with regards to the study respondent's geographical origin. Data collection was performed in a national cross-sectional study, by a questionnaire (self-administered) and also from registries. This study did not detect systematic differences

between groups in their experiences with pregnancy as well as maternity care in Norway.

- **Neelkamal Soares, Joseph Dewalle and Ben Marsh in 2016** [20] performed a study to examine potential use of clinical services at a rural integrated system by generation of optimal groups of telemedicine service locations from HER data using Geographic Systems (GISs). This was a retrospective study that extracted nonidentifiable grouped data of patients/visitors over a length of 2 years from the HER, which also included geomasked locations. Spatially optimized groupings were generated using already available telemedicine service sites by means of calculating patients average travelling distance (ATD) to closest site. The study included Geo data and the techniques used can help in health care planning generation of data load, and location accessibility.

- **Leleand Baskin, Amid Abdullah, Maggie Guo and Christopher Naugler in 2015** [21] took upon a study for the determination of underserviced geographical areas within a city which would guide the choice of new patient service centre location/areas. Data on travel distances for phlebotomy visits and also population data from the Census was utilized in the study. Maps were generated showing actual relative travel distances for patients and also the geographical distribution of the density of patients that are undergoing phlebotomy. The detailed analysis gave clear and direct evidence of communities which were currently underserved by service centres.

- **Aobo Wang and David C. Wheeler in 2015** [22] conducted a study where they constructed Catchment Areas for all cancers based on the state cancer registry data as well as the Bayesian hierarchical regression model. They duly constructed a diagnosis CA using the billing data from the MCC and a Poisson regression model. The MCC Cas were utilized to compare patient characteristics both inside and outside the Cas. Among the cancer patients which were living within the MCC CA, the patient characteristics were more likely to be from minority, females or on Medicaid insurance.

- **Kate Zinszer, Katia Charland, Ruth Kigozi, Grant Dorsey, Moses R Kamya and David L Buckeridge in 2014** [23] did a study to showcase the effective usage of a novel method for defining the CAs of healthcare facilities based on their use. The CAs of 6 healthcare facilities in Uganda was analysed using the method of cumulative case ratio

which included the ratio observed to expected use of a facility for a condition by patients from relatively small areas. The ratio for malaria visits to these facilities was found out using the data from Uganda Surveillance project. There was also derivation of CAs by using various straight line distances from the facilities. The study duly concluded that the cumulative ratio for malaria visits to analyse healthcare facility catchment areas was quite feasible.

- **Shu Chih Su, Norma Kanarek, Michael F. Fox, Alla Guseynova, Shirley Crow and Steven Piantadosi in 2010** [24] conducted a study to determine the geographical source of patients which availed services at a National Cancer Institute Comprehensive Cancer Centre. Statistical Clustering of patient origin was analysed for all the patients and further also by gender, cancer site and race as well using SaTScan software. Initially, the primary clusters were detected for all the cases tumour defined populations were centred at Baltimore and consisted of adjacent or nearby counties of Delaware, Virginia, New Jersey, District of Columbia, etc. The primary clusters thus obtained varied widely in gender, race as well as cancer site. The study concluded that this type of geospatial analysis can provide interesting insights into populations served by these centres, examine centres performance in respect to the community and also aiding in developing a business plan that recognizes regional utility, strengths as well as referral patterns. The study mentioned that the patient population served by these centres is actually much more extensive and consists of differences by cancer site, patient characteristics and probably cancer services offered as well.

3. RESEARCH METHODOLOGY

- **Location of Study Area**

  Manipal hospital is a multi-speciality hospital located in Jaipur, Rajasthan

- **Study Design**

  This is retrospective, descriptive type of study conducted with an aim of determining the nature and strength of the hospital service area for inpatient care at Manipal Hospitals, Jaipur.

- **Study Variables**

  The nature and strength of the hospital service area for inpatient care were identified as the dependent variables while geographic source of inpatients as well as the inpatient speciality services they availed were identified as the independent variables.

- **Study Area**

  The current study was performed in the IP Department of the hospital.

- **Study Population**

  The study population for the current study consisted of patients admitted at Manipal Hospitals, Jaipur i.e IPD patients.

- **Study Period**

  The study was conducted during 10th February 2020 – 10^{h} May 2020, during which both primary and secondary data was recorded.

- **Type of Research**

  Qualitative study of geographic source identification as each patients' geographic area was determined.

- **Sources of Data**

Secondary Data included the hospital information system (HIS) and data collected by the internet's various data source sites like research gate, google scholar, PubMed, etc. for the review of literature.

- **Sample size (n)**

Total sample size for the study was 3482. Total number of patients that were admitted in the hospital between September 2019 - February 2020 were considered in the study. These were as follows :

MONTH	NO. OF PATIENTS ADMITTED (n)
SEPTEMBER	654
OCTOBER	579
NOVEMBER	693
DECEMBER	548
JANUARY	520
FEBRUARY	488

Table 2: No. of samples considered

- **Data collection**

Numbers of patients admitted in the hospital for a period of 6 months (September 2019 - February 2020) were considered. Patient details such as Patient MRN No., Age, Gender, Area, Department, etc. were recorded from the HIS.

- **Instrument**

A zone master tool was used wherein all patient origin areas was already defined in zones on the basis of their distance (Km.) from the hospital. New areas were consequently added to the zone master with new inpatient data. (Annexure)

- **Sampling**

  Complete enumeration, as all the discharges which fulfilled the inclusion criteria were taken into consideration.

- **Processing and Analysis of Data**

  The collected data was entered in a MS excel sheet and inpatients were allocated into different zones according to the zone master. For Geotagging, Google maps were used to plot the geographical areas with high density of inpatients. Visual Maps were constructed in MS Excel only. For documentation and dissemination of data, graphs, charts, and tables were created for better understanding and clarity.

- **Inclusion Criteria and Exclusion Criteria**

  With respect to the Inclusion Criteria, Only Non-scheme patients admitted to the hospital in various wards and patient rooms were included . Scheme inpatients were not included. Also, patients whose local residence information was not available on HMIS were excluded from the study.

4. RESULTS

I. Overall

- **Overall Inpatient Footfall Trends**

Month	Total Inpatients	Total Non-scheme Inpatients	% Non-scheme Inpatients	Total Non-Scheme Plot	Total Non- Scheme Inpatients Jaipur (Zone A+B +C)	% Non-Scheme Inpatients Jaipur (Zone A+B+C)
Sept	1575	659	42%	654	293	45%
Oct	1527	580	38%	579	238	42%
Nov	1580	696	44%	693	322	46%
Dec	1417	550	39%	548	233	43%
Jan	1438	520	36%	520	253	49%
Feb	1421	492	35%	488	236	48%

Table 3: Overall inpatient footfall trends

The number of patients availing inpatient care services has remained fairly consistent. However, there was a slight decrease in the number of Non scheme patients for the same.

- **Overall Zone Wise Distribution**

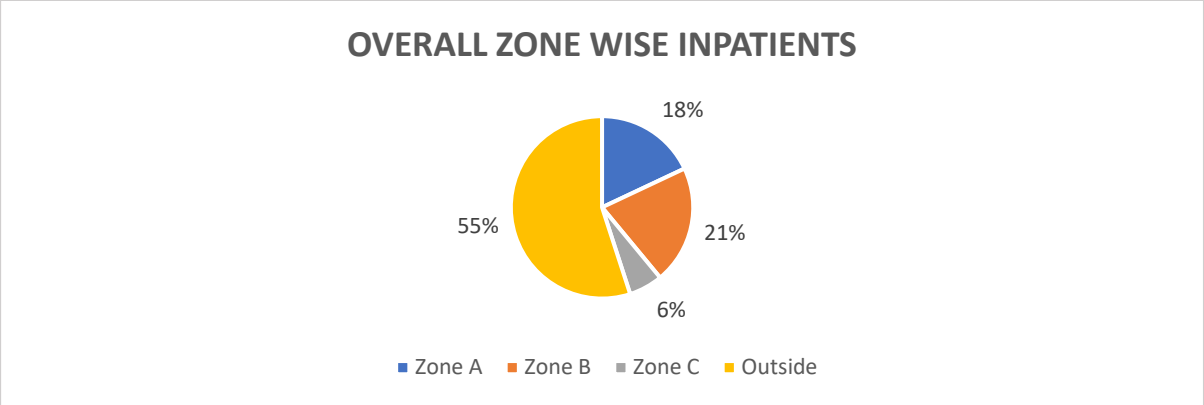

Fig. 2: Overall Zone Wise Inpatient Distribution

The highest number of Nonscheme Inpatients were from Zone Outside (55%), whereas the least number of Inpatients came from Zone C (5%).

