MOBILE HEALTH APPLICATION ADAPTABILITY AND USER BEAHVIOR USING GIS

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CANDIDATE'S DECLARATION

I, Rajeev Kumar, Roll No. - 2K20/GEO/07, Student of M.Tech (Geoinformatics Engineering), hereby declare that the project Dissertation titled "*Mobile health application adaptability and user behavior using GIS*" which is submitted by me to the Multidisciplinary Centre for Geoinformatics, Department of Civil Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other

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Rajeev Kumar.

Place: Delhi

Date: 30th May 2022 RAJEEV KUMAR

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ABSTRACT

As per the WHO data doctor to patient availability in India is very low which creates a burden on the medical staff and infrastructure. This show the country needs modern day technological intervention to share the burden, mobile health application is one of such intervention. In the published report of PWC, it has been mentioned that mobile health applications on one hand are not widely accepted by consumers even though mobiles are quite handy things these days. On the other hand, it has been in a better position from the past due to more features available. This has made us study the behavioral patterns of the users why and how they and for what they are using these apps and in what regularity. Our main study focuses on developing an interactive dashboard which takes the inputs as CSV files and gives the handy tool to the user, to interact with it and find out which app is more popular and for what purpose it's being used.

The Power BI dashboard has been created by using measures and calculated columns to define the data in more appropriate ways. Both of these things entail DAX (Data Expression Language) which can convert Data into more meaningful. Furthermore, Hotspot, Near and Drive time area analysis using Arc GIS Online platform has been done to find the hospitals and user's relation based on their location.

Results have shown us that dashboard is working fine and gives correct outputs. The dashboard in future can be linked to a server which fetches the live data and can give real insights at a moment to understand the behavior of the end-user and we can understand the patterns of users. Furthermore, the future scope of the dashboard lies in the fact that it can be linked to live medical facility data which shows bed availability, type of specialization available and to give the user a option to take medical services through app.

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CHAPTER 1

1.INTRODUCTION

1.1 Background

Mobile health is generally defined as the use of mobile devices to support the delivery of healthcare from a distance in order to monitor and improve the health status of users. One segment of eHealth includes mHealth (mobile health). Mobile health (mHealth) is the use of mobile computer and communication technology in health care and public health as a result of advancements in mobile communication technologies. Many researchers estimate that mHealth has the potential to significantly enhance health-care delivery procedures and benefit people [1]. In the recent decade, the mobile internet infrastructure has grown at an exponential rate all over the world, reaching about 95 percent of the worldwide people in 2016 [2].As the mobile internet is reaching every corner of the world, In underdeveloped countries, smartphones are low-cost sources of technology for meeting health-care demands.Over the progress of smart mobile technology, Mobile health Applications has become a medium for exchanging health information and improving health outcomes via text messaging, mobile apps, and phone conversations [3]. A large Number of Mobile health Application are available on google and apple store such as 1mg, mfine, Practo, Netmeds etc. these apps have been used extensively during the peak of COVID-19 pandemic after that majority of user seems to abandon these apps there may be plenty of reason behind that, but many researchers find that the app has wider usability beyond COVID-19 pandemic.

India having the second highest population on the globe, the allopathic doctor population ratio is 1:1456, the recommended ratio by WHO is 1:1000. The WHO data says that only 18.8% rural and 58.4% urban allopathic doctor possess the educational qualification [4]. This gap can be widened by rapidly increasing population. A significant portion of the people lives in sub urban or

village areas, where the situation is significantly worse. Low-income people, in particular, do not have access to quality health care. As the high-speed network penetration increase in India mobile health application can play a vital role in sharing the burden of healthcare system of the country.

The COVID-19 pandemic has highlighted the serious flaws in our health-care infrastructure when it comes to dealing with the unexpected onset of significant diseases. The impoverished, as expected, are the ones who suffer the most [5]. These app have been found to be very crucial during the COVID-19 pandemic. These app has been focused on wide zones of health care services, the apps, are only effective and useful useful if the community adopt them to have the best use and participation throughout the state, enabling people and healthcare professionals to learn from each other and find effective ways to improve health outcomes in a coordinated effort to tackle the epidemic [5]. India having a heavy burden on its healthcare professional and infrastructure point us towards the new technology in the health sector, to offer health assistance and compensate for the health personnel and the lack of infrastructure in the country. mHealth is unlikely to succeed unless there is interest or demand [6].

As per statistics acquired from Google Trends, a tool that helps detect the current popularity in a given search phrase, India placed in the top 5 nations for search queries such as 'mobile health,' 'health apps, 'medical app', and 'mHealth.' This indicates that digital health is of importance to Indians. In emerging countries, mHealth has had a positive impact on the healthcare industry, and it is expected to do so in India too. These innovation offers great ability to improve accessibility, cut healthcare costs, and increase healthcare worker productivity in India. However, due to a number of roadblocks, mHealth's effect in the Indian healthcare industry remains restricted.

1.2 Obstacles in Mobile Health Sector

I. Technological Capacity

Technological limits cover a wide range mostly in developing countries where the technology is still imported, reflecting the fact that Mobile health Application systems are limited to usage in specific clinical contexts, and mobile systems are limited to a pocket-sized computer that can be modified to overcome these limitations. Furthermore, quality, capacity, and speed are all difficult in this area [7].

II. Lack of basic Infrastructure

Perhaps basic infrastructure is inadequate in many regions. The internet is only reachable to a small percentage of the rural population. The bulk of the poor are unable to purchase a high-quality mobile with mHealth features. Confidentiality are also important factors, provided the infrastructure required [8]. There is no way of confirming yet if the app maker has taken necessary security measures to defend his or her application from unauthorized intrusions in the situation of mHealth apps. mHealth involves a lot of manual engagement, whether it's through Texting, applications, or audio/video consultation, which makes it undesirable. This is a significant impediment and the principal reason why so many customers abandon their accounts. To eliminate manual intervention, certain elements can be automated. In this case, smartphone connectivity with external hardware, sensors, and systems might be incredibly beneficial. mHealth application developers should provide APIs/interfaces to acquire and collect information routinely whenever possible.

III. Low Expectation and Awareness

Major health sector players have failed to explore the potential of mobile health application. As a result, there is a lot of resistance to change and new technologies. Even the patient population suffers if a patient has a negative experience with a mHealth app. loses interest in the subject [8]. Furthermore, a sizable percentage of the population is primarily concerned with fitness. apps. Part of the reason for the low expectations is a lack of awareness of the considerable cost savings. The Indian government has started looking into mobile health apps as a way to improve public healthcare system [9].

According to a 2019 PwC report [10], the main challenges for providers are a lack of enthusiasm among key users, medical professionals' culture, and a lack of understanding on mHealth. Patients, on the other hand, see cost, a lack of suitable apps, and providers' hesitation to use mHealth as the most significant impediments to adoption [10].

IV. Language and Cultural Barrier

The possible advantages of mHealth services including SMS text messaging are limited in certain emerging economies due to linguistic variety. Patient endure unwanted consequences as a result of pharmaceutical misperceptions caused by language discrepancies between patients and

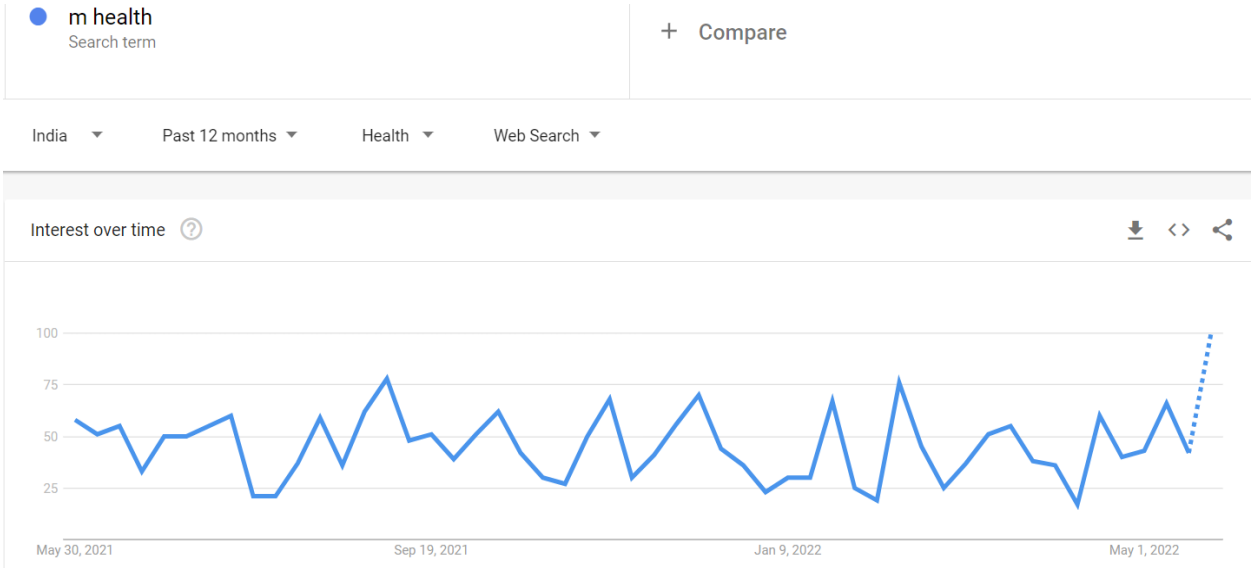
practitioners. The similar issue arises if the medical provider is unable to communicate with the patients in their native tongue [11].

V. lack of Skilled Medical Staff

The scarcity of health practitioners in poor nations is a key impediment to the successful execution of mobile Health Application services. There is a severe scarcity of healthcare personnel in most underdeveloped nations. Furthermore, in order to function the mobile health system, healthcare practitioners must have required skills and competencies [12].

1.3 Ongoing Trend in mHealth in India

The report publishes by PwC shows that the Mobile health application is appreciated by a large portion of the public since they can be used on smart phones, are inexpensive, and are interoperable, which isn't always the situation with medical devices. The mobile health industry is expected to grow exponentially over the coming years in India, as India is among the top countries that have shown immersive potential and maturity towards the adaption of mobile health application [13].



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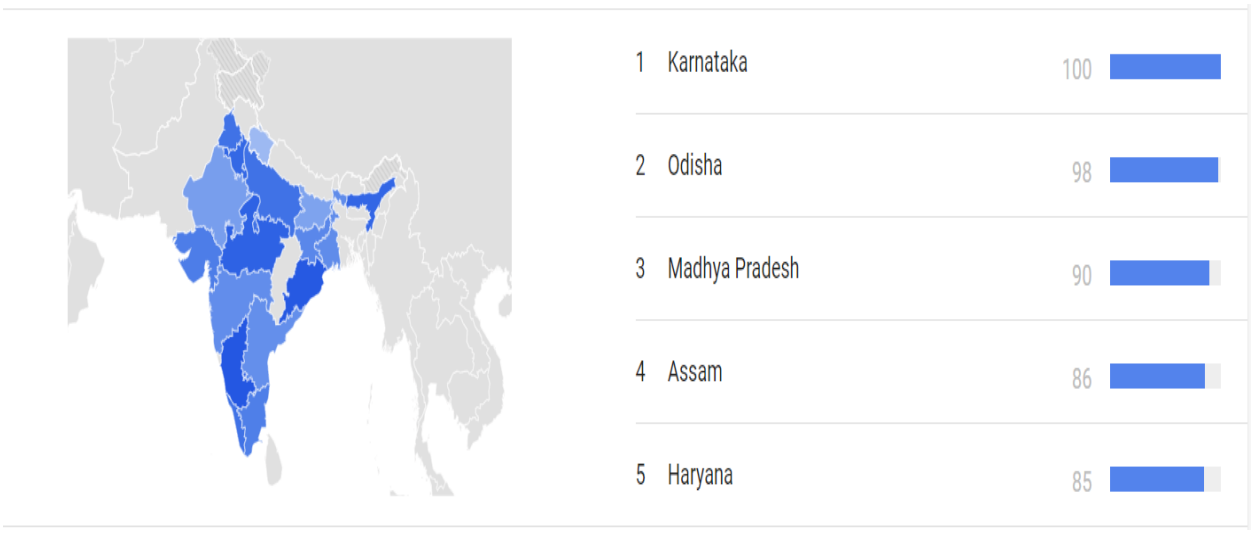

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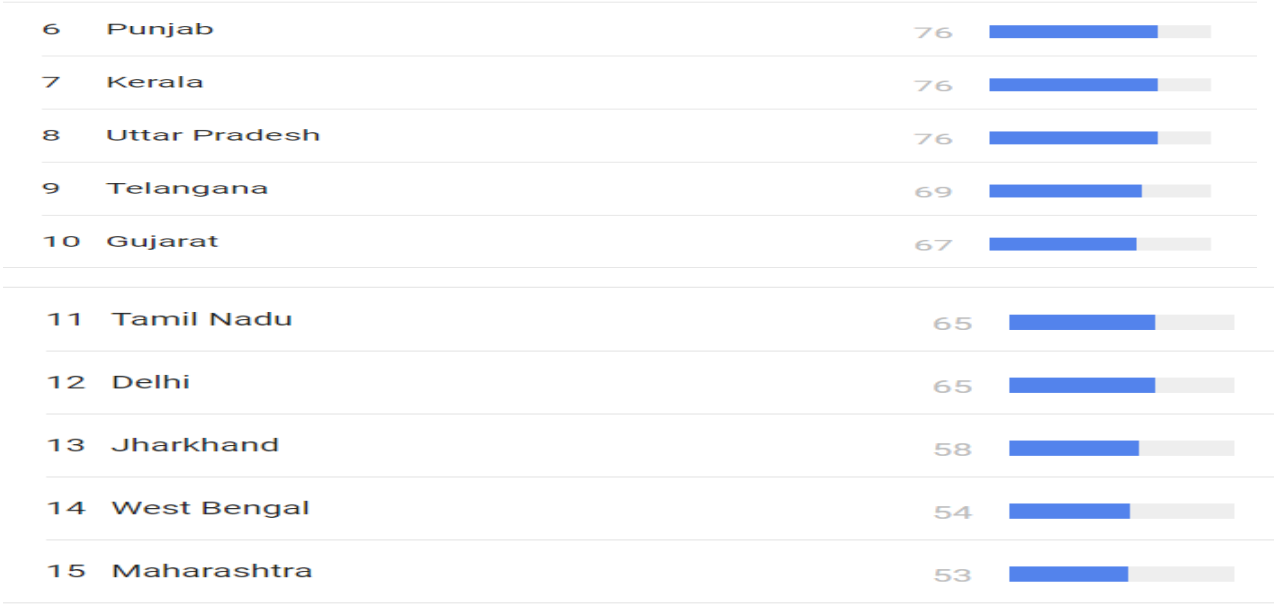


(c)

Figure 1. (a) mHealth Search trend for last one year. (b) , (c) mHealth search query by Sub region (Source: https://trends.google.com)

The above google trends data shows that m health is most popular in Karnataka whereas it is less popular in states such as Delhi, Jharkhand, West Bengal and Maharashtra. In states like Karnataka, Odisha, and Madhya Pradesh, mobile Health is quickly becoming the method of choice for patients to contact their clinicians. Patients can access patient portals to track their steps, glucose levels, consults, and follow-ups, as well as manage their prescriptions and diseases. Patients are considerably more likely to cooperate when doctors and other providers "prescribe"

mobile Health apps as part of their treatment and care because they drove the transition to mHealth apps and platforms [14].

