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Spatial accessibility of swimming facilities in the Greater Helsinki region: a comparison about socioeconomic differences and segregation

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Tiivistelmä

Liikunnan väheneminen ja ylipainon tuottamat terveysriskit ovat alati kasvava ongelma länsimaissa, joka näkyy erityisesti kohonneina terveydenhuollon kustannuksina. Aiempien tutkimusten perusteella hyvä saavutettavuus liikuntamahdollisuuksien äärelle lisää liikunnan määrää. Julksien sektorin tarjoamat liikuntamahdollisuudet ovat yksi keino ehkäistä alueellista eryitymistä kaupungissa, jotta kaikilla asukkailla olisi yhtäläiset mahdollisuudet liikuntapalveluiden äärelle.

Tutkimuksen tavoitteena oli tutkia sosiaalista eriytymistä pääkaupunkiseudulla sekä matka-aikojen eroa kaikista huono-osaisimmilla ja hyväosaisimmilla alueilla lähimpään uimahalliin. Huono-osaisuuden summaindeksi laskettiin Tilastokeskuksen Ruututietokannan pohjalta, jonka avulla väestö jaettiin kvintiileihin, joista matka-ajat lähimpään uimahalliin laskettiin. Tutkimus toteutettiin käyttämällä avoimen lähdekoodin aineistoja ja ohjelmistoja huono-osaisuuden indeksiä lukuunottamatta.

Matka-aikojen laskemiseen käytettiin 250m x 250m matka-aikamatriisia, jonka avulla alueellista saavutettavuutta mitattiin LIPAS-tietokannasta poimittuihin uimahalleihin. Matka-aikoja tutkittiin kuudella eri liikkumismuodolla: kävelylle, pyöräilylle, julkiselle liikenteelle (ruuhka-aika ja keskipäivä) sekä yksityisautoilulle (ruuhka-aika ja keskipäivä). Lyhyimpien matka-aikojen tilastollista merkittävyyttä mitattiin hyvä- ja huono-osaisimman kvintiilien välillä SPSS:ssä Studentin t-testillä.

Tulosten perusteella uimahallien saavutettavuus pääkaupunkiseudulla on yleisesti ottaen hyvä. Uimahallien saavutettavuus oli parhaimmillaan pyöräillen tai autolla. Matka-ajat lähimpää uimahalliin olivat myös selvästi lyhyemmät huono-osaisimmilla alueilla kuin hyväosaisilla alueilla kaikilla liikkumismuodoilla, jonka perusteella voidaan todeta, että pääkaupunkiseudulla sosioekonomisesti huono-osaisimmilla alueilla asuminen ei ole ongelma uimahallien saavutettavuuden suhteen.

Avainsanat

alueellinen eriytyminen, alueellinen saavutettavuus, GIS, liikunta, segregaatio

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Abstract

Lack of physical activity and obesity are increasing problems that have caused higher healthcare expenses for society. As prior studies have shown, there is a connection between proximity to a sports facility and increased physical activity. Public sports facilities are a way of preventing segregation by providing opportunities for recreational sports for everybody.

In my thesis, I studied spatial segregation and accessibility to swimming halls in the Greater Helsinki region. Spatial segregation was studied in terms of travel times to the nearest swimming hall between the most advantaged and the most disadvantaged areas. The disadvantage sum index was used to identify the most advantaged and the most disadvantaged areas which were classified into quintiles by the index. The study was conducted using open source GIS data and applications apart from segregation analysis.

Travel times to the nearest swimming facility were calculated using Helsinki Region Travel Time Matrix (250m x 250m grid). Travel times were calculated for six different types of transportation: walking, cycling, public transportation (rush hour and midday) and private cars (rush hour and midday). Statistically significant differences between the most advantaged and the most disadvantaged quintiles were calculated with Student's t-test in SPSS.

The analysis showed that spatial accessibility to swimming halls in the Greater Helsinki region is generally good. Swimming halls have by far the best accessibility by cycling and private car. Travel times to the nearest swimming halls were shorter with all types of transportation for the most disadvantaged than the most advantaged which indicates that living in a more deprived area does not restrict spatial accessibility to swimming halls.

Keywords

GIS, physical exercise, segregation, spatial accessibility, sports facilities

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Additional information

Contents

1. Introduction

The benefits of physical activity and its impact on individuals' health are well known around the world. Obesity and lack of physical activity are rising, especially in 1st world countries which causes harm to individuals' health as well as costs to the healthcare system. Demand for further investment in opportunities for physical activity has been acknowledged by several studies and national research institutions (Haskell, Blair, & Hill, 2009). Further knowledge and research must be carried out to recognize appropriate target groups and neighbourhoods that are in danger of accumulating health issues or other social hazards related to physical inactivity. Lately, in addition to physical health, the importance of mental health has been acknowledged more and more. Mental health has been acknowledged to be a major issue and contributor to global disease burden (Guo, Dai, Xun, Jamieson, & He, 2014, 62-63; Ströhle, 2009, 780-781). But, physical activity has been found to improve mental health, increase mood and relieve stress and anxiety (Siefken, Junge, & Laemmle, 2019, 72). In addition, an active lifestyle has been found to reduce stress and anxiety in addition to increasing self-confidence and emotional well-being.

Proximity to sports facilities has been found to increase physical activity (Ding, Sallis, Kerr, Lee, & Rosenberg, 2011; Eriksson, Arvidsson, & Sundquist, 2012; Guo et al., 2014; Lee et al., 2016; Lima, Fermino, Oliveira, Rodriguez Añez, & Reis, 2013; Ranchod, Diez Roux, Evenson, Sánchez, & Moore, 2014). Though *spatial (geographical) accessibility* for sports facilities might be on a sufficient level for different socioeconomic groups, it has been shown that certain socioeconomic groups tend to have lower levels of sports facility use when requiring entrance fees (Giles-Corti & Donovan, 2002, 608). When considering children´s physical activity and accessibility to playgrounds it has been shown that living within a walking distance from a play area increased kids' physical activity (Davison & Lawson, 2006). Further measures should be taken to enable not only children and adolescents but also adults and the elderly, to have access to various exercising opportunities.

Dobbs (2005) has found that men and women have different mobility patterns with different means of transportation and the development of a sustainable public transportation system has the potential for serious equality measures. Therefore, it is evident that everybody does not have access to a private car, but everybody should have equal access to physical activity facilities. It is not just the differences of potential or accessibility to recreational sports but also different physical activities that are important to consider. For example, physical exercise activities have been shown to differ between men and women (Suomi et al., 2012, 50) and group activity sports are more popular among women, individual exercise and weekly occurring events are more popular for men (Suomi et al., 2012, 50).

Sporting habits among different socioeconomic groups have been studied to vary and parents' economic background has been shown to affect children's sporting habits and opportunities ("On the move – national strategy for physical activity promoting health and wellbeing 2020.," 2013). Ministry of Social Affairs of Finland and Health (2013) has stated that polarization of health and sporting habits between different socioeconomic groups has been increasing. People in lower socioeconomic classes tend to have more health issues and shorter life expectancy. A family's socioeconomic background also partially determines an adolescent's sporting opportunities (Suomi et al., 2012, 125). Also, success in education and level of education tends to correlate with sporting habits. People that are more successful in school and have higher education tend to exercise more than those that have lower-level education (Karusisi, Thomas, Méline, & Chaix, 2013, 5).

Finnish health policy has had a focus on closing the gap on health issues between different socioeconomic classes but has not succeeded and the gap remains (Suomi et al., 2012, 125). Ministry of Social Affairs and Health (2013, 19) points out that one of the major issues is the equal accessibility to engage in sports, especially for children. Costs for attending organized sports have been rising rapidly in the past decade which poses a huge risk for children of lower socioeconomic families to drop off from exercising.

In Finland, we have a special Act to promote and guide municipalities and the state on responsibilities, cooperation, and funding of sports in Finland. The Act on the Promotion of Sports and Physical Activity (390/2015, 1-3§) is the integral implementation tool for state and municipalities. One of the fundamental objectives of the Act is to provide equal exercising opportunities for both top-level athletes as well as regular citizens. In Finland, many of the sporting facilities are owned by either the state or a municipality. The public sector is still a major provider of sporting facilities in Finland even though privatization has been increasing over the past decades (Suomi et al., 2012, 21). In 2012, the public sector handled around 70% of sports facilities, but earlier in the 1980s, almost all the sports facilities were owned by the public sector.

This thesis has been conducted in co-operation with the research project "*Yhdenvertainen liikunnallinen lähiö* (YLLI)" or "*Equality in suburban physical activity environments (YLLI)*" in English (https://blogs.helsinki.fi/yhdenvertainenliikunnallinen-lahio/). The research group concentrates on accessibility research in case study suburbs Kontula, Helsinki and Huhtasuo, Jyväskylä in Finland and there are several researchers and students working on varying topics about accessibility in the study area. The research group is partially funded by the research and development programme “Lähiöohjelma 2020-2022" or “Suburban Programme 2020-2022" coordinated by the Finnish Ministry of Environment. The YLLI project aims to supply further information about equal access to physical activity spaces. In my study, I aim to analyse the spatial accessibility of swimming halls in the Greater Helsinki region compared with residential segregation in the area. The Greater Helsinki region (cities of Espoo, Vantaa, and Kauniainen) is home to over a million residents and this study will be researching the differences in spatial accessibility to swimming hall facilities, i.e., to recognize opportunities of spatial accessibility and how it varies between people with different socioeconomic statuses. The study will be conducted using GIS (Geographical Information System) tool and statistical tools.

Relevant theories about this thesis are residential segregation in urban areas, service network and allocation of facilities and finally spatial accessibility and threshold for measuring spatial accessibility in the context of recreational physical activities.