- **Overall Month Wise Trend**

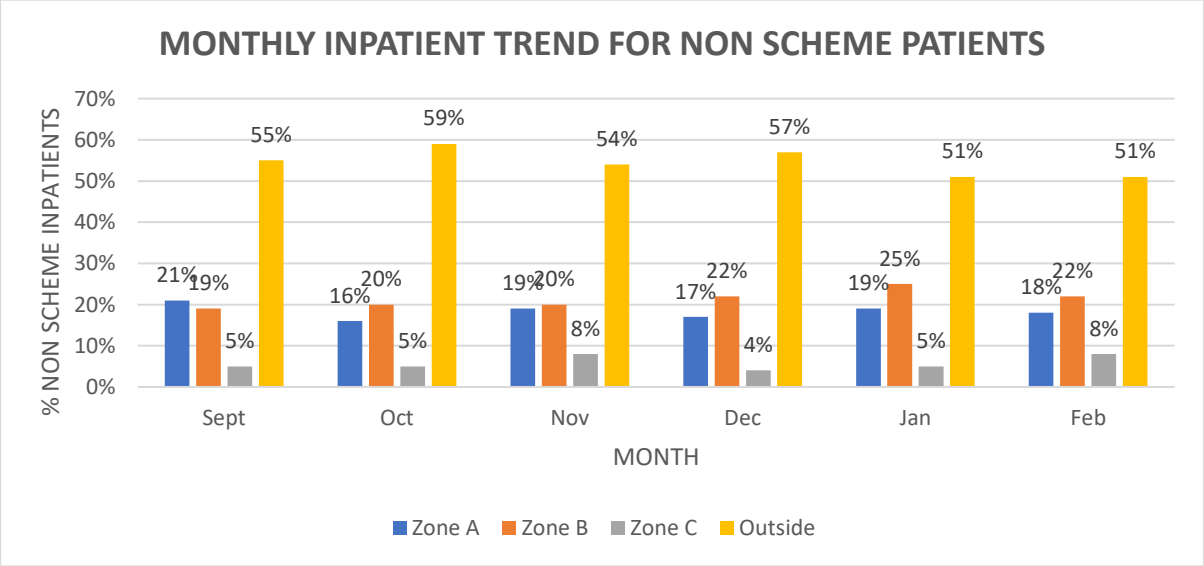

Fig 3: Overall Month Wise Trend

The number of inpatients from Zone B peaked in March (27%), whereas for Zone C and Zone A they peaked in February (8%) and September (21%) respectively.

II. Zone-Specific

- **Zone A**

1. Demographic Distribution

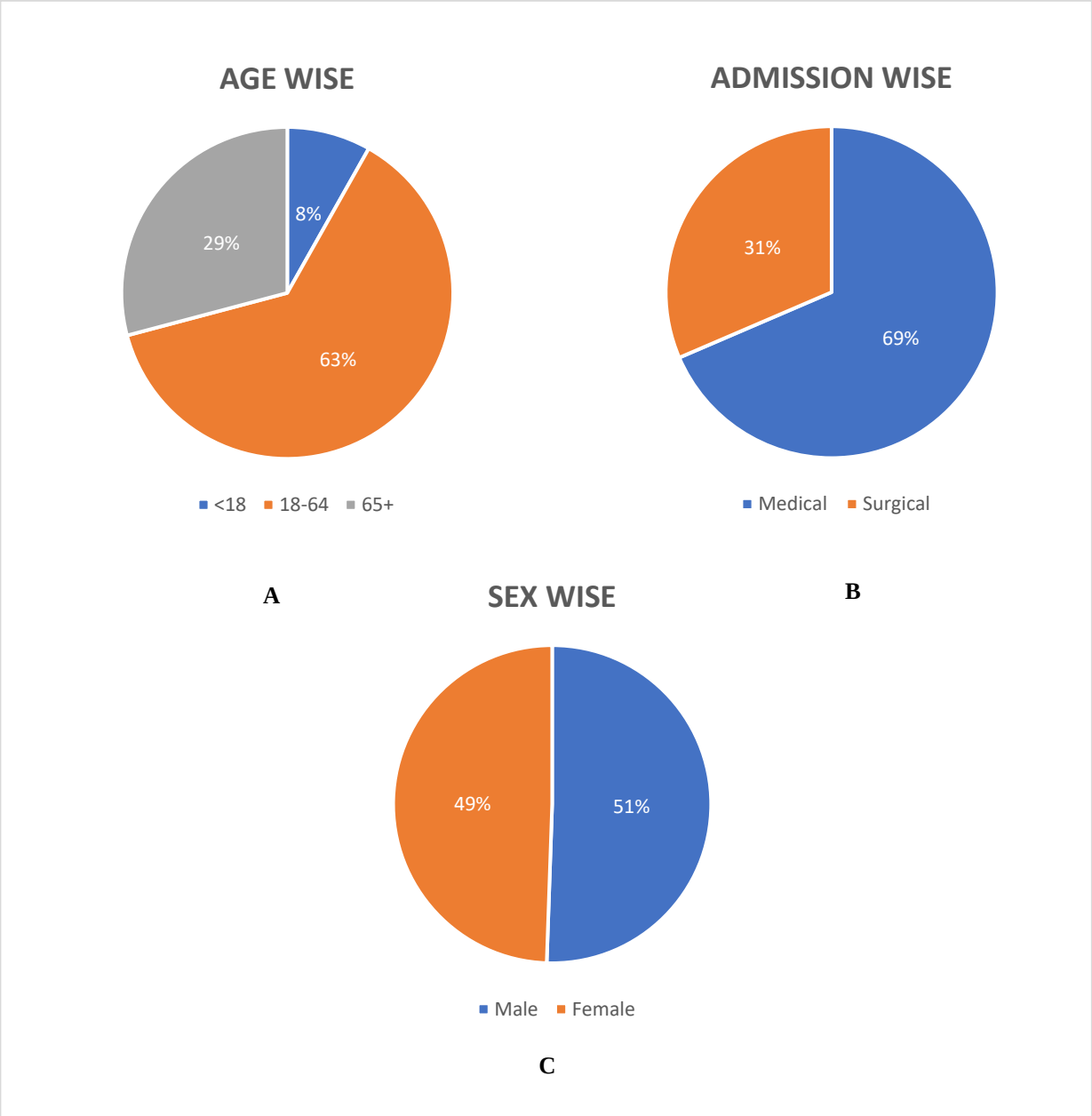

Fig 4: Age Wise, Sex Wise and Admission Wise Distribution for Zone A

Maximum inpatients from Zone A were of age group 18-64 (63%) and majority opted for Medical admission in the hospital

2. Specialty Distribution

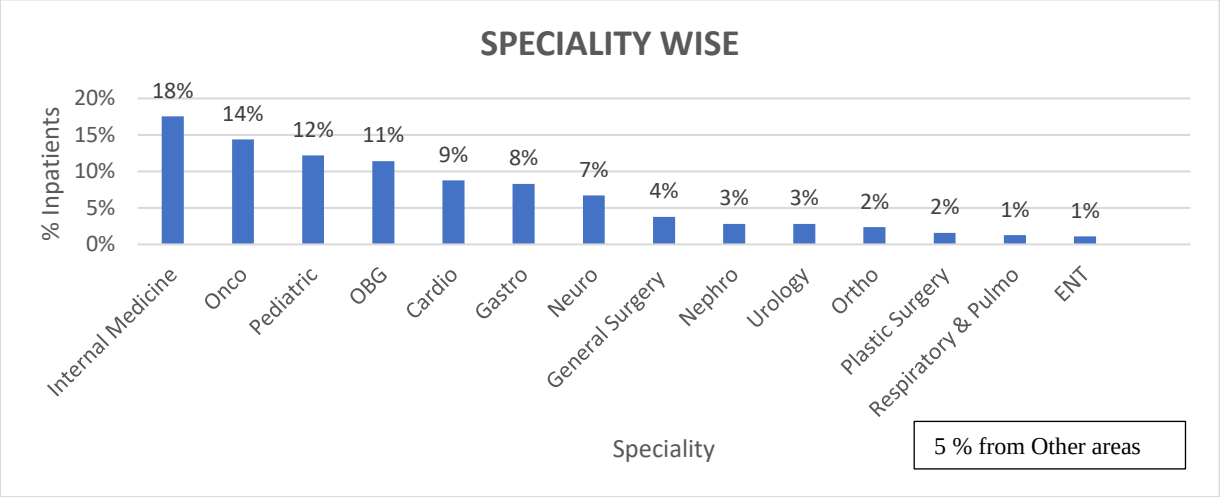

Fig 5: Specialty Wise Distribution for Zone A

The inpatient services that were availed the most included Internal medicine (18%) and Oncology (14%).

3. Geographical Area Distribution

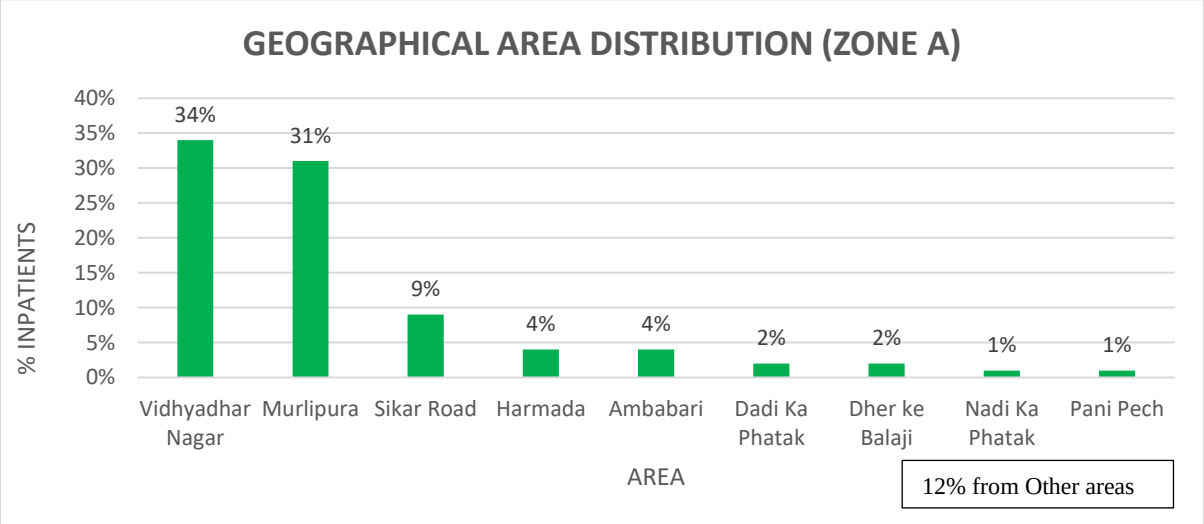

Fig 6: Geographic Area Distribution for Zone A

A major chunk of inpatients from Zone A originated from Vidhyadhar Nagar (34%) and Murlipura (31%) for availing inpatient care at the hospital.