1.4 Strong points of using Mobile Health Applications

I. Quick delivery of medical care

Patient can use mobile health application to quickly connect with doctor and have consultation through video/audio calls, check the availability of medical facility. COVID-19 pandemic has revealed this new mode of medical care, people favor this mode of providing medical services as they do not have to travel or take leave to go to hospital or clinic [15].

II. Easy Monitoring

Patients monitoring is one of the most explored aspects of mobile health application through which the patients can utilize mobile devices and mobile health technology to acquire, enter, or automatically collect health data and transmit it to healthcare professionals via Internet. The capacity to identify a medical symptom in-between appointment and alert a clinician or health manager when the patient's biophysical record puts them at risk is a significant step forward towards medical care delivery [16]. Without the use of mobilevdevices and mobile health technology, there would be no mobile health technology. The most common use of mobile health is keeping an eye on patient's changing medical condition and to accommodate patients in superintending a chronic condition or to make sure they're obeying their post discharge guidelines and taking their medications as prescribed [17].

III. Medication Management and Training:

Remembering the name and correct dose of prescribed medication is pretty apparent for those patients who have more than five dose prescribed in a day as well as for the elderly patients and other high-risk patients put them on sever risk category. When health care provider is unaware about the medications a patient is taking, interactions between drugs are a concern. Adverse drug reaction is also a concern when the patient is hospitalized but not given a prescription for something they should be taking but failed to notify [15]. The mobile health can be helpful in monitoring the dosage and the medicines a patient taking and can provide the reminder for the

same. It is essential for health personnel to acquire adequate understanding of medical problems and solutions in order to provide successful medical care [16]. Smartphones are becoming increasingly significant in poorer countries enhancing health professionals' knowledge [18].

1.5 Role of GIS in Mobile Health Application Sector

1.5.1. Geographic Information System (GIS)

Everyone in every field benefit from GIS. There are several industries that use GIS on a regular basis, including Telecom, Medical, Agriculture, and many others. GIS Server is a multi-user, centrally controlled platform for delivering enterprise GIS applications [19]. GIS Server is a platform for developing and deploying centralized GIS applications and services that may be used by a range of clients to satisfy a variety of purposes [20].

To improve internal workflows, communicate critical concerns, and involve stakeholders, organizations employ GIS Server to disseminate maps and GIS capabilities via Web mapping apps and services. With real-time location knowledge, geographically enabling IT investments, and a centrally managed geodata, the intuitive web map strengthens business and resource decisions. It also improves data security and integrity for information assets [19].

1.5.2. Geomedicine

Geomedicine makes use of modern information technology to send detailed data about a person’s potential environmental exposures to the practitioner At the moment, a doctor has very little health-relevant geographic information at their disposal during a medical diagnostic encounter, and it is certainly not a standard component of a comprehensive medical record. We will see a spike in the number of people who will benefit from a much more exact medical understanding of the links between their health and where they live, work, and play as a result of geomedicine.

There is ample evidence that the usage of geographic data has had a significant impact on health professionals' work. Medical epidemiologists, who are on the front lines of disease investigation, have made substantial use of geographic information systems (GIS) in their fight against diseases that have a clear link between person, place, and time. GIS has also played a key role in safeguarding populations from dangers and harmful exposures that would otherwise go

unnoticed. Physicians will increasingly employ geomedicine to help diagnose, treat, and prevent sickness as this concept is adopted by more health care professionals, and in some circumstances, even provide suggestions to patients on where they should live, work, and play [21].

1.6 Objective

The objective of the study is to;

- To analyze the user' behavior towards the Mobile health applications with the help of an Interactive Dashboard which takes the user's response and reflects the behavior.
- To link the location of the medical facility to identify the user perspective towards the Mobile health application with the presence of a medical facility in the vicinity of the User's location.
- To find out the travel distance and identify nearby facilities for the user's travel.
- To create a hotspot for users and medical facilities.
- Clustering has been done to understand the impact of literacy on the user behavior towards mobile health applications.
- Creation of codes in DAX for analysis of the data in dashboard.

CHAPTER 2

2. LITERATURE REVIEW

The widely acknowledged Unified Theory of Acceptance and Use of Technology (UTAUT) was used as a theoretical framework in one research, along with two extra variables, namely Perceived Reliability and Price Value. In both China and Bangladesh, primary data was acquired from existing mHealth users in generation Y. For Bangladesh and China, a total of 296 and 250 questionnaires were judged suitable for data analysis, respectively [22].

Prior studies on the adoption of mobile health services (MHS) have focused on the subjective cognitive assessments that lead to technology adoption, rather than how to influence such cognitive appraisals using objective message design tactics that are simpler to implement in reality. The current study uses protection motivation theory (PMT) to investigate the antecedents of cognitive evaluations by concentrating on fear and coping appeal message design techniques. To gather data, a two-stage scenario-based survey with 204 participants was undertaken. To test our model, the authors used SPSS and the covariance-based structural equation modelling (CB-SEM) technique with the software LISREL 8.8 [23].

The body of evidence supporting the use of mobile phone treatments for health improvement is rapidly expanding. In particular, the use of mobil phones to offer health behavior change and maintenance treatments is gaining traction across geographies, demographics, and health concerns. Despite the availability of frameworks for modifying and expanding health initiatives, research on best practices for successfully scaling mHealth treatments is not keeping up.

m4RH (Mobile for Reproductive Health) is an SMS-based health information service that originated in two nations and has now been developed and grown to other demographic groups and countries over the course of seven years. Following key principles for scaling up health programmers, such as continuous stakeholder engagement, ongoing monitoring, evaluation, and research, including comprehensive content and usability testing with the target audience, strategic dissemination of results, and the use of marketing and sustainability principles for social

initiatives, have all contributed to success. This study looks at how these variables influenced the m4RH program's vertical, horizontal, and global scale-up [24].

Numerous health-related applications have debuted on the market in recent years, and determining their quality has become critical. The Mobile Application Rating Scale is a widely used instrument built specifically for this purpose (MARS). In Spanish, however, there are no such instruments. As a result, the goal of one of the studies is to translate MARS into Spanish and validate the resulting version. Cross-cultural adaptation, translation, and metric assessment are the three processes that make up the design. The survey comprised 46 mobile applications, 23 of which were for Apple phones and 23 for Android phones. The primary goal of these apps was to increase physical exercise. MARS' internal factor structure and dependability were investigated [25].

The existing procedures of village health workers, traditional birth attendants, health facility employees, and district health managers in collecting, recording, storing, and transmitting birth information in the health information system are presented in this study. The potential for adopting a mobile application as a tool for data capture, transmission, and improving a poor support system has been predicted to enhance the flow of birth data in the Health Information System [26].

The WHO mHealth Technical Evidence Review Group established the mHealth evidence reporting and assessment (mERA) checklist to improve the completeness of reporting of mobile health (mHealth) treatments. The mERA development process included convening an expert committee to identify a suitable strategy, assembling a worldwide expert review panel to produce a checklist, and pilot testing the checklist. To support replication of the mHealth intervention, the minimum set of information needed to define what the mHealth intervention is (content), where it is being implemented (context), and how it was implemented (technical features). The resultant 16-item checklist is presented in this publication, along with a full explanation and elaboration for each item, as well as illustrative reporting instances. We anticipate that broad implementation of these recommendations will help to standardize mHealth evidence reporting and, as a result, increase the quality of mHealth evidence [27].

Another project involves developing a general design model for heterogeneous medical data, as well as the analysis, reconstruction, and display of biological signals on multi-screen portable terminals. This paradigm enables the deployed apps to be useable in a variety of circumstances, allowing for the implementation of a technological platform common to a group of peripheral mobiles while also being adaptive in complicated treatments. As a result, this article describes the architecture of an Intelligent Mobile Assistant Medical, which can deliver medical feedback to patients via mobile devices based on biomedical and environmental data acquired by installed sensors. As a result, the stakes of establishing such systems are high, with implications for patients, medical personnel, and society as a whole [28].

The frequency of serious diseases, as well as the impact of contagious diseases, is rapidly rising in emerging countries. Any use of mobile devices like smart phones towards the community care and health care, sometimes known as "mobile" health or m-health, offers the potential to address multiple sorts of disease incidence. Mobile technologies are readily available at the local, communal, and household level, and they can play an important role in health care. They examine a number of smartphone applications and discuss their drawbacks and benefits. Positive examples abound, although there is scant proof of medical or financial effectiveness, underscoring the need for such an evaluation. [29].

In this study, the user behavior in the developing nations have been analyzed. Mobile health movement, that employs smart phones and related technology for health care, presents a once-in-a-lifetime potential to alter the healthcare available to individuals around the world. Developing countries, despite being high demand of medical staff and infrastructure the growth of mobile health application is rather unrushed. Focus on various challenges that must be handled for the efficient adaption of mobile health applications [30].

CHAPTER 3

3. Study Area

According to the 2011 Census, Delhi has a population of 1.68 million people. In 2011, Delhi's population accounted for 1.39 percent of India's total population. Delhi has a total population of 16,787,941 people, with 8,987,326 males and 7,800,615 females.

The capital of India is Delhi, which is located at 76.96^{o} East, 28.44^{o} North, crossed by 77.40 ^{o} East, 28.76^{o} North. Delhi has a total size of 1,483 square kilometers. As a result, Delhi's population density is 11,320 people per square kilometer. According to the 2011 Census, Delhi's average sex ratio is 868, which is lower than the national average of 943 females per 1000 males. In addition, Delhi's kid sex ration (age less than 6 years) is 871, which is lower than India's 918 [35] Further the Delhi's projected population for the year 2022 is around 32 million [36].

Delhi is India's global hub. Delhi is a multicultural city with a diverse population polling in the city from the whole country. English and Hindi are frequently used for routine transactions. Several other dialects are also used. Some of the biggest neighboring cities include Gurgaon, Noida, Faridabad, and Ghaziabad. The state's altitudes ranging from 213 meters to 290 meters. Rainfall is dominated by the monsoonal weather system, with June to September being its wettest months.

The status of Delhi as a union territory was preserved until 1991, when the National Capital Territory (Delhi) Act was approved, changing the name of the city to the National Capital Territory of Delhi on January 1, 1992. In 1996, Delhi was divided into 9 districts and 27 sub-divisions, all of which were connected to tehsils. The National Capital Territory of Delhi is divided into 11 districts, 33 subdivisions, 59 census towns, and 300 villages, according to the 2011 census [37].

Delhi is one of the world's fastest growing cities with the population growth rate of 20%. [35]. The table 1. Shows the district wise demographic data of Delhi as per 2011 Census, where as figure(8) shows Delhi district map.

Table 1.

District wise Major Demographic Data

District	Population	Literacy	Sex Ratio
North West	3,656,539	84.45%	865
South	2,731,929	86.57%	862
West	2,543,243	86.98%	875
South West	2,292,958	88.28%	840
North East	2,241,624	83.09%	886
East	1,709,346	89.31%	884
North	887,978	86.85%	869
Central	582,320	85.14%	892
New Delhi	142,004	88.34%	822

Figure 2. Delhi Demographic Data (Source: https://censusindia.gov.in/)

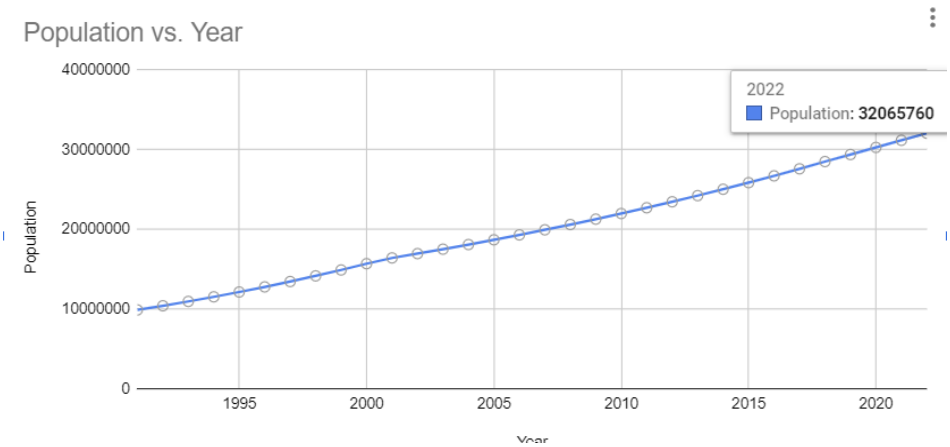


Figure 3. Delhi Projection Population 2022 (Source: https://worldpopulationreview.com)