In my thesis, I aim to study how the most advantaged and the most disadvantaged living areas are equally or unequally geographically accessible to common and publicly available sports facilities. I will use swimming halls as my example modes of commonly and publicly available sports facilities because those are provided by cities to their inhabitants and typically ticket prices are compromised. I am calculating spatial accessibility to swimming halls by four travel modes (walking, cycling, private car, and public transportation). For public transportation and the private car, I am considering also non rush hour time of day and rush hours separately.

2. Background and theoretical framework

A great number of different accessibility analyses have been done both in Finland and internationally (Guo et al., 2014; Higgs, Langford, & Norman, 2015; Karusisi et al., 2013; Kotavaara & Rusanen, 2016). There is also a great number of prior studies of socioeconomic status and physical activity (Estabrooks, Lee, & Gyurcsik, 2003; Moore, Diez Roux, Evenson, McGinn, & Brines, 2008; Pascual et al., 2007; Powell, Slater, Chaloupka, & Harper, 2006). Prior studies have shown inconsistent results in the relation between socioeconomic status and the spatial accessibility of sports facilities. In terms of socioeconomic characteristics and the spatial accessibility of swimming halls, there have been results of disadvantaged areas having better spatial accessibility than more advantaged areas.

2.1. Core terms in the study

2.1.1. Segregation

Segregation is a term that describes how certain demographic groups are separated and are located unevenly in a city. Uneven distribution leads to a situation where some demographic groups are overrepresented in some areas and others underrepresented. Segregation is an undesired spatial phenomenon that can lead to the accumulation of social issues such as unemployment, poverty, and health issues in certain parts of the city. Segregation has often socioeconomic or racial dimensions but can also have aspects of class, education level, or labour market status (Boterman, Musterd, & Manting, 2020; Butler, Hamnett, & Ramsden, 2008; Massey & Denton, 1988; Palardy, 2013).

Massey and Denton (1988, 282-283) concluded segregation as "*residential segregation is the degree to which two or more groups live separately from one another, in different parts of the urban environment*". Skogan (1992) theorizes how segregation occurs in a city. His theory of the S*piral of decay* is about a socioeconomic decrease in a neighbourhood leading to selective migration where wealthy residents leave the district and people with fewer financial options will move in. Spiral of decay theory describes the deterioration process of a neighbourhood where once a certain threshold has been passed, but the process is difficult to reverse.

The deterioration process then might trigger other problems in the area, such as incline to take care of one's houses as residents feel that they will not stay in the area for the long term (Van Lenthe, Brug, & MacKenbach, 2005, 765). Lack of maintenance of the property, housing, and infrastructure will lead to decay of the neighbourhood which will make it harder to attract commercial activity, and thus jobs, leaving room for crime to prevail in the area (Van Lenthe et al., 2005, 765). Similar results of housing segregation have also been found in Finland (Kytö & Kytö, 2016). They found that the existing housing base affects migration within the city. Owner-occupied flats will attract more people with higher income whereas areas heavily dominated by rental flats are more common neighbourhoods for disadvantaged people. Mixing the forms of housing has been seen as an option to prevent residential segregation (Saikkonen, Hannikainen, Kauppinen, Rasinkangas, & Vaalavuo, 2018, 26).

Segregation can be also an ethnic or cultural process in a city. Globally, international migration patterns have been diversified and multiplied over the last decades. Migrants, refugees, international workers, or family members create transnational ties between the countries. In the destination countries, diversification and multiplication of migration can be seen as a rapid change in socioeconomic, ethnic and demographic diversification (Vilkama, 2011, 13). The impact of increased migration can be seen especially in the country’s capital and other greater city regions where international migration is often the most notable. The Greater Helsinki region has not been an anomaly when it comes to global migration trends. The share of foreigners in the Greater Helsinki region is 20 times compared to 1990 (City of Helsinki, 2019b, 6). In 2018 15,8% of residents in the Greater Helsinki region were foreign and the number is expected to increase up to 28,4% by 2035 (City of Helsinki, 2019b, 10). Factors behind the relative increase are migration and higher fertility rates among foreigners (City of Helsinki, 2019c).

Helsinki has had low segregation levels on an international level and has succeeded moderately well in preventing spatial differentiation. Even though historically problems in Helsinki have been absent there have been signs of increasing segregation (Helsinki’s present state and development, 2019, 24). The gap between the most advantaged areas and disadvantaged areas has increased even though no district has had a socioeconomic decrease. Increased numbers in segregation can mostly be explained by more rapid welfare development in advantaged areas in comparison to disadvantaged areas. One of the main reasons Helsinki has succeeded so well in preventing segregation is due to housing policies that mix different social groups and counteract school segregating (Bernelius & Vaattovaara, 2016, 5).

Development of segregation in Helsinki has been studied extensively throughout past couple decades (e.g. (Bernelius & Vaattovaara, 2016; Kauppinen, Kortteinen, & Vaattovaara, 2009; M Kortteinen, Elovainio, & Vaattovaara, 2006; M Kortteinen, Tuominen, & Vaattovaara, 2001; M Kortteinen & Vaattovaara, 1999, 2000, 2015; Matti Kortteinen, Vaattovaara, & Lankinen, 1999; Vaattovaara & Kortteinen, 2003). Segregation research in Helsinki has shifted from violent crime rate statistics and increased polarisation research to focus more on social segregation and clusters of cumulative decline in socioeconomic factors. Vaattovaara and Kortteinen (2015) studied the clustering of poverty using similar parameters that are used in this study. They measured spatial concentrations of poverty by calculating low-income, unemployment and education levels. What they found out was that segregation in Helsinki is a prevalent problem in the Eastern part of the city. Accelerated segregation in the Eastern part of Helsinki is at least to some extent highlighted by the increased number of foreign mother tongue residents in the area which has grown in the 2000s. Residents with foreign backgrounds have had lower socioeconomic status than native-born citizens which may have forced foreigners to move to areas with cumulative poverty among native citizens.

2.1.2. Service locations and service network

Location is one of the most important aspects when setting up any kind of new facility or service. Allocating a strategic location is vital for any private or public project to ensure reaching the goals which the facility is set to achieve. Developing and planning a new facility is often time-consuming and costly which is why finding the right location is important to be successful.

Alfred Weber (Weber 1909, cit. C. S. ReVelle & Swain, 1970, 30) is considered to be the founder of location theory. He published his study in 1909 about the allocation of industrial factories about resources and customers minimizing the distance to cover. Weber did not have modern computing resources such as computers, but his theory gained popularity in the 1960s as computers become more common.

Optimizing the location of the facility can lower costs long term and help to choose the right location in relation to housing and other land use (Owen & Daskin, 1998, 242). Several tools and methods have been developed to help allocate optimal locations for facilities. Owen and Daskin (1998, 425-430) introduce three location problems to facility siting. Each model takes a different approach for new facility locations. Three location problems are median problems, covering problems and centre problems. The median problem is designed to calculate low travelling costs for desirable locations via median travel times. Using median problem suit well for allocating such facilities as libraries or schools where proximity is desired. Covering problems is ideal for example emergency planning as it aims for providing service areas in a predefined area. Centre problem aims to allocate facility so that covered distance is minimized by being located close to potential users or customers. The above-mentioned problems apply to different situations and are forced to trade-offs between different variables. Facility allocation can also be used to calculate suitable locations for undesirable facilities such as garbage dumps (Erkut & Neuman, 1989).

Strategies for allocating a facility varies greatly whether the investment is public or private (Rahman & Smith, 2000, 439). Generally, private facilities are simpler to locate as they usually have a precise purpose for example to minimize costs or maximize profits. Private sector location decisions have few non-economic factors, and the number of shareholders is small (Revelle, Marks, & Liebman, 1970, 692-693). Public investment allocations however are significantly trickier as they need to respond and serve society as a whole. There will always be trade-offs in allocating public facilities both in planning emergency services and amenities for the public. Planning for public facilities demands further thinking on whether to maximize population potential, bringing facilities as close as possible to population concentrations, or having a certain amount of people living within a time frame (C.S. ReVelle & Eiselt, 2005, 4-5). Public facilities projects might face equality problems as they need to serve the whole society but it is a challenge to consider also the residents living furthest away.

2.1.3. Spatial accessibility

The thesis will be examining segregation from the aspect of spatial accessibility. Therefore, it is vital to define the term *accessibility* and different metrics to measure spatial accessibility. It is also important to define core ways to measure spatial accessibility of physical activity facilities, what are the best practices and defining thresholds of spatial accessibility.

Waldo Tobler (1970) coined the first rule of geography: *"Everything is related to everything else. But near things are more related than distant things."* Such is Tobler's first rule of geography which applies to all phenomena which have a spatial dimension. Tobler's thesis can be interpreted that things that are located close to each other tend to be similar than things further away. Tobler's first rule of geography was formulated into spatial autocorrelation in the 1990s when it became the principal key in GIS. In terms of spatial accessibility, it could be interpreted that locations closer to an individual have more interaction and attention than locations further away.

Spatial accessibility has become an essential term and research method in multiple fields but defining the term has not been simple. One of the most used definitions for accessibility is Hansen's (1959) opportunities for interaction. This definition focuses further on the intensity of interaction rather than solely measuring the ease of interaction. In Hansen (1959) study there was already a timely dimension for defining accessibility, it was not just about the distance between things. One of the simplest definitions for spatial accessibility is the proximity of a location to other locations (Kwan & Weber, 2003, 341). Kwan (1999, 211) has presented that there are three key elements in spatial accessibility. Firstly, there is the reference location or locations in which spatial accessibility are studied. Second, there are the destination points where the opportunities for interaction can be measured. The third element is the physical separation of the reference point(s) and the destinations. Separation is modelled by the impedance function to represent the distance decay and the attractiveness of opportunities.

