An Exploratory Study on GIS-based Suitability Analysis of Tertiary Hospitals in Quezon City from the Transportation Perspective

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Abstract: This study focused on the suitability of the tertiary hospitals in Quezon City wherein majority of the hospitals are concentrated in the less populated areas of the city, which may be a sign of poor aggregation. To alleviate these problems, Geographical Information System (GIS) was used to create travel time-based service area maps of the tertiary hospitals; to generate a map that showed the relationship of the service areas with respect to population and preferred hospitals; and to determine the level of suitability of the tertiary hospitals in order to suggest possible new hospital sites. Results showed that for emergency cases, travel time was the most influencing factor, while hospital reputation and personal experience governed for non-emergency cases. It was observed that during emergency cases, majority of the populated areas were not within the critical 5 minute-service area of the tertiary hospitals, hence may suggest low suitability and poor aggregation.

Keywords: GIS, suitability analysis, service area, tertiary hospitals

1. INTRODUCTION

1.1. Background

Hospitals play a vital role in society as it provides complete healthcare to the people — both preventing and curing diseases and sicknesses for emergency and non-emergency situations (WHO, 1963). With the existence of hospitals, well-being can be improved, but this only takes up 20% of the contributing factors of health. Accounting for 40% of the factors influencing health, social and economic aspects such as transportation, service costs, and income affect one's health much greater than medical care since these are the determining factors of one's access to healthcare (American Hospital Association, 2017). Hence, hospital accessibility is important especially to developing countries like the Philippines wherein traffic congestion is an issue and hospitals in numbers are insufficient and considerably expensive (Fralic, 1954).

Aside from the issue of insufficiency of healthcare facilities in the country, traffic congestion in the Philippines directly affects the accessibility of hospitals as well. A recent report states that Metro Manila traffic is the second worst in the world. The study discloses that there is a 73 percent level of congestion for highways. This highly affects the travel time of people going from one location to another especially for key services and emergency situations resulting in deaths.

To alleviate problems concerning fitness of sites, several studies such as El Karim and

Awawdeh, (2020), Aburas *et al*., (2017), and Hassaan *et al*., (2020) use GIS based analysis approach in determining the suitability of the site based on the chosen criteria. From the outcome of the analysis, sites within the study area can be identified from very suitable to not suitable at all for its purpose Moreover, to possibly recommend new hospital sites.

1.2. Study Area

The chosen study area is Quezon City. Among the cities in Metro Manila, Quezon City has the most number of Tertiary Hospitals. According to the Department of Health (DOH) list, there are 57 tertiary hospitals in Metro Manila and 19 of which are located in Quezon City. Accounting for 22.80% of Metro Manila's population, it has the highest population in the metro with 2,936,116 residents (2015 census). Moreover, Quezon City has the largest land area in Metro Manila. It covers around 162.4 square kilometers, taking up 27.13% of the total land area of Metro Manila.

1.3. Problem Statement

Quezon City has a considerable number of tertiary hospitals compared to other parts of Metro Manila, even the whole Philippines. However, upon seeing the location and distribution of these hospitals across the city, looking into the possible unsuitability and scarcity of hospitals in the residential areas is the focus of the study. Majority of the city's tertiary hospitals are heavily concentrated in the southern area away from the populated areas of the city, which may be a sign of poor aggregation or poor city planning.

Moreover, the suitability of these hospitals do not entirely rely on their geographical location. Human behavior, specifically decision factors when choosing a hospital, take a huge role in determining whether these hospitals cater to the needs of the Quezon City residents. The common factors considered when deciding are a hospital's reputation, one's personal experience, travel time to and from the hospital, service costs of medical care and mode of transportation going to the hospital. This is why suitability analysis is needed in order to identify the coverage and level of suitability of the existing tertiary hospitals to be able to determine whether or not these hospitals are sufficient to be able to provide service and care to the residents of Quezon City.

1.4. Objectives

The following are the objectives of this study:

1) To determine the factor the Quezon City residents consider the most when choosing their tertiary hospital during emergency and non-emergency cases,
2) To generate a travel-time based service area map of the tertiary hospitals in Quezon City considering critical times for both emergency and non-emergency cases,
3) To generate a map showing the relationship of the population and the service area of the tertiary hospitals in Quezon City,
4) To generate a map showing the relationship of the preferred hospital based on their preferences and the service area of each hospital, and
5) To determine the level of suitability of the top 5 tertiary hospitals for emergency and non-emergency cases and suggest possible new hospital sites in Quezon City based on the generated maps.

1.5. Significance of the Study

With Quezon City having the most number of tertiary hospitals but with poor distribution across the city, there is a need to check on its suitability to its residents in order to see if the hospitals are adequately serving the people or not. This study helps show to its stakeholders — residents, hospital owners, investors and the like, where there is oversaturation and scarcity of tertiary hospitals for adjustment of both medical response and business strategies and for future possible new site location planning. Also, this study aims to show that suitability of hospitals do not solely rely on its geographical placement. Hospitals can be near but due to multiple factors that humans consider when deciding, tertiary hospitals can end up purposeless within the area.

1.6. Scope and Limitations

This study only considered tertiary hospitals located in Quezon City, so it has enough capacity to surely cater to both emergency and non-emergency situations as it is their purpose. Since medical response cannot be scheduled unless the health issue is not critical, the study included both weekday and weekend travel times in generating the service area of the tertiary hospitals but focused on the morning, noon and evening peak times. As for the travel time simulation, due to the pandemic, field work was strictly restricted, so it was done via Google Traffic. Moreover, only primary and secondary roads were simulated, while speed limits were used for tertiary and other smaller roads. The determination of suitability was based on five common criteria when choosing their preferred hospitals namely travel time, reputation, personal experience, service costs, and mode of transportation separated by their income classes. Although one of the factors is mode of transportation, this study focused on routes that are point-to-point such as private-hire (e.g. Grab), public hire (e.g. taxi), and privately-owned vehicles in determining the service area.

2. REVIEW OF RELATED LITERATURE

2.1. Service Capacity Levels

According to Guidelines on the Licensure Standard for Hospitals and Infirmaries implemented by Health Facilities and Services Regulatory Bureau (HFSRB) under the Department of Health (DOH) , there are three (3) service capability levels namely, primary, secondary, and tertiary. Primary (Level 1) hospitals are emergency hospitals that provide initial clinical care and management to patients requiring immediate treatment, as well as primary care on prevalent diseases in the locality. Secondary (Level 2) hospitals are non-departmentalized hospitals that provide clinical care and management on the prevalent diseases in the locality. Tertiary (Level 3) hospitals are departmentalized hospitals that provide clinical care and management on the prevalent diseases in the locality, as well as particular forms of treatment, surgical procedure and intensive care.

2.2. Levels of Emergency & Ambulance Response Time

In 2017, National Health Service (NHS) England implemented new ambulance standards across the country in order to ensure that the most sick patients receive the fastest response and that all patients get the right response first (Ambulance response times, 2019). Under the new system, all calls are triaged into four (4) categories according to the patient's condition. According to the NHS England (2017), the following are the definitions of each category:

Category 1 are life-threatening cases wherein immediate intervention and response is needed (e.g. cardiac or respiratory arrest and airway obstruction). Category 2 are serious conditions that may require rapid assessment and urgent on-scene intervention and transport (e.g. strokes and chest pains). Category 3 are the urgent problems which are not immediately life-threatening, but still need treatment to relieve suffering and transport to an acute setting. (e.g. uncomplicated diabetic issue). Category 4 are the non-emergency problems that are not urgent but still need assessment and require transportation to a hospital or clinic (e.g. stable clinical cases). Ambulance response time is measured from the moment a 999 call is received until the most appropriate response arrives at the scene, rather than the first. Table 1 contains the standard ambulance response time corresponding to the level of emergency.

