LEX LOCALIS - JOURNAL OF LOCAL SELF-GOVERNMENT
Vol. 21, No. 4, pp. 751-774, October 2023

Spatial Accessibility Models of the Efficient Network of Secondary Healthcare Providers in Slovenia

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Abstract The main purpose of our research was to assess the accessibility of existing providers of secondary healthcare using established theoretical models of spatial accessibility. In the study, we analyzed the optimal locations and the optimal number of healthcare providers needed for an efficient network of secondary healthcare providers in Slovenia. We used four different location–allocation models and found that the MA-model is the most suitable for planning a potentially efficient network of general hospitals in Slovenia. We showed various scenarios for the development of the general hospital network based on three distinct accessibility travel time intervals, while also taking into account various population coverage proportions that can access hospital services within a given travel time interval. The key finding is that the same coverage of the population with hospital services could be achieved with a smaller number of general hospitals, if the hospitals were optimally located.

Keywords: • general hospital • accessibility • network • efficiency • location–allocation models

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https://doi.org/10.4335/21.4.751-774(2023)
ISSN 1581-5374 Print/1855-363X Online
Available online at http://journal.lex-localis.press.

1 Introduction

An efficient healthcare network can be achieved if the given inputs for healthcare achieve the maximum utility for the population. We start from the assumption that utility is directly related to maximizing accessibility to health services. Maximum utility can therefore be achieved by defining the optimal locations of healthcare providers, who must be as close as possible to individual residents. Defining optimal locations requires us to know the theoretical starting points of accessibility to healthcare, possible ways of measuring spatial accessibility, knowledge of suitable travel times to healthcare providers and knowledge of possible models for evaluating optimal locations.

In our study, we were interested in whether the theoretical cues that speak about the accessibility of healthcare providers can also be applied to the case of Slovenian general hospitals. We were interested in whether, with the help of already defined theoretical models, we can discover the accessibility of Slovenian providers of secondary health care, and whether we can also define optimal locations and the optimal number of general hospitals, which is the basis for establishing an effective network of secondary healthcare.

To identify the optimal locations for secondary healthcare providers, we began by analyzing the current state of spatial accessibility. We examined the existing locations of general hospitals within Slovenia's current secondary healthcare network. For this, we defined coverage areas from which existing general hospitals could be accessed by car within various travel time intervals. Then we calculated the number of residents who gravitate towards each general hospital and the percentage of the population that the hospital serves within its coverage area. Considering the number of inhabitants in each settlement and the existing locations of general hospitals, we used the nearest facility tool to determine which hospital a particular settlement gravitates towards, provided that it gravitates to the closest general hospital. For each gravitational area, we calculated the number of residents living within that specific area.

The models we used to calculate time distances and locations are called location-allocation models. In doing so, we used four different location-allocation models within the analysis. Our purpose was to check which of the models best explains and defines the potential network of secondary healthcare providers in Slovenia.

With the help of location-allocation models, we wanted to compare the existing and optimal network of secondary health care providers. We wanted to find out whether, by rationalizing and optimizing the network of general hospitals, we can achieve significant savings for the healthcare system, or whether we can provide the same hospital services with less resources. The first model, based on which we determined the optimal network of secondary healthcare providers, is the MI-model or also called p-median model. With this model, we can locate a certain number of hospital service providers in such a way that the average distance and travel time required by a patient to reach an individual health service provider is as short as possible. By using this model, we can place a specific number of hospital service providers so that patients have the shortest possible average travel distance and time to each healthcare provider. We must predetermine how many facilities we wish to locate as part of the study for the MI-model. Since twelve general hospitals provide medical services within the existing network of secondary care providers, we defined in the MI-model that the optimal locations of the twelve general hospitals should be chosen.

In the second step, we used the MF-model or the model of the minimum number of facilities, which offers us an interesting solution when we are looking for ways to cover all the needs of the population with the minimum number of providers. This model is particularly effective when we do not have a predetermined number of potential hospitals. It is useful for locating the minimum necessary number of different urgently needed health services in an empty geographical space. It differs from other location-allocation models in that it does not seek where to place a limited number of providers to meet the needs of users but tries to minimize the number of providers within the network. For the purposes of our analysis, this means that it was not necessary to define in advance the number of general hospitals that we want to locate within the model.

In the third step, we used the MC-model or the model of maximum coverage, which tries to maximize the needs of users, or the share of the population to which a healthcare service is accessible in a certain travel time. The model allows us to reduce the criterion of area coverage, while it is still possible to define the time interval of accessibility, which defines the maximum travel time from the point of demand to the point of the provider. Within the MC-model, it is necessary to define the number of facilities that we want to locate, so for the purposes of our analysis, we have defined that we want to find the optimal locations of twelve hospital providers. This allowed us to compare the optimal locations of potential general hospitals with the locations of existing general hospitals.

In the last step, we used the MA-model, which is basically similar to the MC-model, but the MA-model assigns different weights to the demand points when determining the optimal locations. The model's objective is to situate medical facilities where patients will be most likely to show up. This model aims to maximize the number of demand points that a healthcare provider can cover based on the current capacity for providing medical services. The model presupposes that as distance increases, it becomes less likely that demand and facility locations would interact. The MA-model gives demand points a weighting based on how far away customers are from the closest healthcare provider, with the weight proportionally decreasing as the distance grows. The MA-model is predicated on the idea that as one gets farther away from the closest healthcare provider, the likelihood of seeing a certain physician decreases. So, areas with higher population densities typically have higher demand. The MA-model allocates providers to areas with larger population densities in comparison to other location-allocation models.