Distance decay is a concept in urban and economic geography (Fotheringham, 1981, 425). In a nutshell distance decay is a theory of spatial interactions that get fewer as the distance grows. The concept of distance decay helps to make accurate measurements of its effects on spatial distribution.

Huff gravity model (Huff, 1963, 1964), which has been more popular to study catchment areas for retail and other commercial use, could also be applied to different study topics. Huff gravity model can be used to calculate potential users in a given customer area. Huff gravity model will not be used in this study to calculate catchment areas of customer potential but instead, more background information and foundation to think about spatial accessibility and mobility towards sports facilities.

Based on prior definitions, spatial accessibility can be split by how it is studied: from a reference point or from destinations to a reference point. The further distinction to spatial accessibility can be made from the perspective of the reference point (Bhat et al., 2000, 3; Kwan, 1999, 211). Depending on the study research, accessibility can be studied from a place or an individual point of view. Place accessibility measures how easily a given place can be accessed from other points and individual accessibility measures the capability of an individual to reach destinations.

As mentioned before, spatial accessibility has had different definitions over the years which is why there have been multiple ways to measure research. The most straightforward form of spatial accessibility analysis is done using spatial separation measures (Curtis & Scheurer, 2010, 58-60). Spatial separation analysis measures travel impedance between the origin and the destination, usually either by distance or by travel time. It only measures the physical distance between the nodes. A step further for separation analysis is when other indicators are included in the equation (Baradaran & Ramjerdi, 2001). Spatial accessibility should not be measured solely on distance but other factors such as travel time, the cost of transport, travel reliability, frequency of travel opportunities, or a combination of these.

Advanced GIS applications have brought new opportunities for spatial accessibility modelling. Earlier, measuring spatial accessibility was restricted to simple distance or travel times analyses that were often simplified or flawed in comparison to real life. With GIS applications we have nowadays more developed tools and computing resources to calculate more precise travel times based on repetition and mean travel times that resemble a more realistic view. Travel time analyses that only considered time spent ‘on the road’ are so-called ‘kerb-to-kerb’ travel time (Curtis & Scheurer, 2010, 60). For a more detailed approach, there are ‘door-to-door’ travel times, which considers time spent waiting for the bus, the time it takes to find a parking spot or walking to the bus stop or a parking lot. ‘Door-to-door’ travel times are quite complex to calculate which is why this kind of information is often not available, but it provides more accurate analysis when it is.

It is evident that locations in immediacy to relative population has better spatial accessibility and places that are further out without an easy way to get there have poorer accessibility. Drawing the line between different categorizations of accessibility is a real challenge as there is no consensus on what good spatial accessibility for services is. How long travel time should be considered good, moderate, or bad spatial accessibility? Is the distance more important than travel time in terms of spatial accessibility? Here are some prior thresholds found for good recreational spatial accessibility.

Reasonable travel times are key for evaluating poor and sufficient thresholds for spatial accessibility. Talen and Anselin (2016) evaluated spatial accessibility by average travel distance and distance to the nearest playground as an indicator of spatial accessibility. In a Canadian study about food market accessibility (Apparicio, Cloutier, & Shearmur, 2007, 4), researchers used distance to evaluate immediate proximity to a supermarket with a threshold of 1000 meters which is approximately a 15-minute walk in an urban setting. Spinney and Millward (2013) have researched travel thresholds for sports and recreational activities. In their comprehensive study, they found that in most cases people used less than 15 minutes to reach a given sporting facility and a maximum of half-hour or 4-20 kilometres in distance. However, there was quite a lot of variation in maximum travel times between different sports. People tend to be willing to spend more time to reach recreational events that they spend a lot of time at once. Such events were mentioned to be golf or winter sports such as skiing, ice skating or snowboarding.

Some studies have limited reasonable travel times and distances to reach everyday exercising facilities in 15 to 20 minutes by cycling or by foot, which correspond roughly to 1-2 kilometres by foot or 5-6 kilometres, respectively (University of Oulu, 2021). According to the national passenger transport survey, most trips with less than a kilometre distance are done by walking but already on 1-3 km trips car was the most popular mean of transportation (Finnish Transport Agency, 2012, 35). Shares of trips done by bike on trips less than one kilometre and 1-3 km are 12% and 15%, respectively.

When considering my case sports facility type (swimming halls), it has been recognised that there is a connection between increased swimming activity and proximity to a swimming pool (Karusisi et al., 2013, 5). They concluded that having a swimming pool within 1 kilometre of residence will most likely increase the utilization of the facility. Higgs et al. (2015) have (Higgs et al., 2015) found similar numbers for distance people are prepared to travel by foot. They also mentioned that 16.4 km is the driving distance that people would be willing to drive to reach physical exercise facilities.

In an American study (Diez Roux et al., 2007) 64% of the respondents mentioned that they exercised within 1 mile (~1.6 km) of their home at least in 50% of the cases. They also found an association between density of exercising opportunities and physical activity levels between 1 and 5 miles (~1.6-8 km). But their results are not directly comparative to European and Northern countries because the United States is famous for the more car-oriented culture than in Europe.

The majority of residents typically spend less than 30 minutes commuting (Bertolini, le Clercq, & Kapoen, 2005, 211). Though this may seem like a short time to commute, half an hour commute to work is the consistent global average (Kenworthy & Laube, 1999, 703). Therefore, it could be even generalised that half an hour mark is a rough universal threshold for at least moderate accessibility for everyday destinations.

In addition, the concept of a 15-minute city (Moreno, Allam, Chabaud, Gall, & Pratlong, 2021), which has been popularized by Paris mayor Anne Hidalgo, is a concept to develop a more sustainable, dense and equal living environment for all the residents. The concept planned to make everyday things available for all the residents within 15 minutes by either of the foot or by cycling. A 15-minute walk would translate approximately to a 1000 m distance in an urban setting (Karusisi et al., 2013, 8).

2.2. Connection between spatial accessibility of sports facilities and socio-economic disadvantages

There have been several types of earlier GIS-based spatial accessibility analyses that consider sports facilities. (Kotavaara & Rusanen, 2016) For example, Higgs et al. (2015) have concluded in prior studies that correlation between proximity to a sports facility and tendency to physical activity have mixed and inconsistent results. In addition, Kotavaara and Rusanen (2016, 28) have studied the spatial accessibility of swimming halls on a national scale in Finland using a 1km x 1km grid. They concluded that the accessibility to swimming halls in Finland is poor and at best swimming halls in Finland are typically accessible by cycling, public transport, or a private car. They also found that spatial accessibility to swimming halls is moderate in urban areas and poor in rural areas. These previous studies indicate that GIS-based analyses are usable in providing spatial analysis of accessibility and differences among neighbourhoods but further research with additional methods should be used for more comprehensive conclusions.

In addition, several studies have shown the connection between living in a socio-economically disadvantaged neighbourhood and physical inactivity compared to those living in the more advantaged neighbourhoods (Van Lenthe et al., 2005). A connection has been shown that residents in less advantaged areas tend to walk to work but are less likely to engage in physical activity in their leisure time in comparison to more advantaged neighbourhoods. Interestingly, it has been concluded that the proximity to sports facilities or socio-economic status of the neighbourhood is not the only factor to have an impact on the frequency and the duration of outdoor physical activity of residents but also the aesthetics of the environment (Humpel, Owen, & Leslie, 2002, 196). Aesthetic neighbourhood characteristics have been stated to have a positive effect on residents' physical activity habits which included characteristics such as safety. It has also been shown that physical activity levels are connected with socioeconomic status and the area of residence (Sallis, Bauman, & Pratt, 1998, 383). They found that if the area of physical activity was visually pleasing and there were attractions such as shops, the chance of engaging in physical activity was higher.

3. Study area and its characteristics

3.1. Greater Helsinki region

The study area of this thesis is the Greater Helsinki region which covers in addition to the City of Helsinki also its surrounding cities Espoo, Vantaa, and Kauniainen (Figure 1). Together these cities form a unified urban area with a common labour and housing market region. The Greater Helsinki region has seen fast growth over the past decades and along with the continuously growing housing and labour market it is one of the fastest-growing urban areas in Finland (Vilkama, 2011, 87).

Though the Greater Helsinki region is in practice a unified urban area these cities act as their governmental entities as any other municipality in Finland. These cities, which are municipalities by definition, each have their city councils, governmental organizations and obligations that are designated to municipalities such as public infrastructure, schools, libraries, and health care.

Although these cities act as individual entities, they still cooperate on multiple levels on planning, health care and other services.