Table 1. NHS England's Call Category and its Response Time Targets

CATEGORY	CALL DEFINITION	AVE. RESPONSE TIME	90% RESPONSE TIME
1	Life-threatening cases	7	15
2	Serious Conditions	18	40
3	Urgent problems	-	120
4	Non-emergency problems	-	180

2.3. Income Classes

Albert *et al*. (2015) divided the income distribution into three (3) broad income classes or seven (7) income classes based on multiples of the country's official poverty lines. Poverty lines represent the minimum (per capita) income required by a household in order to meet both food and other non-food basic needs (Albert et al., 2018). The three broads income classes are defined as follows: households with an annual per capita income below twice the poverty line are called low-income households, while households with incomes between twice the poverty line and 12 times the poverty line are called middle-income households, and lastly those with incomes more than 12 times the poverty line are considered to be high-income households (Albert et al., 2020).

2.4. Factors considered in deciding hospital preferences

There are numerous factors that may influence an individual's choice of hospital. Several studies such as Brelje (2015), Javalagi *et al*. (1991), and Jiang *et al*. (2020) are examining the association between factor and patient choice. Travel time is defined as the time needed to travel from the individual's home to a health facility (one-way travel) (Jiang et al., 2020). This considers the proximity of the hospital to the consumer's home. Reputation is the status or image of the hospital to the consumer. It considers the quality of the hospital, hence the importance of the staff and their level of expertise as well as the available hospital facilities and services (Brelje, 2015). Personal experience is one's own experience and past encounters of the hospital's services and staff (Kamra et al, 2016). This includes the individual's encounter with the courteousness of employees and friendliness of doctors, which reflects the service attitude of the doctors in a healthcare facility (Jiang et al., 2020). Service cost is how much the medical services are. It considers the importance of the out-of-pocket (OOP) cost for medical and drug fees (Jiang et al., 2020) and its overall hospital fees. Mode of transportation is how the patient gets to the hospital. It considers the ease of access and convenience of going to their destination. As this is often linked to hospital proximity, it is

considered an important factor but is often overlooked because of mobile culture wherein going to places, near or far, isn't a hindrance anymore and is an easy search. Rapid-response transportation is available as well (Brelje, 2015).

2.5. Geographic Information

2.5.1. Definition and application of GIS

Geographic Information System (GIS) is a combination of both software and hardware that integrates data. It collects, manages, analyzes and presents spatial data on earth through maps and 3D scenes. GIS can be used for a lot of things such as navigation, planning and community development, energy use tracking, space utilization, etc. (Ali, 2020). GIS has a crucial role in health care, surveillance of infectious diseases, and mapping and monitoring of the spatial and temporal distributions of vectors of infection (Murad, 2018). There are numerous applications of GIS in medical research including finding disease clusters and its possible causes, improving deployment for emergency services, and determining if an area is being serviced by health services (Murad, 2018).

However, in the Philippines, GIS is not widely used yet especially for traffic management. GIS in the country is usually utilized by private companies, some government agencies and studies on the natural sciences but not the Department of Transportation (Iskomunidad, 2012). Hence, information such as service area and suitability maps related to traffic in the Philippines are limited and difficult to find.

2.5.2. Network Analysis

Network analysis is one of the most frequently used GIS tools in utilities and transportation planning fields (Murad, 2004). Network analysis is a spatial analysis technique which can answer a range of questions related to linear networks, such as roads, railways, rivers, facilities, and utilities. It utilizes network data, usually linear features to compute the distances between two points or nodes in the network. (Murad, 2018). Some applications of network analysis are route planning, identifying the closest facility by distance or travel time, determination of service areas (e.g. areas within 15 minutes of drive time of a school), etc. Murad (2018) also tackles the importance of using maps for health service locations in GIS applications and its accessibility techniques.

3. METHODOLOGY

3.1. Preparation for Data Collection

3.1.1. Identification of Tertiary Hospitals and Critical Time Setting

According to the List of Licensed Government and Private Hospitals (as of December 31, 2019) released by the Department of Health (DOH) - Health Facilities and Services Regulatory Bureau (HFSRB), there were 19 Tertiary or Level 3 hospitals in Quezon City.

The response time for the different emergency levels set by the National Health Service (NHS) in England was adopted while keeping the 5-minute requirement of 911 in the Philippines as the 5-minute is not completely definite. The following are the critical times used for emergency cases: 5, 7, 15, 18, and 40 minutes. For non-emergency cases, it was

decided to let the residents of Quezon City determine the critical times for non-emergency cases, which were obtained from the Hospital Preference Survey that is to be discussed further in Section 3.2.2. The top 5 most answered times they are willing to travel to the hospital during non-emergency are considered as its critical times; these are 15, 20, 30 and 45 minutes, and 1 hour.

3.1.2. Division of Income Classes

In this study, the division of income classes was based on Albert *et al*, 2020. Instead of adapting the seven (7) income classes, only the three (3) broad income classes were utilized. For simplicity purposes, then indicative ranges were rounded up to nearest thousands. The 3 income classes are defined as follows: households with monthly income less than PHP 20,000 are categorized as lower income, while households with monthly incomes between PHP 20,000 and PHP115,000 are categorized as middle income, and lastly households with monthly incomes more than PHP 115,000 are categorized as upper income.

3.1.3. Primary and Secondary Roads in Quezon City

Given that there are hundreds of roads and streets in Quezon City, only the primary and secondary roads were considered for the simulation of travel time using Google Traffic. According to the Department of Public Works and Highways (DPWH) ATLAS, there are six (6) primary roads and twenty-four (24) secondary roads.

3.2. Data Collection

3.2.1. Simulation of Travel Time Using Google Traffic

Given that any field work was restricted due to the COVID-19 pandemic, the simulation of travel time was performed using Google Traffic. For three (3) weeks, the travel time along the roads were simulated during the AM, Noon, and PM peak periods for weekdays, while Noon and PM peak periods for weekends. For this study, the AM peak period is defined as 6:00 AM to 8:00 AM, Noon period as 11:00 AM to 1:00 PM, and PM peak period as 5:00 PM to 7:00 PM., which were based on the level of congestion from Manila Traffic Report from Tomtom Traffic Index. The goal of the simulation was to collect the travel time and distance which were utilized to compute the road speeds needed in network analysis. Once all data was collected, the average speeds for each peak period were calculated for weekdays and weekends.

3.2.2. Hospital Preference Survey

In order to collect data for the preference based on income class criteria, a hospital preference survey was created using Google Forms, which was open to all Metro Manila residents who are at least 18 years old. The survey consisted mainly of 3 parts:

1) Personal Information - name, age, and gender were asked for optionally, while the location (barangay and city) and monthly household income were required.
2) Preference for emergency and non-emergency cases - the respondents were asked score each factor from 1 to 5 according to its importance (5 being highest and 1 lowest); rank the five (5) factors from 1 to 5 according to its level of priority with respect to each factor (1 being the top or highest priority and 5 being the least

priority). This was asked for both cases.

3) Hospitals within proximity - The top three (3) closest tertiary hospitals from the respondent's location and the preferred hospital to go to for emergency and non-emergency cases were asked in this section.

For this study, a minimum target number of responses was computed for using the sample size equation from Taherdoost (2017). This resulted in a sample size of 385 respondents wherein a level of confidence of 95% and margin of error of 5% were adapted based on the study by Taherdoost (2017).