At this point, another decision needed to be made to analyze the optimal locations and the optimal number of secondary healthcare providers. This decision involves determining a reasonable travel time for individual patients to reach the nearest healthcare provider. Travel time is a crucial factor, as many clinical outcomes or health benefits offered by healthcare providers are linked to it. There is no consensus in the literature or among healthcare policy advocates on defining the appropriate travel time to the nearest general hospital. As a result, we selected the three most frequently mentioned accessibility time intervals for our research. The responsibility of determining the most suitable travel time falls on healthcare policymakers. We considered three different time intervals of accessibility: 30-minute, 45-minute, and 60-minute journeys by private vehicle. We derived these time intervals from Slovenian health policy documents and media discussions about new health reforms. These intervals are also commonly mentioned in theoretical studies (Fortney et al., 2011).

Incorporating various models within the location-allocation method, we utilized the ArcGIS Network Analyst tool for our network analysis. ArcGIS enabled us to generate multiple geographic maps, highlighting the hypothetical optimal hospital locations that patients can access by car within the predetermined time intervals.

To analyze the optimal locations and the optimal number of secondary healthcare providers in Slovenia, we required data on the locations of towns and villages, population size, the Slovenian road network, and towns with over 5,000 inhabitants. Together with the Statistical Office of the Republic of Slovenia (SURS), we were able to obtain verified information on the locations of cities and their respective populations. SURS uses a hierarchical network of identically sized units to collect population statistics for each administrative unit. This enabled us to associate each spatial unit with precise population data on geographic maps. For accurately determining the number of inhabitants, we employed a spatial unit of 500m x 500m and relied on publicly available data from 2019.

We incorporated basic road network information into ArcGIS using the freely accessible digital map, OpenStreetMap, which is increasingly utilized for analysis purposes. We chose OpenStreetMap because it is updated daily, unlike many other maps. We made some modifications to the road network data collected from OpenStreetMap, removing irrelevant categories such as bicycle routes, walking paths, bus stops, and horse paths. We also added some road sections not available on OpenStreetMap. We add information on the typical driving speed to the road network with the classification of national routes for 2019.

We strove to set up hospitals in communities with at least 5,000 inhabitants using SURS population data. According to our rationale, service providers in densely populated locations can accommodate more demand points and have higher attendance than providers in sparsely populated locations. A total of 39 distinct settlements were identified using the data gathered.

2 Literature overview

The fundamental objective of most healthcare systems is to improve the health and well-being of the entire population or at least achieve a superior level of health. Ensuring access to healthcare is a critical first step in preserving and enhancing the overall health status of a population (Unal et al. 2007; Jin et al. 2019). The health state of the population in the specified region may be considerably influenced, leading to a rise in morbidity and mortality, in circumstances when healthcare providers' capacity is not completely exploited, or their locations are inadequate (Oliver and Mossialos 2004).

Accessibility to health services is not only important in ensuring the good health of the population but is also crucial if we want to deal with the rationalization and optimization of health care. This has been pointed out more and more frequently by studies in recent years, especially during the Covid-19 health crisis (Murad et al., 2021). Previous studies have shown that spatial accessibility is one of the key factors for providing hospital services in an efficient manner (Shen et al. 2020; Smith et al. 2017). Alhothali and others (2022) also agree with this, stating that considering the spatial accessibility of health services is a critical part of planning and managing health services.

Optimization models are an important tool for researching accessibility to existing healthcare services and for developing new alternatives. These alternatives may include improving access to existing healthcare providers or establishing new healthcare facilities (Rahman and Smith 2000). Accessibility to healthcare services is significantly influenced by factors such as geography, population density, road network and geographical barriers between health service providers and points of demand (Guagliardo 2004; Wang 2007; Dai 2010). Location-allocation models provide the greatest benefit in planning and determining the most suitable locations for facilities (Spaulding and Cromley 2007; Tomintz et al. 2013). By reducing distance and time, these models adeptly address location issues while determining the most suitable locations for facilities. Additionally, they target geographic regions with the greatest demand and potential for diverse opportunities (Spaulding and Cromley 2007; Wang et al. 2018). A wide variety of location-allocation models exists, each utilizing distinct strategies and mathematical techniques to resolve problems.

Location-allocation models have been a subject of research since the 1960s, spanning fields such as geography, economics, industry, and public administration (Teixeira and Antunes 2008). These models have been categorized in a number of different ways in the literature (Daskin 2008). When researching the optimal location of healthcare providers, these models are most often used together with GIS tools, which is reflected in the similarity of their content and methodology. Within healthcare, four location-allocation models are most often mentioned: the first model is called the minimum impedance problem (MI-model), the second model is the minimize facilities problem (MF-model), the third model is the maximize coverage problem (MC-model) and the fourth the model is the maximize attendance problem (MA-model).

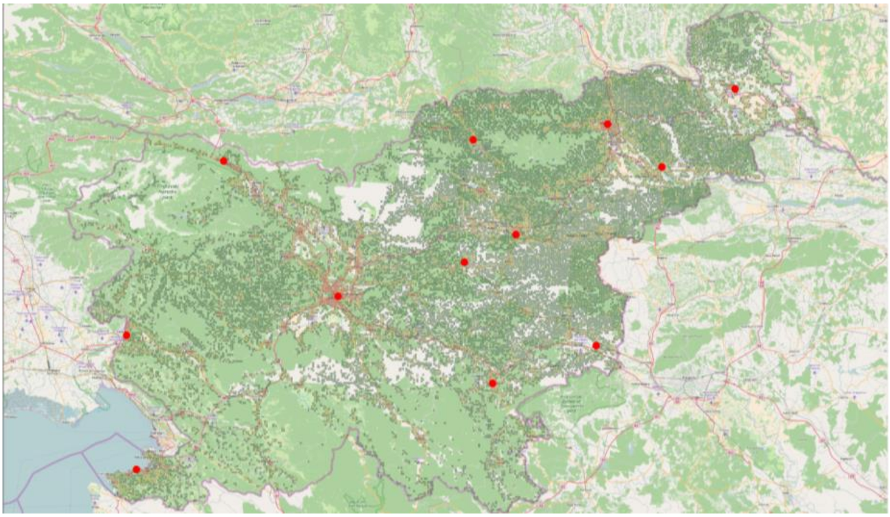
The goal of the MI model is to distribute a particular number of healthcare facilities, like general hospitals, in a way that reduces the total weighted costs between demand points and solution facilities. According to Church and Murray (2009) and Rahamn and Smith (2000), this model decreases the typical travel distance and time for people in need of medical care. In contrast, the MF-model seeks to identify solutions that require the fewest healthcare professionals while yet meeting the demands of the population within a specified area or time frame (Zanjirani et al. 2012). According to Church and Murray (2009) and Rahamn and Smith (2000), the MC-model focuses on maximizing coverage of demand points, which translates to maximizing the population's access to healthcare services within a certain timeframe or geographic area. The MA-model, on the other hand, seeks to maximize provider attendance within a suitable time interval. In this model, demand points do not carry equal weight; larger populations generate higher demand (Holmes et al. 2010; Algharib 2011). According to the patient's distance from the provider, the MA-model requires variable demand ratios and/or different weighted demand points, with the weight decreasing proportionally as the distance between the two grows (Spaulding and Cromley 2007; Murawski and Church 2009).