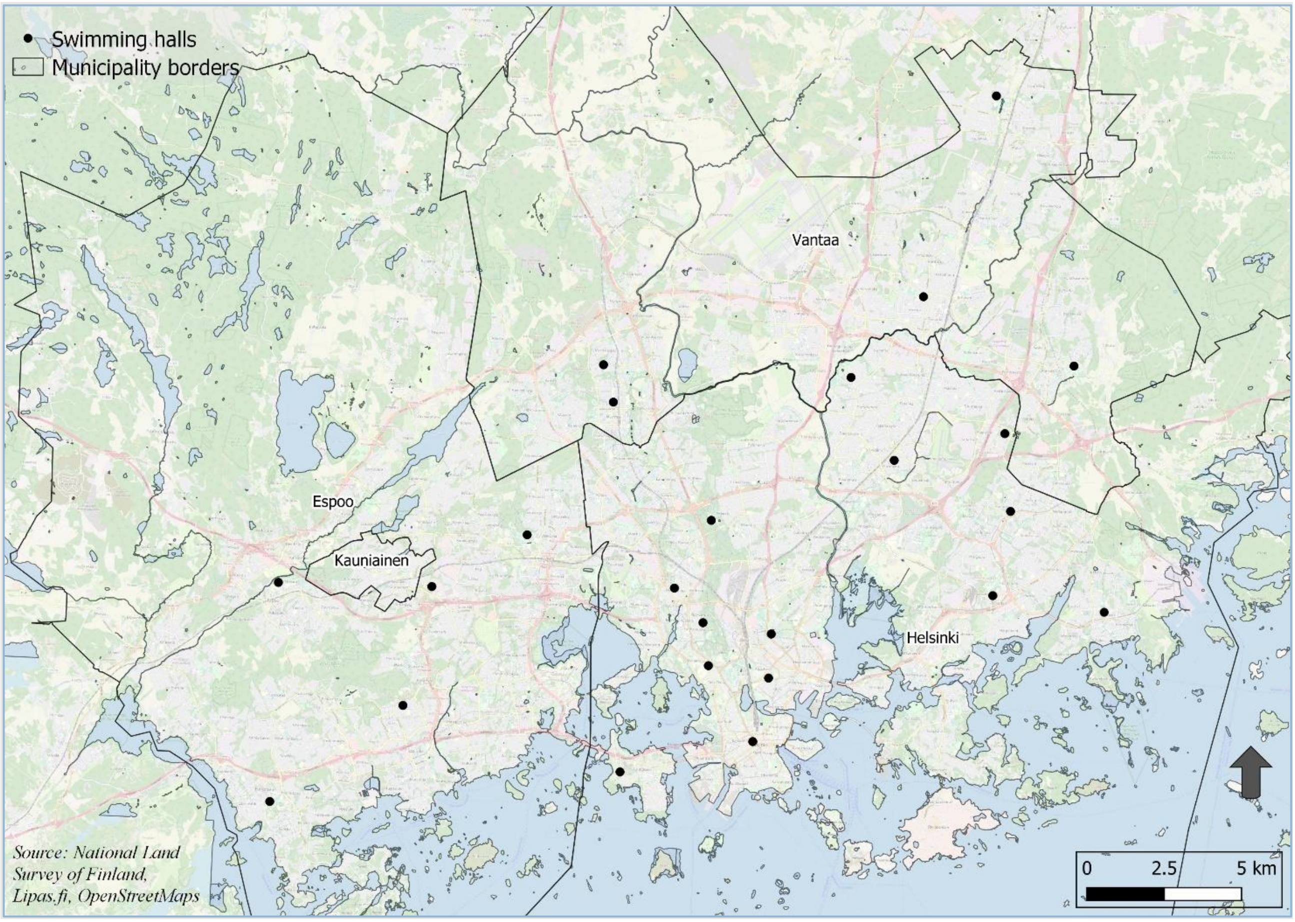

Figure 1. Map of Greater Helsinki region, cities in the study, and swimming halls in the region.

Helsinki is the capital of Finland and is located in Uusimaa, the southern part of Finland. The Greater Helsinki region has the highest population density in Finland but there is also a high variance in density in the city. Figure 2 illustrates the population density and location of high population areas on the 250m x 250m grid. Helsinki city centre and areas nearby are very dense in population but there are also other areas of high population density in the Greater Helsinki region, namely near metro and train stations. The study area of the Greater Helsinki region has 770 km² of land which means that there are also more rural areas as well as several parks and forests that have little if any residents.

Each of the four cities has its characteristics and vary in many ways when it comes to income, education, price of housing, type of housing, means of transport, and other factors that characterize each city. The Greater Helsinki region consists of four independent cities but in practice, central

Helsinki operates as the cultural and economic centre of the whole area. There are multiple smaller centres in the area that have higher concentrations of population, services, and offices.

Though levels of segregation have been low in the Greater Helsinki region compared to international levels, cities in the area have noted increasing levels of segregation and the challenge it has caused (Vilkama, 2011, 90). Levels of segregation were low especially before the economic depression of the 1990s, but levels have then risen due to differentiation of labour market, division for white- and blue-collar jobs, which favours certain workers that are located in proximity to offices located in their neighbourhood and increased numbers in immigration (Vilkama, 2011, 90). Cities in the Greater Helsinki region are actively trying to prevent and stop residential and social segregation via housing, siting, planning, and other regional development policies (Vaattovaara & Kortteinen, 2003, 2129).

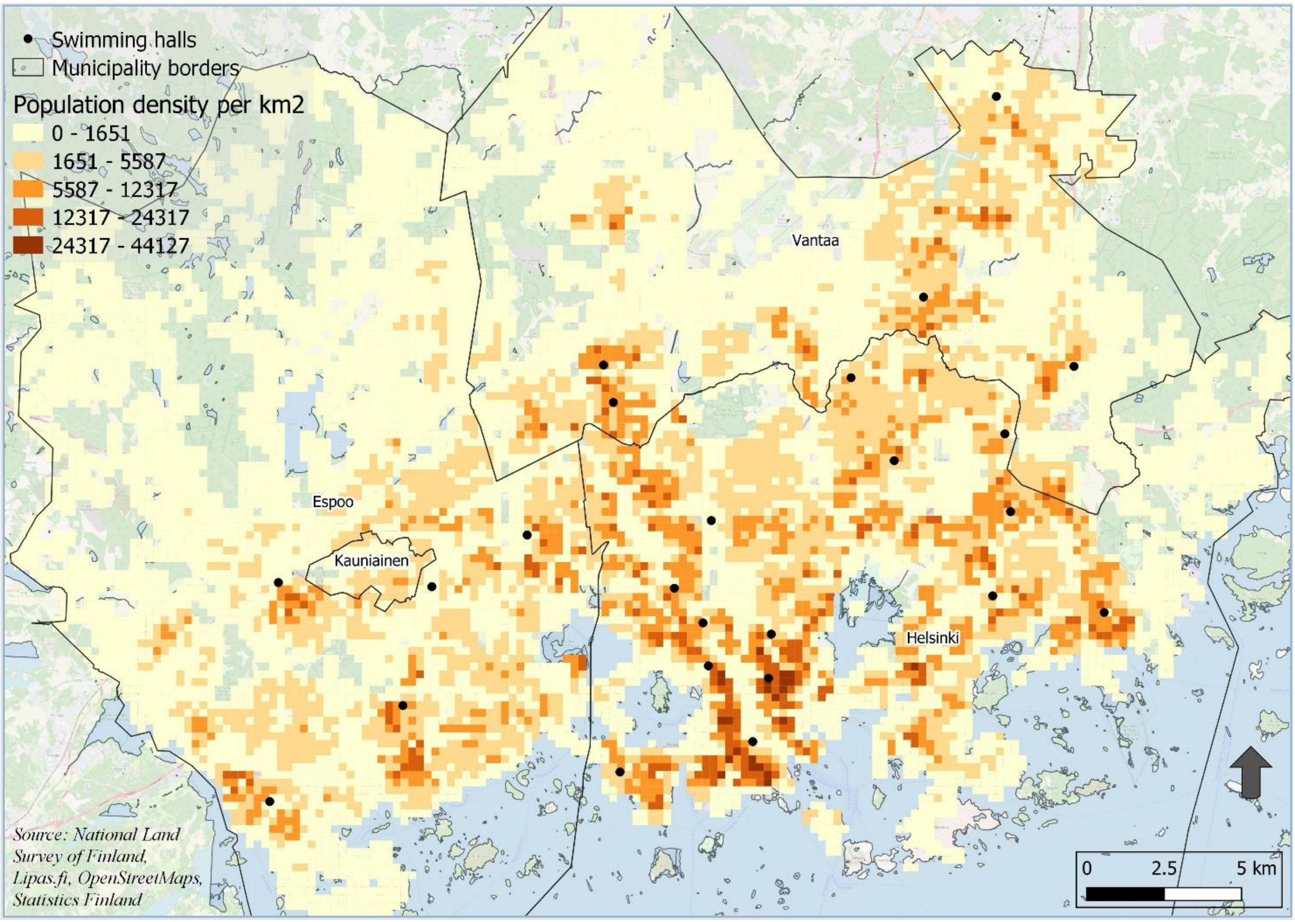

Figure 2. The population density in the Greater Helsinki region 2019.

The number of inhabitants in the Greater Helsinki region was 1.2 million in the summer of 2021 which is a little over a fifth of all the residents in Finland (Statistics Finland, 2021). A substantial share of population growth in the Greater Helsinki region is due to immigration (Vilkama, 2011, 87). Immigration numbers are high especially in Helsinki, Espoo, and Vantaa. The Greater Helsinki region also gains some net migration from the rest of Finland, but residents of the Greater Helsinki region often migrate also away from the Greater Helsinki region.

In terms of sociodemographic features, Helsinki, the capital with a population of approximately 660 000 (Statistics Finland, 2021), is quite a polarized city in many ways. There are a lot of very prosperous areas and individuals but simultaneously there are areas and individuals with significant levels of cumulative disadvantage living there (Helsinki's present state and development, 2019, 16).

Despite low levels of segregation in the past, there has been an increase in segregation and in processes that have prevented segregation (Helsinki's present state and development, 2019, 16). Some areas in Helsinki have seen a significant increase in people with foreign mother tongues for up to 40% (Bernelius & Vaattovaara, 2016, 6). Significantly risen numbers of non-Finnish or non-Swedish speaking residents can be seen for example some schools have 50% of pupils being of foreign background. Growth in immigration and share of foreign mother tongue residents has been steep especially in the 2000s as the number of foreign mother tongue residents grew by +136% between 2000 and 2011 (Vilkama, 2011, 96-97). During that period 62 000 new foreign individuals either moved to the Greater Helsinki region or were born there and their share of the local population grew from less than 5% up to 10%.

