Accessibility of tertiary hospitals in Finland: a comparison of administrative and normative catchment areas

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Highlights

- Traditional hospital districts are not always optimal in terms of accessibility

- Administrative borders are reconsidered in terms of Finnish health care reform

- Population grid data facilitate hospital catchment determination

- Limited improvements in spatial accessibility were achieved by optimization

Abstract

The determination of an appropriate catchment area for a hospital providing highly specialized (i.e. tertiary) health care is typically a trade-off between ensuring adequate client volumes and maintaining reasonable accessibility for all potential clients. This may pose considerable challenges, especially in sparsely inhabited regions. In Finland, tertiary health care is concentrated in five university hospitals, which provide services in their dedicated catchment areas. This study utilizes Geographic Information Systems (GIS), together with grid-based population data and travel-time estimates, to assess the spatial accessibility of these hospitals. The current geographical configuration of the hospitals is compared to a normative assignment, with and without capacity constraints. The aim is to define optimal catchment areas for tertiary hospitals so that their spatial accessibility is as equal as possible. The results indicate that relatively modest improvements can be achieved in accessibility by using normative assignment to determine catchment areas.

Keywords

Finland; accessibility; Geographic Information Systems; health care; tertiary hospitals

Introduction

One of the principles of Finnish health care policy, which is also in Finland's constitution, is the right of every resident to receive adequate health services regardless of ability to pay, or place of residence. Accordingly, the majority of hospitals in Finland are public, owned by municipalities or joint municipal authorities. The spatial organization of health care is a trade-off between providing efficient and equal health care to the population. This is especially difficult in Finland, with its small, but geographically dispersed population. In Finland, the current geography of health care dates back to decisions made soon after World War II. Mainland Finland (excluding the autonomous Åland Islands, off the southwest coast of Finland) was divided into 20 hospital districts, each with a central hospital (Fig. 1). A hospital district is responsible for providing hospital services and coordinating specialized public hospital care within its area (Saarivirta et al., 2010; Teperi et al., 2009).

The hospital districts in Finland are grouped into five tertiary care regions organized around the five university teaching hospitals located in Helsinki, Turku, Tampere, Kuopio and Oulu (Fig. 1). The main function of these regions, or university central hospital regions, is to centralize care delivery for highly specialized, complex or rare conditions, surgeries and other forms of treatment (Act on Specialized Medical Care (1062/1989), 2010; Teperi et al., 2009). Such services typically require a large catchment area to ensure sufficient client volume. This is necessary to maintain the provision of high-quality services, in terms of both economic efficiency and the expertise needed to provide highly specialized care. Ultimately, this may contribute to improved client safety, which has been suggested in many studies (e.g. Finks et al., 2011).

The five tertiary care regions in Finland are often colloquially referred to as “million districts,” suggesting that each should serve its equal share of about five million inhabitants. In reality, however, this has never been the case, as illustrated in Fig. 2. Over the entire period since the inception of the tertiary care regions in the 1970s, the tertiary hospitals in Helsinki and Tampere have together served at least 50% of the entire population, leaving the other three tertiary hospitals with considerably lower shares of the population. The population in the catchment area of the Helsinki tertiary hospital has been constantly increasing, accentuating the differences between catchment areas.

A significant proportion of the Finnish population has always been concentrated in the coastal regions in the South and West. To date, settlement of the eastern and northern parts of the country has been encouraged many times in an effort to achieve more balanced regional development (Westerholm, 2002). Despite these efforts, in recent decades, the population has increasingly retracted toward the South of Finland, which has been accompanied by considerable urbanization (Tervo, 2005). This development challenges the existing spatial divisions of health care based on districts defined in the 1940s and a hospital network that was mainly constructed during the 1950s and 1960s. The increasingly uneven population distribution may lead to increased demand for services in certain areas, whereas in others, the population base may no longer be sufficient either to maintain specialized health service delivery or to ensure its high quality.

It is worth scrutinizing the tertiary regions’ suitability to serve the population’s health care needs. Currently, an initiative is underway to reform health care provisions along with the administrative regions. The reform entails fundamental changes to responsibilities for health care provision. The current tertiary regions have been suggested as prime candidates for the new geographical regions for health care provision. Health care services and administration could be aggregated into these new regions to ensure quality, equal access to health care services and cost reductions. In addition, according to the latest Health Care Act (1326/2010), a person should have the right and freedom to choose where to go for treatment. Assuming that hospitals have similar service levels – as they ought to – it is reasonable to expect that choices will be influenced by distance.

Access to health care

The large catchment areas necessary to guarantee adequate client volumes for tertiary hospitals inevitably raise the question of how tertiary care can be accessed, which mainly implies distance. The question of whether a service is within a reasonable distance from potential patients is common in health care, and distance has been shown to affect utilization of health care and health outcomes across many settings (Tanser et al., 2010). The question regarding distance and its effect on equity arises particularly in situations where a network of public services is reduced or its allocation is adjusted. However, in cases where more service facilities are established, the debate may concern the issue of who has the greatest need for better access to services. Despite strong views on the topic, it is possible that the actual implications of service-network changes are poorly understood and, arguably, sometimes overestimated. This makes it important to properly understand what really constitutes access to health care, and how it can be assessed.