The MA-model's findings differ from those of previous location-allocation models in that they identify the optimal locations of general hospitals in areas with a higher population density. This guarantees a larger presence of medical professionals in areas with the greatest need, thereby satisfying the population's desire for hospital services.

3 Research

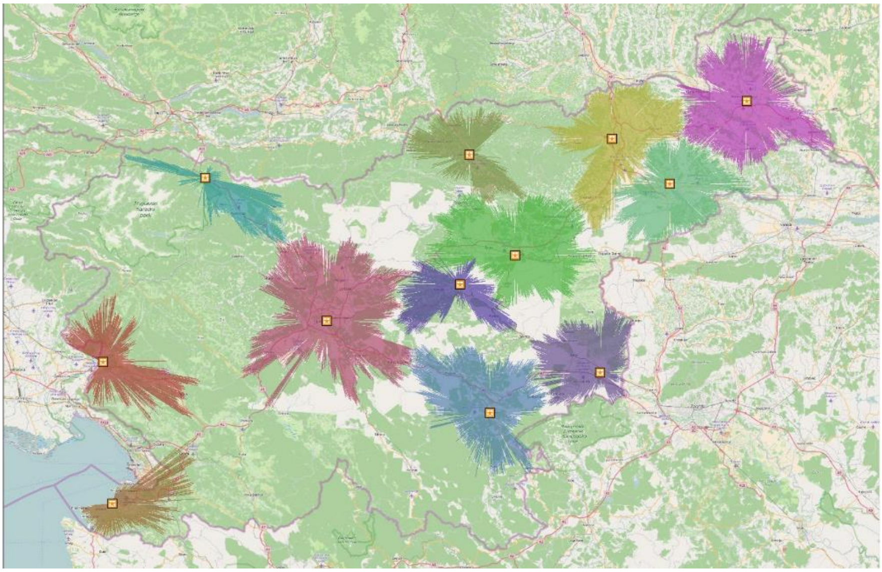
In the first step, we present the population distribution or population density and the locations of existing Slovenian general hospitals. At first glance, we can see that the population density in Slovenia is uneven, which is reflected in the greater number of inhabitants living in the eastern and central parts of Slovenia, while the western part of Slovenia is less populated. The current situation shows that in the eastern part of Slovenia we have seven general hospitals and one university clinical center, in central Slovenia there is one university clinical center, and in western Slovenia we have three general hospitals, as shown in Figure 1.

Figure 1: Population distribution and location of existing general hospitals



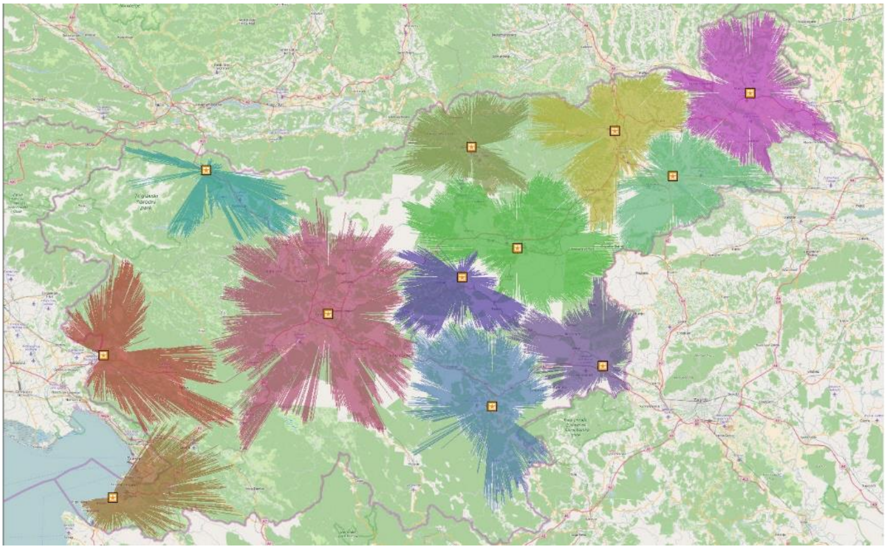
In the following, we show the population distribution and the proportion served by each general hospital. We consider three different travel time intervals of accessibility: up to 30 minutes, 30-45 minutes, and 45-60 minutes. The population distribution for each hospital is depicted in Figures 2, 3, and 4.

Figure 2: Accessibility to existing general hospitals within a 30-minute travel time interval



Existing general hospital locations serve 84.34% of the population, leaving 323,092 residents without secondary healthcare access within a 30-minute interval. The University Clinical Center Ljubljana serves the largest share of the population (28.53%), while the Brežice General Hospital serves the smallest (2.69%).