3.3. Data Analysis

3.3.1. Criteria Definition

The main criteria of this study is the hospital preferences based on income classes. This criteria is further categorized into the two (2) types of emergency case, three (3) income classes, and five (5) preference factors, which are illustrated in the Figure below.

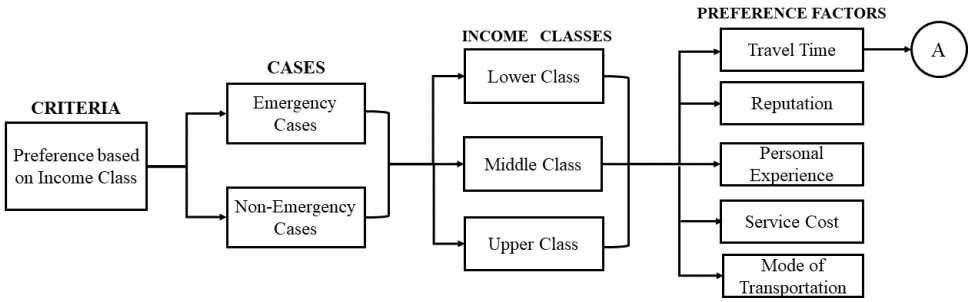


Figure 1. Classification of Preference based on Income Class Criteria

The travel time preference factor is further classified into the two (2) types of emergency cases, day of the week, and the traffic peak periods - AM, Noon, PM (see Figure 4).

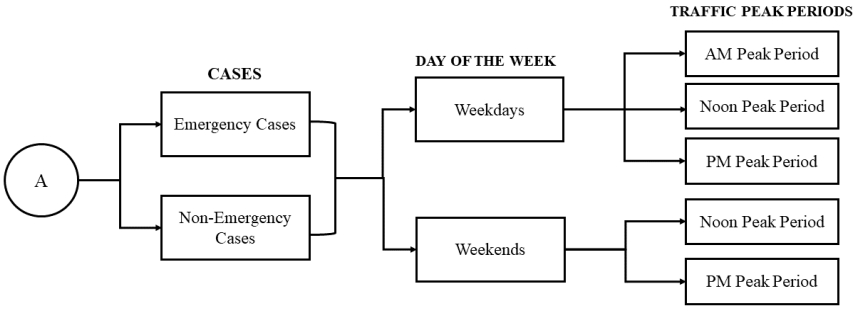


Figure 2. Classification of Travel Time Preference Factor

3.3.2. Hospital Preference Analysis

3.3.2.1. Generation of Preference Maps

Four (4) types of preference maps were generated based on the data collected from the distributed survey.

1) Preference maps based on the importance of each factor - shows the average scores of each factor for emergency and non-emergency cases per income class.
2) Preference maps based on the level of priority of all five factors with respect to each

other - illustrates the ranking of all five (5) preference factors for emergency and non-emergency cases per income class.

3) Preferred hospital map - showcases the preferred hospital of each barangay per income class for both emergency and non-emergency cases.
4) Preference map based on the top priority - shows the governing factor that is considered to be the top priority of each barangay.

3.3.3. Service Area Analysis

3.3.3.1. Determination of Road Parameters

In preparation for the network analyst, the length, speeds, and travel time for each peak period were needed for the generation of service area maps. To determine the length of the road segments, the 'Calculate Geometry' function of ArcGIS was used wherein, the Projected Coordinate System (PCS) was set to WGS 1984 UTM Zone 51N.

As mentioned in section 3.1.3., only primary and secondary roads in Quezon City have simulated speeds using Google Traffic. For the remaining roads, the following speeds were adapted from the speed limits written in the DPWH manual; 30 kph for tertiary and municipal roads and 20 kph for residential roads, streets passing through school zones, and others. From this, the travel time for both weekday peak periods and weekend peak periods were computed using the 'Field Calculator' function.

3.3.3.2. Network Analyst

The 'Network Analyst' extension was utilized to perform service area network analysis with a travel time impedance. A new service area was created and the tertiary hospital location/s were loaded as the facilities. Then the impedance was assigned to the desired travel time dataset (e.g. travel time during weekday AM peak period), while the default breaks were the values corresponding to the critical times mentioned in section 3.1.1. Once all the layer properties were finalized, the service area was solved and generated.

3.3.4. Suitability Analysis

There were two types of suitability analysis; (1) analysis of tertiary hospitals with respect to population and (2) analysis of preferred hospitals for both cases.

Given the time constraint, only the top five (5) hospitals, depending on how many respondents prefer going to that specific hospital during emergency and non-emergency, were considered for a detailed suitability analysis. Moreover, additional service area maps were generated for each of the top five hospitals for both cases and were utilized during the two (2) suitability analysis found in section 3.3.4.1. and section 3.3.4.2.

3.3.4.1. Suitability Analysis of Tertiary Hospitals with respect to Population

This suitability analysis compared the service area of all the tertiary hospitals with population. A population map showcasing the population of each barangay was generated using the 2015 Census of Population obtained from the Philippine Statistics Authority (PSA). To generate this type of suitability map, the population map was overlaid on top of each service area map. The transparency for the population map was set to 55%, while 0% transparency was assigned for the service area maps.

3.3.4.2. Suitability Analysis of Preferred Hospitals during Emergency and Non-Emergency Cases

For this analysis, another set of preferred hospital maps were generated featuring the barangays that chose any of the top five (5) hospitals as its preferred hospital. For the suitability analysis, the preferred hospital maps were overlaid on top of its corresponding service area map. The transparency for the preferred hospital map was set to 55%, while 0% transparency was assigned for the service area maps.

4. RESULTS AND DISCUSSION

4.1. Analysis of Demographics of the Respondents

39.3% of the total respondents said that they are from Quezon City and that their hospital for emergency cases is in Quezon City, which shows that travel time is indeed valued when it comes to emergency cases. However, 15.2% stated that they are from Quezon City, but they prefer hospitals outside. The rest of the pie is from outside of the city. About the same is the division for non-emergency cases, but more residents prefer hospitals outside of the city. In this study, 53.5% of the barangays (76 out of 142) were represented in the survey, which means that the address distribution of the respondents were quite spread out considering that half were considered. The respondents were mainly from the middle and upper classes hence representing the majority of the conclusions in the study.

4.2. Top Priority Factors

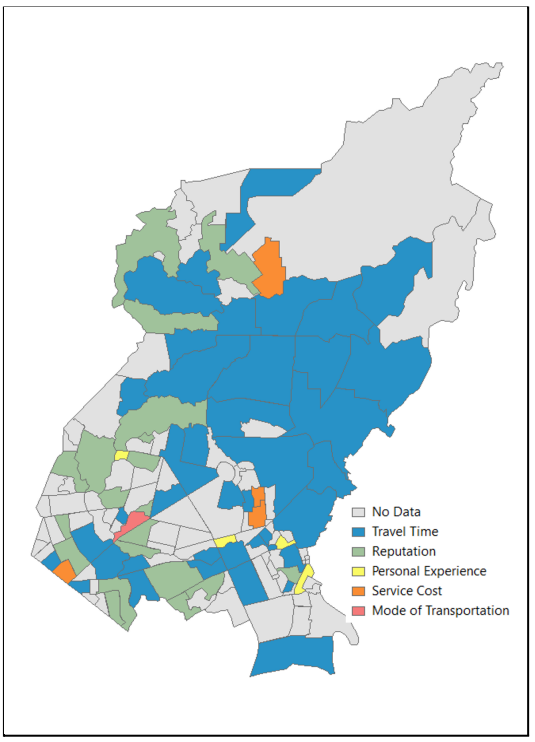


Figure 3. Top Priority Factor for All Classes per Barangay in Quezon City during Emergency Cases

The topmost factor the majority consider is their travel time to the hospital as seen from Figure 3. This reflects the need for hospitals to be situated near them due to the urgency of medical emergency cases. However, although travel time is the noticeable trend, it is not difficult to see that there are some areas wherein reputation is their top priority especially those barangays located at the southern part of the city. The situation is urgent, but this change in factors is probably caused by the current setup of the tertiary hospitals in the city leading to the overlook of its importance. Nonetheless, it is unarguable that travel time is the most important factor when deciding their preferred hospital as time is valuable. In contrast to this, for non-emergency cases, there is no trend observed, but reputation and personal experience are their top picks. This is probably because non-emergency cases are planned hospital trips with specific purposes. Hence, a reputable hospital or a hospital they are familiar with would be a better option in situations like this.