Immigration patterns have shifted in the 21st century. Reasons behind immigration have diversified from mostly refuge and returning citizens to immigrating for family or work-related reasons. Especially foreign labour force has been in an increase as a reason for immigration (Vilkama, 2011, 99). Immigration in the 2000s has seen a rise in low-wage working migrants moving to the Greater Helsinki region but there has also been an increase in educated individuals in the area. Diversification of immigration has caused a higher employment rate among immigrants, but the average income level of foreign nationals and immigrants is still below average in Finland. Foreign mother tongue residents in the Greater Helsinki region have not scattered evenly throughout the area. Helsinki and Vantaa have fewer immigrants from higher-income quantiles than Espoo and Kauniainen. Vilkama (2011, 99-100) found that differences in income levels among cities in the Greater Helsinki region with foreigners are similar to the local population which indicates that immigrants' housing patterns are alike with the local population. These housing patterns apply only to more advantaged immigrants and there are disadvantaged immigrants in all of the cities. Socioeconomically the most disadvantaged areas are located in the northeast and eastern Helsinki

(Helsinki's present state and development, 2019, 25). As the city's socioeconomic average increases the most disadvantaged areas have lagged between 2010 and 2016. Socioeconomic segregation of certain districts becomes even more evident if the change is studied since 2000.

3.2. Swimming halls in Finland

In Finland, municipalities are obligated by law to provide sports facilities and physical exercise services for their residents (*Act on the promotion of sports and physical activity (390/2015)*, 2015, 3-5§). Therefore, the public sector is a major producer of physical exercise services. According to the LIPAS database (Suomi et al., 2012, 21), over 70 % of sports facilities are owned by the state, a municipality, or a municipality-owned company. Swimming halls in Finland are almost exclusively owned by the public sector (97 %).

Municipalities are a major provider of swimming facilities in Finland and swimming halls are a traditional service for Finnish municipalities to offer. In Finland, swimming halls are such a common service provided by that public that almost everybody in the country lives within a 50 km radius of a swimming hall (Kotavaara & Rusanen, 2016, 19). In urban areas, there are often several swimming halls in comparison to rural areas that have fewer facilities in terms of geographical coverage (Suomi et al., 2012, 19). Still, swimming halls are considered to be one of the most equally accessible sports facilities in Finland (Suomi et al., 2012, 8). Not only are there swimming halls all around Finland but the Act on the Promotion of Sports and Physical Activity (390/2015, 3-5§) requires municipalities to pay attention to special groups as well. Typically, there are discount tickets available for different groups such as students, pensioners, children, or the disabled. Special treatment and discounts make sports facilities, and swimming halls, more accessible for everybody. Swimming halls were selected to be the case study because they fit the aforementioned criteria of being available for everybody, spatially and socially.

Therefore, I will study the spatial accessibility of swimming halls to measure segregation in the Greater Helsinki region. According to the LIPAS database (University of Jyväskylä, 2019), there are 25 swimming halls located in the Greater Helsinki region. These 25 swimming halls chosen for the study have a pool length of at least 25 meters and do not have any user restrictions i.e., in commercial use for the public. Private swimming halls and swimming facilities with some user restrictions have been removed from the dataset. Water parks and spas have been excluded from the study as they are not seen as relevant to the framework of the study.

According to Nissinen and Möttönen (2013, 110), swimming is the 6th most popular form of physical exercise among adults in Finland. Swimming in Finland is also a very equal sport when it comes to users of swimming halls. Women and men tend to use swimming halls at an equal rate (Suomi et al., 2012, 50) which makes swimming halls a great subject for my research since equality is a key factor in this study.

As discussed in the previous section, swimming halls considered suitable for this study vary in size. The smallest swimming hall in this study is in Siltamäki with a pool size of 154 m². The largest pool area in the swimming hall is Mäkelänrinne which has 2 064 m². In Table 1 there is basic information about the number of swimming halls per city, pool m² and proportion of pool m² per resident. Helsinki has the most swimming hall as it is by far the largest city. Espoo and Vantaa show quite similar numbers in all columns apart from Espoo having a higher pool m² ratio per resident. Kauniainen, being by far the smallest city, has only one swimming hall. Due to only having one swimming hall and small population its residents/pool m² are a little inflated. Also, swimming hall visitors are not restricted to using sports facilities in the city they live in. If they live close to the city border, they might just use the closest swimming facility available which might be in another city. There is also a chance that people commuting might make a stop at a swimming facility in another city if that is on the way. There are no statistics on where the visiting users are living either. A full list of swimming halls considered in the study is found in Table 6 (in Appendix 3).

Table 1. Number of swimming halls per city, pool m², and residents/pool area m² ("Lipas Liikuntapaikat.fi," 2021; Nissinen & Möttönen, 2013, 115)

City	Number of swimming halls	Pool m²	Residents/m²
Helsinki	14	7 439	80
Espoo	5	2 788	90
Vantaa	5	2 803	72
Kauniainen	1	350	27

According to Nissinen & Möttönen (2013, 110), swimming is gaining more and more popularity in Finland. In all the categories for adolescents, adults and seniors' number of active swimmers had risen from 1994 to 2013. The most significant increase has been seen in adolescent numbers as growth in percentages has been 47%. Data from 2010 show that there are 833 000 active swimmers in Finland.

4. Materials and methods

4.1. GIS datasets

Analyses done for the thesis were conducted using GIS (Geographical Information System) tools and methods. The spatial accessibility analysis of the study was carried out using the Helsinki Region Travel Time Matrix (https://blogs.helsinki.fi/accessibility/helsinki-region-travel-time-matrix-2018/). Helsinki Region Travel Time Matrix consists of a grid with 250m x 250m cells (13 231 grid cells in total) which allowed doing a time-based analysis from any grid cell to any grid cell using different means of transport. There are other factors included in the calculation such as time of the day or the time it takes to prepare the vehicle (Toivonen et al., 2014).

In Table 2 there are listed all the datasets used in the thesis, source, format, description, and a short explanation of how the data is used are also included.

Table 2. GIS datasets used in the thesis.

Name	Source	Format	Description	Use
Sports facilities	LIPAS database, University of Jyväskylä.	Vector	A comprehensive database of sports facilities in Finland.	Points of interest in the study. Swimming hall points are used for spatial accessibility analysis.
Helsinki Region Travel Time Matrix		Vector	Travel times grid in 250m x 250m cells.	Used for calculating travel times from points of interest
Population grid dataset	Statistics Finland	Vector	Population Database (2019) grid sizes 250m x 250m.	Joined with travel time matrix for population and index calculations.
OpenStreetMap	OpenStreetMap	Vector	A collaborative project to create a free editable geographic database.	Background map for visualization.

4.1.1. LIPAS sports facility GIS database

LIPAS sports facility GIS database (https://www.lipas.fi/) is a national and public GIS system that is managed by the Faculty of Sport and Health Sciences at the University of Jyväskylä. LIPAS project was launched to have all the data about Finnish sports facilities in one place. Once data is collected in one place it is easily accessible for the public and a comprehensive database is available for anyone who requires the information (Lipas Liikuntapaikat.fi).

The University of Jyväskylä is not responsible for collecting or uploading any sports facility data to the LIPAS database but they manage the database that contains all the sports facility information. Municipalities, owners of sports facilities and other sports organizations are responsible for making sure that their information in LIPAS is true and correct (“Lipas Liikuntapaikat.fi,” 2021).

In LIPAS service there are a variety of sports facilities collected into the database. There are only sports facilities that have been particularly built for physical exercise use, courses for recreational use and outdoor activities and places and areas for leisure and recreational outdoor activity along with their facilities and services. Places or areas that are not maintained or marked as places for recreational or physical exercise used in the detailed plans of the municipalities are not collected in the database.

Data in the LIPAS database is divided into eight main types of sports facilities:

1. Recreational destinations and services
2. Outdoor fields and sports parks
3. Indoor sports facilities
4. Water sports facilities
5. Cross-country sports facilities
6. Boating, aviation, and motorsports
7. Animal sports areas
8. Maintenance facilities

Data in the LIPAS database is available for the public. Data can be accessed by anyone and it can be used for any non-commercial purposes. Sports facility data can be viewed online from Lipas.fi online map service that allows users to search for sports facilities and see their locations on a map. LIPAS data is available in point, line, and polygon forms, depending on the type of destination or facility. Data from the database is available to download or can be accessed via WFS and WMS web services using GIS software such as QGIS or ArcGIS.

4.1.2. Helsinki Region Travel Time Matrix

Often spatial accessibility is better being measured by travel times rather than distance to represent real life. Spatial accessibility models often lack important factors such as traffic, time of the day, average waiting time or speed limits which can add up to drastic differences throughout the day.

Helsinki Region Travel Time Matrix is produced by the Digital Geography Lab of the University of Helsinki (https://www2.helsinki.fi/en/researchgroups/digital-geography-lab) to measure spatial patterns and mobility in the Greater Helsinki region (Toivonen et al., 2014). Helsinki Region Travel Time Matrix is a grid (n = 13 231) covering the whole Greater Helsinki region. The data set is a set of text files that contain travel times from each cell to each cell, calculated from centroids of the cells. Helsinki Region Travel Time Matrix consists of 250m x 250m grid cells.

Students and staff in Digital Geography Lab have been working to make the Greater Helsinki Region Travel Time Matrix a comprehensive tool to measure travel times and to make a tool that lacks the parameters mentioned earlier. In this thesis, I used the latest available data published in 2018 to measure spatial accessibility. Helsinki Region Travel Time Matrix consists of four different means of transport: walking, cycling, public transportation, or private car. (Saavutettavuuden maantiedettä | Digital Geography Labin saavutettavuus- ja liikkumistutkimus, 2021).