This study concentrates on spatial accessibility, which is one of the dimensions of the more extensive term "access." Following the definition by Penchansky and Thomas (1981), access to health care is an umbrella term that encompasses a set of characteristics reflecting the fit between health care providers and their clients. In their famous taxonomy, the authors outline the "five As of access": availability, accommodation, affordability, acceptability and accessibility. The first four of these mostly relate to health service supply and organization, people's ability to pay for services and their satisfaction with services provided (Cromley & McLafferty, 2002; Wyszewianski & McLaughlin, 2002). The fifth characteristic, accessibility, is a geographical term, which is determined by how easily a client can physically reach a health care facility (Moseley, 1979; Wyszewianski & McLaughlin, 2002). Generally, spatial accessibility highlights the location of services in relation to the population in need. It describes geographical barriers, such as distance or travel time, which impede movement in space. While spatial accessibility only constitutes a single dimension of access, the location of health care facilities may give rise to significant regional disparities in access. The study of spatial accessibility is focused on identifying areas of poor access to health care and quantifying the geographical match between people and health care services (Cromley & McLafferty, 2002).

The topic of spatial accessibility and health care falls mostly in the domain of geography and related disciplines. Geographical research into health care accessibility has been conducted for decades, but the emergence of GIS has provided significant impetus to research, especially since the 1990s (Musa et al., 2013). GIS are generally understood as a set that consists of equipment, software, databases, management, analysis and presentation of all types of geographic information. GIS can be used as decision-support tools for various problems involving spatial data, and can be applied in various sectors, including health care. The development of GIS over time is proportional to the general development of computer science (Fradelos et al., 2014). Therefore, advances in computer science also signify more possibilities to tackle increasingly complex or extensive problems in the field of GIS.

In health care, there has been considerable interest in GIS-based analysis due to its potential to improve the health care delivery system's spatial efficiency and equity. As a result of the increased sophistication of GIS software and the proliferation of spatial data, the number of studies in this field grew rapidly after the late 1990s and early 2000s (McLafferty, 2003). For instance, the spatial accessibility of health care facilities has been examined using GIS-based methods in several countries, such as New Zealand (Bagheri et al., 2009; Brabyn & Skelly, 2002), Australia (Clark and Coffee, 2011; Roeger et al., 2010), Ireland (Kalogirou & Foley, 2006), Canada (Schuurman et al., 2010) and China (Pan et al., 2016). Other studies have focused on spatial accessibility to health services in rural areas (Liu et al., 2001; McGrail & Humphreys, 2009; Russell et al., 2013; Schuurman et al., 2006), developing countries (Blanford et al., 2012; Rahman & Smith, 2000), or areas prone to natural disasters (Paul & Batta, 2008). In addition, circumstances where immediate medical attention is necessary, such as heart-related incidents and strokes, have been studied (Hare & Barcus, 2007; Pedigo & Odoi, 2010). Indeed, there is a wide range of publications about the use of GIS-based analysis and measures of access to health care services, as indicated in extensive literature reviews by Allan (2014), Graves (2008), Higgs (2004) and McLafferty (2003).

In the domain of GIS, analyses of spatial accessibility are typically based on network models representing real-world transportation networks. The elements of the network are assigned a "cost", which may denote geographical distance, travel time, energy consumption, or virtually any other measure of impedance. This allows least-cost paths to be calculated through the network between any locations using a shortest-path algorithm. Technically, least-cost paths are determined between points. If paths need to be calculated to or from areal units, such as administrative regions, the areal units must be represented by points. The centroid of a region is typically used for this purpose. Least-cost paths calculated using GIS can be considered approximations of routes chosen by people in the real world. Under the assumption that people act based on reasonable decisions and therefore seek to minimize distances traveled, demand can be spatially assigned to the closest service facility. This kind of spatial assignment of demand constitutes "normative" catchment areas, which are the areas that "should be" under the premise of rational behavior (Chou, 1997; Cromley & McLafferty, 2002; O'Sullivan & Unwin, 2003).

Instead of just describing and measuring the spatial accessibility of service facilities, GIS-based analysis can also be used to optimize the spatial configuration of services. This process is called location-allocation, which can be used to simultaneously determine the number of facilities, their location and the allocation of demands between facilities. A classic problem of this kind is the *p*-median problem, where the task is to locate a predetermined number of facilities (p) from a set of candidate sites to minimize the sum of weighted distances between demand locations and facilities (Cromley & McLafferty, 2002). The *p*-median problem can be formally expressed as follows:

$$\min_{\{x_{ij}\}} \sum_{i=1}^{n} \sum_{j=1}^{m} s_{ij} x_{ij} \qquad (1)$$

subject to:

$$\sum_{j=1}^{m} x_{ij} = 1 , \qquad i = 1, \dots, n \qquad (2)$$

$$x_{jj} - x_{ij} \geq 0 , \qquad i = 1, \dots, n; j = 1, \dots, m; i \neq j \qquad (3)$$

$$\sum_{j=1}^{m} x_{jj} = p \qquad (4)$$

where:

$s_{ij} = w_i c_{ij}$

w_i = amount of demand at i; $w_i \geq 0$

c_{ij} = shortest-path travel cost from i to j

$$x_{ij} = \begin{cases} 1 \text{ if demand location } i \text{ is assigned to facility site } j \\ 0 \text{ otherwise} \end{cases}$$

$$x_{jj} = \begin{cases} 1 \text{ if a facility is opened at site } j \\ 0 \text{ otherwise} \end{cases}$$

The *p*-median problem is founded on the assumption that demand is allocated to the nearest facility, that is, customers will always patronize the closest service provider. Equation (2) states that each demand location is to be assigned to only one (nearest) facility site. Equation (3) only permits a demand location to be assigned to a facility site if a facility is located at that site. Equation (4) allows exactly p facilities to be sited (Miller & Shaw, 2001).