Figure 3: Accessibility to existing general hospitals within a 45-minute travel time interval



In a 45-minute interval, 4.65% of the population lack access to existing general hospitals, leaving 95,752 residents without secondary healthcare services. The University Clinical Center of Ljubljana covers the largest share (32.10%). Interestingly, the smaller Celje General Hospital, rather than the larger Maribor University Clinical Center, ranks second in population coverage, providing services to 11.72% within a 45-minute travel time frame.

Figure 4: Accessibility to existing general hospitals within a 60-minute travel time interval

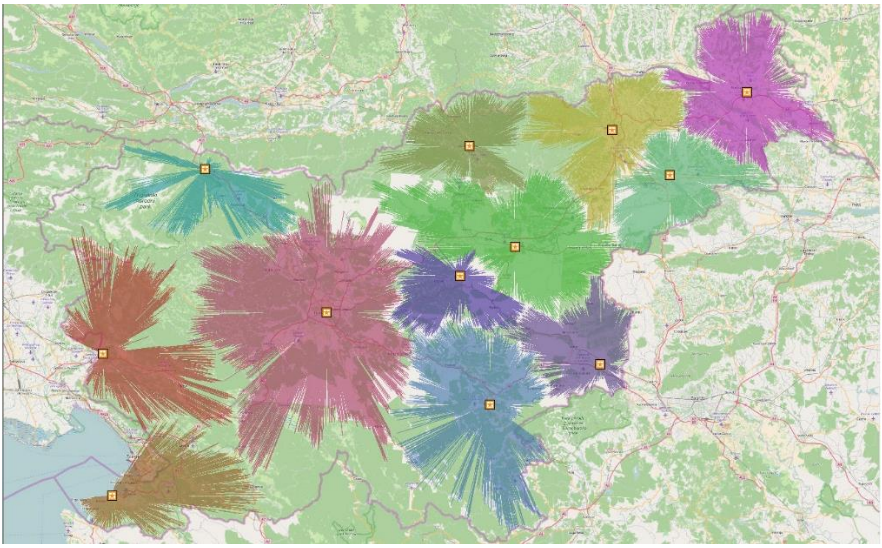
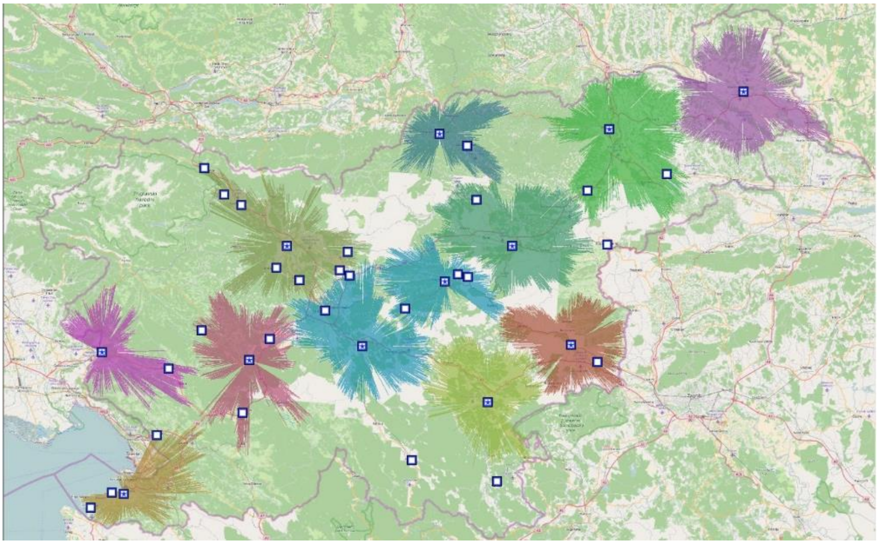


Figure 4 displays areas where patients can reach the nearest general hospital by private car within 60 minutes. The population coverage is significantly high, with minimal empty space between gravity zones, indicating that only a small proportion (1.18%) lacks access to existing general hospitals within a 60-minute travel time interval.

In the following, we present the results of location-allocation model analyses, which show the potential network of secondary health activity. Some of them are practically very useful and represent a good basis for health policy makers.

The first model, based on which we determined the optimal locations of Slovenian general hospitals, is the MI-model or model of p-median. The outcomes of the MI-model enabled us to make a direct comparison between the optimal locations of twelve general hospitals and the positions of the existing general hospitals. In the following, we show Figure 5 shows the spatial accessibility projection of optimally located secondary healthcare providers using the MI-model in a 30-minute travel time interval.

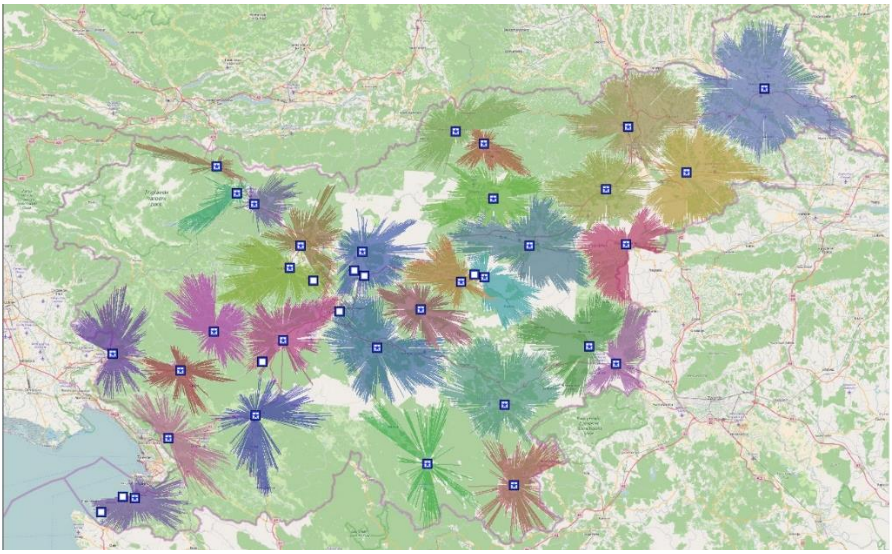
Figure 5: MI-model projection of the network of general hospitals in a 30-minute travel time interval