4.3. Preferred Hospitals of Quezon City Residents

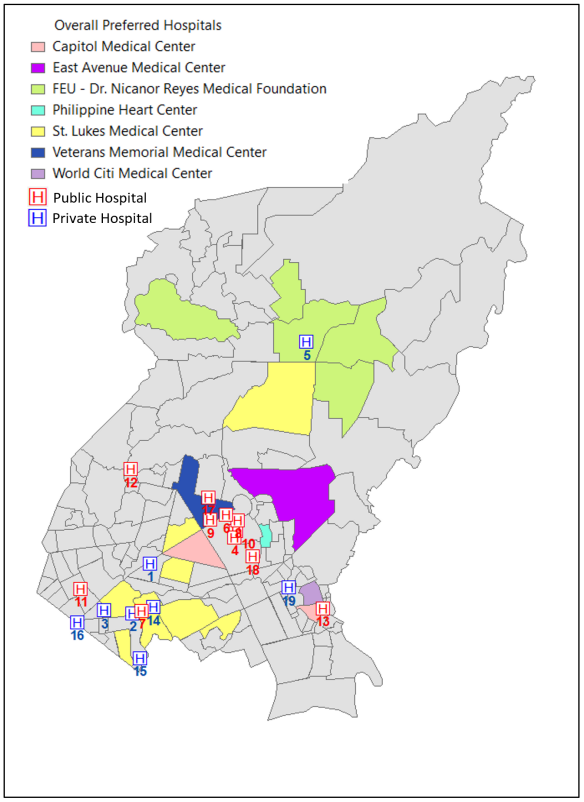
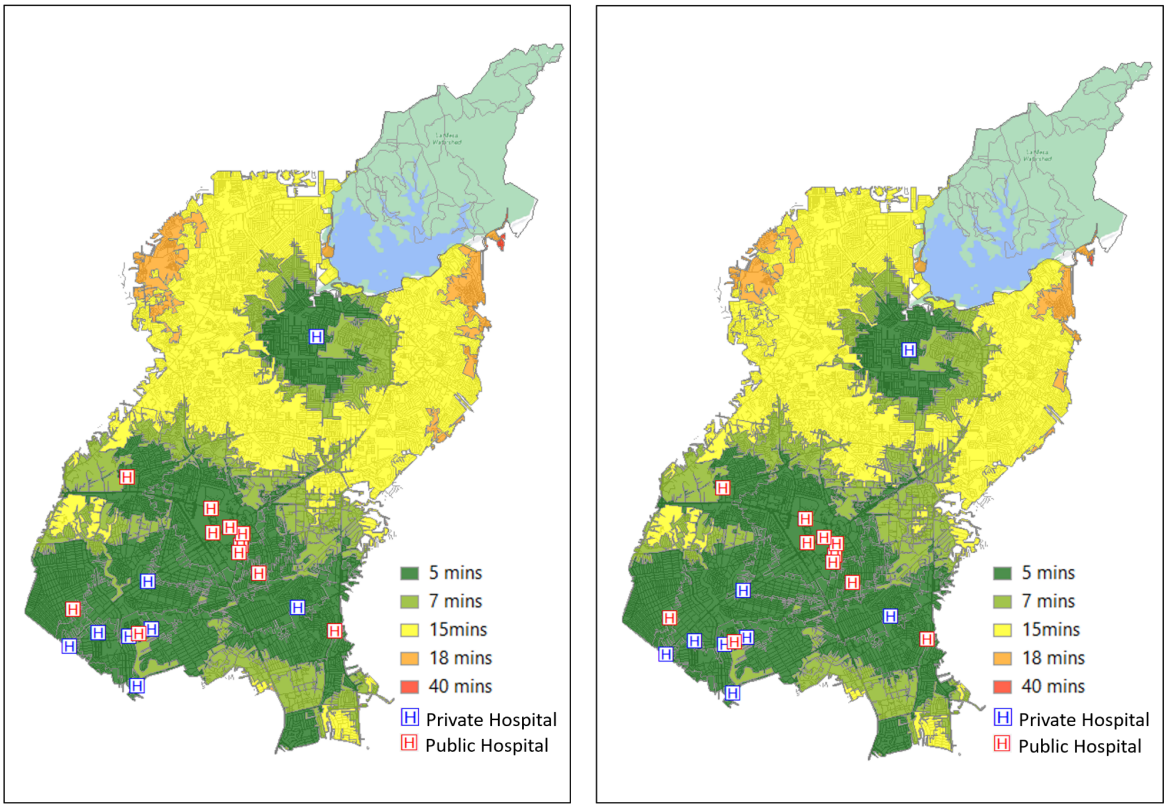


Figure 4. Preferred Hospitals of Quezon City Residents for All Classes during Emergency Cases

Figure 4 shows the summary of preferred hospitals of each barangay when all income classes are considered. Overall, it can be seen that St. Luke's, FEU, Capitol Medical Center, Philippine Heart Center, and East Avenue Medical Center are the most preferred hospitals for emergency cases. The other hospitals they preferred follow the priority factor of travel time. Only Brgy. Pasong Tamo failed to follow this as St. Luke's is quite far from them looking at the map. As for non-emergency cases, the order of picks are St. Luke's, Capitol Medical Center, FEU, Dr. Fe Del Mundo Medical Center, and Veterans Memorial Medical Center. Clearly St. Luke's is a popular choice for both throughout the city as it gathered the most responses.

4.4. Travel time-based Service Area of the Tertiary Hospitals in Quezon City



(a) Weekday (b) Weekend

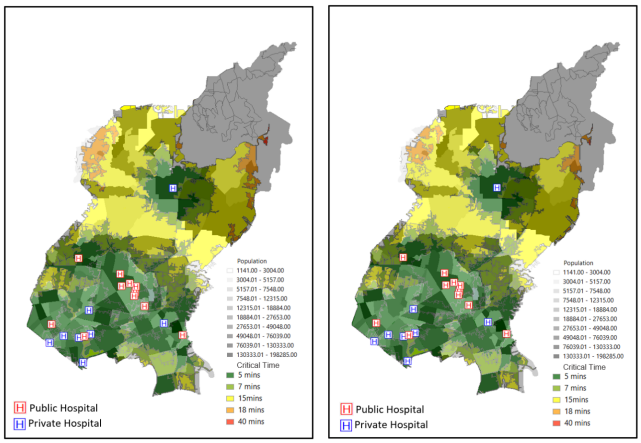
Figure 5. Travel time-based Service Area of All Quezon City Tertiary Hospitals during Emergency Cases

For all the hospitals, the whole Quezon City is serviceable depending on the considered critical time. However, since five (5) minutes is the one set by 911 as the medical emergency response time in the country, it can be observed that a hospital's coverage is very small. One hospital can probably just service 3 to 4 barangays under five (5) minutes - less than 10% of the land area based on the individual service areas of the hospitals.