4. Geotagging

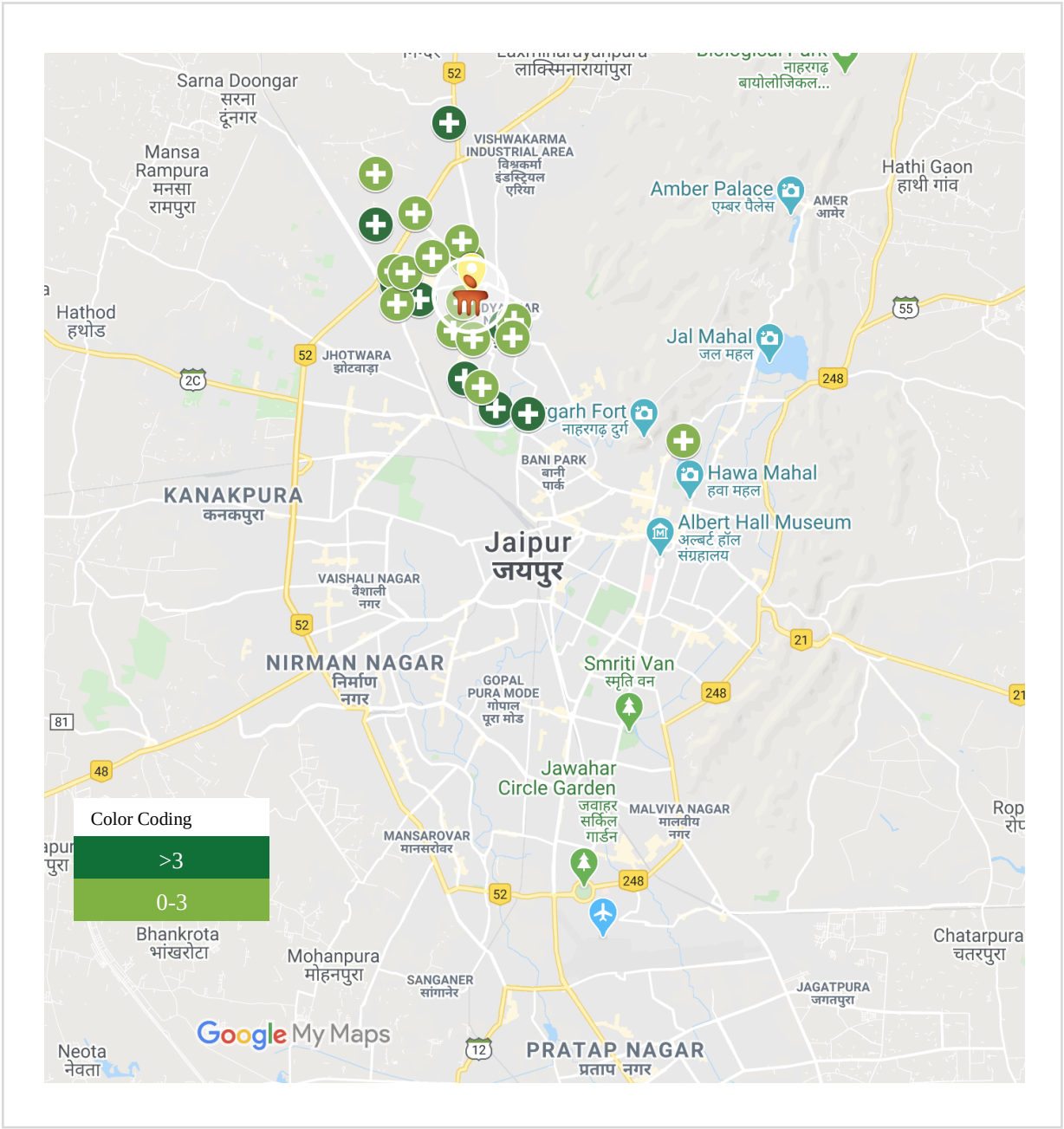

Fig 7: Geotagging for Zone A

Geotagging for Zone A inpatients that have availed inpatient services at Manipal Hospitals, Jaipur showcases small clusters of patients that have their local residence within 1-5 km from the hospital. As the itself is located in Vidhyadhar Nagar, maximum patients are attracted from the same area. Other nearby areas such as Murlipura as well as Sikar road also provided with a good chunk of inpatients.

- **Zone B**

1. **Demographic Distribution**

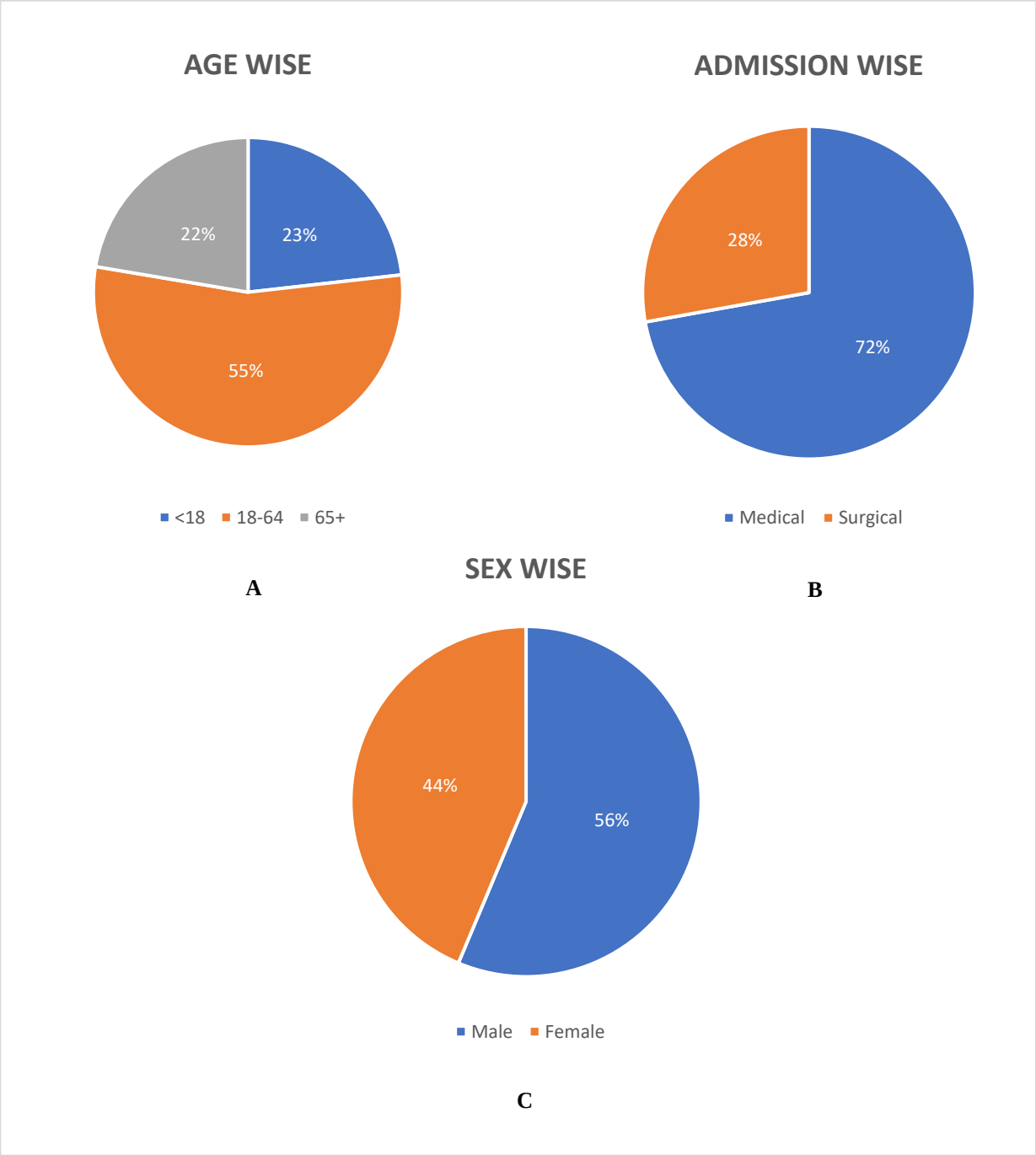

Fig 8: Age Wise, Sex Wise and Admission Wise Distribution for Zone B

The inpatients availing admission to the hospital for medical was relatively high (72%) with more Male patients (56%).

2. Specialty Distribution

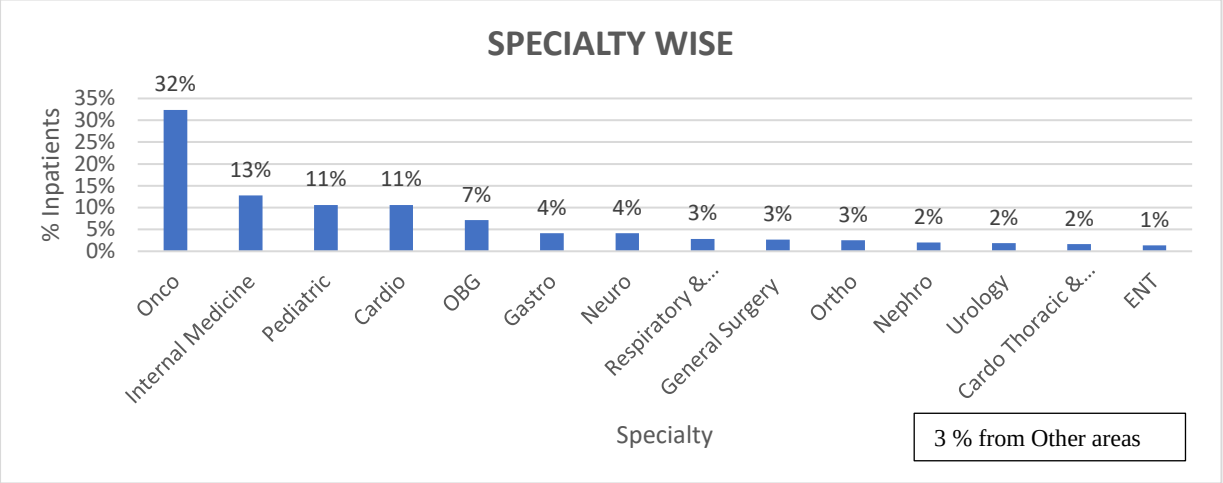

Fig 9: Specialty Wise Distribution for Zone B

Oncology services were the most availed services in Zone B (32%) with relatively low uptake for other services such as Orthopedics (3%), Cardiology (2%), ENT (1%), etc.

