ACCESSIBILITY OF HEALTH CARE INSTITUTIONS: A CASE STUDY BY USING GIS

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ACCESSIBILITY OF HEALTH CARE INSTITUTIONS: A CASE STUDY BY USING GIS

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ABSTRACT
Equitable provision of health care services is a major challenge for developing countries. The degree of accessibility of health care institutions is one of the most significant indicators for measuring the efficiency of a health care system. Accessibility is a complex indicator that reflects the number of health care institutions, their geographical distribution and the impact of different types of barriers (economic, social, cultural, etc.). Geographers have been mainly concerned with geographical accessibility for the calculation of which they have tried different methods. Over the last twenty years, GIS has provided valuable tools for the measurement of geographical accessibility. In this study, we use GIS tools to investigate the accessibility of health care institutions in the Büyükçekmece district of Istanbul. We found no major accessibility problems in the district as even those inhabitants living the farthest from the health care centers can reach the closest medical institution in less than 30 minutes. Nevertheless, these results are based on the assumption that patients always visit the closest health care center which is not always realistic.

Keywords: medical geography, health care provision, accessibility, geographic information systems, Istanbul, Turkey.

1. INTRODUCTION
Public provision of health care services is among the biggest problems in developing countries and the accessibility of health care institutions is one of the most important factors in constituting healthy communities. The degree of accessibility of health care institutions is one of the most significant indicators for measuring the efficiency of the health care system (Gatrell and Elliott 2009). The access of public to health care institution could be seriously restricted by distance (Black and al 2004). Longer distances may affect especially the access of elderly and of physically-impaired people to health care. In general, longer the distance to health care facilities the risk of fatalities (Jones et al 1998; Hare and Barcus 2007), although this is disputed by some studies (Drummer and Parker 2004).

The study of accessibility to health care has long been of interest to medical geographers and other social scientists (Quah 1977; Joseph and Phillips 1984). Such studies on health care accessibility have not been confined to the more developed countries (Hare and Barcus 2007; Jones et al 1998; Pearce et al 2006; Ohta et al 2007; Liu et al 2002; Kalogirou and Foley 2006; Philips et al 2000) or urban areas; a substantial number of studies has also been published on health care accessibility in developing countries (Perry and Gesler 2000; Rosero-Bixby 2004; Gibson et al 2011; Okafor 1990; Murad 2004) and rural areas (Brabyn and Skelly 2002; Tsoka and Le Sueur 2004; Arcury et al 2005).

There are many studies in which GIS were used as a tool in querying the physical (geographical) accessibility of health care institutions (Love and Lindquist, 1995; Wilkinson et al. 1998; Albert et al. 2000;
Phillips et al. 2000; Black et al. 2004; Murad, 2004). In addition to these, World Health Organization (WHO) also developed a GIS-based model for physical accessibility of health care institutions. Analysis, such as price efficiency and total number of patients who have ability to reach hospitals, can be performed by means of this model. The subject of this study is to analyze the accessibility of health care institutions located in Istanbul’s Büyükçekmece district by using the high ability of GIS in analyzing spatial data.

2. LITERATURE REVIEW

According to Quah (1977; also in Penchansky and Thomas 1981; Oliver and Mossialos 2004), accessibility of health care is a complex indicator for the health of the health care system in a country or region and implies adequacy in numbers, fair geographical distribution and absence of any type of barrier (economic, social, or cultural) to medical care. Penchansky and Thomas (1981, p. 128) also argue that there are several dimensions (availability, accessibility, accommodation, affordability and acceptability) that we need to consider when discussing access of population to health care facilities, while Gulliford et al (2002, p. 186) contend that “the availability of services, and barriers to access, have to be considered in the context of differing perspectives, health needs and material settings of diverse groups in society”. Based on these arguments, Joseph and Philips (1984), Aday and Andersen (1974), Luo and Wang (2003) and Guagliardo (2004) distinguished between potential accessibility (which refers strictly to physical accessibility or to the number of people residing within a certain range who could potentially use the services of these health care facilities should they face no barrier) and revealed accessibility (or actual utilization of health care facilities, which takes into account the barriers mentioned above).