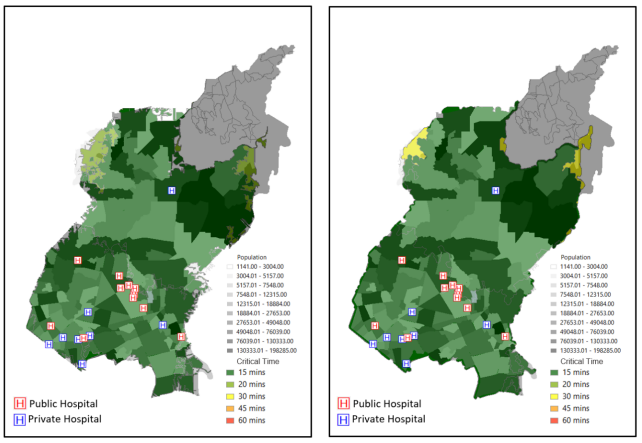
When considered as a whole, more areas are covered by all 19 since there are overlaps in their service area. For the 5-minute mark, about 40% of the total land area is covered. However, the north of Quezon City still remains the same since there is only one hospital. Hence, a well-spread distribution of tertiary hospitals would have been suitable for a city as large and populated as Quezon City.

Based on the responses of the residents, for non-emergency cases, the order of preference for the critical times are 30 minutes as the most preferred, followed by 1 hour, 45 minutes, 15 minutes and 20 minutes. With this, all of Quezon City is serviceable by the hospitals individually during non-emergency cases since the majority of them can service by 30 minutes, at most 45 minutes. When considering all tertiary hospitals together, the whole Quezon City is already serviceable within 30 minutes when their service areas overlap with each other. This then does not become a problem during non-emergency since people can technically choose whichever hospital as long as it is within Quezon City. It also validates the trend in the respondents' behavior that travel time is not a problem when it comes to choosing their preferred hospital in situations like these.

4.5. Suitability Analysis of Tertiary Hospital and the Population



(a) Weekday (E) (b) Weekend (E)



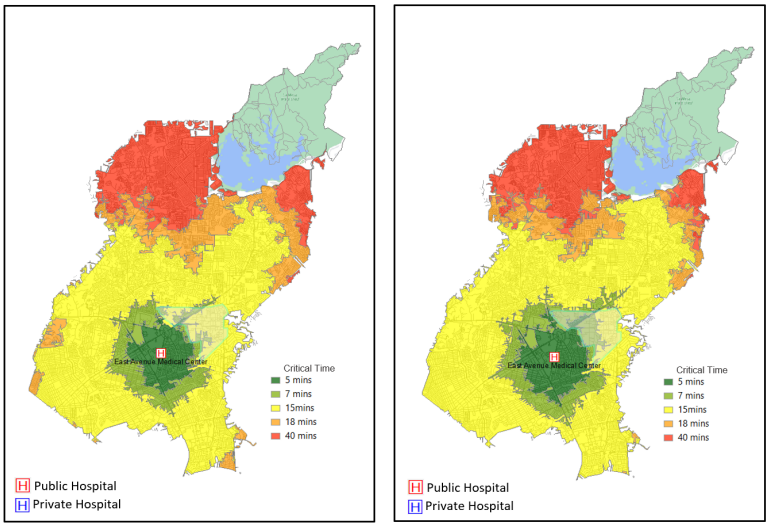
(c) Weekday (NE) (d) Weekend (NE)

Figure 6. Suitability Map of the Service Areas of the Tertiary Hospitals in terms of Population in Quezon City

In this study, one way of determining the suitability of the hospitals is by overlaying the population map over the service area maps. The hospitals are suitable if they can cater to the barangays that are populated. Figure 6 shows the suitability of all the tertiary hospitals by overlaying Quezon City's population map with the four (4) service areas of the hospitals combined. Looking at Figures 6-c and 6-d, for non-emergency cases, the 19 tertiary hospitals are suitable enough for the population looking at it from the travel time perspective by utilizing the service area. However, since travel time is not really a top deciding factor and that there are other factors which have more weight for non-emergency, there is no guarantee that all the 19 hospitals are indeed suitable for the Quezon City residents.

On the other hand, the hospital distribution becomes a problem for emergency cases. Looking at Figure 6-a and 6-b, it can be observed that the barangays that have the most population are not serviceable by the 5-minute response time. The north of Quezon City is mainly residential, so the population count is high there, but only one tertiary hospital is available. A lot of the barangays situated in that area are only serviceable at the 15-minute mark due to FEU - Dr. Nicanor Reyes Medical Foundation, Inc. Hence, even if 19 is a relatively good number of tertiary hospitals for a city in the Philippines, these hospitals are not suitable due to its aggregation especially when population distribution is that of Quezon City's where hospital locations are opposing the amount of people.

4.6. Suitability Analysis of Preferred Tertiary Hospital during Emergency Cases Only

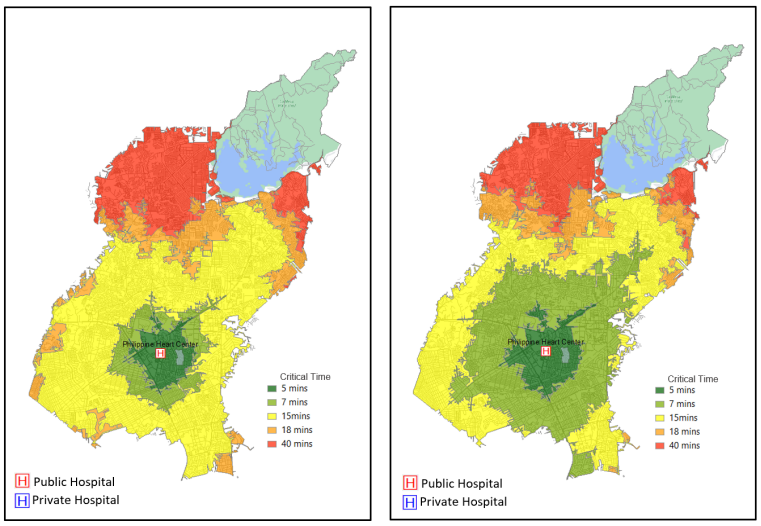


(a) Middle Class and All Classes, Weekday (E)

(b) Middle Class and All Classes, Weekend (E)

Figure 7. Suitability Map of East Avenue Medical Center for Emergency Cases

Looking at Figure 7, East Avenue Medical Center is unsuitable for Brgy. U.P. Campus during emergency situations because it is not within the 5-minute service area of the hospital. It is understandable that Brgy. U.P. Campus prefers this hospital as this is already one of the nearest to them. No service area of other tertiary hospitals includes them. Hence, this means that currently they are a critical area following the 911 standards. The possible solution to this is to check if a secondary hospital can attend to this or to build a tertiary hospital southeast of FEU - Dr. Nicanor Reyes Medical Foundation, Inc.