Aims of the study

Given the aforementioned background and theoretical context, this study aims to define the catchment areas of tertiary hospitals in Finland in connection with its ongoing extensive country-wide health care reform. In this study, tertiary hospitals' normative catchment areas are determined according to spatial accessibility, and the results are compared to the current situation. This is performed using GIS-based data and methods. As explained above, accessibility is measured and assessed here only in terms of potential accessibility in space, that is, the opportunity of the population to physically access tertiary-level health care facilities in Finland. Other dimensions of access, or the actual utilization of health care services, are not taken into consideration. The aim of the study is to produce information about equity in the spatial accessibility to tertiary health services for the population. The results are produced as numerical measures of spatial accessibility, enabling comparisons between catchment areas and different scenarios, and their potential implications for service delivery and health care planning are discussed.

While many past studies of spatial accessibility typically focus on a specific area or subgroup of clients, this study assesses the entire population of a country. On the other hand, this study differs from other country-wide catchment area analyses because, instead of opting to use administrative regions, it uses grid-based data free of administrative divisions as a basis for analysis. A distinct advantage of this approach is that catchment area boundaries are not influenced by administrative regions which often vary vastly in size, shape and population. When administrative units are used as a basis for a catchment area analysis, the whole population of a regional unit will be assigned to a single hospital, even if the hospital is not the best choice for everyone living in the region in terms of spatial accessibility. Furthermore, the need to treat the areal units as points in accessibility analyses is particularly problematic for irregularly shaped administrative regions. The use of grid-based data can therefore significantly reduce the distortion in the results that is inherently produced by areal units. Finally, while most studies concerning the spatial accessibility of health services and hospitals focus on the present situation, this work aims to reveal possibilities for estimating travel times to hospitals in different scenarios in the context of health care reform.

Materials and methods

To analyze spatial accessibility, three types of geographical information are required (Tanser et al., 2010). First, information about origin location is needed, which, in the context of health care, is typically the population in the study area. This information may range from individual-level information to data aggregated to zones of any size. The second piece of information represents destinations, which are health care facility locations. Finally, it is necessary to know the distance between all pairs of origins and destinations.

In this study, the origin (population) data were acquired from the Grid Database 2013 (Statistics Finland, 2013). The database includes information on the whole population in grid cells of 250 meters per side, independent of administrative divisions. Due to the computational complexity associated with the high number of small cells, though, the cells were further aggregated to comprise larger 5×5 km cells. The tertiary hospital locations are used as destination data. The distance information between any given pair of origin and destination is obtained using a road-network database that includes all roads and streets in Finland. The database is based on the freely available Digiroad database maintained by the Finnish Transport Agency (2013) and has been further refined by Esri Finland. It contains a travel-time estimate for each individual road segment. The estimates are determined by functional road classifications and assumptions about typical driving speeds on different roads, which are calculated separately for urban and non-urban areas. The travel-time estimate is used as the sole distance metric in this study. Therefore, in this study, the notion of "nearest" is only used to refer to the hospital closest in terms of travel time. It is worth noting that the estimate is based on car travel, and it excludes other transport modes. While this may seem restrictive, travel time by road is a comprehensible and commonly used indicator of distance. In addition, personal-use vehicles are unequivocally the dominant means of transport in Finland, accounting for almost 60% of all trips, and nearly 75% of kilometers traveled (Finnish Transport Agency, 2012). Therefore, it is reasonable to expect trips to tertiary hospitals to be made predominantly by car. In Finland, clients are also entitled to reclaim taxi fares, which provides comparable transport for those who do not own a car, or who cannot access (or prefer not to use) public transport.

The distance calculation is based on determining the fastest route between an origin location (the centroid of a 5×5 km grid cell) and each of the destinations (tertiary hospitals). This information provides the basis to assess spatial accessibility, comprising the current situation and three different scenarios (Table 1). In the case representing the current state, travel times between each grid cell and a tertiary hospital are calculated within the administrative tertiary care regions. In case B, a similar calculation is conducted, but without administrative boundaries, thus resulting in normative catchment areas instead of mandated ones. This scenario is further refined in case C, where a hypothetical capacity constraint is introduced to the analysis. This constraint stipulates that an equal proportion of the population must be assigned to each tertiary hospital. If the proportion of population assigned to a hospital exceeds the constraint, the remaining population must be assigned elsewhere, while the overall population-weighted travel time is minimized. Finally, a location-allocation (*p*-median) analysis is conducted for case D, where the intention is to find out whether the current spatial configuration of tertiary hospitals is the optimal one. This is achieved by hypothetically allowing any combination of five hospitals out of the 20 central hospitals in Finland, which are treated as candidate locations, to serve the entire population. No capacity constraint is imposed on this analysis. The assessment of the current situation and all the scenarios are geographically limited to mainland Finland, which excludes the autonomous Åland Islands. The calculations are conducted using the Closest Facility and Location-Allocation functions of ArcGIS software and its Network Analyst extension (Esri, Redlands, CA, USA).