The MI-model identifies optimal general hospital locations within a 30-minute interval in Nova Gorica, Koper, Logatec, Kranj, Grosuplje, Ravne na Koroškem, Zagorje ob Sava, Novo Mesto, Celje, Krško, Maribor, and Murska Sobota. Comparing with existing locations, Nova Gorica remains unchanged. Izola moves to Koper; Ljubljana's University Clinical Center splits into Logatec and Grosuplje; Jesenice relocates to Kranj; Trbovlje shifts to Zagorje ob Sava; Slovenj Gradec moves to Ravne na Koroškem; and Brežice relocates to Krško. Novo Mesto, Celje, Maribor, and Murska Sobota remain in the same locations, while Ptuj isn't replaced by another location in this model.The MI-model, which aims to reduce the average distance between objects and demand points, serves as an example for researching optimal healthcare system locations. While our analysis used accessibility travel time intervals as criteria, the model's applicability may be greater in other healthcare areas, such as determining optimal locations for medical centers to minimize travel costs for home visits or central warehouses distributing medicines and medical materials to healthcare providers.

The second model we tested is the MF-model. This model effectively serves the population with minimal providers, without needing a predetermined number. It identifies minimum essential health services locations in vacant spaces, minimizing network providers rather than assigning a limited number of operators. Figure 6 shows the spatial accessibility projection of optimally located secondary healthcare providers using the MF-model in a 30-minute travel time interval.

Figure 6: MF-model projection of the network of general hospitals in a 30-minute travel time interval

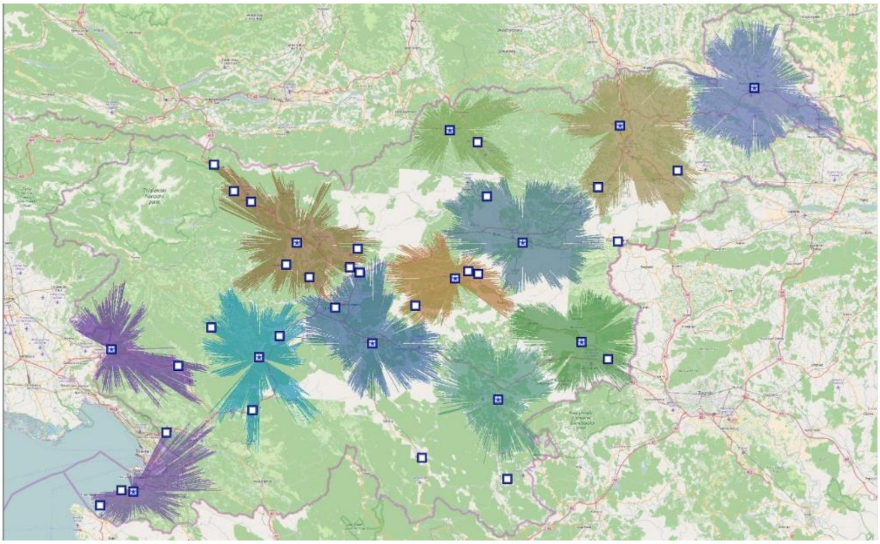


The MF-model may not be ideal for our research as it assumes 100% population coverage, limiting economically justifiable compromise solutions. It calculates the minimum number of general hospitals required to meet time limits but doesn't allow for population coverage criteria. The MF-model results, shown in Figure 30, indicate that 31 general hospitals must be located within a 30-minute interval to satisfy population needs. Comparing 30-minute and 60-minute interval models reveals differences. Optimal locations for the 31 general hospitals include Nova Gorica, Koper, Sežana, Ajdovščina, Idrija, Jesenice, Bled Radovljica, Postojna, Vrhnika, Škofja Loka, Kranj, Kamnik, Grosuplje, Litija, Kočevje, Ravne na Koroškem, Slovenj Gradac, Velenje, Zagorje ob Savi, Hrastnik, Novo Mesto, Črnomlje, Celje, Krško, Brežice, Slovenska Bistrica, Rogaška Slatina, Maribor, Ptuj, and Murska Sobota.

The MF-model could be effective within health care in finding the optimal locations of the minimum number of emergency centers or clinics with personal doctors, i.e. for those health service providers where full coverage of demand points must be ensured.

The third model, the MC-model or maximum coverage model, aims to maximize user needs and the population proportion with accessible services within a specific time frame. This model permits reduced area coverage while still defining an accessibility time interval, which sets the maximum travel time from the demand point to the provider. Figure 7 shows the spatial accessibility projection of optimally located secondary healthcare providers using the MC-model in a 30-minute travel time interval.