Data for walking is measured without adding any additional times for the travel chain. There are two travel times calculated for cycling: slow and fast for which the travelling speeds have been set to 12km/h and 19 km/h respectively. For each travel time by cycling has been added one minute for the time it takes to unlock the bike and to return it (Tenkanen & Toivonen, 2020, 5-6).

Public transportation travel times that have been calculated with a ‘door-to-door’ travel chain for both midday and rush hour are chosen to include total travel times which include waiting times at home. Total travel times have been chosen for the analysis to have travel times as realistic as possible to reflect real life. There are data for public transport travel time including and excluding waiting time at home for both rush hour and midday when departures vary. Rush hour and midday have also their travel distances measured (Tenkanen & Toivonen, 2020, 2-3).

Private car travel times, which also has been calculated for both midday and rush hour, are calculated as the whole travel chain. ‘Door-to-door’ approach for public transportation and private cars includes the average time it takes for walking to the parking lot, driving to a destination, average time search for a parking spot and finally walking from the parking lot to destination in addition to actual driving time. There is also data calculated for travel time by car following speed limits which would be the theoretically fastest way of driving from point A to point B (Tenkanen & Toivonen, 2020, 3-4).

4.1.3. Population grid database

Population grid database (Ruututietokanta) is a GIS database managed by Statistics Finland. Data is applicable for the whole of Finland and a subscription is required from Statistics Finland to access the data with the best spatial resolution (250 m). But the grid for information can be acquired in 250m x 250m (restricted access), 1km x 1km (open access), or 5km x 5km grids (open access). Data about the Finnish population contains different characteristics about residents and workplaces. Characteristics used in this thesis are population, level of education, mean income and working status. If there are less than 3 or 10 objects (people) within the cell, depending on the data group, data in the grid cell is protected for privacy reasons. In these cases, the cell values are set to No Data (Statistics Finland, Ruututietokanta, 2021). The population grid database is compatible with and available in the same grid sizes as the Helsinki Region Travel Time Matrix.

4.2. Disadvantage sum index

The population grid database provides the information for population density and to calculate the disadvantage sum index. The disadvantage sum index provides information about spatial segregation in the Greater Helsinki region and thus help in the further analysis regarding the relationship between segregation and spatial accessibility.

I calculated a sum index for disadvantage based on the population database (Ruututietokanta) provided by Statistics Finland (2020). The sum index for disadvantage was later used for the classification of population grid cells. The sum index for disadvantage was calculated based on prior formulas used by the City of Helsinki (City of Helsinki, 2019a). The index illustrates the socioeconomic differences in Greater Helsinki region with three different key factors. Three key factors calculated into the sum index are 1) the relative proportion of low-income households (5^{th} quintile of the data), 2) unemployment rate, and 3) share of people with no university-level degree of the labour force. After summing up these three parameters the sum index was then adjusted to the city mean so that value 100 stands for city average. A complete list of parameters and their description for the disadvantage sum index can be found in Table 4. The formula for calculating the disadvantage was following:

Equation 1: *(("ko_ika18y" - "ko_al_kork" - "ko_yl_kork") / "ko_ika18y" + ("pt_tyott" / "labour_force") + ("tr_pi_tul" / "tr_kuty")) / (grid cell-based citywide mean / 100*

Values used for citywide means were:

- Greater Helsinki region: 0.83
- Helsinki: 0.86
- Vantaa: 0.91
- Kauniainen: 0.61
- Espoo: 0.73

Calculating the mean for each city separately and for the whole Greater Helsinki region is important as cities vary in sociodemographic and structural terms. The disadvantage sum index is adjusted to the mean of the study area which distorts the data if some other number is used instead of the mean. As can be seen from above, mean values for socioeconomic factors differ between cities. Helsinki is quite close to the whole region average and the City of Vantaa has a little higher mean than the whole Greater Helsinki region. The city of Kauniainen has by far the lowest mean which might be affected by its small size. The city of Espoo mean value is below the whole region average but larger than for the City of Kauniainen.

Table 3. Variables used to calculate disadvantage index. Source: Statistics Finland (2020).

ko_ika18y	Aged 18 or over, total, 2019	Aged 18 or over reports the number of inhabitants aged 18 or over living in the area
ko_al_kork	Academic degree - Lower-level university degree, 2019	University / tertiary-level degree, lower: lower-degree level tertiary education (level 6)
ko_yl_kork	Academic degree - Higher level university degree, 2019	University / tertiary-level degree, higher: higher-degree level tertiary education (level 7) and doctorate degrees or equivalent (level 8)
pt_tyott	Unemployed, 2018	The unemployed labour force comprises people aged 15 to 64 who were unemployed on the last working day of the year
tr_pi_tul	Households belonging to the lowest income category, 2018	Households earning per consumption unit at most EUR 17 301 per year (deciles 1-2).
tr_kuty	Households, total, 2018	Households, the total is the number of households who are living in the area
Labor_force	= "pt_vakiy"- "pt_0_14" - "pt_opisk"- "pt_elakel" - "pt_muut"	Total population excluding under 14-year old's (pt_0_14), students (pt_opisk), pensioners (pt_elakel) and others (pt_muut), that are not in the labour force.

To study segregation in the study area, the population was classified into quantiles by sum index of disadvantage. Classification into quintiles (five groups with an even number of cells) was done using QGIS symbology tool so that number ‘1’ is the most advantaged quartile and ‘5’ is the most disadvantaged quartile. Using *Graduated Symbology* in QGIS I was able to classify the dataset into quintiles. Classification into quintiles for the data was done for the whole Greater Helsinki region as well as each city on its own. Each cell was given a value between 1 and 5 to represent the quintile the cell belongs to. Classification for each city was done to be able to make further analysis between the cities later on.

However, the disadvantage index requires all the necessary info about the percentage of low-income households, education, and unemployment of the grid cell to be able to calculate the sum. This information is not available to every single cell which means that analysis can only be carried out to cells that have all the required information. Information that is absent from grid cells is unlikely to affect the reliability of the study as the disadvantage sum index covers 97.36% of all residents in the Greater Helsinki region.

4.3. Analysis

Spatial accessibility analysis focused on swimming halls for which the travel times were calculated using different modes of transportation. Transportation modes used in this study were walking, cycling, public transportation, and private cars. GIS analyses were carried out using QGIS software which is an open-source GIS software f. For further data analysis, I used IBM SPSS Statistics. SPSS was used for conducting Student’s t-test (Independent samples t-test).

I used separately midday and rush hour travel times for public transportation and private cars and average cycling time between slow and fast cycling. A complete list of transportation modes that were used in the thesis can be seen in Table 4.

Table 4. List of transportation modes included in the thesis (from the Helsinki Region Travel Time Matrix).

Transportation method	Description
Walking	Travel time by foot. The walking pace is 70 m/min
Cycling	Average travel time between fast (19 km/h) and slow (12 km/h)
Public transportation (midday)	Travel time by public transport during midday (optimized between 12:00-13:00 PM)
Public transportation (rush hour)	Travel time by public transport during rush hour (optimized between 08:00-09:00 AM)
Private car (midday)	Travel time by private car during midday (optimized between 12:00-13:00 PM)
Private car (rush hour)	Travel time by private car during rush hour (optimized between 08:00-09:00 AM)

One of the main subjects in the thesis are swimming halls in the Greater Helsinki region. Data for swimming halls were extracted from the LIPAS database of sports facilities in Finland. Sports facility code '3110' for swimming halls was used to select the facilities from the complete dataset. Then municipality codes for Greater Helsinki regions' municipalities were used to filter swimming halls from desired locations. Swimming halls that have been chosen for this study belong in the "public indoor swimming pool" class which excludes open-air swimming pools and private swimming pools. This classification has been done due the fact that only swimming facilities that are open throughout the year and are open for the public.

The Helsinki Region Travel Time Matrix data was used to calculate the shortest travel times from each cell of the grid to the nearest swimming hall. Helsinki Region Travel Time Matrix is a set of text format data that contains travel times of individual cells. The data requires first a user to know the reference points for analysis. Using the locations of swimming halls, I was able to connect them to the grid cells where they were located on the travel time matrix layer. After defining the grid cell IDs, I fetched the text files containing the travel times and imported them into QGIS. Once all the text files were imported, I added the travel time information to the travel time matrix grid by joining by attribute.

Before conducting any further analyses with travel times, the data was needed to be pre-processed and cleaned. If travel times were not available for some cells, they had a placeholder value of '-1' for *NODATA*. Travel times that were lacking had to be replaced by *NULL* values for not to interfere with the calculations and from distorting the results of the analyses. After the clean-up, the data was ready to be used for further analyses.

The shortest travel times from each grid cell were calculated using the *min()* function in the field calculator to calculate the shortest travel time for each cell using travel times from all 25 swimming halls and each swimming hall [e.g. min(travel_time_walking_swimming_hall_1, travel_time_walking_swimming_hall_2)].

Then I divided all populated grid cells into quantiles based on the sum index for disadvantage. Then I compared the most advantaged and the most disadvantaged quintiles and their travel times to the closest swimming hall. I conducted Student's t-test in SPSS to see if there is a statistically significant difference. The test compares the means of two independent samples. Student's t-test was carried for each city separately and also to the whole Greater Helsinki region. But one should keep in mind that the population grid data, which is classified into quintiles are based on an absolute number of grid cells. This means that I did not divide the total population into quintiles but grid cells. So, the analysis did not indicate anything regarding the amount of population but the location of most advantaged and most disadvantaged grid cells. More people are living in the most disadvantaged quintile grid cells than in the most advantaged quintile cells. Residents living in the most advantaged quintile cells accumulate to a total of 144 494 residents and 345 092 in the most disadvantaged quintile cells.