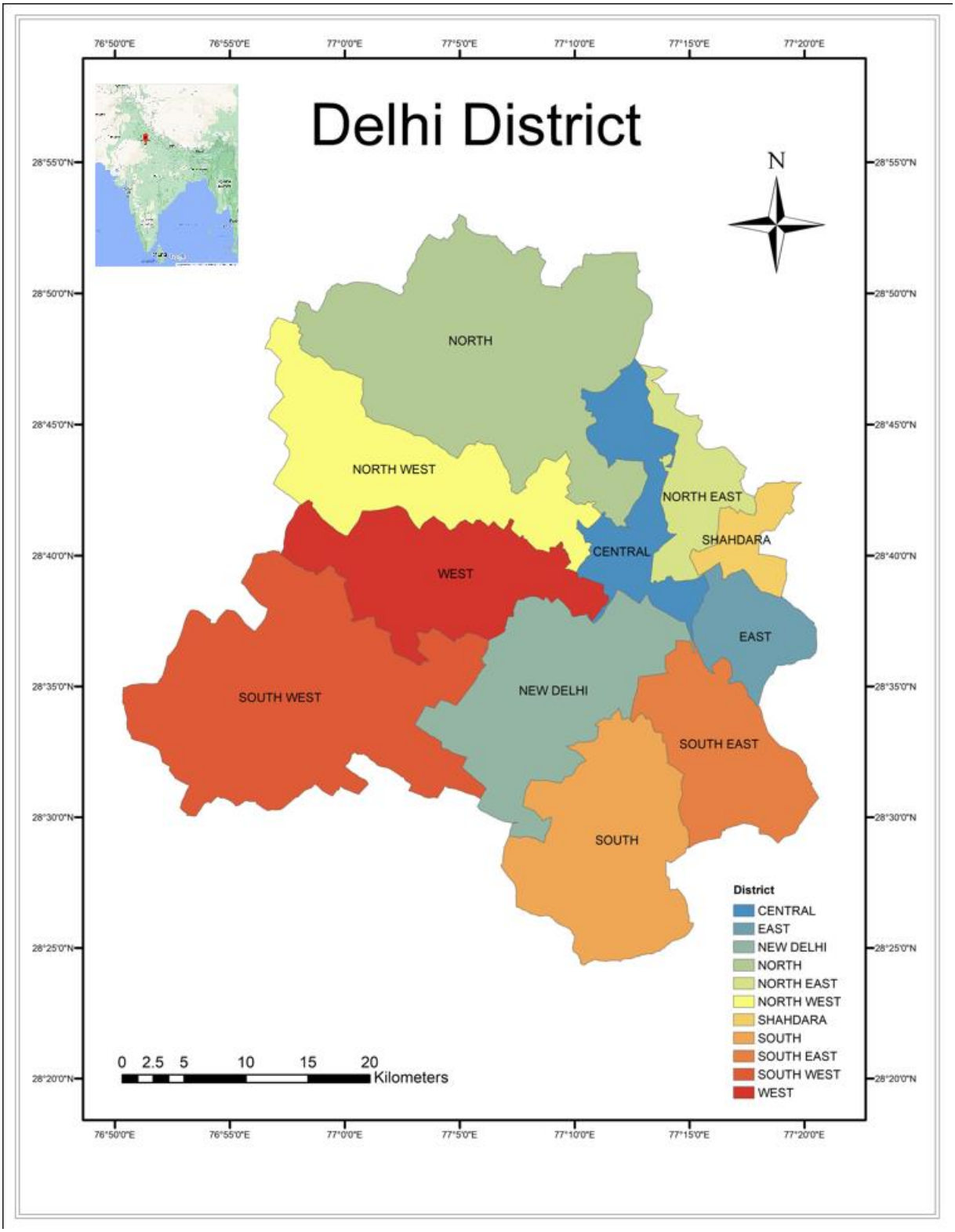


Figure 4. Delhi District Map

The health infrastructure in Delhi is among the best in the country. The state provides some of the most advanced medical services, as well as the most cutting-edge treatment technology. As of 2010, Delhi had 807 medical facilities with a combined of 41,706 beds. there were 942 dispensaries in Delhi.Delhi has a variety of Super Specialized Hospitals both in public and pri vate sectors [37].

CHAPTER 4

4 Methodology

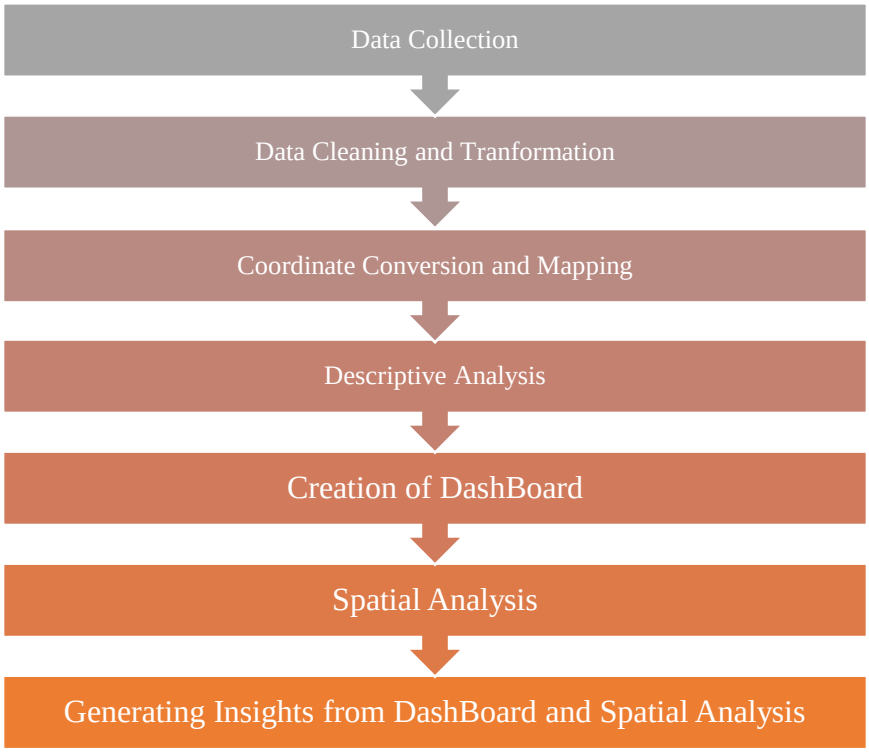


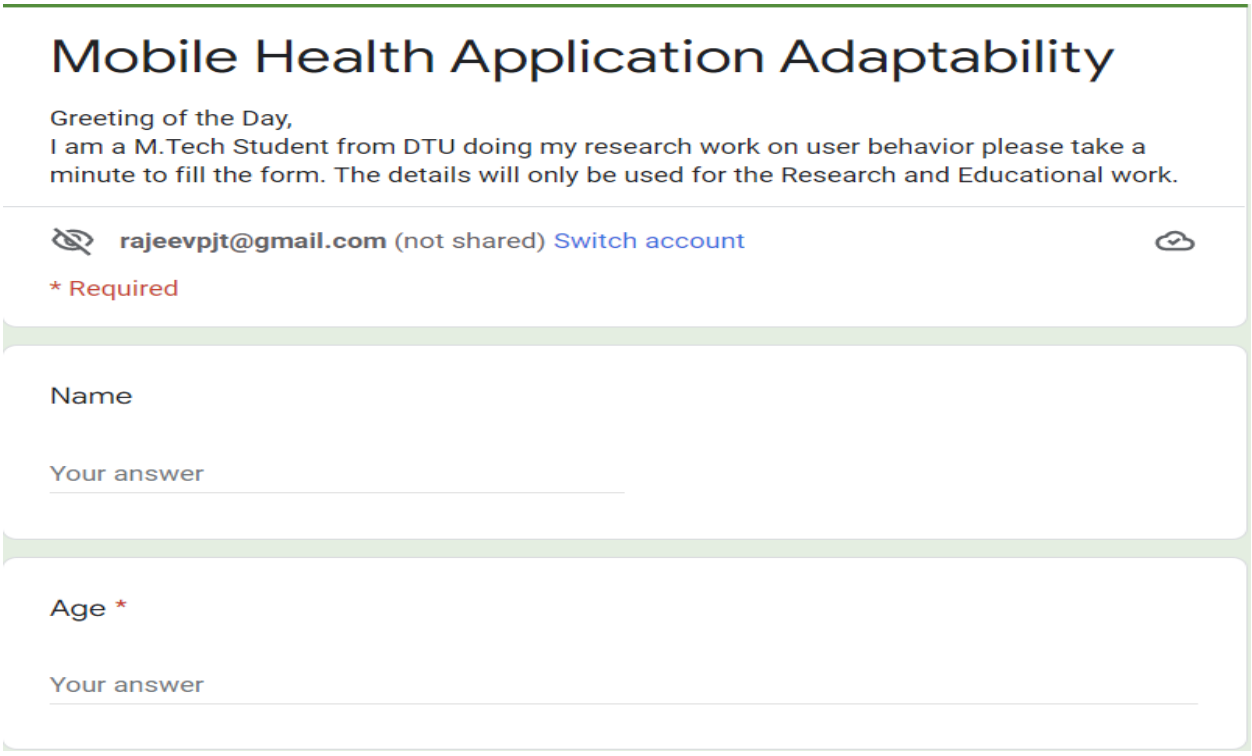
Figure 5. Steps of Methodology

4.1. Data Collection

The data collection has been done through Google forms by preparing a questionnaire. Data gathering using Google Forms is simple and straightforward, with respondents filling out the questionnaire/form online. Google Forms provides various templates for developing forms based on various topic [31]. In this research the Google form have been designed from scratch. The data collection questionnaire has been designed by keeping in mind the respondent privacy hence no questions are put which breach the privacy concern of the respondent and pull back the respondent to fill out the form. Furthermore, various questions have been designed on scale to make it easy for respondent to answer [32]. The respondent has been provided a choice to answer or to skip the question as per their convenience to do so least number of questions have been kept compulsory [31]. The google form have been divided into three sections the first section contains the information about the user such as age, locality, education etc. the next two section of the google

form is based on the respondent answering a vital question which “Have they ever used the Mobile Health application” this has only two options “YES” and “NO”, if a respondent answer ye to this question then the respondent is pushed forward to a different set of questionnaire which collect the user information about the use of mobile health application and if a user answers No to question the respondent is pushed forward to the set of questionnaire which collect the information about reasons of not using the mobile health application [33].

The focus of data collection is to get the user locality based on the pin code and their behavior towards the Mobile health applications there for the data collection include both the qualitative and quantitative data [34]. The purpose of collecting quantitative data is to perform the behavioral analytics whereas the purpose of collecting the qualitative data is to categorize the user into different segment based on the location and the features gathered through data collection. The target region of the study is NCT of Delhi so the pin codes of Delhi is provided and rest pin codes are kept in others [32], [33]. The Google form is then circulated among the users to collected the responses. Operationalization of the data is been done to measure the factors which can’t be directly measured [34]. The below figure range (a) to (i) shows the form through which data is collected.



(a)

Gender *

- ◯ Male
- ◯ Female
- ◯ Prefer not to say

Highest Education level *

- ◯ 12th or Below
- ◯ Graduate
- ◯ Post Graduate
- ◯ Higher

Locality

Your answer

(b)

Highest Education level *

- ◯ 12th or Below
- ◯ Graduate
- ◯ Post Graduate
- ◯ Higher

Locality

Your answer

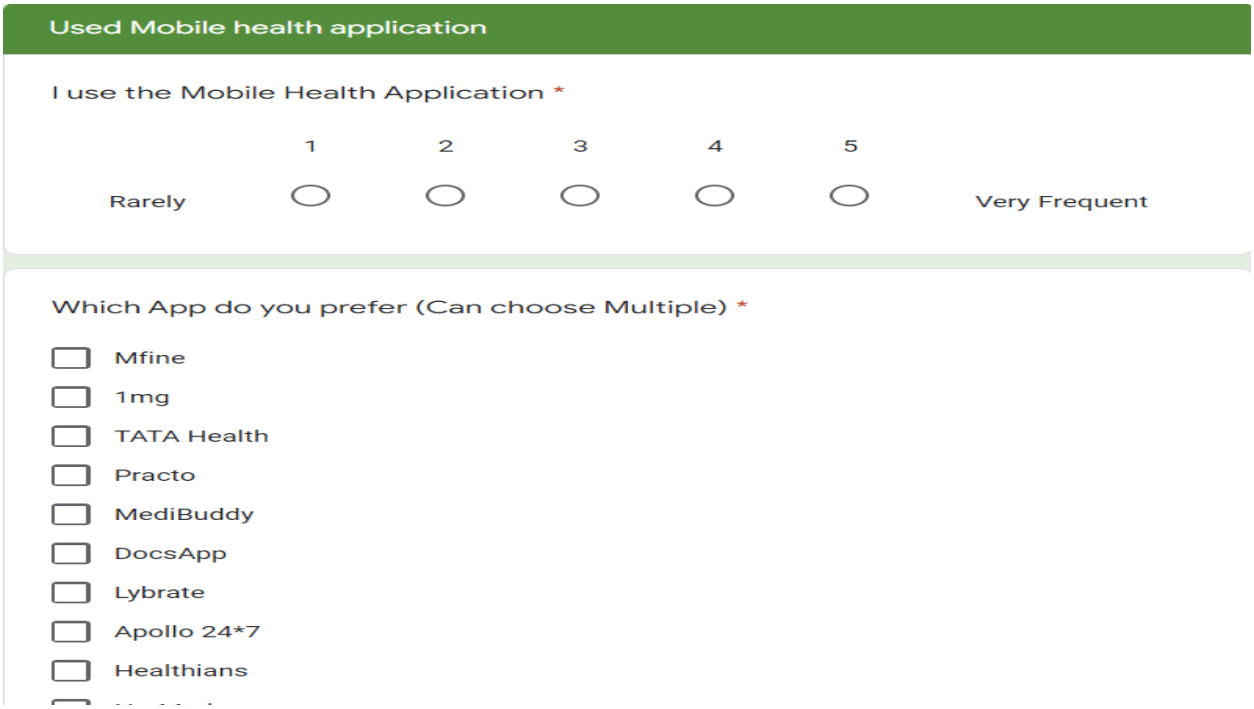
Pin Code *

Choose

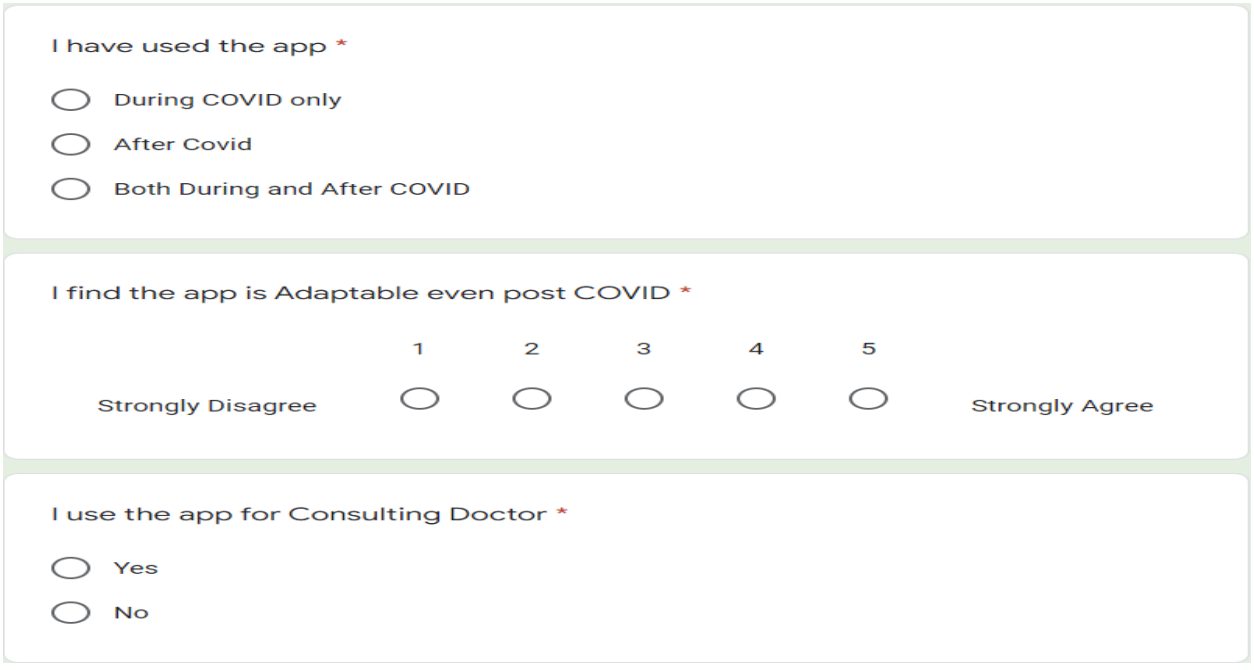
Have you ever used Mobile health application ? *