Figure 7: MC-model projection of the network of general hospitals in a 30-minute travel time interval



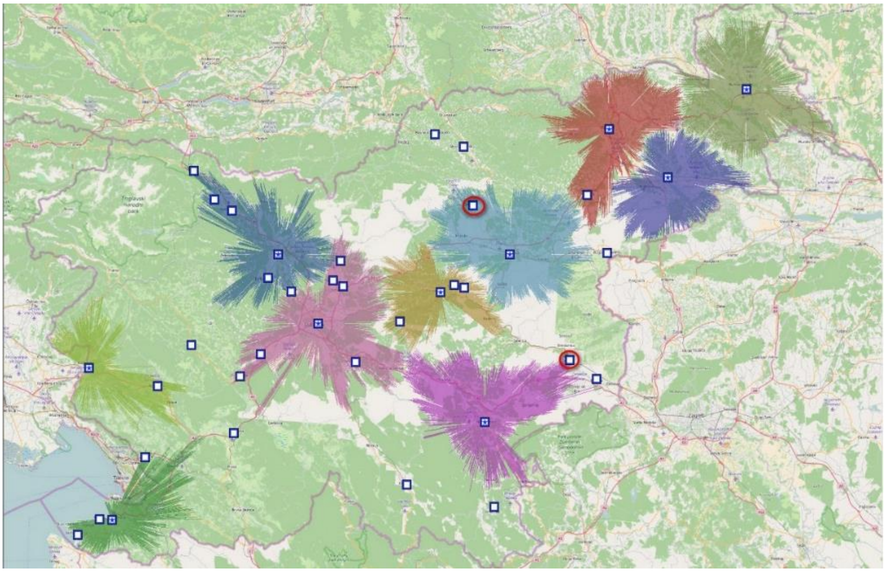
The MC-model identifies twelve optimal general hospital locations within a 30-minute travel time interval in Nova Gorica, Koper, Logatec, Kranj, Grosuplje, Ravne na Koroškem, Zagorje ob Sava, Novo Mesto, Celje, Krško, Maribor, and Murska Sobota. Comparing this to existing Slovenian general hospital locations, Nova Gorica's location remains unchanged. Izola General Hospital moves to Koper, two new locations in Logatec and Grosuplje replace the University Clinical Center of Ljubljana, Jesenice General Hospital moves to Kranj, Trbovlje General Hospital relocates to Zagorje ob Sava, Slovenj Gradec General Hospital moves to Ravne na Koroškem, and Brežice General Hospital is replaced by a location in Krško. Novo Mesto, Celje, Maribor, and Murska Sobota General Hospitals remain in their current locations, while Ptuj General Hospital's location remains unchanged within this model.

The MC model maximizes population coverage with health services by optimizing hospital locations considering travel time and limited providers. It recognizes that resource scarcity may prevent meeting all needs in healthcare systems where demand exceeds supply, and an optimally located provider network helps balance care needs and resource constraints.

The fourth model, the MA model, is similar to the MC model but weighs demand points based on their distance to the nearest provider, with the weighting decreasing as the distance increases. The MA-model results differ from other models as it determines optimal general hospital locations in larger or denser areas with more potential patients. This ensures maximum utilization of new hospitals in areas with the highest demand. These results are relevant for our research problem because we must balance accessibility and limited funds. The ideal solution is to locate a specific number of secondary healthcare providers that serve the largest possible population proportion, considering healthcare provider constraints. We based the minimum number of general hospitals on an 80% coverage rate, which is a standard in most countries (World Health Organization 2020). Using the MA-model, we found optimal locations for Slovenian general hospitals with 80% population coverage in various time intervals. While there's some agreement on suitable travel times, the decision on acceptable time intervals for creating a healthcare network remains with health policymakers. We designed three projections for the secondary healthcare network, covering 30-, 45-, and 60-minute accessibility intervals, leaving the network choice to health policymakers.

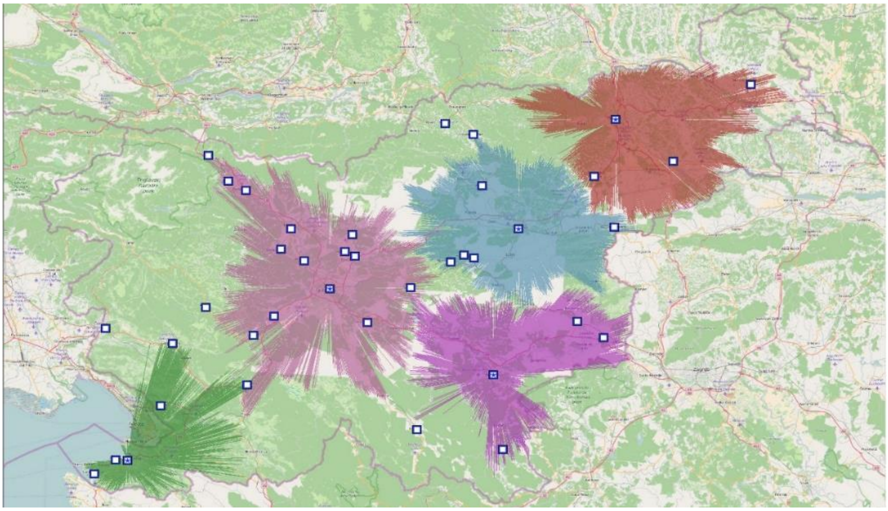
In order to provide access to secondary healthcare services for 80.74% of Slovenia's population, the MA-model offers ten secondary healthcare providers that are each optimally situated within a 30-minute driving distance. Even with nine hospitals, 78.11% of the population is still served, giving 1,611,285 people access. These hospitals are placed in the best possible locations, as shown by the spatial accessibility projection of the MA-model for a 30-minute journey time period.

Figure 8: MA-model projection of the network of general hospitals in a 30-minute travel time interval