Results

Administrative regions (case A)

There are relatively large differences in spatial accessibility between the tertiary hospitals, as far as the current administrative regions are concerned (Table 2, Fig. 3A). In terms of median travel time, the longest travel times can be found in the regions of Kuopio and Oulu. This is unsurprising, since these two regions are geographically extensive and embrace the most remote and sparsely populated areas of Finland. In contrast, the spatial accessibility of the hospital in Helsinki is very good: the median travel time is a mere 25 minutes. The Tampere and Turku regions represent an intermediate level of spatial accessibility, with median travel times of a little over one hour.

In addition to average travel times, the assessment of population coverage is important. In the case of administrative boundaries (Table 2), the travel time necessary to cover 95% of the population living in the catchment area is identified. The longest times by far can be found in the Oulu and Turku regions. While this result is by no means unexpected for the Oulu region, the long threshold time of Turku is due to the region's archipelago, which relies on slow ferry services. The travel times to achieve 95% population coverage in the other regions are more moderate. It is worth noting that this value is more than three hours in the Helsinki region, despite the hospital in Helsinki appearing to be easily reachable in terms of the median travel time. This suggests that the arbitrary boundaries of administrative regions give rise to patches of low spatial accessibility in areas where such a situation is not expected to otherwise occur.

Normative catchment areas, uncapacitated (case B)

When the grid cells are assigned to the nearest hospital, certain changes can be detected in the map (Fig. 3B). The normative catchment areas assume a more compact shape compared to the administrative regions (Fig. 3A), as the convoluted or elongated parts of the regions are assigned to other hospitals. Although assignment to the nearest hospital results in reduced travel time for almost 750 000 inhabitants, with some hospitals it leads to increased travel times, as shown in Table 2. The most important reasons for this are that the entire northern part of the Turku region is assigned to hospitals in Oulu and Tampere, and the southern part of the Tampere region is assigned to Helsinki. These shifts increase the median travel time in the catchment areas of Tampere and Helsinki, whereas the corresponding figure is dramatically decreased for Turku. As far as the entire population of the country is concerned, the median travel time remains unchanged, while 95% population coverage is reached in a reduced time.

The cumulative population coverage of each of the five hospitals, as a function of travel time to the nearest hospital, is presented in Figure 4. The tertiary hospital in Helsinki stands out as a facility offering good spatial accessibility for a significant proportion of the population. With the other hospitals, the cumulative curves rise more gently, reflecting a more scattered distribution of population in their corresponding catchment areas. This twofold character of spatial accessibility illustrates the challenge of equal provision of tertiary health care in circumstances where the spatial distribution of population is uneven and scattered.

While improving overall spatial accessibility, the normative assignment aggravates the already unequal distribution of population between hospitals (Fig. 5). Even in the current situation (case A), the hospital in Helsinki has a dominant role by serving a third of the country’s population, which is significantly higher than for other hospitals. In case B, nearly 40% of the entire population is assigned to the hospital in Helsinki – a change that almost exclusively happens at the expense of the hospital in Turku. For other hospitals, the changes are less significant.

Normative catchment areas, capacitated (case C)

The notion of "million districts" (i.e., an equal distribution of about five million people across the five tertiary care regions) was assessed as a hypothetical situation where an equal proportion of the population is assigned to each tertiary hospital. This was conducted in a way that is similar to case B, but with a capacity constraint enforcing an equal proportion of the population being assigned to each hospital, while minimizing overall travel time. As indicated in the resulting map (Fig. 3C), this type of assignment results in a small catchment area being drawn around the tertiary hospital in Helsinki, whereas the catchment areas of the other four hospitals are large in comparison. This is also apparent from the results shown in Table 2. Again, the results depict the difficulty in defining appropriate catchment areas in an unevenly populated region: attempting to ensure equal client volumes (and thus, quality of service provision) between hospitals may lead to highly unequal catchment areas with regard to spatial accessibility. Conversely, an optimal situation in terms of spatial accessibility causes imbalanced client volumes and concomitant problems with service delivery and medical workforce competence.

Location-allocation (case D)

The analysis for this scenario was conducted to determine whether the current configuration of tertiary hospitals is optimal in terms of spatial accessibility. This was solved as a *p*-median problem, in which all 20 central hospitals (including those currently possessing tertiary status) in mainland Finland served as potential locations. From these, five locations that minimize the overall population-weighted travel time, were identified. The locations selected by the analysis for providing the best overall spatial accessibility were the current tertiary hospitals. Regarding the assignment of grid cells to hospitals, the results of this scenario are similar to case B. The analysis confirmed that the current situation is, indeed, the one that minimizes the population-weighted travel time. This result is because tertiary hospitals are located in some of the most populated cities in Finland. Therefore, the configuration cannot be improved by switching the status of existing health care units, when the number of tertiary hospitals in Finland remains fixed at five.

Discussion

In general, the availability of tertiary health care in Finland is relatively good, but concerns about disparities in its spatial accessibility have been raised. The hospital districts in Finland were defined just after World War II when the spatial distribution of the population was quite different from that of today. In light of plans for profound health care reform, it will be necessary to critically evaluate the whole population's spatial accessibility to tertiary hospitals after decades of development leading to increasingly uneven population distribution.