Poor countries suffer from lack of or insufficient medical infrastructure. Moreover, the health care facilities tend to concentrate in the capital and the biggest cities while vast rural areas remain uncovered by medical services. Economically and socially more advanced countries generally have an adequate number of health care facilities but problems may still exist due to their unequal territorial distribution or due to the existence of certain barriers that may restrict the access of certain categories of people to health care. While we do not intend to minimize the importance of these social, economic or cultural barriers, in this study we focus mainly on the issue of geographical (physical) access to health care facilities.

Geographical accessibility is a topic that has preoccupied medical geographers for quite some time (Quah 1977). They have tried different methods to evaluate accessibility. Many authors have used basic cartographic methods to map the availability of health care facilities and highlight potential inequalities (Knox 1979). They have also used sophisticated mathematical models to understand the effect of distance on geographical accessibility of health care facilities (Mitropoulos et al 2006; Knox 1979; Koening 1980; Joseph and Bantock 1984) and statistical methods to reveal the existence of factors or barriers that affect the access of population to health care services (see also Guagliardo 2004 for an interesting review of these models and statistical methods). For example, Vedia Dokmeci and collaborators (Dokmeci 2002; Dokmeci and Ozus 2004; Şentürk et al 2011) have investigated the distribution of different types of health care facilities (hospitals, physician offices and pharmacies) in Istanbul. Using a regression analysis, they found that the most important factors that influence the distribution of these health care facilities are population income and education level. Moreover, they found that, while state hospitals are more evenly distributed, private hospitals tend to concentrate in high-income districts (Şentürk et al 2011).

Over the last 20 years GIS has provided a valuable tool for the measurement of geographical accessibility (Gatrell and Elliott 2009; Kohli et al 1995; for an interesting review of the literature on the use of GIS to assess accessibility to health care services see also Higgs 2004). GIS, just like other data management systems (DMS), is an information system used for obtaining, organizing, storing and analyzing large-scale data (Black et al 2004; Aronoff, 1989; Burrough, 1986). GIS differs from other DMSs in its possession of
information on the location of data it analyzes, and the capability of GIS software to perform a wide variety of assessments related to geographical locations by means of its high spatial analyzing ability. GIS software receives this ability from “topological” properties it possesses. Topology is defined as the geometric relationships of objects found in GIS environment to each other and relationship (such as proximity and inclusion) between one object and the other object is determined due to this property. This constitutes the basis of spatial analysis and due to these properties GIS are ideal for measuring spatial accessibility (Black et al 2004; Murad 2004).

Health services planning and GIS are two interconnected concepts that require spatial data. The location of health care institutions, distribution and characteristics of patients are primary spatial data that should be considered during the planning of local health care services (Murad, 2004). Spatial querying tools and related GIS capabilities such “buffer” and “overlay” make GIS a very efficient tool in querying the accessibility of health care institutions both for today and in the future (Love and Lindquist, 1995; Black et al 2004). Accessibility can be assessed by either measuring the distance from residence to the health care facility (linear distance or road distance) of by estimating travel time. In some cases perceived distance or perceived travel time could also be considered (Arcury et al 2005; Love and Lindquist 1995).

Travel time is the preferred indicator for most studies because it takes into account the state of the roads and the main mode of transportation (which together determine average speed). In the more developed countries, where automobiles are ubiquitous, driving time is generally employed (Brabyn and Skelly 2002; Luo and Wang 2003; Philips et al 2000; Hare and Barcus 2007; Liu et al 2002). Some authors (mainly from Europe where public transportation is more developed and more efficient than in North America or Oceania) have also included the use of public transportation in their calculation of travel time (Lovett et al 2002). In the less developed countries, researchers often use walking time or travel time by public transportation to measure distance from the nearest hospital (Tsoka and Le Sueur 2004; Perry and Gesler 2000; Rosero-Bixby 2004).

What could be considered an acceptable distance for people to travel for medical care? There is no universally accepted range. For example, Rovali and Kiivet (2006) put this range at 30 minutes beyond which they found that geographical access to inpatient care was diminished. Hare and Barcus (2007) have estimated that people residing at more than 45 minutes from health care facilities are more likely to be marginalized. Finally, Brabyn and Skelly (2002: 7) consider one hour as an adequate range because one hour is “a threshold that ambulance drivers talk about”. They also warn that “people who have to travel more than one hour are paying a high cost (financially and emotionally) to visit a hospital”.