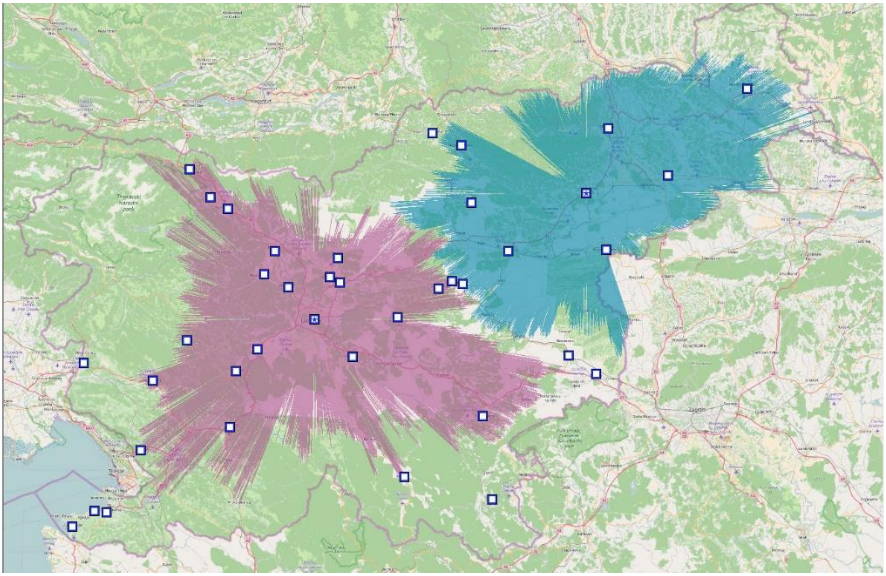
The geographical accessibility forecasts for optimally placed general hospitals are then shown, taking a 45-minute travel time into account. By strategically placing five general hospitals, we can ensure that 84.35% of Slovenia's population, which amounts to 1,740,072 residents, have access to secondary healthcare services within this 45-minute travel time period. Reducing the number of hospitals to four, however, causes the coverage rate to decline to 77.65%, providing 1,601,793 residents with access to secondary healthcare services. Figure 10 visually represents the ideal locations for five Slovene general hospitals within a 45-minute travel time interval. Surpassing the typical coverage rate standard positively impacts accessibility, which in turn benefits patients in need of medical care. Enhancing healthcare accessibility can ultimately lead to better health outcomes for the population, as individuals find it more convenient to seek and receive essential healthcare services.

Figure 9: MA-model projection of the network of general hospitals in a 45-minute travel time interval.



When the accessibility interval is expanded to a 60-minute travel time, there is a notable decrease in the number of required general hospitals. With merely two general hospitals, 81.45% of the population, which equates to 1,680,207 Slovenian residents, can access healthcare services within this 60-minute travel timeframe. On the other hand, if the number of hospitals is lowered to only one, the coverage rate declines significantly to 55.49%—a rate insufficient for establishing an optimal secondary healthcare network. In this scenario, the hospital would only be accessible to 1,144,725 residents over the course of a 60-minute time period. Figure 11, displayed below, presents the MA-model results, demonstrating the spatial accessibility projection with two ideally positioned general hospitals. The findings of the MA-model are shown in Figure 10, which is included below. It shows the spatial accessibility projection with two general hospitals that are optimally located.

Figure 10: MA-model projection of the network of general hospitals in a 60-minute travel time interval.



4 Discussion

This article's primary contribution is the development of a theoretical model for the secondary healthcare network based on location-allocation theory, enabling a comprehensive understanding of healthcare network factors. By doing so, we fulfill the main objective of this study: to create and test the most effective location-allocation model for Slovenia's secondary healthcare network. Addressing healthcare network questions is vital for every healthcare system worldwide, as these questions not only determine healthcare supply but also help rationalize healthcare service demand. Healthcare networks, both globally and in literature, are recognized as crucial non-financial selection mechanisms influencing rational patient behavior as healthcare service users.

The MA-model proved to be the most effective approach for determining the optimal secondary healthcare provider network. This approach finds a compromise between the economic effectiveness and the accessibility of healthcare services when calculating the optimal locations and the optimal number of general hospitals. The MI-model turned out to be less suitable, because in the context of the problem we were not interested in the minimum average travel times of all patients to general hospitals, but rather in the time limits within which general hospitals should be accessible to as many residents as possible. However, the results of the MI-model allowed us to directly compare the optimal locations of twelve general hospitals and the locations of existing general hospitals.

The MF-model, or model of the minimum number of facilities, offered us an interesting solution, because with its help we defined how to cover the needs of the population with the minimum number of contractors.

Although it seemed that the MF-model was still the most suitable for solving our scientific problem, the network projections contain some assumptions that reduce its interest. Namely, the model assumes that all the needs of the population must be covered, which means that it analyzes optimal locations assuming 100% coverage of the population. In practice, it is not possible to cover the needs of the entire population. This is also the reason that the mentioned model is not the most suitable for our research problem.

The MC model allowed us to lower the area coverage criterion, while still being able to define an accessibility time interval that defines the maximum travel time from the point of demand to the point of the provider. Within the MC-model, it was necessary to define the number of facilities that we wanted to locate, so for the purposes of our analysis, we defined that we wanted to find the optimal locations of twelve general hospitals. This model also enabled us to compare the optimal locations of potential general hospitals with the locations of existing general hospitals. The MC-model thus enabled us to calculate certain relevant solutions, based on which we could create an effective network of secondary healthcare providers.

Nevertheless, it is crucial to realize that hospitals cannot be positioned to fully meet the needs of the entire population. In our analysis, we investigated the minimum number of general hospitals needed at different travel time intervals, while targeting at least eighty percent population coverage. By studying different scenarios, we can better understand the trade-offs between economic efficiency on the one hand and access to health services on the other. Health policy makers must also find a balance between efficiency and accessibility to hospital providers. Understanding different location-allocation models to define the optimal network of secondary health activity can contribute to better decisions that ultimately benefit the overall health and well-being of the population.

Through the use of personal vehicles, we were able to create a set of geographic maps that show where general hospitals should be placed in order to serve patients in the shortest amount of time possible. It is important to stress that choosing an appropriate time frame for building a healthcare network depends on the choices made by healthcare policy maker. The first travel time interval was determined to be a 30-minute trip, the second to be a 45-minute trip, and the third to be a 60-minute trip. As a result, we arrived at three distinct conclusions regarding the most suitable locations of well-located general hospitals and the optimal number of general hospitals required to offer access to healthcare for eighty percent of the population within the allotted journey times.