5. Results

5.1. Cumulative share of population reached in various travel times

To compare travel times to the nearest swimming hall facility between different types of transportation, we need to look at the cumulative share of the population reached in various distances (travel times) in the Greater Helsinki region (Figure 3). In Figure 3, there are cumulative sum percentages of the population that can reach a swimming hall with different means of transportation. In general, spatial accessibility to swimming halls can be stated to be reasonable in the region. Over 90% of all the residents in the Greater Helsinki region have access to a swimming hall in less than 20 minutes by car which is the standout mode of transportation to reach a swimming hall alongside cycling.

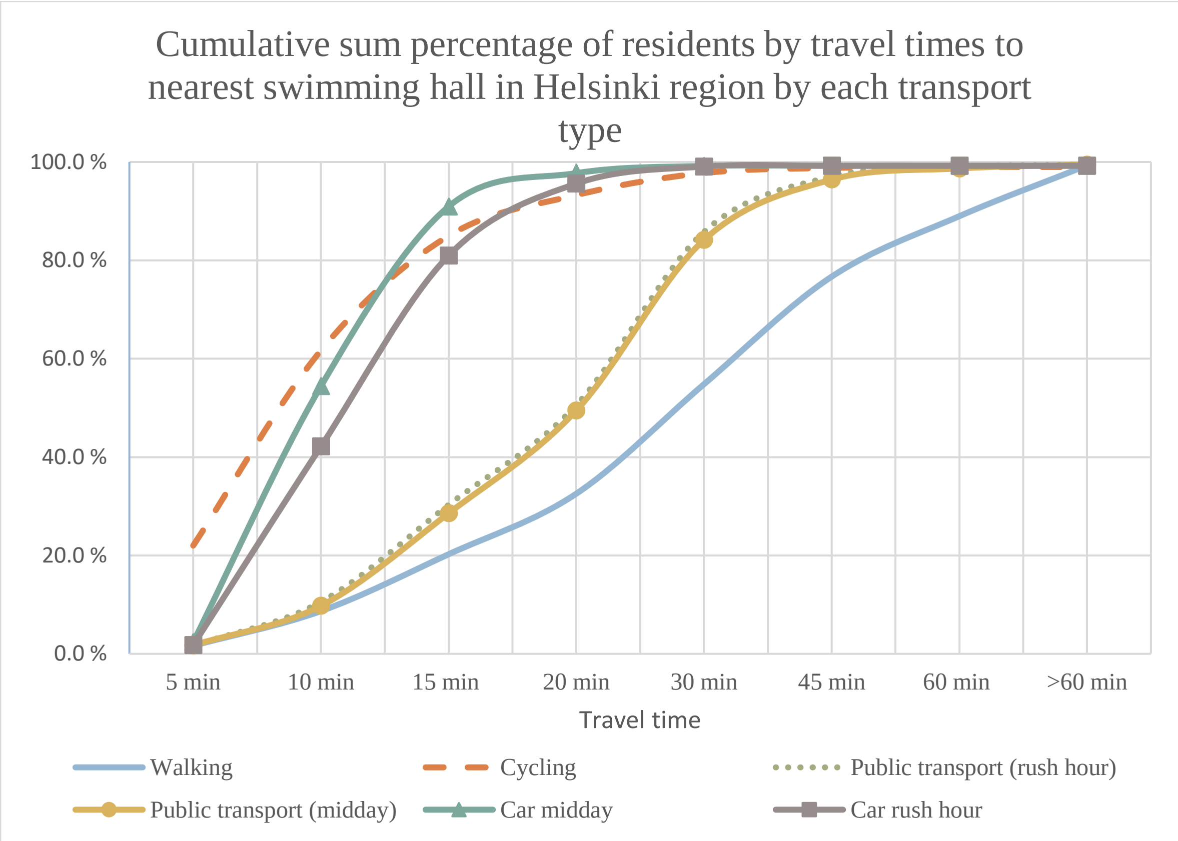

Figure 3. Cumulative share of population reached in various distances (travel times) from the closest swimming hall by different travel modes.

When it comes to spatial accessibility of swimming facilities of the whole population of the Greater Helsinki region, public transportation and walking are the inferior way. Roughly half of the population have access to an indoor swimming facility by public transportation within 20 minutes, and time of the day does not seem to make a significant difference. In 45 minutes of travelling by public transportation, the cumulative share of the reached population has risen to over 90%. Evidently, spatial accessibility to swimming halls in the Greater Helsinki region is the worst by walking. In less than 15 minutes, which could be considered to correspond roughly a little bit more than a kilometre, only 20% of the population can reach their closest swimming hall. In less than 20 minutes, the share of the population reached is 33%, and in 30min it is around 54%. It cannot be stressed enough that these numbers are calculated from all the residents in the Greater Helsinki region and the number could vary greatly between different parts in the region.

5.2. Patterns of spatial accessibilities by different transportation modes

Figures 4-10 illustrate the pattern of spatial accessibility and travel times (minutes) for all modes of transportation. These maps illustrate how the spatial pattern of each transportation mode differs from each other.

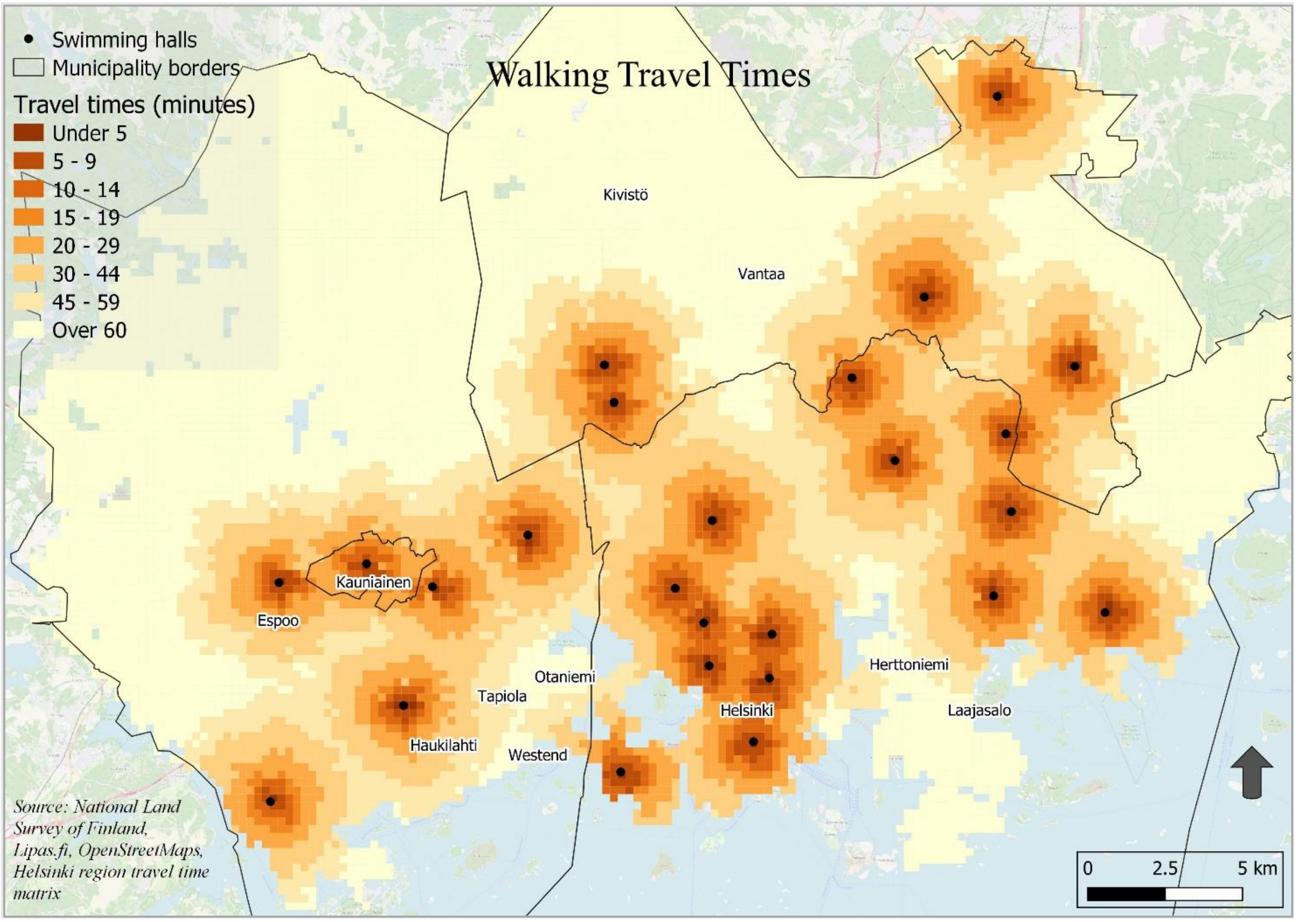

Figure 4. Travel times by walking to the nearest indoor swimming hall.

Figure 4 illustrates the spatial accessibility of swimming halls by walking in the Greater Helsinki region. Walking is by far the slowest mode of transportation included in my calculations. There are areas where spatial accessibility to swimming halls by walking is moderately good. The inner city of Helsinki is the standout area for spatial accessibility for swimming halls. This densely populated area has 5-7 swimming halls, depending on how the inner city is defined. Living within the proximity to a swimming hall is a privilege for few, but even by walking, most areas close to the city centre in Helsinki have access to their nearest swimming hall within 30 minutes. Other clusters of swimming halls can be found in eastern Helsinki and Kauniainen which both have two swimming halls right across the municipality border in Espoo.