However, in some of the more developed of the developing countries (the so-called emerging markets), such as Turkey, the situation may be more complex and therefore it may be more difficult to assess accessibility using travel time. While the number of automobiles has increased tremendously in Turkey over the last two decades, most people still rely on public transportation for moving around. Moreover, due to the high population density in the Turkish cities, many people may be within walking distance from most objectives. In big cities, such as Istanbul, traffic may also be an important variable. During rush hours, traffic may be much slower and travel time much longer than during other times of the day. This may constitute an important limitation for those studies that are based on travel time.

Measuring distance following the road network is a relatively straightforward operation and it is very easy to do using GIS. There is no universally accepted definition for acceptable range. Each researcher may decide on a range (or ranges) based on his or her experience and knowledge of the area. (There are many factors that should be considered, such as topography or population density.) For example, in a similar study done in the Shaanxi Province (China), Gibson et al (2011) measured accessibility of households to rural health centers using a five- kilometer and a ten-kilometer range.
GIS-developed models have an important role in facilitating mobility (Boothby and Drummer 2003). Planners benefit from GIS-based studies by learning about those areas that are underserved by health care institutions (Kalogirou and Foley 2006). Using GIS, they can also identify the optimal location of new facilities. The main purpose would be to allocate the right number of users to those locations and minimize the distance patients have to travel to use those medical facilities (Mitropoulos et al 2006). GIS tools may also allow planners to anticipate changes in the demand for medical services and act accordingly (Murad 2004). This could result in better allocation of resources based on population needs for health care and, therefore, in better accessibility (Gatrell and Senior 2005).

3. DATA AND METHOD
The first step was to identify the health care institutions that are located within the boundaries of the research area. These data were then transferred into a GIS environment. Next, the road network was digitized using the “street” base map of ArcMap 10.1 software and Google Earth. In addition, we determined the topographical condition of the research area with the help of Digital Elevation Model (DEM) obtained from the images of Aster satellite using a 30 m resolution.

We then produced buffer zones at 1 km and 3 km around the health care institutions. As we have seen in the preceding chapter, these ranges are arbitrarily selected by researchers based on their previous experience and on the specific local conditions. We chose to draw the first buffer zone at 1 km because this is a very densely populated district where people are used to walk (shorter distances) to run their errands and this distance could be covered in approximately 15 minutes on foot. The second buffer zone was chosen at 3 km because this distance could be covered by a car or by public transportation in about 10-15 minutes during normal traffic conditions.

Another spatial analysis we performed is the “shortest distance” analysis from two outlying points to the closest health care institutions.

4. STUDY AREA
Büyükçekmece became a new district of Istanbul after separating from Catalca in 1998 and was included within the boundaries of Metropolitan Municipality in 2008. Today, there are 23 neighborhoods located within the boundaries of Büyükçekmece (3.35% of total land area of Istanbul province) and 201,077 inhabitants reside here according to the address-based population registration system (ABPRS) as of 2012 (figure 1a-1b).

Figure 1: (a) Buyukcekmece sub-province; (b) Neighborhoods of Buyukcekmece
While Batikoy is the most populated neighborhood of Büyükçekmece with a population of 30,703, Ahmediye is the least populated neighborhood with only 1327 persons residing here. The population density of the district (158 km2 of land area), was calculated at 1277 persons/km2, with Batikoy, Dizdariye, Fatih and Ataturk being the most densely-populated neighborhoods (figure 2).

In terms of topography, except for the steeper slopes towards the Marmara Sea and towards the Büyükçekmece Lake, Büyükçekmece district appears to be relatively flat. The highest point of the district, situated in the south towards the Marmara Sea, is 221 m (figure 3). These topographical characteristics have favored higher building and population densities.
This topographical characteristic has also allowed for higher road densities. The total length of asphalt roads is 1007 km and they are connecting all neighborhoods in the district. The district is served by 19 health care institutions located within the boundaries of the research area (figure 4).

Figure 4: Hospitals and roads of Buyukcekmece.

5. RESULTS

Analyses performed in this section are based on the measurement of the accessibility of people residing within the boundaries of the district to the health care institutions. Therefore, analyses rest upon the spatial relationship between the centers of settlement and health care institutions. In this regard, the proximity of residential areas to health care institutions within the research area was identified primarily by creating buffer zones around these facilities. First we draw a buffer zone at 1 km from the health care institutions (figure 5).
As can be seen from the above map, health care institutions agglomerate in the southern part of the district, where the population is denser. Of the district’s total area of 158 km², an area of 33 km² (20.88%) is located within 1 km of distance from the hospitals. This figure can be said to be quite good given that the population was concentrated within this zone. This proximity is of great importance especially for emergency situations. The proximity plays a vital role in the patients who should be rushed to hospital as soon as possible and in cases that require immediate intervention.