- ◯ Yes
- ◯ No

(c)


Used Mobile health application
I use the Mobile Health Application *
1
2
3
4
5
Rarely
Very Frequent
Which App do you prefer (Can choose Multiple) *
Mfine
1mg
TATA Health
Practo
MediBuddy
DocsApp
Lybrate
Apollo 24*7
Healthians

(d)


I have used the app *
During COVID only
After Covid
Both During and After COVID
I find the app is Adaptable even post COVID *
1
2
3
4
5
Strongly Disagree
Strongly Agree
I use the app for Consulting Doctor *
Yes
No

(e)

I use the app for Lab Test *

- Yes
- No

I use the app for Ordering Medicines *

- Yes
- No

I use the app for any other Purpose

- Monitoring Health condition
- Metitation/Yoga/Workout
- Other

(f)

Does hospital association affect the choice of app *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Are you satisfied with the Audio/Video consulting *

	1	2	3	4	5	
Strongly Dissatisfied	○	○	○	○	○	Strongly Satisfied

Are you satisfied with the overall services provided by the app *

	1	2	3	4	5	
Strongly Dissatisfied	○	○	○	○	○	Strongly Satisfied

(g)

I face Network issue while using the Mobile Health Application *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Frequency of the network related issue *

	1	2	3	4	5	
Never	○	○	○	○	○	Very Frequent

Does the feedback about the app is deciding factor *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

(h)

Rate the services provided by the app *

1	2	3	4	5
○	○	○	○	○

Rate the User Interface of the App *

1	2	3	4	5
○	○	○	○	○

How to improve the adoptability of mobile health application (your feedback and suggestions) ?

Your answer

(i)

Not used Mobile health application

Are you aware of such kinds of App *

- ◯ Yes
- ◯ No

I have privacy concern *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Mobile health application does not have good Doctors *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

(j)

Mobile health application are not user friendly ? *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

I prefer to visit the Doctor *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

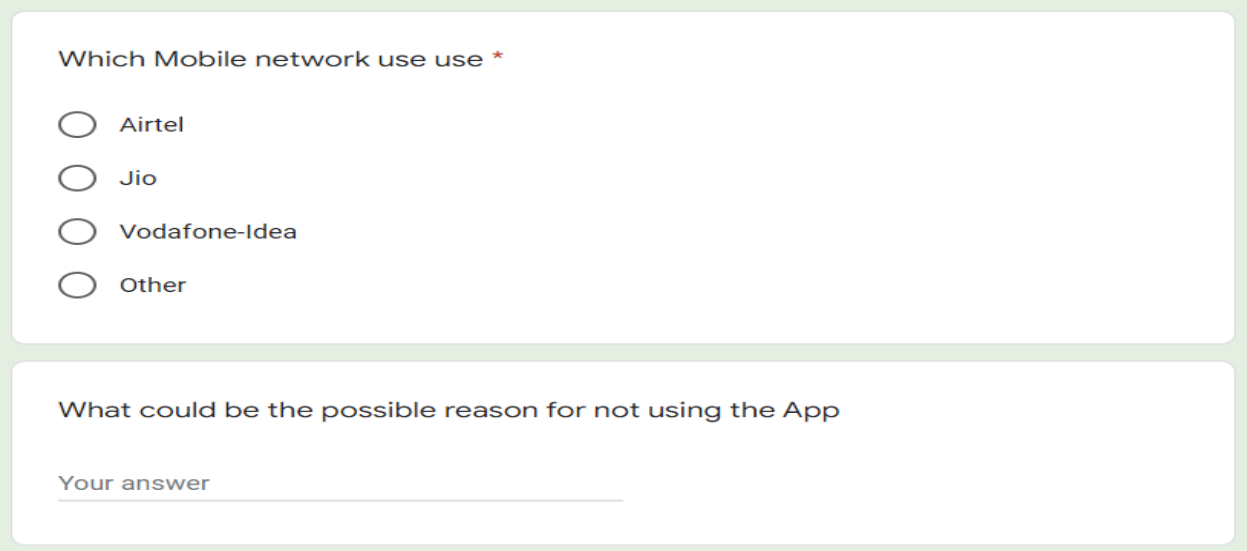
I prefer to visit the Lab/Pharmacy *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Not used the app as I have network connectivity issue *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

(k)



(l)

Figure 6. (a) to (i) Google form

4.2 Data Cleaning and Transformation

The collected data contain different attributes to use these data with effective way the next step is to clean the data, Data cleaning is the process of handling various anomalies in the data which is to be used for the further analysis. The need of data cleaning arises from the fact that the data may contains obvious null values, error or the values and outliers.

1. Handling missing values
2. Identifying Error in the data

There are majorly five prospect to handle these values: (1) Deleting the entire record from the data set (2) Deleting the missing value only (3) Manual replacement of missing value (4) Replacement of missing value with the statical value based on the available data set (5) Replacement of missing or erroneous value with the predicted value **[38]**. The method for data transformation entails identifying data sets and kinds, specifying the structure of required transformations, and specifying how variables will be modified or aggregated. It entails taking data out of its actual source, altering it, and transmitting it to the target destination.

4.3 Data Conversion to Longitude and Latitude

The Respondent's behavior, locality and Pin codes have been collected through Google form further to convert these localities and pin codes concatenation have been on the two columns to form a proper address which includes locality and pin code [39]. Now we require Longitude and Latitude of these location for the analysis [40]. These addresses have been converted to longitude and latitude with the help of Google earth Pro, Google offers high-resolution satellite images (at various sizes) for the entire world, as well as a simple, interactive interface that can be learned with little training or experience and can be used on most desktop PCs. The following KML files can be read by Google Earth, allowing the user to easily create meaningful maps from a variety of data sources [41]. After that these points have been exported as KML file these KML files can be converted into shape file through any GIS tool, the conversion to shape file is needed as the handling of shape file format is easier in GIS tools [40].

The data regarding Major Hospitals/Sub district Hospitals and dispensaries have been collected from [42], also some of the private clinics have been mapped with the help of Google Earth Pro by individually locating them, similarly these Mapped Hospital layer have been exported as KML file from Google Earth Pro [39].

Figure 7. Respondent Location Mapped on Google Earth

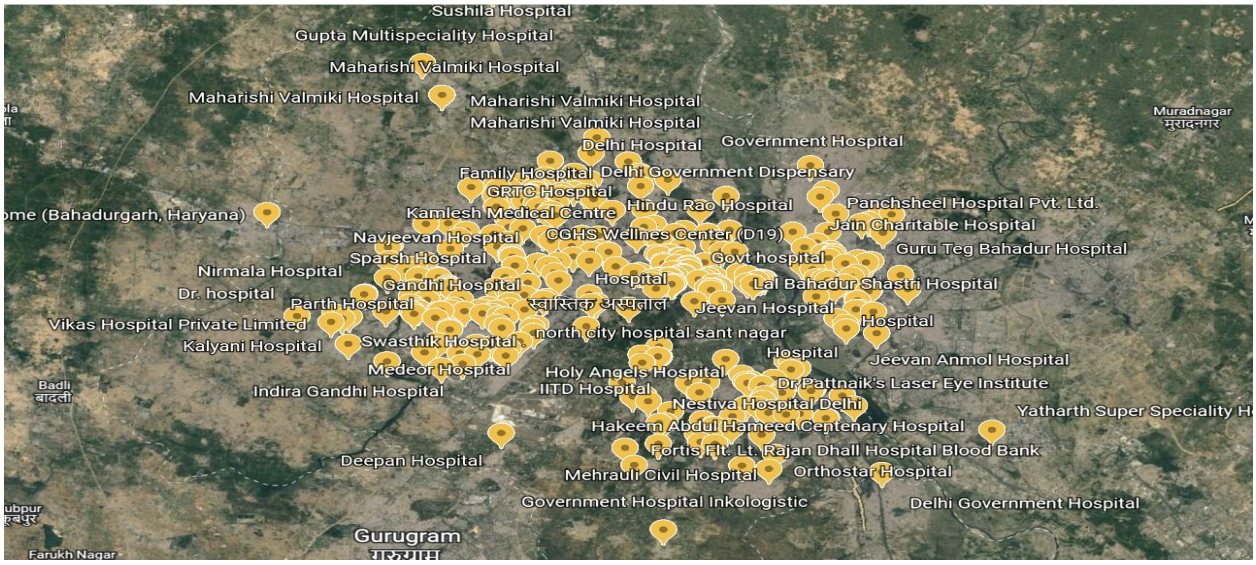


Figure 8. Medical facility Location Mapped on Google Earth

4.4 Mapping of Data

As discussed earlier the data which were mapped on Google earth was converted into shape through ArcGIS Map. ArcGIS for Desktop, which consists of multiple programs. The most commonly used apps are ArcMap and ArcCatalog. For three-dimensional (3D) visualization, the Arc Scene and Arc Globe apps are utilized [43]. The Arc Toolbox window and the Model Builder application, which are accessible from both ArcMap and ArcCatalog, provide access to core ArcGIS for Windows spatial analysis features [44]. Delhi District shape file which reflects all the

district of Delhi is also imported into the ArcGIS Map to show where the Respondents are located on the Map in relation with the study Area [45]. Medical facility location is also overlayed on the Delhi District Map to show where the medical facility is present these will be used for generating the links between user behavior and the presence of medical facility along with the distance between them is one of the crucial factors which govern the adaptability of Mobile health application [43], [45].