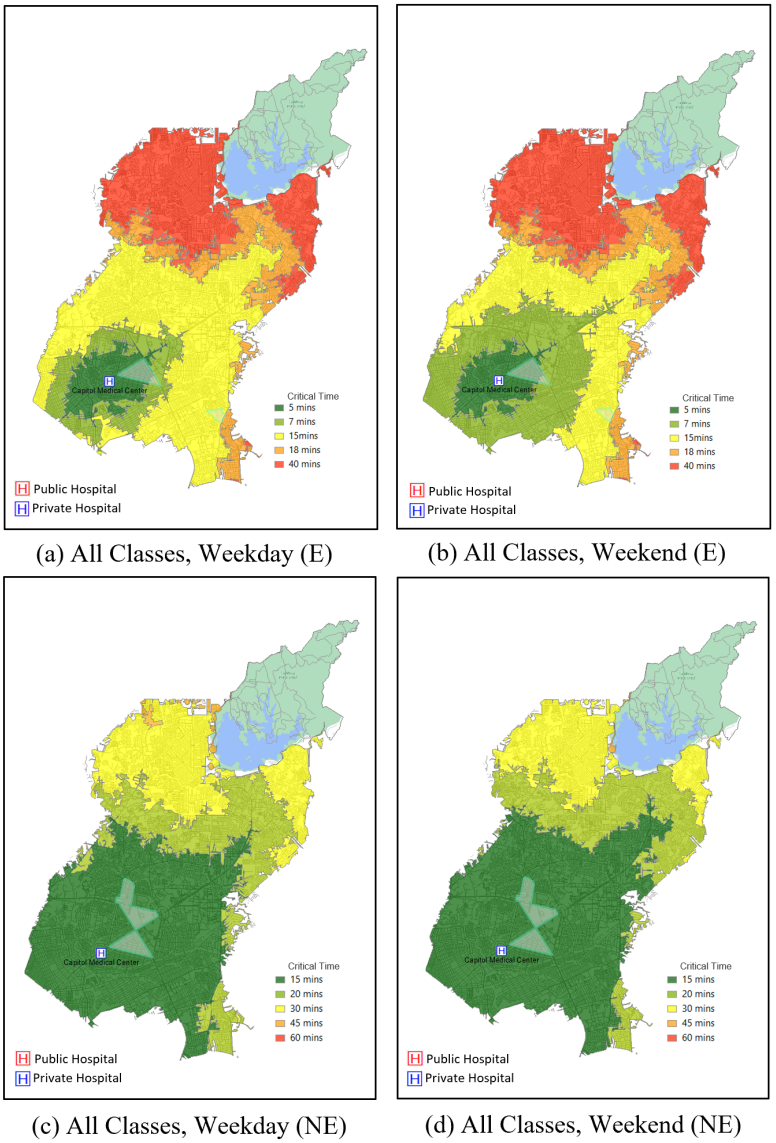
(a) Upper Class and All Classes, Weekday (E)

(b) Upper Class and All Classes, Weekend (E)

Figure 8. Suitability Map of Philippine Heart Center for Emergency Cases

The barangay that prefers them is Brgy. Teachers Village East. They are serviceable within 5 minutes, hence responding to emergencies is not a problem. The respondents definitely honor travel time as the most important factor during emergency cases.

4.7. Suitability Analysis of Preferred Tertiary Hospital during both Emergency and Non-emergency Cases



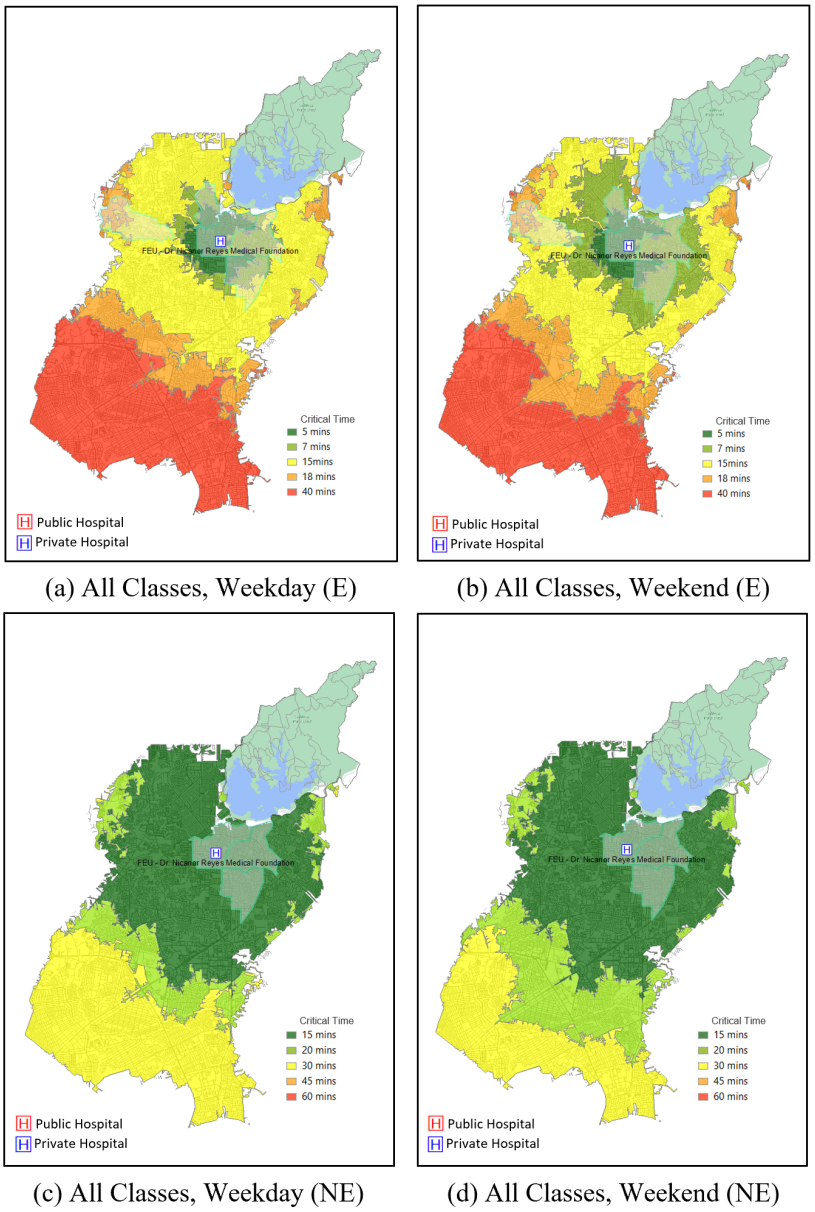
(a) All Classes, Weekday (E) (b) All Classes, Weekend (E)

(c) All Classes, Weekday (NE) (d) All Classes, Weekend (NE)

Figure 9. Suitability Map of Capitol Medical Center, Inc. for Emergency and Non-emergency Cases

One of the three (3) tertiary hospitals preferred for both emergency and non-emergency cases is Capitol Medical Center, Inc. For non-emergency cases, Capitol Medical Center, Inc. is suitable for Brgys. Culiat, Matandang Balara, Bagong Pag-asa and South Triangle. Indeed travel time is not a top priority, but if the other factors are already considered in their preference then this becomes suitable because their area is serviceable by their chosen hospital.

On the other hand, considering that travel time is the topmost deciding factor for emergency cases, this hospital might not be suitable for certain barangays. Capitol Medical Center, Inc. is not suitable for the residents of Brgy. Matandang Balara and Milagrosa. Although they are still serviceable, following the 5-minute response time, they are already too far. However, if the NHS England's response standard is adopted in the Philippines, then this hospital can be suitable to these barangays at a level 1 to 2 emergency category.