3. Geographical Area Distribution

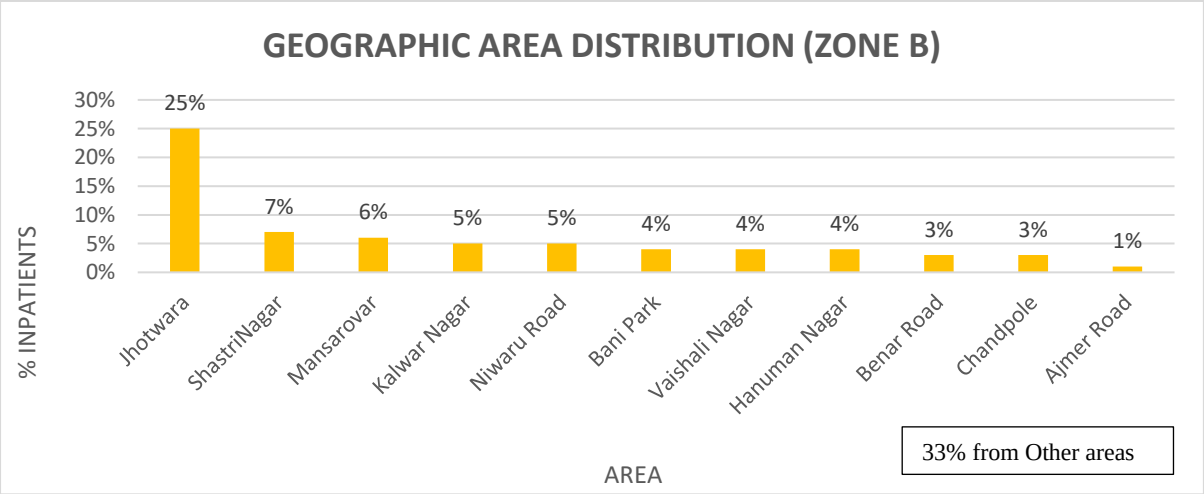

Fig 10: Geographic Area Distribution for Zone B

Jhotwara was the place of origin for patients seeking largest portion of inpatient care in Zone B (25%), which seems even more striking when compared to others such as Benar Road (3%), Chandpole (3%), etc.

4. Geotagging

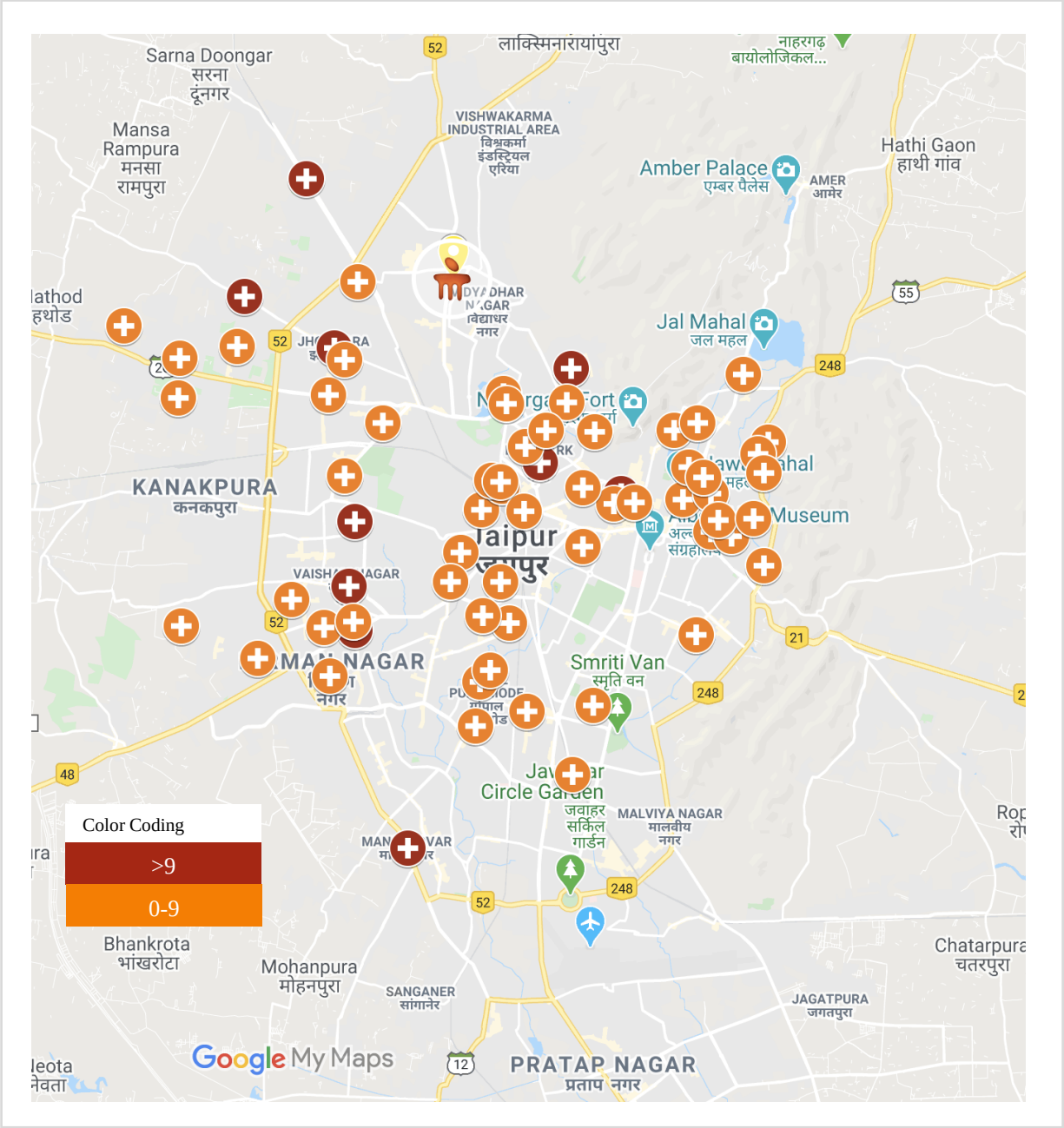

Fig 11: Geotagging for Zone B

Zone B geotagging showcases wide range clusters with a distance limit of 5 – 15 km from the hospital. This zone has brought in patients from areas such Jhotwara, Shastri Nagar, Mansarovar, etc. The distribution was again uneven with Jhotwara, situated nearby, accounting for huge share of inpatients.