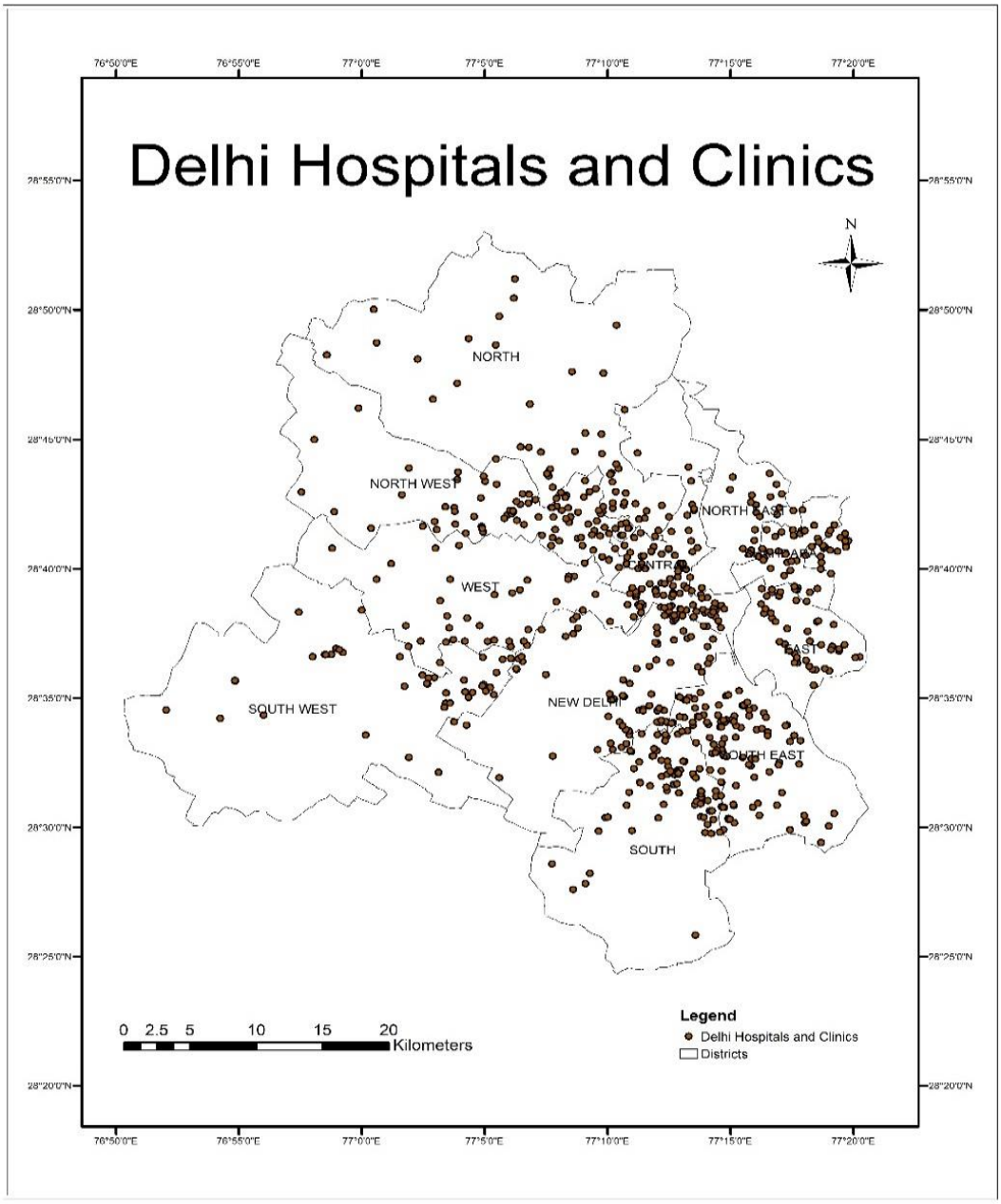


Figure 9. Location of Medical facility in Delhi

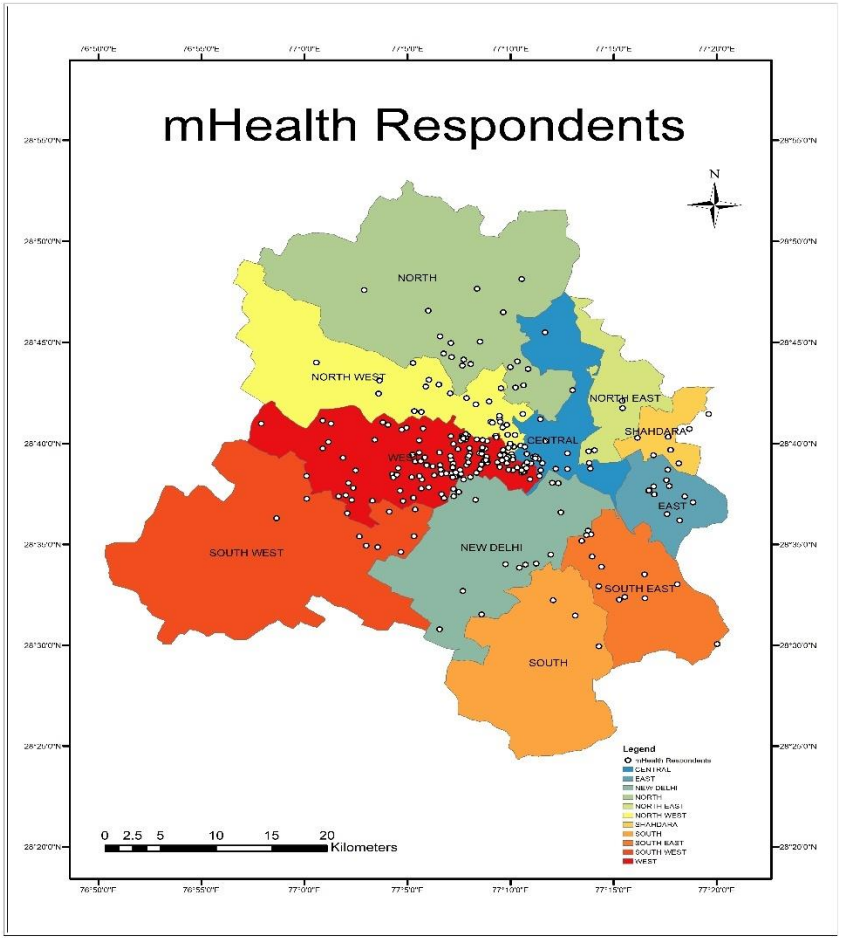


Figure 10. Location of Respondent

4.5 Descriptive Analytics and Data Visualizations

Descriptive analytics is a set of procedures for delineate, abridge, and analyzing dataset. In every institution whether it's research, educational, business or any other deriving the outcome from the data is vital. Here we want to know the causes that are pulling back the Mobile health application user and assisting the problem that adaption of mobile health application can share the burden of medical facilities. The use of statistical methods help us to form the various matrix from the data in order to present the data in more easy to understand way such as data average, median,frequency of occurrence and cumulative and continuous distribution of the data variables to identify user's behavior [46].

Exploratory data analysis relies heavily on visualization as humans have more clear understanding towards the graphical visuals. Before reporting the conclusions, data analysis tool

has been utilized for visualization to evaluate, scrutinize, and confirm trends of the data. Before developing action plans, decision makers may use visualization to analyze and debate the findings. To execute the same, BI tool have been used for various graphics and visualization. Understanding the design principles of the study visuals and user interfaces is kept in manner for producing high-quality data graphics or interactive exploratory Dashboard. To present data simply, plainly, and honestly, words, numbers, typography, color, and graphical shapes are mixed and incorporated in an interactive system in certain way. They show a wide range of data kinds, including as numbers and categories.

There are numerous approaches for visualizing data that are interactive and dynamic in nature, and when it comes to visual context, there are plots, graphs, slicers, stacked column charts, Histogram, Bar Charts, tables, matrix, and other types of visual contexts to consider. In this study Power BI is used to make the visualization and an Interactive dashboard which consider multiple factors to reveal the behavior and finding and to support the decision making. Microsoft Power BI is a business intelligence tool from Microsoft that allows to study data, communicate insights, and get answers quickly using interactive data visualization and dashboards on various platform such as apps, desktops, and mobile devices. The user or individual can analyze the information more easily and conveniently with the use of images and filters [47]. Calculated columns and measures are created using the Data Analysis Expressions (DAX) programming language, which is utilized across Microsoft Power BI. It is a set of functions, operators, and constants that can be used to compute and return one or more values using a formula,or expression. In this study, DAX is used to handle a variety of computations and data analysis challenges, as well as to extract and produce new information from existing data in the Data model [47].

4.6 Geospatial Analysis

The Spatial analysis is done with the help of ArcGIS Online which is a mapping and analytic tool that runs in the cloud. Make maps, analyze the data, and work collaboratively with it. Get accessibility to work process applications, mapping and statistical analysis from all across the world. The tool can be used to examine and visualize 2D and 3D data, smart data-driven styles can be used. Keep your maps private or share them with everyone, anywhere. Build maps, scenarios,

apps, and notebooks in collaboration with your coworkers. You can use simple analytic tools to better comprehend your data. With ArcGIS Online, you can do all of this and more [48].

4.6.1 Clustering:

A cluster is defined objectively in a data set using dissimilarity measurements such as edit distance, density in a Euclidean or non-Euclidean data space, distance determined using proximity measures, or probability distributions [49]. All measures agree that a threshold value for clustering and object grouping should be specified [50]. which are dissimilar and should be isolated from the cluster Clustering improves results. Because the properties of all items inside a cluster are less variable, they can be represented graphically. efficiently summarized Clustering has also been used in other disciplines, such as guessing missing values in data. recognizing data outliers [50].

Clustering is done dynamically at several scales, which means that as you zoom out, more points are aggregated into fewer groups, and as you zoom in, more cluster groups are created. When you zoom in to the point where the clustering area surrounding one point feature no longer contains any other characteristics, that feature is no longer clustered and is instead presented as a single point feature with the layer's styling preferences applied. Using the given slider, you may change the amount of point features organized into clusters [48]. When you specify more clustering, a larger number of features are grouped into each cluster, but when you specify less clustering, each cluster has fewer features. You can enable clustering pop-ups to appear when you click a cluster on the map when you enable clustering on a point layer. The default clustering pop-up displays information about the clusters, including their number of characteristics [49]. You can also tailor the clustering pop-up to your preferences. The feature pop-up you defined on the layer appears when you click any uncluttered point feature [51]. This tool partitions characteristics into clusters and use K means method. The technique contains heuristics when randomly chosen locations is chosen for the Iterative Method, as well as the tool may provide a different result each time you run it (even using the same data and the same tool parameters). This is due to the fact that determining the initial seed features needed to create the clusters is a random process. The appropriate clusters are more difficult to determine due to this new heuristic solution [52].

Here the Dynamic clustering is done by using the location of the user and the features which were collected using the google form. Various clusters have been analyzed on the base map in ArcGIS to identify the user's behavior as per their location [52]. The Enriched data factor have also been used to identify the user behavior as per the enriched features

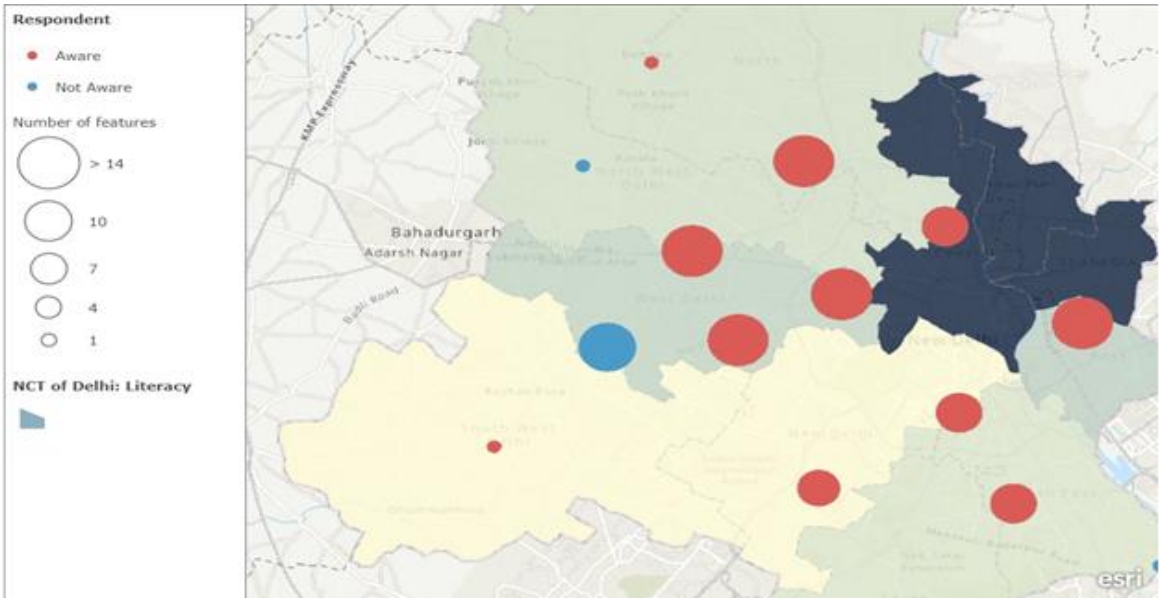
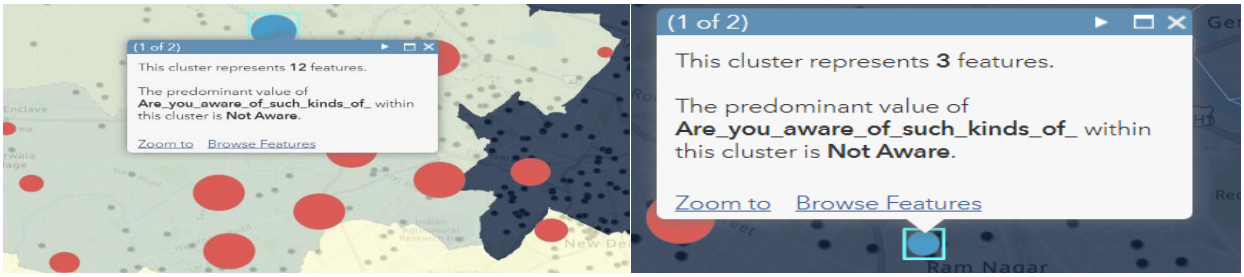


Figure 11. Upper primary level literacy Map overlayed by Awareness clusturing

The above Map tries to connect the literacy rate above Upper primary level and the awarness about Mobile Health Application. It was observed that the area havinh high literacy rate have less awareness about the app.



(a) (b)

Figure 12. (a) Feature Inside High comparative literacy Zone (b) Feature inside Moderate comparative Literacy Zone

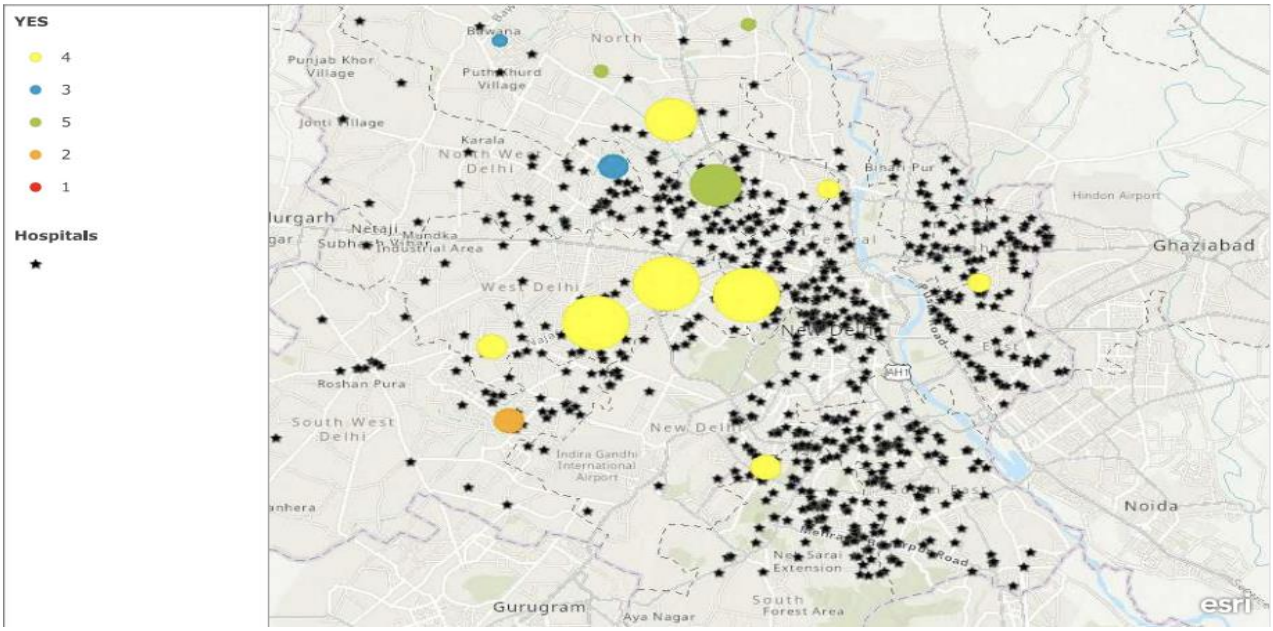


Figure 13. User rating in relation with presence of medical facility

4.6.2 Hot Spot Analysis:

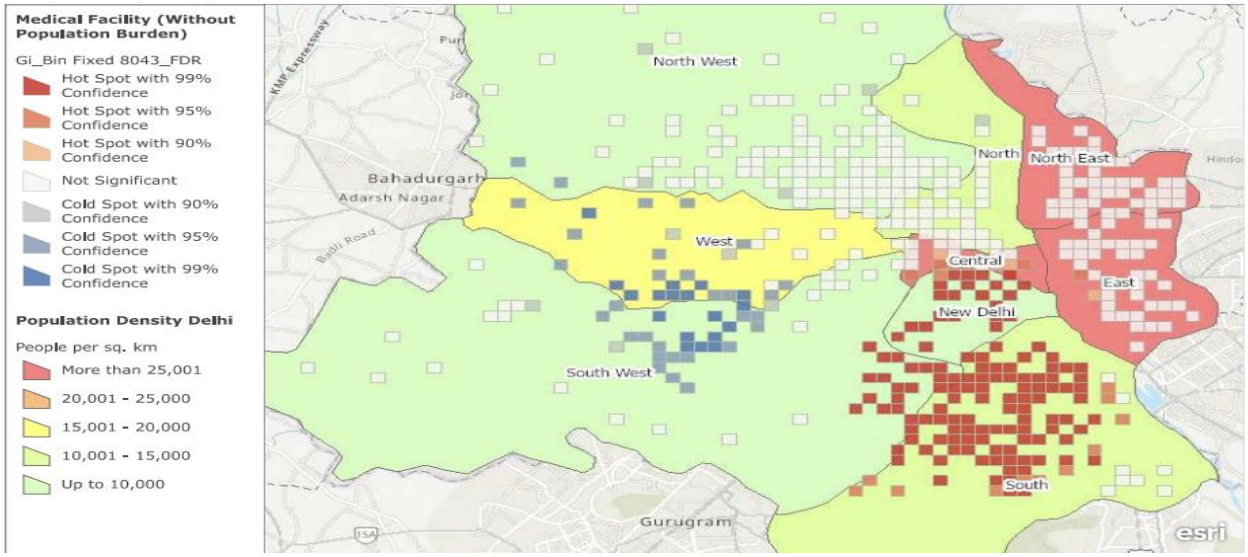
The Gi* algorithm is used for calculated by the Hot Spot Analysis tool for each feature in a dataset. The z-scores and p-values that result indicate where characteristics with lower or higher point concentrate spatially [53]. This tool operates by examining each feature in the perspective of its surroundings. A high-value feature is intriguing, but it may or may not be a statistically relevant hotspot [53]. A feature must have a great value and be accompanied by additional characteristics with high values in order to be statistically significant [50].