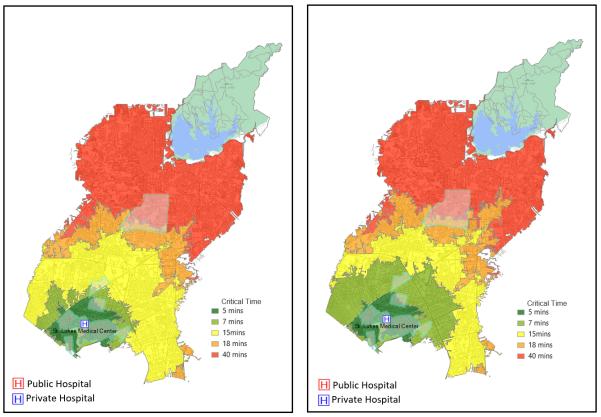
(a) All Classes, Weekday (E) (b) All Classes, Weekend (E)

(c) All Classes, Weekday (NE) (d) All Classes, Weekend (NE)

Figure 10. Suitability Map of FEU - Dr. Nicanor Reyes Medical Foundation, Inc. for Emergency and Non-emergency Cases

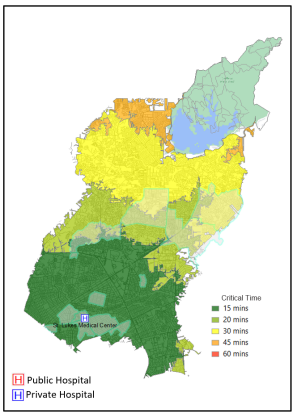
All of the barangays that preferred them are just beside them. There is not one barangay located in the southern part of Quezon City that preferred this hospital even for non-emergency cases. Similar to the non-emergency case of Capitol Medical Center, FEU is suitable as well for all the barangays that chose them for non-emergency situations as all are within the serviceable area.

However, the case would once again be different during emergency situations. FEU is only suitable for Brgy. Fairview for all three classes. It is the only barangay wherein the whole area or about 95% of it is within the 5-minute mark set by 911. The rest of the barangays did not hit the 5-minute mark although they are very near therefore, making FEU an unsuitable hospital for them. With FEU's current location, it seems that only Brgy. Fairview is serviceable within 5 minutes, and the rest of the barangays are already part of the critical area. This means that new hospitals are needed for these areas to be serviceable during emergency situations. Scarcity of tertiary hospitals here is very evident.

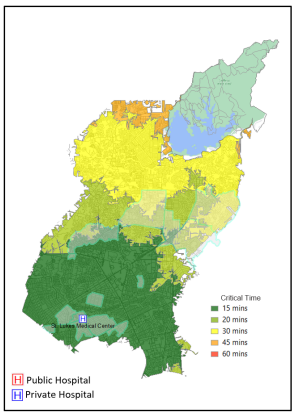


(a) All Classes, Weekday (E)

(b) All Classes, Weekend (E)



(c) All Classes, Weekday (NE)



(d) All Classes, Weekend (NE)

Figure 11. Suitability Map of St. Luke's Medical Center for Emergency and Non-emergency Cases

The top most preferred tertiary hospital for both situations is St. Luke's Medical Center. Barangays that chose them come from different ends of Quezon City. The probable reason for this is the reputability and familiarity of people with this specific hospital. Similar to the two hospitals-Capitol and FEU, in terms of travel time, St. Luke's is a suitable hospital for the barangays that prefer them for non-emergency situations.

As for emergency cases, St. Luke's is not suitable for all the barangays that chose them. For all three cases, St. Luke's is only suitable for Brgys. Damayang Lagi, Mariana, Kalusugan, Santol and Tatalon. As seen in the maps, only these barangays are within the critical time of 5 minutes. The other barangays are already critical areas and are not fit to be serviced by St. Luke's during emergency situations as they are already beyond the required time.

After all the analysis done between the service area of the top 5 hospitals and the barangays that chose them, it can be deduced that for emergency cases, hospitals need to be well-distributed and reputable in order to cater to as many of the Quezon City residents. This is because travel time is important, and one hospital can service about 10% of the land area only.

As for non-emergency cases, the hospital's location does not really matter since reputation will be the governing decision factor for the majority of Quezon City residents. This means that the hospital's suitability will be more dependent on the other factors. In a transportation study perspective, all the 19 hospitals are already enough to cater to the whole Quezon City. The only problem would be the reputation of these hospitals as the residents tend to stick with St. Luke's Medical Center despite having a lot of tertiary hospitals.

5. CONCLUSION

Healthcare is important to society as it defines lifestyle hence its accessibility needs to be guaranteed. However, in developing countries like the Philippines, traffic, service costs, and insufficient number of hospitals versus the population hinder Filipinos from availing it. Therefore, a GIS-based suitability analysis approach is one of the solutions to determine which sites are the best depending on the multiple criteria set to see if the existing hospitals are suitable and accessible to Filipinos.

Quezon City has 19 tertiary hospitals, but it is poorly distributed across the city. 18 of these hospitals are located in the least populated areas of the city hence leaving the populated barangays to a possible scarcity in tertiary hospitals. Moreover, although there is relative abundance in tertiary hospitals in Quezon City, factors such as travel time, reputation, personal experience, service costs, and mode of transportation, can control which hospitals are suitable and which are not. Therefore, these are the possible causes of unsuitability of the tertiary hospitals.

With the goal of doing a suitability analysis through a transportation study perspective, the objectives of this study is (1) to determine the topmost deciding factor of the Quezon City residents for emergency and non-emergency cases, (2) to create a service area map of the tertiary hospitals, (3) to create a map exhibiting the relationship of the population and the service area of the tertiary hospitals, (4) to create a map showing the relationship between the barangays that preferred the specific hospital and its service area for the top 5 most picked for emergency and non-emergency, and (5) to determine whether the hospital is suitable or not given the maps.

In achieving these objectives, information on the residents' preferences were collected through a survey and the speeds for the service area maps were obtained through a travel time simulation via Google Traffic, done for the primary and secondary roads of Quezon City. These data were inputted in ArcGIS in order to generate the preference, service area, and suitability maps. These maps are used to identify the suitability of the hospitals for a transportation study.

It was observed that for emergency cases, the top decision factor is travel time, while for non-emergency cases, it is either reputation or personal experience. During emergency cases, time is important hence travel time indeed needs to be prioritized. Generally, the preferred hospitals of the Quezon City residents during emergency cases are the hospitals near them. The top 5 picks for this are St. Luke's Medical Center, FEU - Dr. Nicanor Reyes Medical Foundation, Inc., Capitol Medical Center, Philippine Heart Center, and East Avenue Medical Center. Contrary to this, for non-emergency cases, chosen hospitals were those they considered reputable although not near them. The top preferred hospitals for this are St. Luke's Medical Center, Capitol Medical Center, FEU - Dr. Nicanor Reyes Medical Foundation, Inc., Dr. Fe Del Mundo Medical Center, and Veterans Memorial Medical Center.

Moreover, in the generated service area maps of the tertiary hospitals in Quezon City, it was seen that there is a difference between the serviceable area of weekdays and weekends for both emergency and non-emergency cases, so generating one for weekdays and another for weekends is acceptable. Also, for non-emergency cases, the whole Quezon City is serviceable since at most the city will be covered in 30 minutes, which was the most preferred critical time by the residents according to the survey. As for emergency cases, following the 5-minute rule of 911, a lot of the barangays in the northern area are already critical areas.

Knowing the population distribution in Quezon City and the preferred hospitals of some barangays, and having the service area maps of each hospital for both emergency and non-emergency cases during weekdays and weekends allowed the analysis of suitability to be

conducted. Since only travel time has data, which is supported by the service area, the suitability analysis in this study is done through a transportation perspective. This is helpful in terms of emergency cases since travel time weighs the most in this but not as much for non-emergency cases.