- **Zone C**

1. **Demographic Distribution**

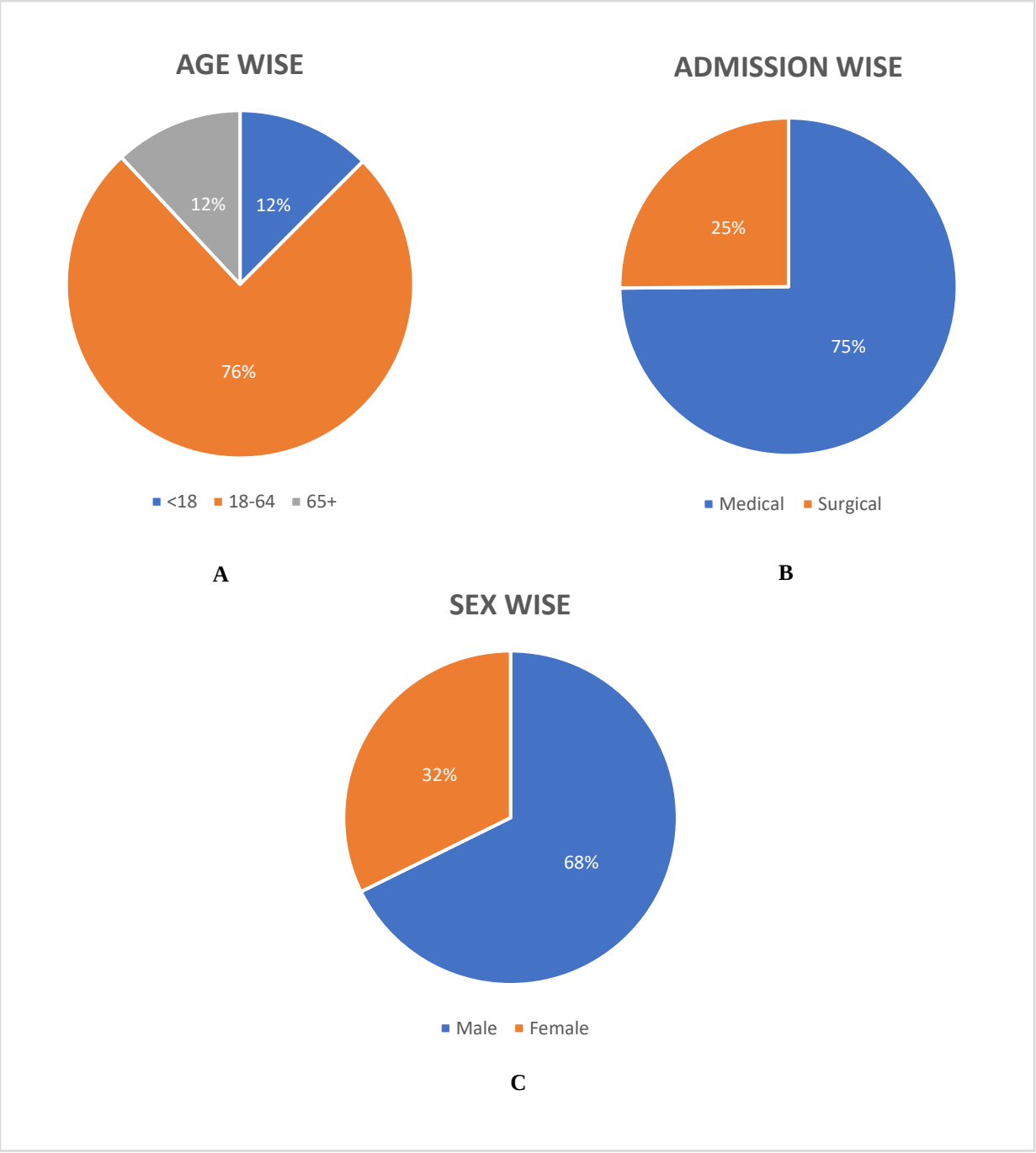

Fig 12: Age Wise, Sex Wise and Admission Wise Distribution for Zone C

The ratio of inpatients among the age group 18-64 was highest (76%) in comparison to other zones. Zone consisted of more Male patients (68%) with similarly high Medical admissions.

2. Specialty Distribution

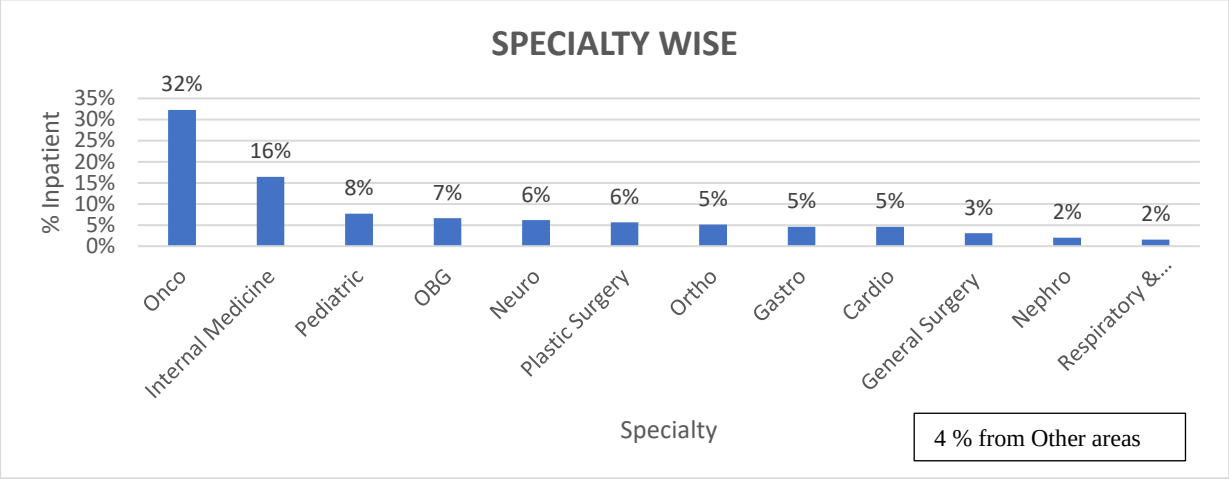

Fig 13: Specialty Wise Distribution for Zone C

Similar to Zone B, Zone C also has Oncology patients utilizing highest inpatient care services from the hospital (32%).

3. Geographical Area Distribution

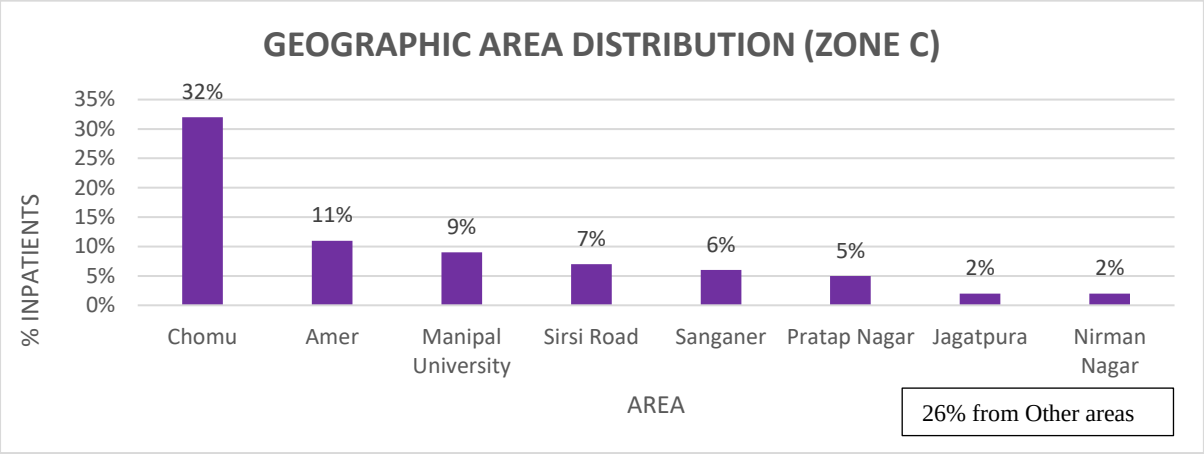

Fig 14: Geographic Area Distribution for Zone C

Highest number of incoming patients admitted in the hospital from Zone C were from Chomu (32%). Second highest were from Amer (11%).

4. Geotagging

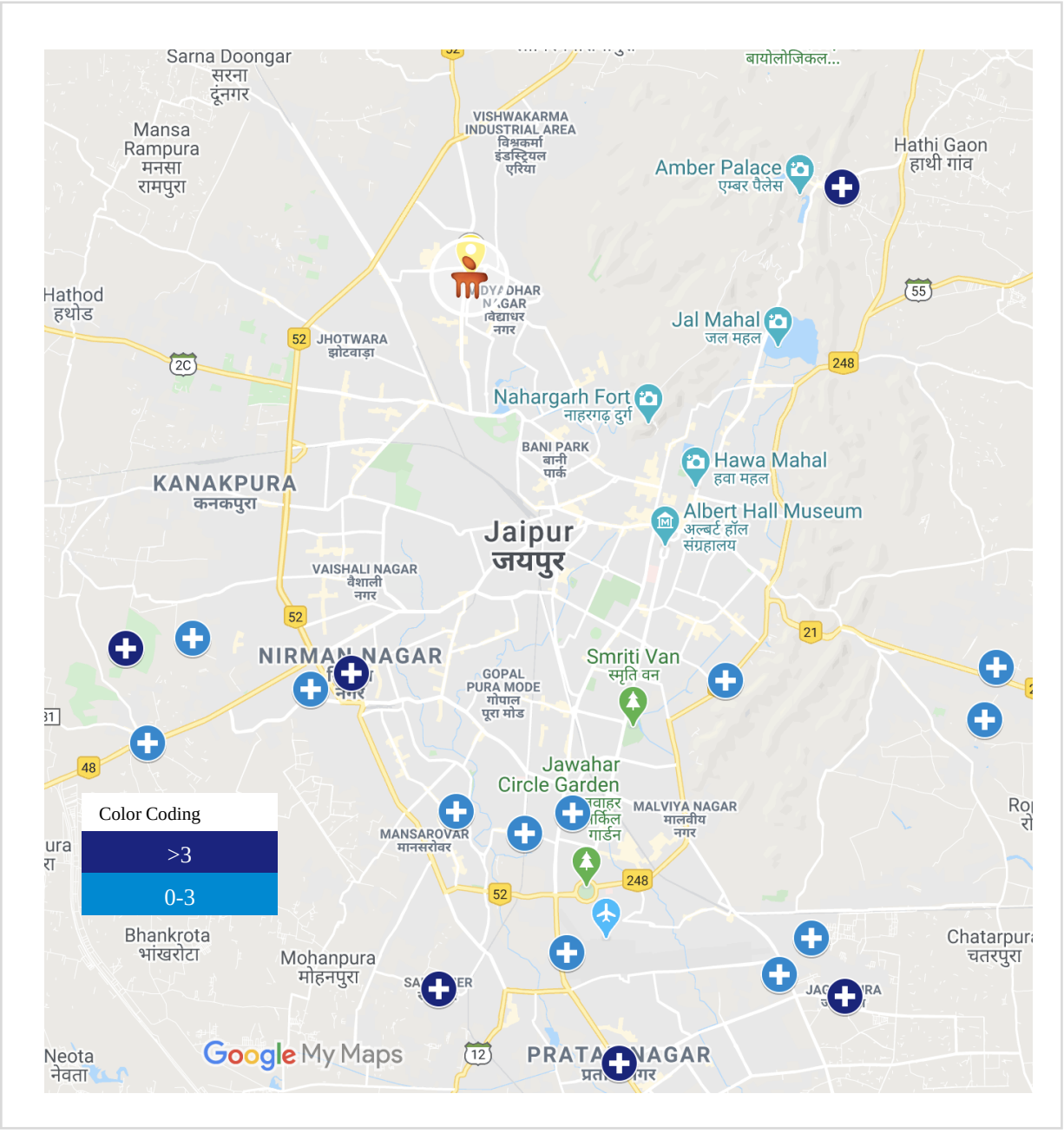

Fig 15: Geotagging for Zone C

Zone C Geotagging identified inpatients coming from even far away from the hospital i.e in the range of 15-25 km from the hospital. Small clusters identified include Chomu, Amer, Manipal University, etc. Chomu could be identified as one of the highly served regions even in comparison to other regions such as Sanganer, Pratap Nagar, Jagatpura, Nirman Nagar,etc.