In the figure 14 (b) shows the concentration of Mobile Health application user and medical facility.

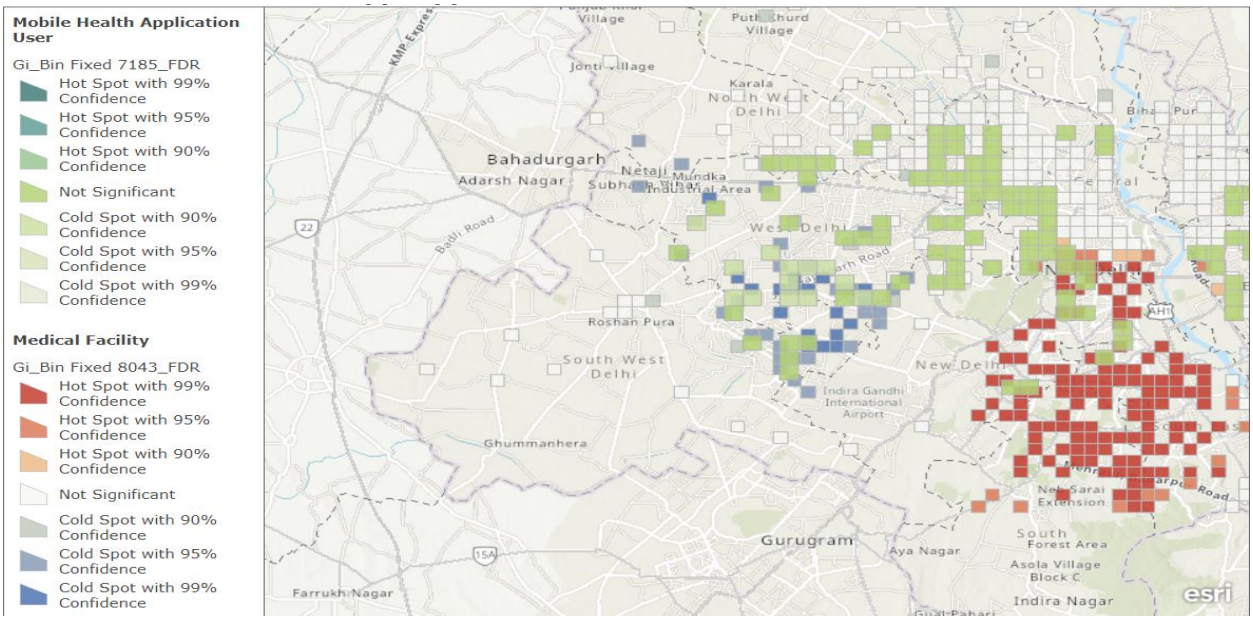
Table 2. Hotspot Analysis results

Type	Valid Input Points	Outlier	Polygon cell size	Number of Aggregation	Peak clustering Distance	Number Output Hotspot	Hot Spot
Medical Facility	701	20	819 Meter	461	5572.10 Meter	133	Red shows High Occurrence. Blue
User	153	1	1073	102	7185.28	13	

							shows Low Occurrence



(a)



(a)

Figure 14. (a) Hospital Hotspot (b) Hospital Hotspot overlayed by User Hotspot

4.6.3 Drive Time Area Analysis:

Drive time area analysis tool of ArcGIS Pro and ArcGIS Online is based on the basic yet most usable feature of mapping the drive area with certain condition enabled on while doing the analysis. This help to find the service area of a particular business or to help to find the user about what area within a specified limit can be driven [48]. It gives the freedom to choose the routes based on the available routes or to find the drive time area while considering the traffic or without considering the traffic [54]. The Drive time area uses the light vehicles, such as pickup trucks, to develop travel-time-saving alternatives. One-way roads are followed, illegal turns are avoided, and other car-specific restrictions [55], are followed. When congestion data is available, variable travel speed is applied when you select a start time [54], [55].

The concern of using this analysis is to find the drive time area of 2KM from the user location and to link this with the usage of App furthermore, the link or Near chart will be used to identify the near 5 medical facility and type of facility near the user.

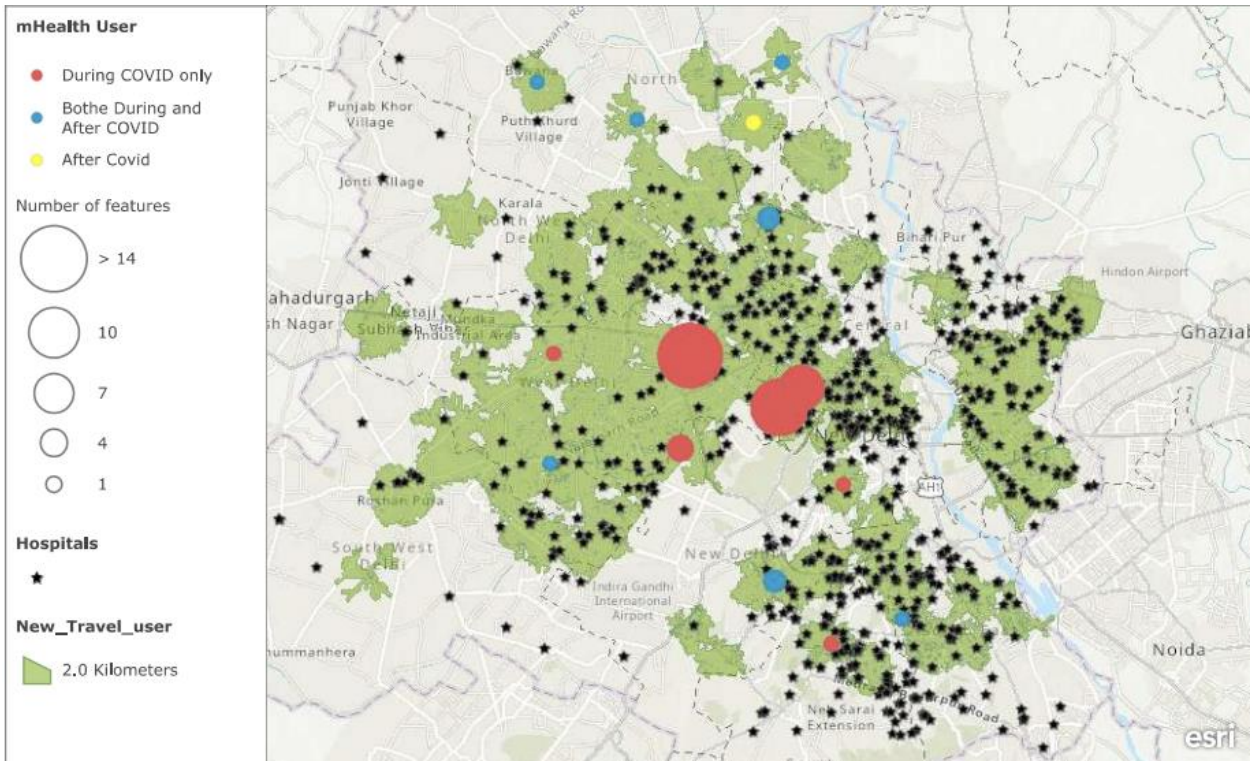
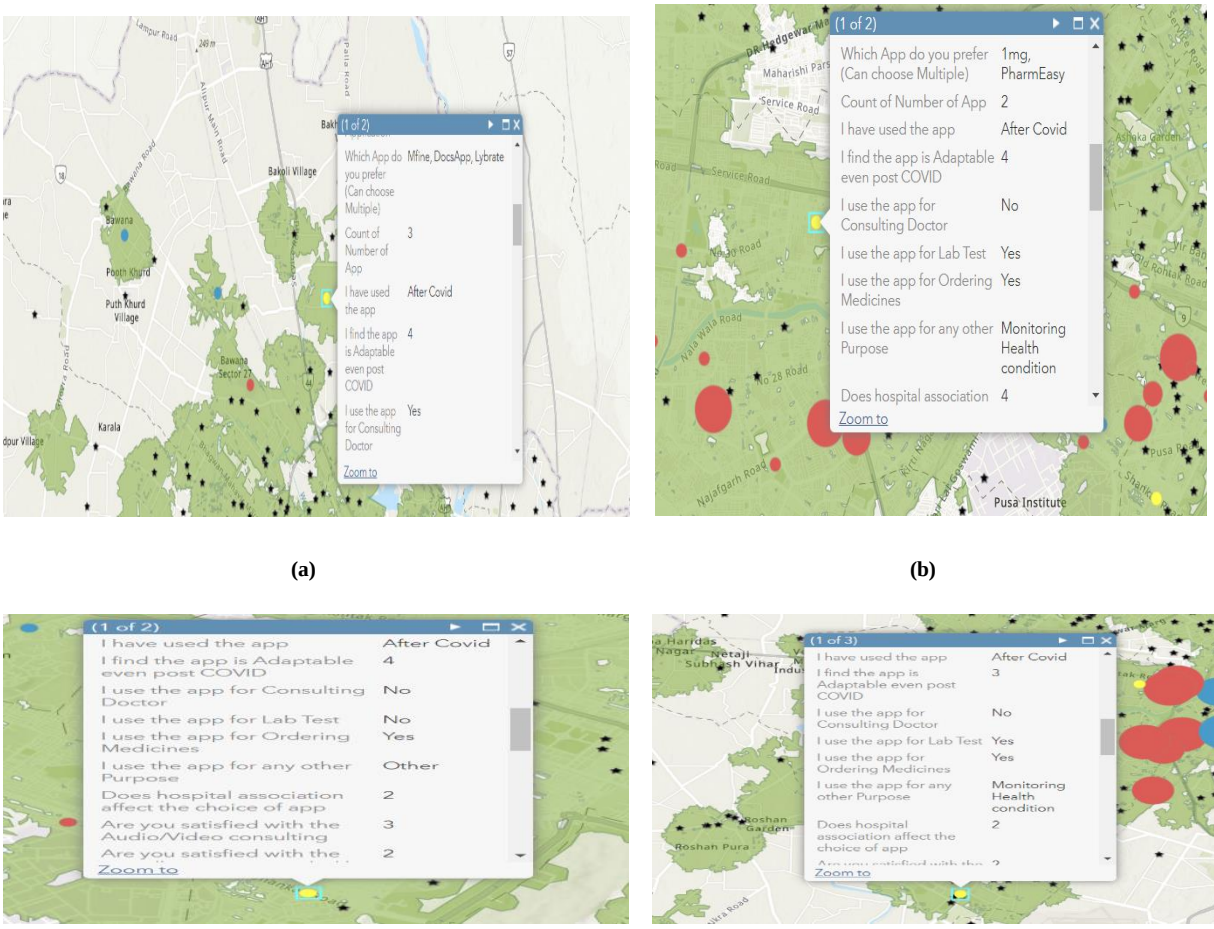


Figure 15. Drive time Area analysis overlayed by usage time period cluster.



(a) **(b)**

(c) **(d)**

Figure 16. (a) After COVID User property having no hospital within 2KM (b) After COVID User property having hospital within 2KM (c) After COVID User property having hospital within less than 2Km of Drive Area (d) After COVID User property having hospital very closely to user

4.6.4 Near Analysis:

The Find Nearest tool measures the distance among input data and nearby features using either a line distance or a journey mode. The provided number of close features is prioritized by proximity from the input parameter for each input feature [54].

The three routing solvers in the Network Analyst extension for ArcGIS is used to perform the Near Analysis. This is based on the algorithm known as Dijkstra's algorithm, which finds the shortest paths. They implement two types of paths-finding algorithms: the first one is a hierarchical one, and the second one is a direct descendant. The algorithm is used to find the shortest paths on

an undirected, non-negative, weighted graph [56]. Each point is assigned a state by the algorithm, with a node's state consisting of two characteristics: the length measurement and the priority mark. The "distance value" of a node is a metric of its source path, while the "status mark" is a function that determines when the distance value of a node equals the shortest route. The status designation is permanent if this is the case; else, it is momentary [57]. In the transportation data world, it can be used to solve various constraints such as one-way restrictions, side-of-street restrictions, and junction impedance. It can also be adjusted to take into account other user settings. The performance of the algorithm is improved by implementing better data structures, such as d-heaps. It also has to model the locations [56], [57], along an edge instead of just on junction points.

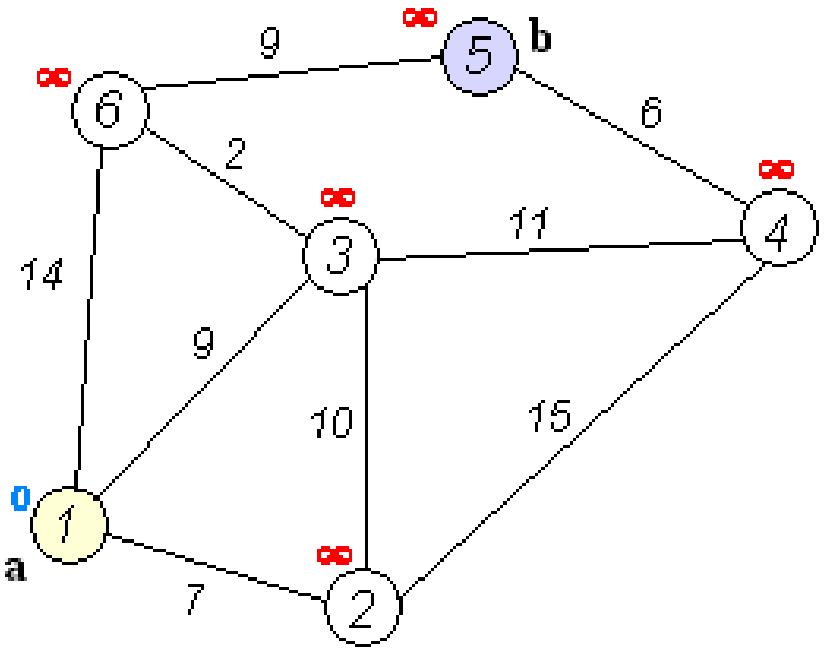


Figure 17. Dijkstra's Algorithm for shortest path

The Concern of Using Near Analysis is to find out the five nearest medical facility near the user by calculating the Euclidean distance from the user's location to the medical facility. Minimum 5 facility is been looked within the search distance of 3km.