Key findings

In this study, normative catchment areas for tertiary hospitals were determined according to spatial accessibility, and the results were compared to the current situation. The spatial accessibility of tertiary hospitals is reasonably good in the current administrative division. The optimum assignment of population to the five hospitals can achieve only a limited reduction to total travel time, and in so doing, introduces the negative aspect of an even less balanced population distribution across hospitals. However, enforcing an equal assignment of population to hospitals results in marked differences in spatial accessibility. When considering the significance of the results, it is important to realize the reasons behind the modest improvement achieved by means of normative assignment. Tertiary hospitals are located in the biggest cities, and most people in Finland either live in these cities, or close to them. Consequently, assignment to the nearest hospital does not have any effect on spatial accessibility for most of the population, and improvements in travel times are limited to the fringes of catchment areas. This was also confirmed by the location-allocation (p-median) analysis conducted in the study, which proved that the current configuration of the five tertiary hospitals among all central hospitals is best in terms of spatial accessibility. It is certainly possible that allowing candidate sites to be located anywhere, without confining them to the locations of the current central hospitals, might yield different results. However, considering the generally high investment costs of relocating existing hospitals or constructing new ones, particularly for tertiary hospitals, there is no justification for performing this type of analysis here.

Unlike previous studies that set out to define catchment areas using GIS methods, this study used grid-based population data instead of data based on administrative divisions. Unfortunately, the full spatial resolution of the grid-based data could not be utilized in the study due to long computation times, but even a coarser resolution of 5 km was enough to demonstrate how the catchment areas assume a more natural shape compared to the artificial boundaries of the administrative districts. The use of grid-based data in the determination of catchment can be particularly useful in situations in which health care reform introduces the free choice of care providers, as the grid-based assessment may be more capable of predicting the spatial distribution of demand for health care services.

Limitations

This study is fundamentally based on the assumption that, in the presence of free choice and all hospitals being equal, a person will attend the closest hospital. Even if free choice of health care may hypothetically improve spatial accessibility to health services by allowing the closest facility to be chosen, choice is not always straightforward. It is reasonable to expect that besides distance alone, personal customs and travel patterns may intervene in the choice of which hospital to attend for treatment. This is most likely in areas located in the transition zone between two or more adjacent catchment areas. In addition, it is possible that hospitals are not equally attractive. This may be related to the general reputation of a hospital, previous (positive or negative) experience, the presence of individual practitioners known for their expertise, or a hospital's setting, to name but a few obvious examples. Although Finland's tertiary hospitals are expected to provide similar services, with the exception of certain specialized treatments that are provided only in specific hospitals, factors such as these may strongly influence the choice of hospital.

As another limitation of the study, spatial accessibility of tertiary hospitals was assessed only in terms of car transport. While cars are the dominant means of transport in Finland, this excludes many other traffic modes – public transportation by bus or train, in particular – and the assessment of spatial accessibility may thus become biased. Services tend to be more accessible to people who have cars than to those who do not (Haynes, 2003). For this reason, different socio-demographic groups may obviously have different access capabilities.

Policy considerations

This study strived to utilize GIS methods to provide decision-making support for Finnish health care reform in which districts dating from decades ago will be reconsidered. GIS can certainly offer a wide range of opportunities for health care planning, as manifested in the increasing number of studies conducted in this field in recent years. Still, it is necessary to bear in mind that the determination of hospital districts is ultimately a political decision, influenced by many aspects – spatial accessibility being merely one of them. For instance, in Finland, the boundaries of the Turku and Tampere tertiary care regions were revised at the beginning of 2013 so that the Turku region can encompass a considerable proportion of the Swedish-speaking population living on the west coast of Finland. The administrative region of Turku has become less efficient in terms of spatial accessibility as a result of this otherwise justified arrangement to protect the rights of a linguistic minority. Yet, it is safe to say that spatial accessibility is the single most important factor for determining catchment areas. It would be counter-intuitive to expect a hospital to primarily serve people other than those living in proximity to the hospital. Because of the central role played by spatial accessibility – even if not always explicitly acknowledged – it is essential to see past artificial administrative boundaries when devising plans to reorganize health care. The assessment of spatial accessibility can be particularly useful in evaluating the implications that reform may have on health care service availability. Reform may involve expansion, relocation or reduction of services, all of which can be efficiently analyzed with GIS-based methodology.

Concluding remarks

Although spatial accessibility is an important aspect in the equal provision of health services, it is not always analyzed using objective criteria. Considering that methods and data for performing such analyses are currently widely available, the assessment of spatial accessibility may provide interesting insights into health care planning, such as the ongoing health care reform in Finland. The assessment can help identify regional inequities in access to health care and, in some cases, it may actually correct false impressions concerning spatial accessibility. Therefore, policy-makers should be encouraged to utilize accessibility analyses as a rational basis for planning and as a decision-support tool. Still, there is no denying the view that spatial-accessibility assessment should involve several measures, instead of relying only on the widely used measure based on travel times in personal-use vehicles on the road network. These measures might include other modes, such as public transportation, as well as perceived accessibility. It is also important to recognize that normative assessment is limited to identifying hypothetical catchment areas around facilities. When possible, assessment should be augmented with information on actual utilization patterns and choice exercised by health service users, which could provide knowledge on how accessibility potential is progressed to realized accessibility. In any event, analysis of spatial accessibility deserves its position in health care planning and management, among other criteria used to evaluate the equity and efficiency of health care provision.