- **Outside**

1. Demographic Distribution

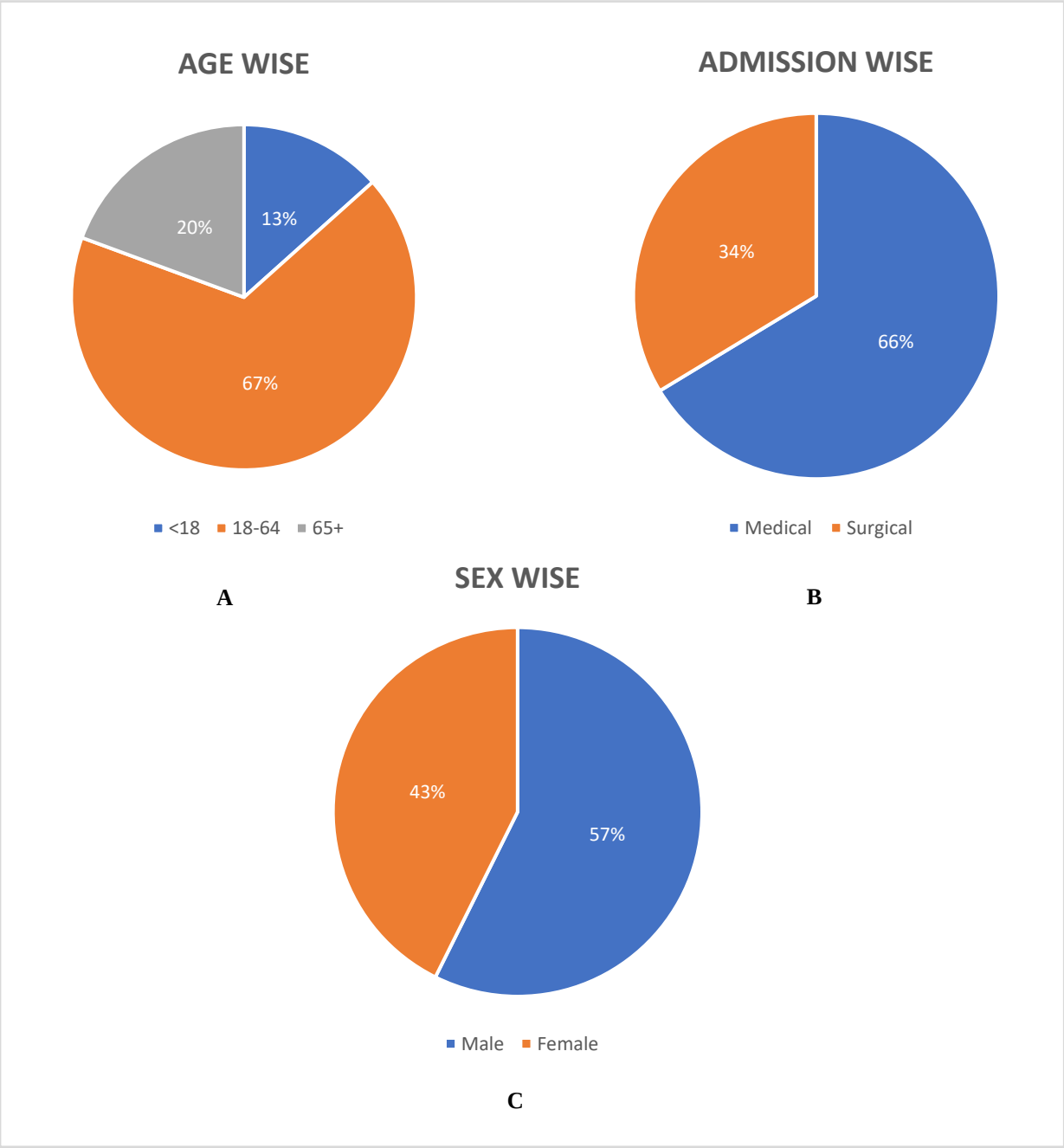

Fig 16: Age Wise, Sex Wise and Admission Wise Distribution for Outside

No real difference was observed in the demographics of outside patients in comparison to other zones, with similar age group of 18-64 (67%), more Male patients (57%) and more surgeries taking place (66%).

2. Specialty Distribution

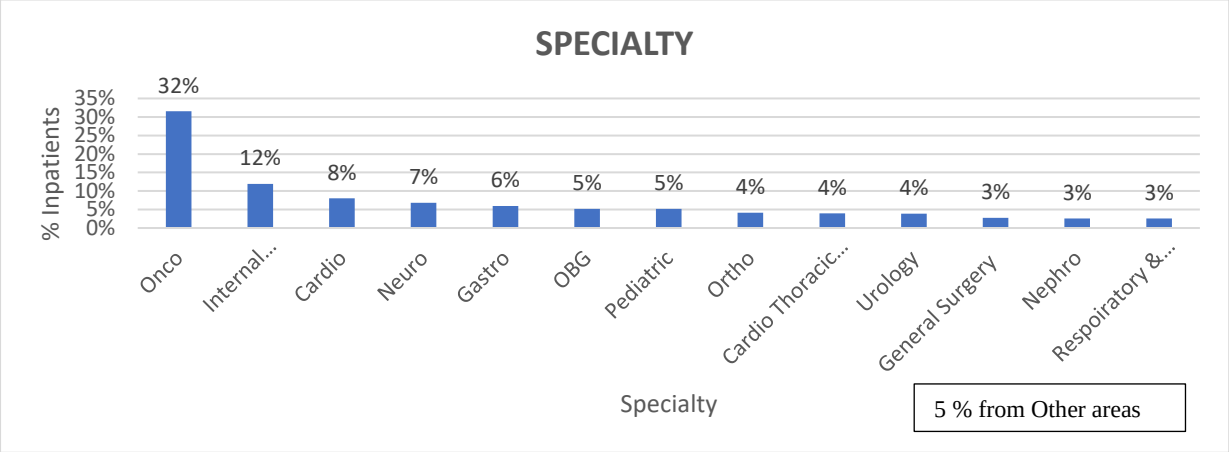

Fig 17: Specialty Wise Distribution for Outside Patients

Highest number of patients from outside were admitted in the hospital for Oncology (32%).

3. Geographical Area Distribution (Only Rajasthan)

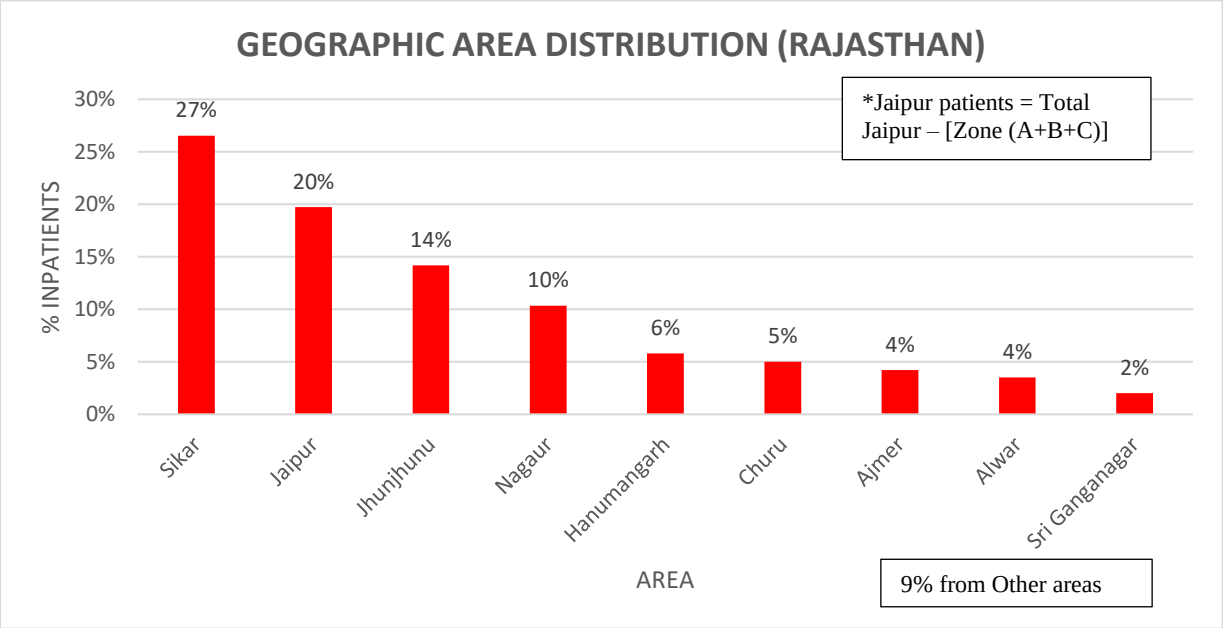

Fig 18: Geographic Area Distribution for Rajasthan

Highest number of incoming patients admitted in the hospital from Zone C were from Chomu (32%). Second highest were from Amer (11%).