Looking at the population and the service area, it is concluded that the 19 tertiary hospitals are unsuitable when it comes to serving the demand in numbers since they are situated in areas with the least population. Only one of them-FEU - Dr. Nicanor Reyes Medical Foundation, Inc., is near the populated barangays. This defeats the purpose of having many tertiary hospitals when their locations are poorly planned. Based on the service area maps, FEU cannot service the majority of them within 5 minutes and too many people reside in the area that one hospital definitely cannot handle. To accomodate more people, for future references, a tertiary hospital can be built to the east or west of FEU in order to widen the service area in that part of the city.

As for the preferred hospital by the barangays and its service area, generally, for non-emergency cases, when focused on the transportation aspect, all hospitals are suitable for the whole Quezon City as 30-minute critical time is enough leeway to cover the whole city.

As for emergency cases, suitability cannot be generalized as there are some barangays wherein their chosen hospital was unsuitable, Nonetheless, the main factor to determine this is whether their barangay is located in the 5-minute service area of their chosen hospital. Quite a number of barangays had an unsuitable choice since the 5-minute service area is really small and there are times that reputation took over their preference. This shows that for both cases even when travel time is considered, the reputation of a hospital still matters, which made St. Luke's a top choice for both cases. Therefore, even when there are 19 tertiary hospitals in Quezon City, majority of the demand is for St. Luke's due to its reputation.

6. RECOMMENDATION

The results of this study can be used as an initial or exploratory data on the suitability of the tertiary hospitals in Quezon City for emergency and non-emergency cases.

Since this is only a part of the complete study, it is recommended to continue this research by obtaining data for the other four (4) factors namely reputation, personal experience, service costs, and mode of transportation. This is so a suitability map can be generated for easier drawing of conclusions.

For improvements in the methodology, it is recommended to do travel time simulation again since the data was obtained during covid hence travel time and speeds are different from normal. Also, increasing the number of roads simulated can make the service area generated more accurate to the real-life conditions.

In addition to that, in order to make better maps and draw better conclusions and interpretations, targeting specific respondents for the study would make it better. Since there are parameters which income classes affect, it would be better to have a goal of the number of respondents for each income class to ensure that all of them are represented and their preferences are clearer.

Nonetheless, future studies do not need to focus on Quezon City. They can widen their scope such as making it the whole Metro Manila since as seen, there is an overlap in hospital preferences, which means these are correlated. In the case that widening is difficult, choosing a different city that is smaller is possible too. This is to see if suitability can be higher if the area is smaller and hospitals are fewer depending on the hospitals within the city.

REFERENCES

Aburas, M. M., Abdullah, S. H. O., Ramli, M. F., & Asha'ari, Z. H. (2017). Land Suitability Analysis of Urban Growth in Seremban Malaysia, Using GIS Based Analytical Hierarchy Process. *Procedia Engineering*, 198, 1128–1136. https://doi.org/10.1016/j.proeng.2017.07.155

Albert, J. R. G., Dumagan, J. C., and Martinez, A., Jr. (2015). Inequalities in Income, Labor and Education: The Challenge of Inclusive Growth. *Discussion Paper No. 2015-01*. Quezon City: Philippine Institute for Development Studies. https://dirp4.pids.gov.ph/webportal/CDN/PUBLICATIONS/pidsdps1501.pdf (Accessed on June 5, 2021)

Albert, J. R. G., Santos, A.G.F., and Vizmanos, J. F. V. (2020). Profile and Determinants of the Middle-Income Class in the Philippines. *Discussion Paper Series No. 2018-20*. Quezon City: Philippine Institute for Development Studies.

Albert, J.R.G., and Vizmanos, J. F. V. (2018). Vulnerability to Poverty in the Philippines:An Examination of Trends from 2003 to 2015. *Discussion Paper Series No. 2018-10*. Quezon City: Philippine Institute for Development Studies https://pidswebs.pids.gov.ph/CDN/PUBLICATIONS/pidsdps1810.pdf (Accessed on June, 5, 2021)

Ali, E., (2020) Geographic Information System (GIS): Definition, Development, Applications & Components. [Online].

Ambulance response times. (2019, August 22). Ambulance response times. The Nuffield Trust. https://www.nuffieldtrust.org.uk/resource/ambulance-response-times

American Hospital Association. (2017, November). Social determinants of health series: Transportation and the role of hospitals. Chicago, IL: Health Research & Educational Trust. Accessed at www.aha.org/transportation

Amin, Z. A. (2017, September 16). Definition, Classification and Function of Hospital. https://www.slideshare.net/zulfiquer732/definition-classification-and-function-of-hospital

Brelje, J., (2015) Relevant decision criteria and their level of importance in consumers' choice of hospital. *Honors Program Theses*. 182.

Census of Population | Philippine Statistics Authority. (2015, July 31). Philippine Statistics Authority. https://psa.gov.ph/statistics/census/2015-census-of-population

El Karim, A. A. and Awawdeh, M. M. (2020) 'Integrating GIS accessibility and location-allocation models with multicriteria decision analysis for evaluating quality of life in Buraidah city, KSA', *Sustainability (Switzerland),* 12(4). doi: 10.3390/su12041412.

Fralick, P. C. , Piercey, . W. Douglas and Scarborough, . Harold (2020, April 16). Hospital. *Encyclopedia Britannica*. https://www.britannica.com/science/hospital

GIS in the Philippines. [Online] Available at: https://iskomunidad.upd.edu.ph/index.php/GIS_in_the_Philippines#III..09Users_of_GIS [Accessed 7 January 2021].

Hassaan, M. A., Hassan, A., & Al-Dashti, H. (2020). GIS-based suitability analysis for siting solar power plants in Kuwait. *The Egyptian Journal of Remote Sensing and Space Science.* https://doi.org/10.1016/j.ejrs.2020.11.004

Javalgi, R., Rao, S.R., & Thomas, E.G. (1991). Choosing a hospital: analysis of consumer tradeoffs. *Journal of health care marketing*, 11 1, 12-22 .

Jiang, S., Gu, Y., Yang, F., Wu, T., Wang, H., Cutler, H., & Zhang, L. (2020). Tertiary hospitals or community clinics? An enquiry into the factors affecting patients' choice for healthcare facilities in urban China. *China Economic Review,* 63, 101538. https://doi.org/10.1016/j.chieco.2020.101538

Kamra, Vishal, et al. (2016). Factors Affecting Hospital Choice Decisions: an Exploratory Study of Healthcare Consumers in Northern India. *Asia Pacific Journal of Health Management,* vol. 11, no. 1, 2016, pp. 76–84., doi:10.24083/apjhm.v11i1.249.

List of Regulated Health Facilities and Services. (2020, December 31). Health Facilities and Services Regulatory Bureau. https://hfsrb.doh.gov.ph/

Murad, A. A. (2004). Creating a GIS application for local health care planning in Saudi Arabia. *International Journal of Environmental Health Research,* 14(3), 185–199. https://doi.org/10.1080/0960312042000218606

Murad, A. (2018) Using GIS for determining variations in health access in Jeddah city, Saudi Arabia, *ISPRS International Journal of Geo-Information,* 7(7). doi: 10.3390/ijgi7070254.

NHS England. (2017). NHS England» Ambulance Response Programme. England.nhs.uk. https://www.england.nhs.uk/urgent-emergency-care/improving-ambulance-services/arp/

Taherdoost, H. (2017). Determining Sample Size; How to Calculate Survey Sample Size. *International Journal of Economics and Management Systems,* 2(2367-8925).

Weekly Traffic Congestion by Time of Day. (2020). [Figure]. Tomtom Manila Traffic Philippines.