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Conflict of interests

The authors declare that there is no conflict of interest.

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Table 1. Description of the cases assessed in the study.

Case	Description
A. Administrative regions	The current situation: population grid cells are assigned to the administrative hospital within each tertiary care region.
B. Normative catchment areas, uncapacitated	Each grid cell is assigned to the closest hospital on the basis of travel time, irrespective of any administrative districts.
C. Normative catchment areas, capacitated	Same as B, but the capacities of the hospitals are not assumed to be unlimited. Instead, the capacity of each hospital is set to 20% of the total population of Finland. A grid cell is only assigned to the closest hospital if allowed by capacity; otherwise, the grid cell is assigned to a hospital with free capacity while minimizing the population-weighted travel time.
D. Location-allocation	The five best locations for tertiary hospitals are determined from the 20 central hospitals (including those possessing tertiary status) in mainland Finland using the *p*-median procedure on the basis of travel time. No capacity constraint is imposed.

Table 2. The median travel times, and the time threshold ensuring 95% population coverage of Finland's five tertiary hospitals, expressed as hours and minutes. Figures are provided separately for the current administrative division, normative catchment areas based on allocating population to the nearest hospital without a capacity constraint, and normative catchment areas with a capacity constraint requiring an equal proportion of the entire population to be allocated to each hospital.

Hospital	A. Administrative regions		B. Normative catchment areas, uncapacitated		C. Normative catchment areas, capacitated	
	Median	**95%**	**Median**	**95%**	**Median**	**95%**
Helsinki	0:25	3:09	0:29	2:21	0:17	1:19
Tampere	1:14	2:50	1:18	3:20	1:11	2:14
Turku	1:06	5:15	0:24	1:24	1:22	2:12
Kuopio	1:55	2:47	1:56	3:09	2:04	3:52
Oulu	1:48	4:18	1:48	4:18	2:40	4:41
All	*0:56*	*3:30*	*0:52*	*2:21*	*1:20*	*4:10*

Figure 1. Tertiary care regions and the central hospital districts in Finland, excluding the autonomous Åland Islands.

Figure 2. The percentage of population in the tertiary care regions in five selected years between 1970 and 2010.

Figure 3. Accessibility zones of Finland's tertiary hospitals within the administrative regions (A) and catchment areas based on allocation to the nearest hospital without a capacity constraint (B) and a constraint requiring an equal proportion of the entire population to be assigned to each hospital (C). Accessibility in each situation is depicted as one-hour increments of travel time: the darker tone indicates a longer travel time. The gray lines represent the boundaries of the current tertiary care regions.

Figure 4. Cumulative distribution of population allocated to the nearest tertiary hospital, presented as a function of travel time. The horizontal axis is truncated at 300 minutes.

Figure 5. The share of population for each tertiary hospital according to the current administrative regions (first bar) and normative allocation to the nearest hospital (second bar).

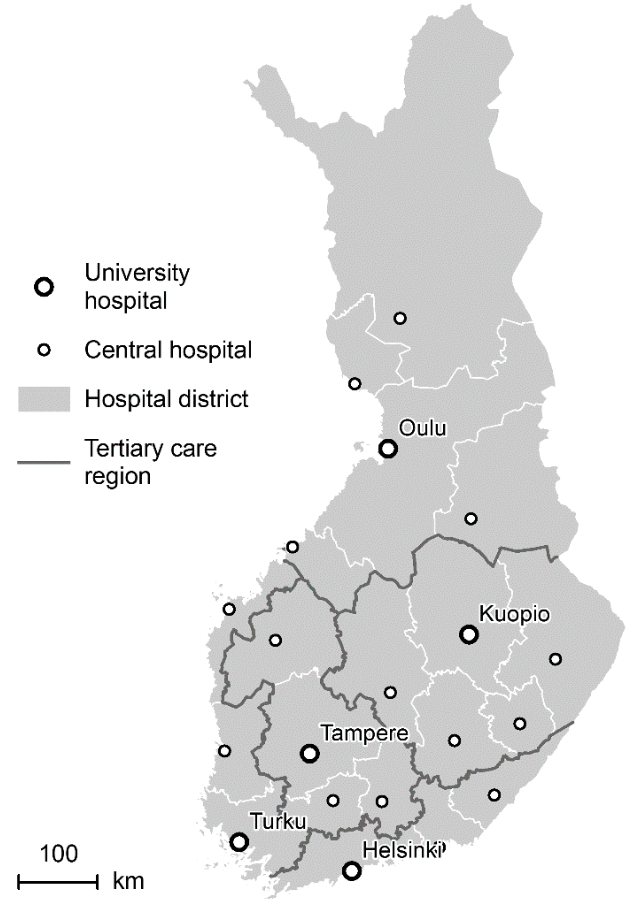

Figure 1. [single column]