4. Rajasthan district Distribution

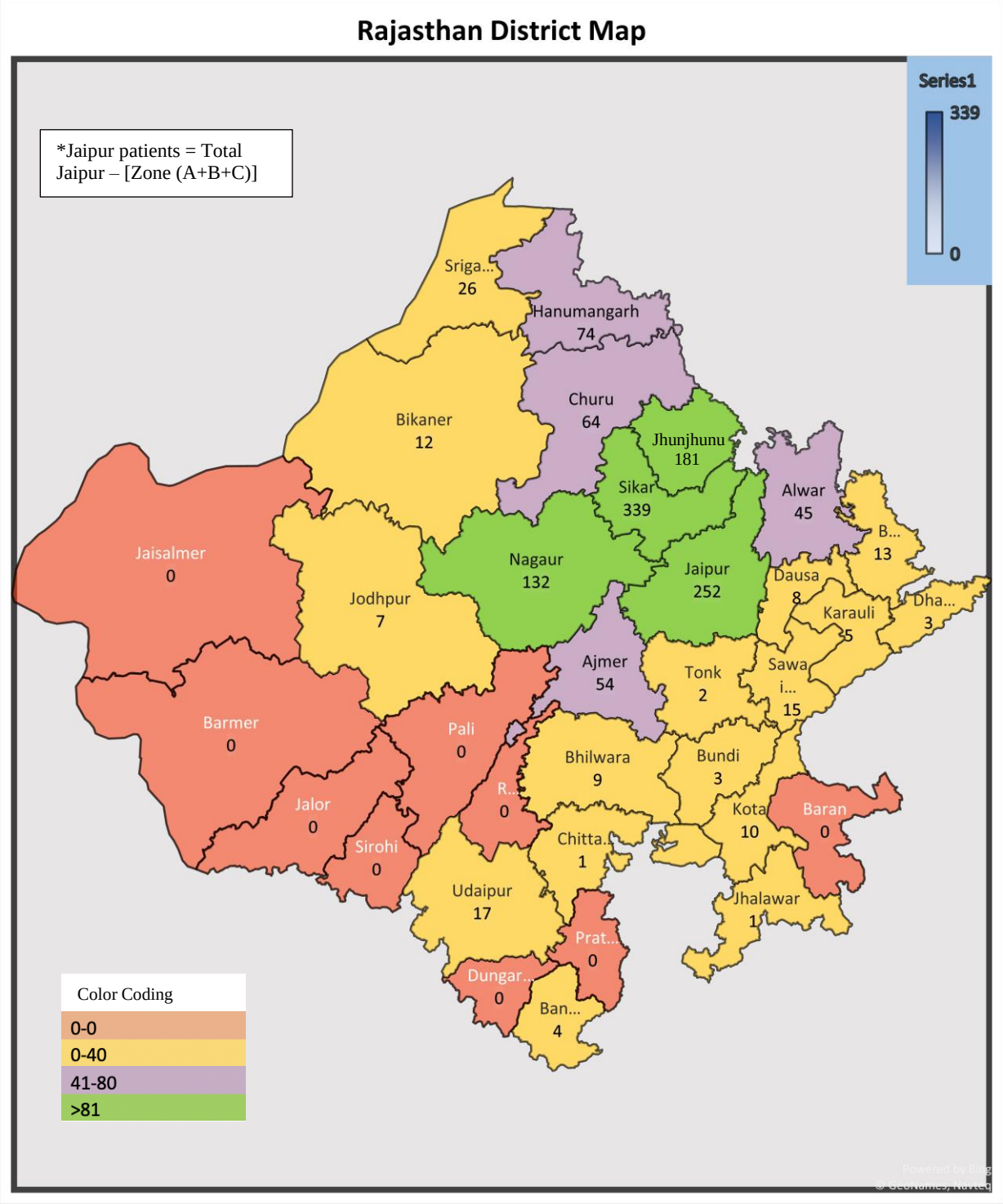

Fig 19: Distribution for Outside patients within Rajasthan

Outside of Jaipur, Nagaur (132), Sikar (339) were the district that were majorly served by the hospital for inpatient care. Underserved districts included Jaisalmer, Barmer, Pali, Jalor, etc.

5. Geotagging

Fig 20: Geotagging for Rajasthan

Geotagging of Outside patients within Rajasthan showcases interesting insights into the reach of the hospital inpatient services within the state. With distance from the hospital playing a significant role in availing of services, the cluster showcases inpatient recruit from districts such as Nagaur, Sikar, Hanumangarh, etc.

5. DISCUSSION

Detection of geographical patterns and precise identification of a particular facility's catchment area is vitally essential for: understanding and knowing the population served, for planning and testing service delivery and also for analyzing the effectiveness of various services offered. On the other hand, a mistaken view of the catchment area can subsequently lead to inefficient and inadequate services and service delivery, incorrect specification of the catchment population and potentially flawed decision-making on subjects regarding business growth, resulting in a poorly functioning health facility.

The study illustrates the application of Mapping tools such as Geotagging and Visual Maps to assess the source of patients admitted at Manipal Hospitals, Jaipur. Results confirmed the expected outcome that the major portion of inpatients was drawn from areas surrounding the hospital, although these areas themselves diversified in reach on the basis of the demographics of the population or the specialties that were availed (Figs. 4–18). There was a slight decrease in the overall inpatient footfall trend to the hospital along with decrease in the ratio of Non-scheme patients (Table 3).

Clusters or Zones were identified (Table 1) on the basis of distance (in km.) from the hospital The highest number came from Outside, while Zone B accounted for highest number of inpatients among nearby areas (Fig. 2) while the monthly trend remained fairly consistent indicating similar clusters (Fig. 3) which was similar to other studies using distance as a measure for identifying service areas [23].

Zone Specific Analysis extracted unique details regarding demographics, specialty, and area-wise density in line with the study performed at NCICCC [24]. In Zone A, the inpatients of the age group 18-64 formed the highest consumer group, where rate of admission was surgery was high with an equal representation of both males and females. Internal Medicine department accounted for the highest number of patients served (Fig. 5), forming patient clusters which could be identified easily via Geotagging (Fig.7). The geographic visualization performed via the free Google tool is already used widely due to its ease of use as well as utility and is one of the various methods which could also be useful in identifying suitable locations for setting up of new services as mentioned in other studies [21].

In Zone B and C, yet again the age group 18-64 was the major user, but with increased participation of other groups in Zone B (Fig. 8) Planned admissions for Medical treatment were more in number than admissions for surgeries, especially in Zone C (Fig. 12). Oncology inpatient services were the most utilized in both zones (Figs. 10 & 13) which gives an indication regarding the cluster disease burden similarly studied by others [2].

Outside analysis gave interesting results regarding the reach of hospital inpatient services. Jaipur, being the location area of the facility recruited maximum patients but the Visual Map for geographic distribution of inpatients within Rajasthan showed a healthy inpatient inflow from surrounding areas such as Sikar, Nagaur and Jhunjhunu (Fig. 19) which indicates further analysis could help in identifying catchment areas even in non-urban and semi-urban areas as proposed in the study done by Schuurman N et al [8].

There were several limitations to the study which hampered a more meticulous analysis such as scheme patients not being included in the study as they indirectly contribute to the revenue of the hospital via word-of mouth. Additionally, Inclusion of patients being admitted to the facility more than once, such as day care patients or others, would would have created bias regarding patient density at their residence location area. For some patients, data has been collected as the current residence location. However, patient migration has not been taken into account. Therefore, discrepancies could have also occurred for patients migrating to a new residence location. Most importantly, no statistical tool has been used for mapping and visualizing geographical data, which limited the extent of the study.

Geographic information system (GIS) technology consisting of tools such as Geotagging and Visual Maps can enable various health systems to analyse patient demographic and geographic data instead of assuming or ignoring the geographic and utilization characteristics of populations for planning purposes. This strategy essentially complements the health care business planning process of estimation of market volume and market share.

In the future, there will be an upsurge in data available from already widely used sources such as Big data and wearable devices. Hospitals have the opportunity to analyse this data and come-up with innovations and solutions that could benefit the entire healthcare system.

6. CONCLUSION

In summary, mapping of patients availing inpatient services provides an illustrative mechanism for visualizing inpatient service patterns. Analysis via Geotagging and Visual Maps adds another layer of understanding to the distribution of patients admitted to the hospital. Firstly, it was able to identify and define various zones centering around the location of the hospital for all inpatients and many subgroups. Secondly, these zones or clusters differed in the proportion of the overall population served, which has led to an increased competition in the market due to abundance of similar services elsewhere. Thirdly, we believe analyses like these should well be incorporated within hospital reporting regarding patients catered to and service to the surrounding community as well. Lastly, this analysis may facilitate us to increase our understanding of patient behavior, especially as we reach out to special groups such as minority, female, and young or elderly populations.

7. RECOMMENDATIONS

- **Make Patient source of origin based geographic distribution and demographic analysis part of hospital operations analysis.** A monthly geographic distribution and demographic analysis could be performed for overall hospital services as well as for different service lines – OPD, IPD, Home Care, etc. This will enable hospital administrators to identify trends in patient service-seeking behavior, quality and effectiveness of services, etc.

- **Use of Mapping tools and spatial statistics for continuously monitoring the facility's catchment area.** Tools such as Geotagging and Visual Maps to be made use of for identifying hospital's reach locally as well as beyond borders.

- **Analyzing trends in Marketing.** Patient source of origin studies provide a visible avenue for evaluating the orientation and directional dispersion of customers. The methods suggested in the study can be used to convert small patient clusters into well-defined market areas. Further recommended use for marketing includes:

    i. Determination market potentials
    ii. Pinpointing of various promotional efforts
    iii. Interpretation of variations in sales penetration
    iv. Determination of sales territories
    v. Evaluation of the location for new facilities
    vi. Analyzing various differences in promotional response

- **Craft an awareness stage content strategy for under-serviced areas.** For areas of with low inpatient share (Dausa, Alwar, Tonk, etc.), a content strategy should be developed for promoting IPD services which would include SEO, Social Media, etc.

- **Market Penetration of highly-services areas.** For areas already attracting patients to the hospital for IPD care (Jhotwara, Murlipura, etc.), target customers on the basis Zone wise demographics. For example, in Jhotwara area, Oncology services could be marketed to Males of the age group 18-64 years.