Another buffer zone was drawn at 3 km of the health care centers (figure 6).

The map above shows that 89 km² (56.33%) of the district’s territories is located within 3 km from a health care facility. When we compare this map with the map displaying population density in the district it becomes clear that the great majority of the district’s population lives within an acceptable distance from health care institutions.

Another analysis performed with regard to spatial analysis of health care institutions is the “shortest distance” analysis. We performed this analysis for two points in the north of the
district situated farthest from the health care centers which are all concentrated in the south. We selected for this analysis a point in the north of the district (northwest from Büyükçekmece Lake) and a point in the northeast (figures 7 and 8).

The first point used for our analysis is situated at 11.9 km from the nearest health care facility (figure 8). This means that a person who resides there could reach the closest health care center by car in no more than 15 minutes given the low population density and easier traffic in this part of the district. By public transport this may take longer but still within the 30 minutes considered acceptable by Rovali and Kiivet (2006).

Figure 7: Farthest distance analysis-route 1.

The second spot selected for distance analysis is located in the northeast of the lake and this distance is the farthest distance to the health care institutions within the boundaries of the district (figure 8). The distance in this case is 15 km and can be covered in a period of 20 minutes by car and 30-35 minutes by public transport taking the traffic into account. In case of emergency, an ambulance needs to cover the distance twice; however, ambulances are not restricted by speed regulation and benefit from the right of way in traffic. Therefore, we estimate that an ambulance responding promptly could take a patient to the hospital in less than 30 minutes.
6. CONCLUSION

Büyükçekmece has a total of 19 health care institutions. Considering a total population of a little over 200 thousands inhabitants results a ratio of one health care center for 10,000 inhabitants. Although all these centers are located in the south, this study found that there are no major problems related to accessibility. The great majority of people in the district lives within three kilometers from a health care institution, distance that can be covered by a car or bus in about 10-15 minutes during normal traffic conditions. People living on almost 21% of the district’s area reside within walking distance (one kilometer) from a health care center. Also those areas that are not included within the 3 km buffer zone have much lower population densities. However, even when considering the longest distance from a health care facility estimated travel time does not exceed 30 minutes which was considered by Rovali and Kiivet (2006) the longest acceptable range for delivering health care services. Based on the results of this study, we can conclude that there are no problems related to geographical accessibility in the Büyükçekmece district.

There are, however, a few limitations to the results of this study which need to be mentioned here. Firstly, we assume that patients will always patronize the closest medical facility to their residence. This assumption, while very practical for the purpose of our research could be far from reality (see also Mitropoulos et al 2006). Besides distance there are many barriers to effective use of health care centers. For example, many of these 19 health care institutions in the Büyükçekmece district are private and offer medical services for a fee which not all residents could afford. The second limitation derives from the assumption that residents always patronize medical facilities in their district. This is again not realistic considering that residents are not restricted by law from using any health care center they want, the district boundaries are very discreet and the districts are well connected. As a matter of fact, often certain neighborhoods are better connected by roads and public transport to other districts than to other neighborhoods in the same district. Moreover, many residents work in other
districts and may prefer to visit health care centers close to their work place or somewhere in between work and residence.

Another result of our study is that GIS proved to be a useful tool in this medical geography application. GIS has a variety of analysis tools that can be used in many urban applications, such as transportation, health, and education where they can provide a wide range of conveniences to urban geographers and planners. GIS makes it also possible to achieve better outcomes with its tools such as overlay and proximity.

Another feature of GIS is that it is a technology-driven system or science. In other words, benefits of GIS will increase with the emergence of new methods, applications and techniques. This is visible when comparing studies using GIS 20 years ago with recent studies. ArcMap, which was used as research tool for this study, can be a very good example to this. ArcMap started to offer “basemap” to its users together with its ten software versions, and thus users found the opportunity to access many maps, satellite images and aerial photographs from all parts of the world. In this study, “shortest path” analyses were made via “street” basemap.

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