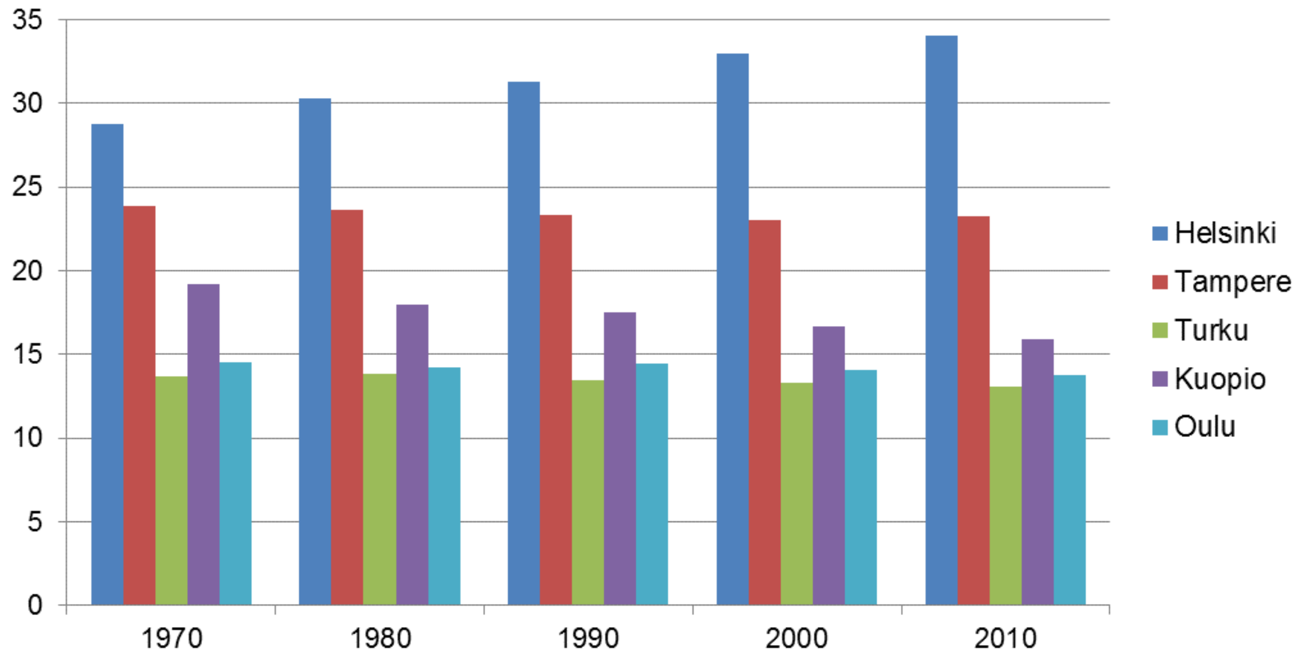

Figure 2. [2-column]