In our examination of projections for an optimal secondary healthcare network, we identified the maximum accessibility interval that would still be acceptable for patients and determined the optimal locations of Slovenian general hospitals accordingly. We only took into account areas with over 5,000 inhabitants as potential locations, following the criteria used by several prominent authors in their assessments of healthcare service accessibility (Buzai 2013; Huerta Munoz and Källestål 2012). Results tend to differ based on the specific criteria; in our research, we primarily concentrated on how optimal locations and the necessary number of general hospitals shift in response to changes in the selected travel time interval. This factor is crucial in numerous studies that aim to define the optimal locations for healthcare providers (Huerta Munoz and Källestål 2012; Jankowski 2014; Dos Anjos Luis and Cabral 2016). By utilizing different models to establish maximum travel times, we showcased an array of network structures and possible general hospital locations in Slovenia.

Many researchers operate on the assumption that a 30-minute travel time is the most appropriate interval for patients to reach the nearest hospital (Messina et al. 2006; Rooväli and Kiivet 2006). Our research indicates that in this case ten hospitals in the optimal locations can guarantee a population coverage rate of eighty percent. Within the secondary healthcare services network, these general hospital locations would be found in the following cities: Celje, Koper, Kranj, Ljubljana, Maribor, Murska Sobota, Nova Gorica, Novo mesto, Ptuj, and Zagorje ob Savi. Two hospitals would be removed from the list of providers in comparison to the existing situation, while several hospitals would be relocated. Trbovlje General Hospital would move to Zagorje ob Savi and Izola General Hospital would relocate to Koper.

According to several researches (Hare and Barcus 2007, for example), a 45-minute interval might be preferable. Slovenia would require five general hospitals with this prolonged accessibility interval. The following cities would have the best hospital locations: Celje, Ljubljana, Koper, Maribor, and Novo Mesto. The hypothetical network would require seven fewer general hospitals than the current one, and Izola General Hospital would move to Koper.

Baron and Skelly (2002) consider that medical assistance within a 60-minute time interval is still acceptable, but at the same time warn that the health status of patients who take such a long time to reach the nearest hospital may be at risk. In this case, Slovenia would only need two general hospitals, with Ljubljana and Slovenska Bistrica serving as the best locations.

According to Baron and Skelly (2002), receiving medical care within 60 minutes is acceptable, but they warn that patients who must travel an hour to reach the nearest hospital may have a compromised medical condition. In both the current and potential secondary healthcare provider networks, some geographical areas lack access to general hospitals within 30-, 45-, and 60-minute intervals, resulting in extended travel times. One potential solution for these areas could involve allocating private healthcare service providers, subject to agreement and decision-making in healthcare. At this juncture, it is crucial to consider patient outcomes, although they were not measured in this study. This should be conducted in collaboration with medical professionals and healthcare decision-makers.

A growing number of issues, including an aging population, increased public awareness, and the development of contemporary medical technology, are placing increasing resource demands on the healthcare system. This pattern is supported by other studies addressing healthcare issues (Ravšelj and Aristovnik 2016; Sturmberg and Bircher 2019). When patients had limited access to healthcare services due to the COVID crisis, improving accessibility and optimizing healthcare services became even more important (Mason and Menard 2022). We anticipate that pressure from increasing medical expenditures will be a major factor in the future, underscoring the necessity of prudent cost management (Heider et al. 2014). Farinha and other authors (2009) provide an example of creating a network of primary and secondary care services aimed at reducing costs, as illustrated in the case of Portugal. A similar study was recently conducted by Smith et al. (2017), who showed the possibilities for the rationalization of specialist health services in Great Britain. However, our projections represent the first professional analysis of rational management possibilities in the healthcare field in Slovenia.

5 Conclusions

To optimize the distribution of hospital services, policymakers may be interested in moving some of the current general hospitals in Slovenia. A new network of secondary healthcare providers might be defined using one of the location-allocation models, according to the analysis. In addition, the study provided us with two important conclusions on the most suitable locations and the optimal number of general hospitals that are required to guarantee the accessibility of medical services. Projections of the layout of the network of secondary healthcare providers are based on different travel time intervals of accessibility to hospitals. Our analysis identified the hypothetical optimal locations of general hospitals that patients could reach in each of three different travel time intervals. This information is important to health policy makers as it can guide them in deciding where to allocate funds to build or relocate hospitals. Our analysis also identified the optimal number of facilities representing the hypothetical number of general hospitals that would be needed for each travel time interval. The location-allocation models showed that if we want to ensure access to general hospitals within a 30-minute travel time interval for the majority of the population, Slovenia needs ten general hospitals. If we choose the 45-minute travel time slot for accessibility, the country would need five general hospitals, but if we choose the 60-minute travel time slot, it only needs two general hospitals.

It is also essential to consider that hypothetically optimally located general hospitals must also differ in size. The size is required to vary according to the percentage of the population that gravitates to each general hospital. Hospitals in more densely populated areas need to be larger to meet the increased demand, while hospitals in less populated areas need to be smaller, as there is also less demand for health services.

Additional factors such as financial resources, existing hospital infrastructure, population density, regional differences and geographical barriers would also be reasonable to consider in further studies that will deal with the definition of a network of general hospitals.

Our study offers new starting points for policy debates on access to health care, allocation of financial resources and regional differences in the provision of hospital services. Based on the findings of our research, health policy makers can make better decisions to improve access to health services and treatment outcomes for the Slovenian population. Further research could investigate how the size of hospitals should be adjusted based on the selected travel time interval and the proportion of the population served by each hospital. In addition, such studies could investigate the potential impact of these changes on the quality of health services provided and the overall efficiency of secondary health care providers and the sustainability of the health care system. The key for health policy makers is to make a decision that establishes a balance between accessibility, efficiency and, at the same time, the quality of health services, which ultimately improves the health status and well-being of the population.

Acknowledgment:

We would like to thank all the institutions that contributed to obtaining data from the databases.

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