8. REFERENCES

1. McLafferty SL. GIS and Health Care Annu Rev Public Health. 2003; 24:25–42.
2. Aamodt G, Samuelsen SO, Skrondal A. A simulation study of three methods for detecting disease clusters. Int J Health Geographics 2006; 5:15.
3. Biggeri A, Catelan D, Rinaldi L, Dreassi E, Lagazio C, Cringoli G. Statistical methods for geographical surveillance in veterinary epidemiology. Parassitologia 2006; 48:73–6.
4. Abe T, Martin IB, Roche LM. Clusters of census tracts with high pro- portions of men with distant-stage prostate cancer incidence in New Jersey, 1995 to 1999. Am J Prev Med 2006;30: S60–6.
5. Gordon A, Womersley J. The use of mapping in public health and planning health services. J Public Health Med. 1997;19(2):139-147.
6. Studnicki J. The minimization of travel effort as a delineating influence for urban hospital service areas. Int J Health Serv 1975; 5:679-93.
7. Dranove D, White WD, Wu L. Segmentation in local hospital markets. Med Care 1993; 31:52–64.
8. Schuurman N, Fiedler RS, Grzybowski SC, Grund D. Defining rational hospital catchments for non-urban areas based on travel-time. Int J Health Geogr 2006; 5:43.
9. Diesfeld HJ. The definition of the hospital catchment area and its population as a denominator for the evaluation of hospital returns in developing countries. Int J Epidemiol 1973; 2:47–53.
10. Kamel Boulos MN, Geraghty EM. Geographical tracking and mapping of coronavirus disease COVID-19/severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) epidemic and associated events around the world: how 21st century GIS technologies are supporting the global fight against outbreaks and epidemics. Int J Health Geogr. 2020 Mar;19(1) 8.
11. Huang C, Xu X, Cai Y, et al. Mining the Characteristics of COVID-19 Patients in China: Analysis of Social Media Posts. J Med Internet Res. 2020;22(5):e19087.
12. Theunissen C, Bottieau E, Van Esbroeck M, Tsoumanis A, Florence E. Should We Screen HIV-Positive Migrants for Strongyloidiasis?. Pathogens. 2020;9(5):E388.
13. Campbell AD, Colombatti R, Andemariam B, et al. An Analysis of Racial and Ethnic Backgrounds Within the CASiRe International Cohort of Sickle Cell Disease Patients:

Implications for Disease Phenotype and Clinical Research [published online ahead of print, 2020 May 16]. J Racial Ethn Health Disparities. 2020;10.1007/s40615-020-00762-2.

14. Jeny F, Uzunhan Y, Lacroix M, et al. Predictors of mortality in fibrosing pulmonary sarcoidosis. Respir Med. 2020;169:105997.
15. Vilchez Sanchez F, Tomas Perez M, Sanchez Jareno M, Loli Ausejo D, Quirce S, Dominguez Ortega J. Allergic sensitization profiles among the foreign-born population in the north of Madrid [published online ahead of print, 2020 Apr 27]. *Eur Ann Allergy Clin Immunol*. 2020;10.23822/EurAnnACI.1764-1489.143.
16. Monk EJM, Yee KP, Allan R, Gayton IB. Determination of true patient origin through motorcycle mapping: design and implementation of a community-defined geographic infrastructure surveillance tool in rural Sierra Leone [published online ahead of print, 2019 Jul 17]. Trans R Soc Trop Med Hyg. 2019;trz063.
17. Doll D, Orlik A, Maier K, et al. Impact of geography and surgical approach on recurrence in global pilonidal sinus disease. Sci Rep. 2019;9(1):15111.
18. Reimer A, Bruckner-Tuderman L, Ott H. Mapping health care of rare diseases: the example of epidermolysis bullosa in Germany. Orphanet J Rare Dis. 2018;13(1):197.
19. Sjetne IS, Iversen HH. Do experiences with pregnancy, birth and postnatal care in Norway vary by the women's geographic origin? a comparison of cross-sectional survey results. BMC Pregnancy Childbirth. 2017;17(1):37.
20. Soares N, Dewalle J, Marsh B. Utilizing patient geographic information system data to plan telemedicine service locations. J Am Med Inform Assoc. 2017;24(5):891-896.
21. Baskin L, Abdullah A, Guo M, Naugler C. Use of geospatial mapping to determine suitable locations for patient service centers for phlebotomy services. Am J Clin Pathol. 2015;144(5):727-730.
22. Wang A, Wheeler DC. Catchment area analysis using bayesian regression modeling. Cancer Inform. 2015;14(Suppl 2):71-79. Published 2015 Apr 19.
23. Zinszer K, Charland K, Kigozi R, Dorsey G, Kamya MR, Buckeridge DL. Determining health-care facility catchment areas in Uganda using data on malaria-related visits. Bull World Health Organ. 2014;92(3):178-186.
24. Su SC, Kanarek N, Fox MG, Guseynova A, Crow S, Piantadosi S. Spatial analyses identify the geographic source of patients at a National Cancer Institute Comprehensive Cancer Center. Clin Cancer Res. 2010;16(3):1065-1072.

9. ANNEXURE

Area	Zone
Sikar Road	Zone A
Ambabari	Zone A
Dadi Ka Phatak	Zone A
dher Ke Balaji	Zone A
Harmada	Zone A
Murlipura	Zone A
Shiv Nagar	Zone A
Vidhyadhar Nagar	Zone A
VKI	Zone A
Jagdamba Colony	Zone A
Pani Pech	Zone A
Karni Colony	Zone A
Shaitan Singh Colony	Zone A
Bhawani Nagar	Zone A
Alka Puri	Zone A
Dwarika Puri Colony	Zone A
Hanumant Tower	Zone A
Kartarpur Phatak	Zone B
Sanjay Nagar	Zone B
Shankar Nagar	Zone B
Sodala	Zone B
Vivekanand Nagar	Zone B
Bhakar Ki Dhani	Zone B
Indra Nagar	Zone B
Civil Lines	Zone B
Ganpati nagar	Zone B
Sunder Nagar	Zone B
Tripolia	Zone B
Green Triveni	Zone B
Banipark	Zone B
prem nagar	Zone B
Vijay Pura	Zone B
Kalwar	Zone B
Mazdoor Nagar	Zone B
Alsisar	Zone B
anand Nagar	Zone B
Badi Chaupar	Zone B
VASANT VIHAR	Zone B
Ram Nagar	Zone B
surajpole Bazar	Zone B
Shivaji Nagar	Zone B
Sikar House	Zone B
Santosh Nagar Colony	Zone B
m.i.road	Zone B
Hatoj	Zone B
Jaswant Nagar	Zone B
Keshav Nagar	Zone B
Krishna Nagar College Road	Zone B
Ajmer Road	Zone B
ashok nagar	Zone B
CHANDRA NAGAR COLONY	Zone B
Defence Colony	Zone B
Ghatgate	Zone B
Hanumant Nagar	Zone B
shubash Chowk	Zone B
Krishna Nagar	Zone B
Nari Ka Naka	Zone B
Kumawat Colony	Zone B
Khirni Phatak	Zone B
Krishna Vihar	Zone B
Krishna Mandir	Zone B
KARNI MATA KA MANDIR	Zone B
Niwaru Road	Zone B
Ayodhya Nagar	Zone B

Jhotwara	Zone B
Shastri Nagar	Zone B
Adarsh Nagar	Zone B
Khatipura	Zone B
Laxmi Nagar	Zone B
Vaishali Nagar	Zone B
Bani Park	Zone B
Tonk Road	Zone B
Niwaru Road	Zone B
BenarRoad	Zone B
Ganesh Nagar	Zone B
Kalwar Road	Zone B
C-Scheme	Zone B
Nehru Nagar	Zone B
Tonk Phatak	Zone B
Lalarpura	Zone B
Hari Nagar	Zone B
Loha Mandi	Zone B
Janta Colony	Zone B
Jda Colony	Zone B
Ajmer Road	Zone B
Arjun Colony	Zone B
Chand Bihari Nagar	Zone B
Choudhary Colony	Zone B
Haldiyo Ka Rasta	Zone B
Hanuman Nagar	Zone B
Mansarovar	Zone B
Nindar	Zone B
Pataliyo Ki Dhani	Zone B
Pathik Nagar	Zone B
Queens Road	Zone B
Satyanagar	Zone B
Shyam Nagar	Zone B
Shyam Puri	Zone B
Jagdamba Nagar	Zone B
Balaji Vihar	Zone B
Bihari Nagar	Zone B
Jagannathpuri	Zone B
Imali Phatak	Zone B
Vijay Dwar	Zone B
Badanpura	Zone B
Umroo Vihar	Zone B
Aravali Nagar	Zone B
Bapu Nagar	Zone B
Chandpole	Zone B
Gopal Nagar	Zone B
GopalPura	Zone B
Hawa Sadak	Zone B
Kardhani	Zone B

Chomu	Zone C
Sita Pura	Zone C
Amer	Zone C
Sirsi Road	Zone C
Karni Vihar	Zone C
Basant Vihar Colony	Zone C
Nirman Nagar	Zone C
Kamla Nehru Nagar	Zone C
Malviya Nagar	Zone C
Sidhharth Nagar	Zone C
Galta Gate	Zone C
Jawahar Nagar	Zone C
Manipal University	Zone C
Choup	Zone C
Biharipura	Zone C
Sanganer	Zone C
Durgapura	Zone C
Parshvanath Colony	Zone C
pratapnagar	Zone C
Prabhat Colony	Zone C
Choki Dhani	Zone C
Mahaveer Nagar	Zone C
Morija	Zone C
jagatpura	Zone C
Sananer	Zone C
brahmpuri	Zone C
Indira Nagar	Zone C
Ajmer Road	Zone C