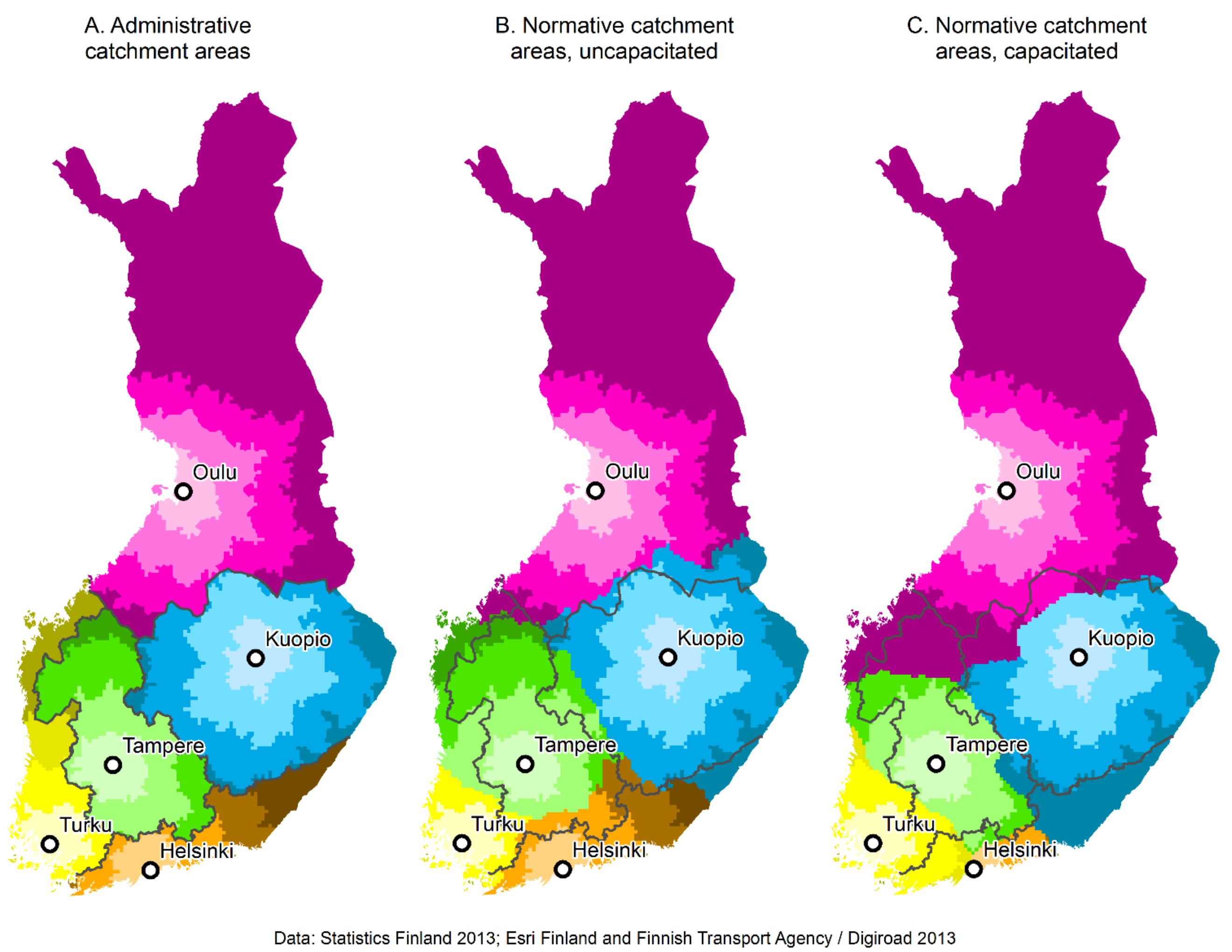

Figure 3. [2-column]

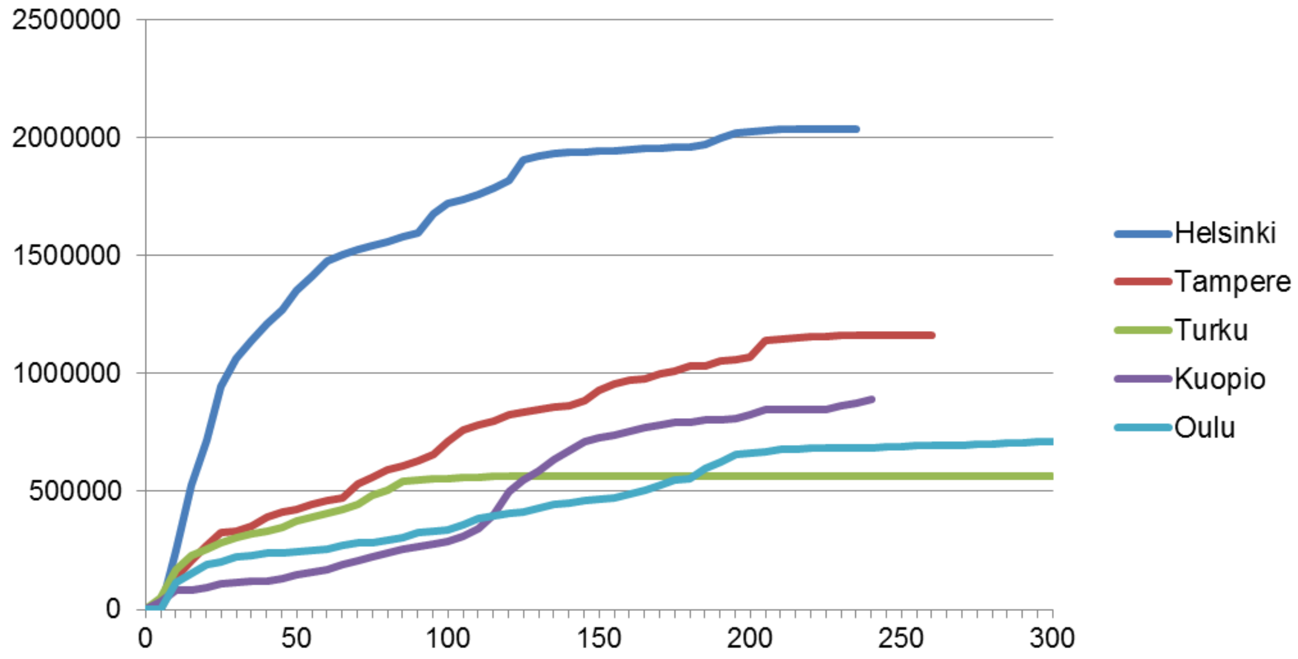

Figure 4. [2-column]

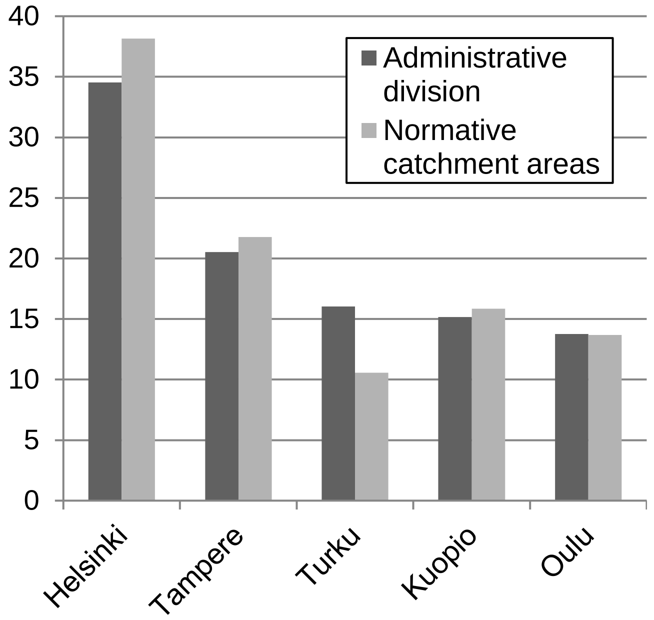

Figure 5. [single column]