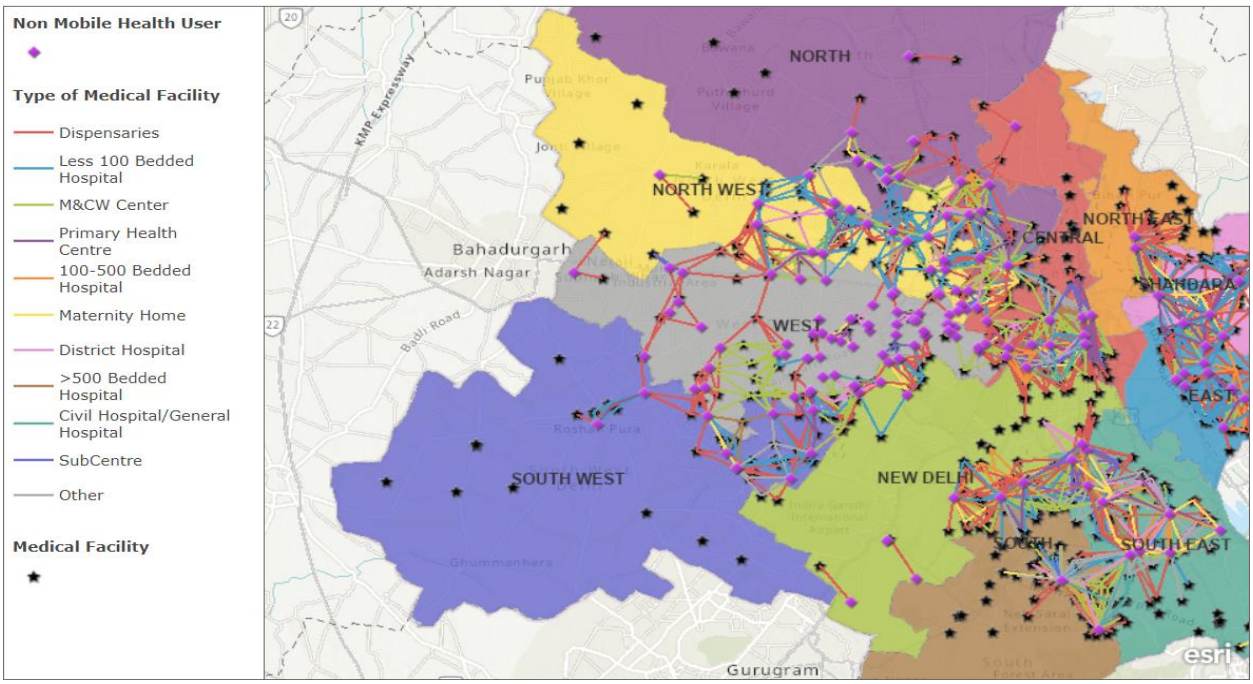
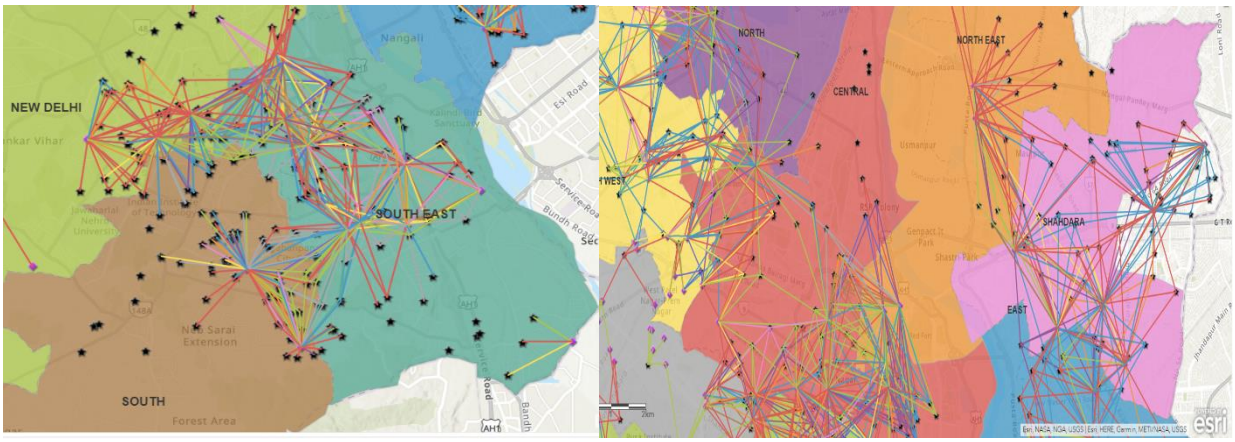
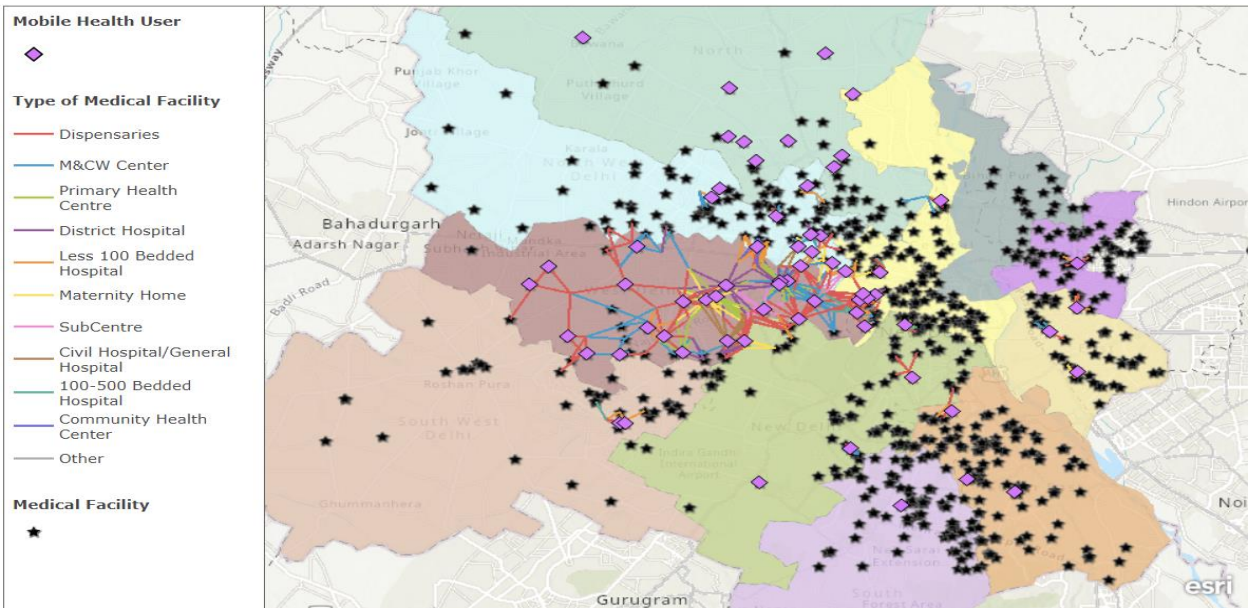


Figure 18. Type of medical facility (Near five facility) near the non-mobile health user

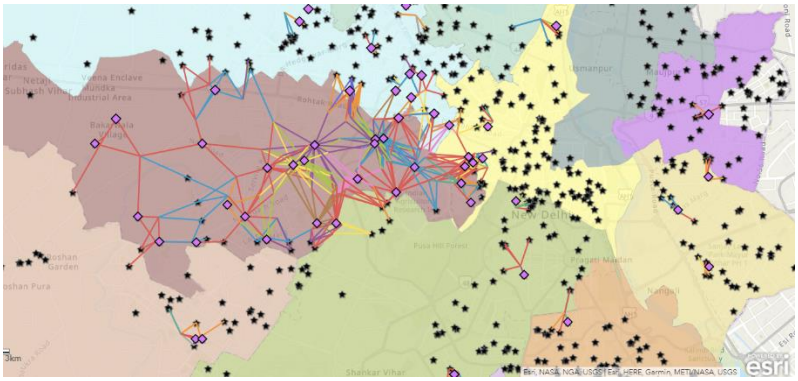


(a) (b)

Figure 19. (a) Closer view of nearest medical facility to non-mobile health application user in south and south east Delhi (b) Closer view of nearest medical facility to non-mobile health application user in central, North and North east Delhi



(a)



(b)

Figure 20. (a) Type of medical facility near mobile health user (b) Closer view of type of medical facility near to mobile health user in West and New Delhi district

CHAPTER 5

5. Results

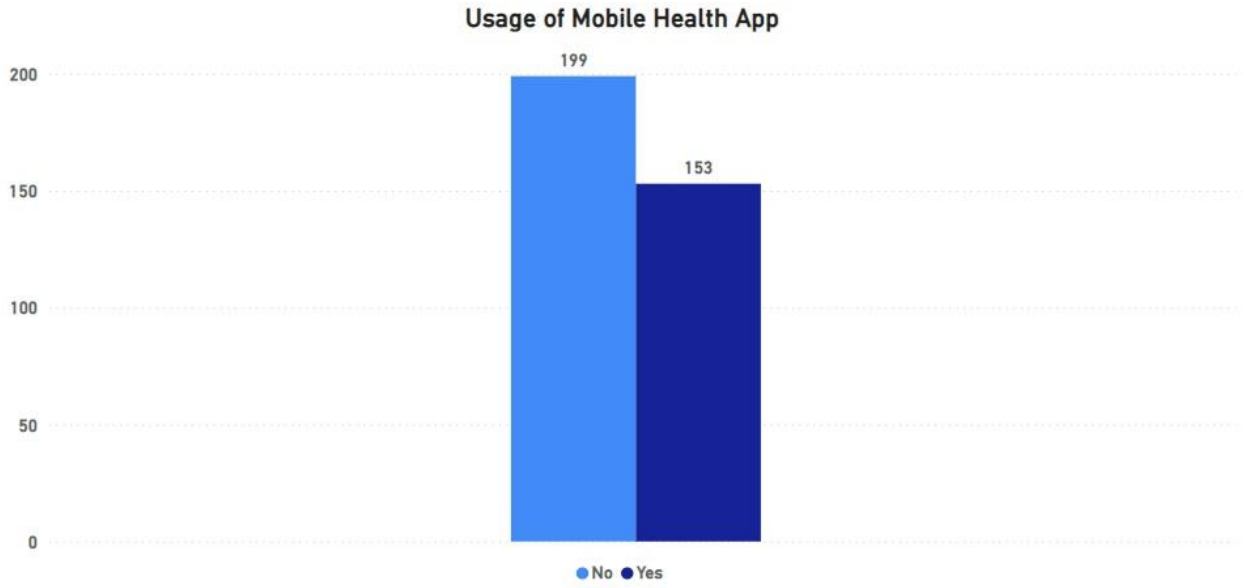


Figure 21. Mobile health user and non-mobile health user

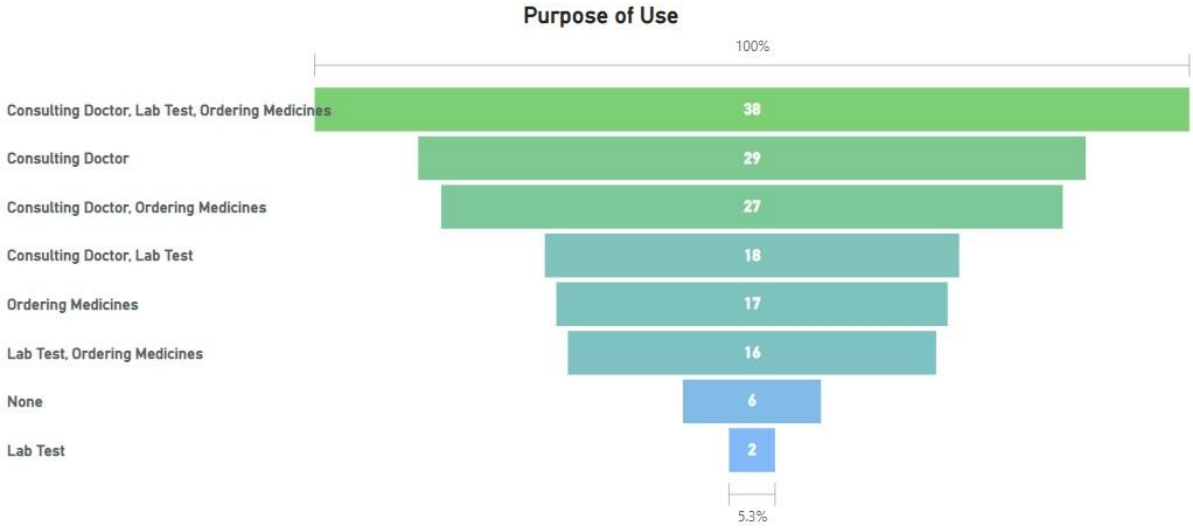


Figure 22. Purpose of Using mobile health Application

In the purpose of usage of mobile health application, it is visible from the dashboard that 24.84% of mobile health application user in our dataset is using the app for consulting the doctor, ordering medicine and lab test together.

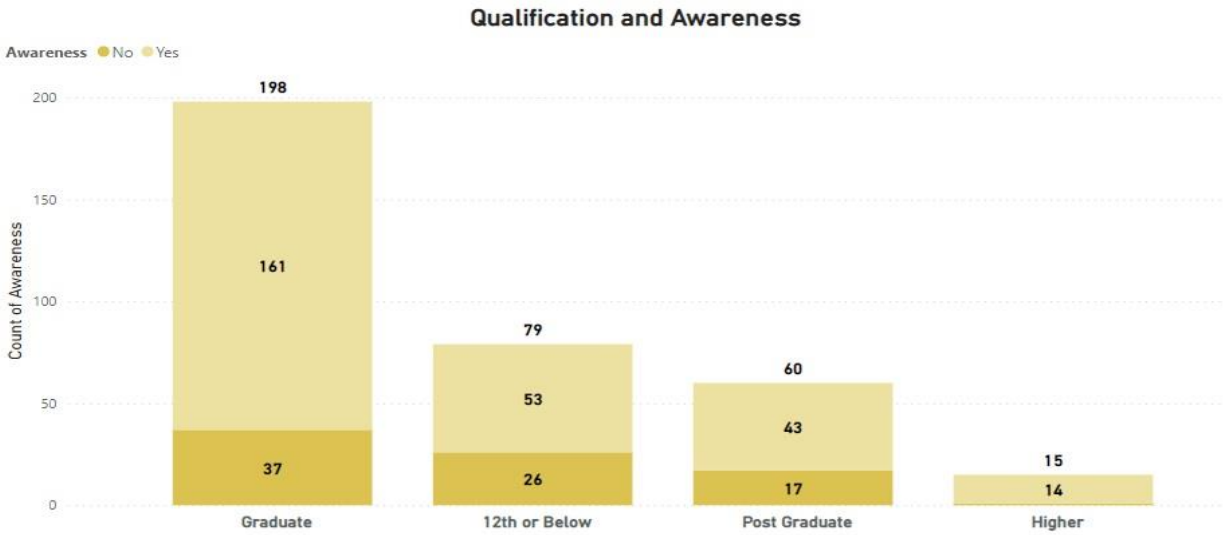


Figure 23. Qualification and Awareness comparison

Qualification and awareness analysis show that majority of the people who are aware of these apps are graduates. However, the respondent having higher than master's level education are almost all aware of these apps. The GIS map shows that the awareness is spread across all the literacy rates.

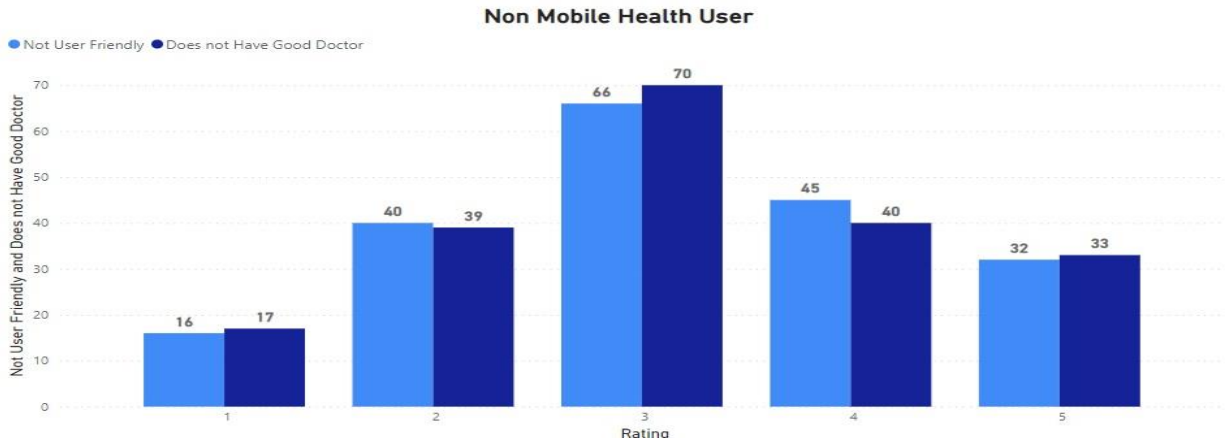


Figure 24. Rating of Mobile health Application

Whosever not using these apps and what could be the possible reason for that has been shown in non-mobile health application user, the dashboard shows that 40% of non-mobile health application user are not aware about the app and large proportion says that non-availability of good doctors and because of not user-friendly features are making people to not prefer these mobile health apps. In addition, out of all respondent's maximum of the people have rated 3 scales (Likert scale rating). The Rating map shows that the rating of Mobile health apps is high in the zones where medical facility is not in the vicinity.

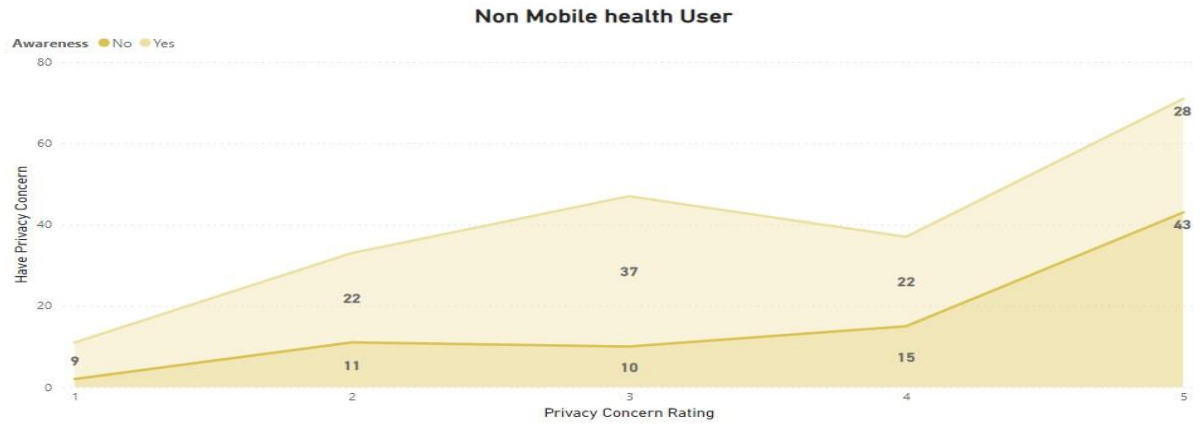


Figure 25. Rating of Mobile health Application

In the Mobile health user line chart, it has been observed that the majority of the people are aware of such apps but due to privacy concerns they are not using these apps. Also, it has been found that 7% of respondent have solely used the app after COVID-19 pandemic, the Drive time area map shows that the user's having used the app after COVID-19, doctor's consultation is not their primary concern.

The Hot Spot analysis performed shows that Mobile Health Application User are creating Hot Spot which partially overlap with the Hot Spot of the Medical facility this shows that concentration of medical facility is away from the concentration of User. i.e., availability of medical facility in great concentration is a governing factor for mobile health application adaptability.

CHAPTER 6

6. Recommendation, Suggestion and Conclusion

This topic has been studied to analyze user behavior through create an interactive dashboard for the users and to corelate the availability of medical facility near the user so that user behavior can be analyzed. This has been made possible by using the Microsoft Power BI tool which gives us the freedom to choose different insightful visuals and DAX to make possible conversion of the raw dataset into meaningful data. The finding for this dashboard development comes with values over cards and visuals in terms of percentage and dynamic maps.

This development of the dashboard can help the over-pressured medical system as well as the under-pressure mobile health applications. It will help the user in choosing the best possible media for health by utilizing live bed availability, several doctors available, type of facility available, specialist availability in nearby hospitals etc. that can give chance to the user to not waste time and utilize the first aid from the mobile health application. GIS is used to map the user behavior along with the medical facility. It can help in both ways like understanding the behavior of the user and the hospital's hotspot patterns and its utility. Various factor has such as literacy, population, Rating, Awareness and Travel distance have been mapped to find the zones where these factors can play an important role in guiding the user behavior.

The limitation of this study and dashboard is the behavioral patterns of the user are quite unpredictable and change very often. On one hand, the user may be willing to use the health application for various purposes like in COVID-19 times. On the other hand, they might feel to see their doctor for the treatment or even will go to purchase the prescribed medicines from the store etc. the dashboard is also truly dependent on the life and the quality data to predict or to find out the most suitable way of treating themselves.

The advancement in this dashboard can be done by creating power automate flows for refreshing the dashboard periodically or even when some changes happen in the dataset like deleting, adding and modifying the dataset which in turn helps the user to choose any of the available facilities of medical health. Furthermore, GIS data can also be linked to other factor governing behavior and a more efficient behavioral map can be plotted to identify the zones of low usage and adaptability

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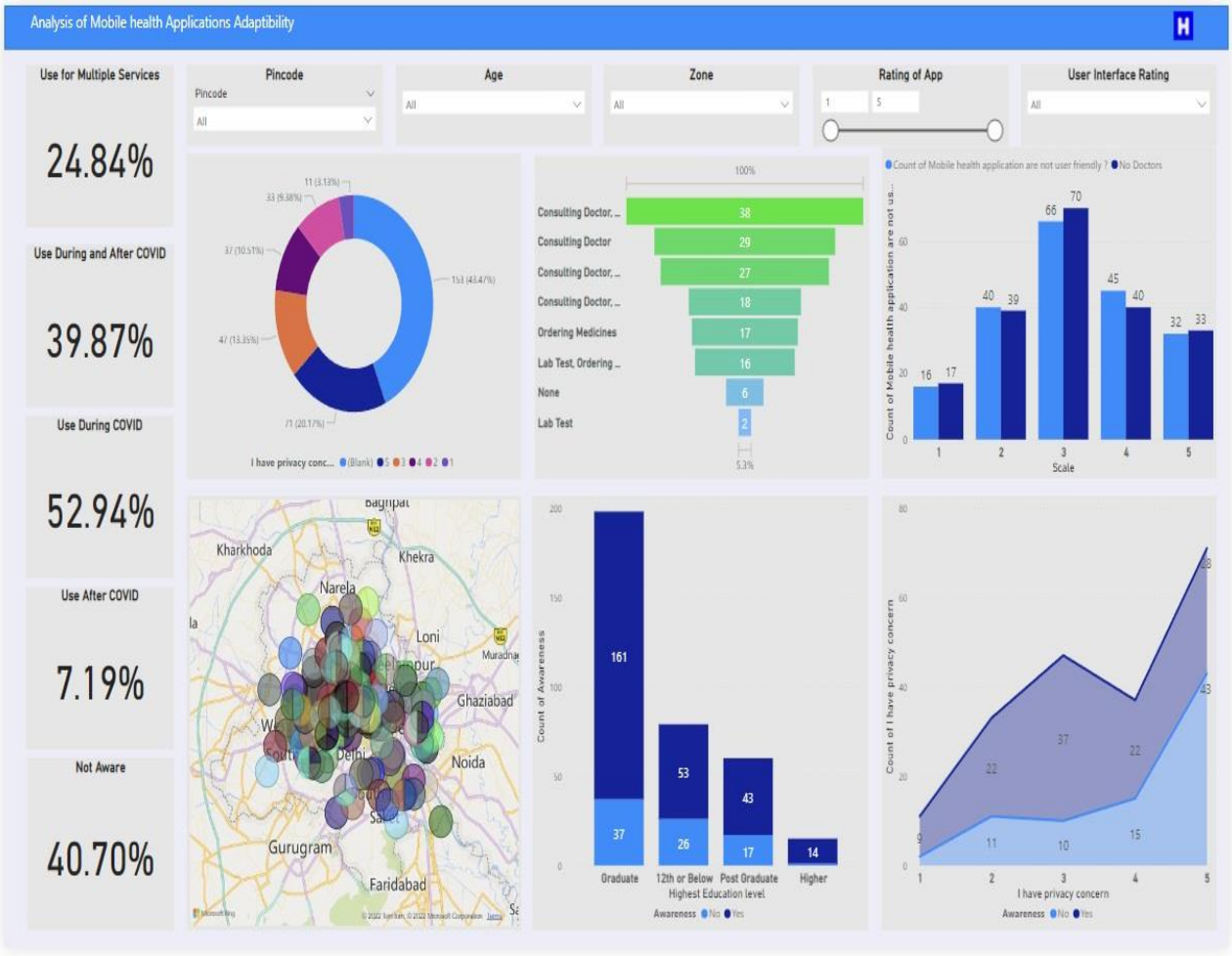
Appendix: Dashboard and DAX



DAX

```
1 Usage Area = switch(true,'Mobile Health'[I use the app for Consulting Doctor]= "Yes" && 'Mobile Health'[I use the app for Ordering Medicines]="Yes" && 'Mobile Health'[I use the app for Lab Test]="Yes","Consulting Doctor, Lab Test, Ordering Medicines",'Mobile Health'[I use the app for Consulting Doctor]= "Yes" && 'Mobile Health'[I use the app for Ordering Medicines]="Yes" && 'Mobile Health'[I use the app for Lab Test]="No","Consulting Doctor, Ordering Medicines",'Mobile Health'[I use the app for Consulting Doctor]= "Yes" && 'Mobile Health'[I use the app for Ordering Medicines]="NO" && 'Mobile Health'[I use the app for Lab Test]="Yes","Consulting Doctor, Lab Test",'Mobile Health'[I use the app for Consulting Doctor]= "NO" && 'Mobile Health'[I use the app for Ordering Medicines]="Yes" && 'Mobile Health'[I use the app for Lab Test]="Yes","Lab Test, Ordering Medicines",'Mobile Health'[I use the app for Consulting Doctor]= "Yes" && 'Mobile Health'[I use the app for Ordering Medicines]="NO" && 'Mobile Health'[I use the app for Lab Test]="No","Consulting Doctor",'Mobile Health'[I use the app for Consulting Doctor]= "NO" && 'Mobile Health'[I use the app for Ordering Medicines]="Yes" && 'Mobile Health'[I use the app for Lab Test]="No","Ordering Medicines",'Mobile Health'[I use the app for Consulting Doctor]= "NO" && 'Mobile Health'[I use the app for Ordering Medicines]="NO" && 'Mobile Health'[I use the app for Lab Test]="Yes","Lab Test","None")
```

```
1 Usage Area = switch(true,'Mobile Health'[I use the app for Consulting Doctor]= "Yes" && 'Mobile Health'[I use the app for Ordering Medicines]="Yes" && 'Mobile Health'[I use the
  app for Lab Test]="Yes","Consulting Doctor, Lab Test, Ordering Medicines",'Mobile Health'[I use the app for Consulting Doctor]= "Yes" && 'Mobile Health'[I use the app for
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  "Yes" && 'Mobile Health'[I use the app for Ordering Medicines]="NO" && 'Mobile Health'[I use the app for Lab Test]="Yes","Consulting Doctor, Lab Test",'Mobile Health'[I use the
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  use the app for Lab Test]="No","Ordering Medicines",'Mobile Health'[I use the app for Consulting Doctor]= "NO" && 'Mobile Health'[I use the app for Ordering Medicines]="NO" &&
  'Mobile Health'[I use the app for Lab Test]="Yes","Lab Test","None")
```