The Greater Helsinki region has only a few places that have higher population densities. Often swimming halls tend to be in proximity to residential centres to increase the number of potential users - and this affects also the spatial accessibility pattern. The central location of swimming halls and relatively fast mode of transportation is what makes cycling in short and medium distances a great way to access swimming halls in the area. By cycling, most residents in the Greater Helsinki region can access their nearest swimming hall in less than 15 minutes (Figure 3).

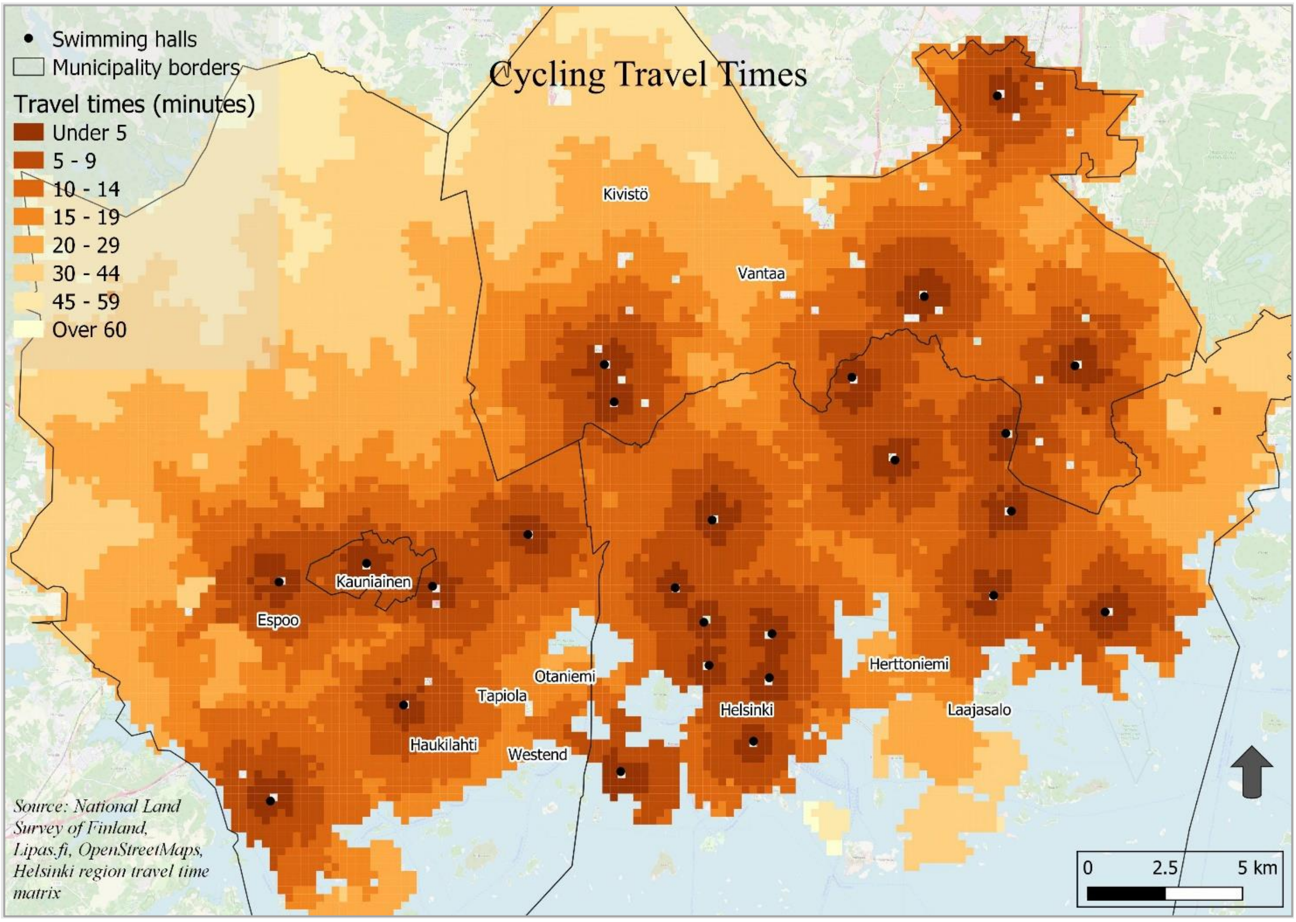

Figure 5. Travel times by cycling to the nearest indoor swimming hall.

However, there are a couple of areas that seem to be gaps between swimming hall catchment areas by cycling. In Helsinki southeastern areas of Herttoniemi and the islands in the southwest corner of the study area (see Figure 5) do not have a swimming facility anywhere close to these areas. Especially, this southwest corner and its island is a challenging place in terms of spatial accessibility due to its geography: it is an island with only one major road and bridge connecting it to the mainland.

High population density areas in Vantaa are mostly separated by the airport to the east and west (Figure 2). There are swimming halls located in both areas that provide moderately good spatial accessibility to swimming halls by cycling. There have been a lot of new development projects in Vantaa after the completion of the Ring Rail Line (Kehärata)(Finnish Transport Infrastructure Agency, 2018, 29). New train connections opened opportunities for new residential areas, of which Kivistö can be noted to be lacking good connections to the nearest swimming hall, at least by cycling. In Espoo, where most of the swimming halls are in the central part of the city, in proximity to train tracks, the spatial accessibility is quite good. Though, in southeastern parts of the City of Espoo, in student village Otaniemi, a little gap can be seen. The same problem includes neighbouring areas of Westend and Tapiola. Otaniemi and Tapiola have had swimming halls in the past but they have since been shut down, leaving the area without a swimming hall in the area (Rantalainen, 2018; Seuri, 2008).

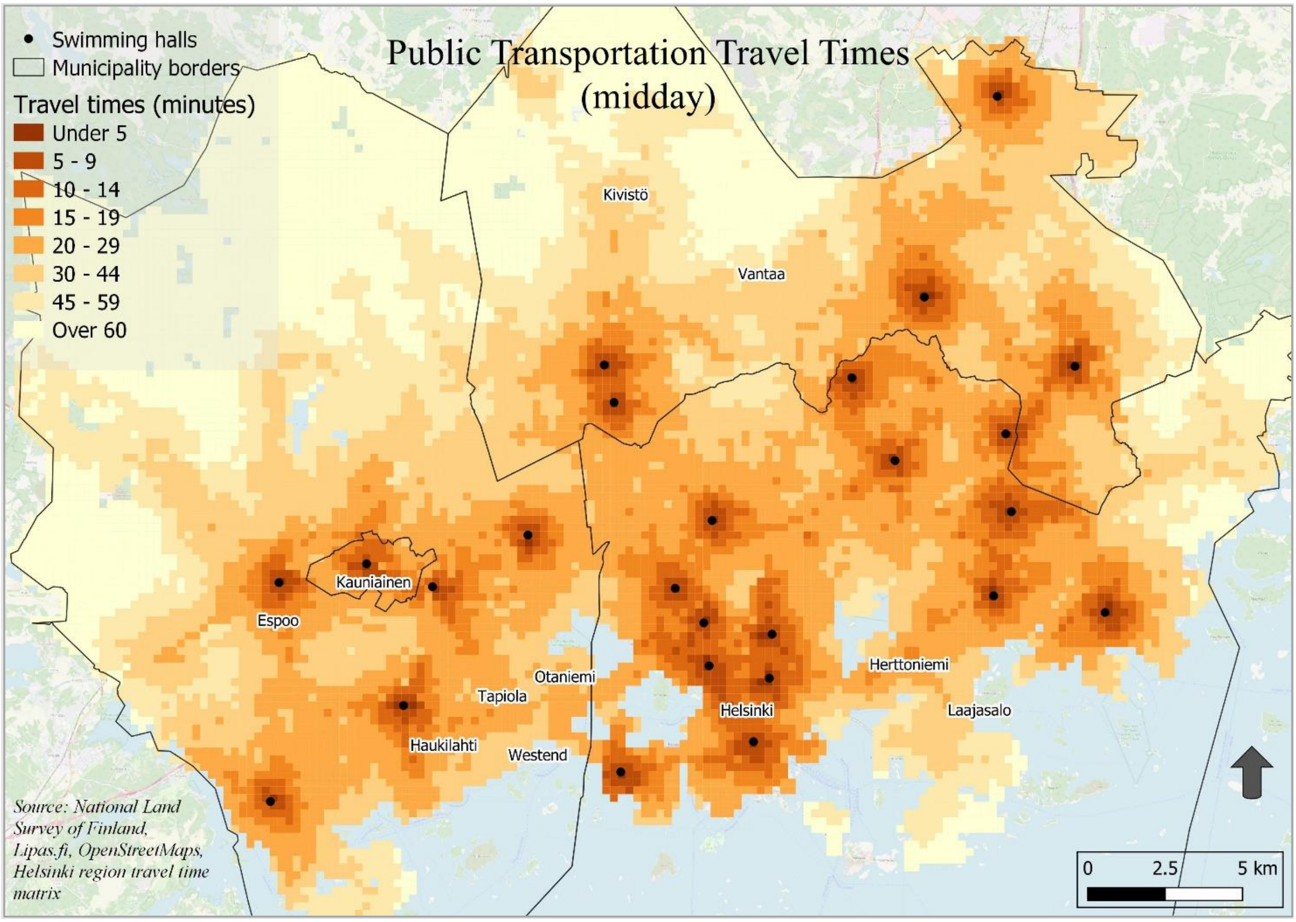

Figure 6. Travel times by public transport (midday) to the nearest indoor swimming facility.

Spatial accessibility for public transportation can be found in Figures 6-7. As Figure 3 confirms, there is not much difference between the travel times between travelling by public transportation during midday or rush hour. Spatial accessibility by public transportation is quite poor especially with very short distances but reach increases somewhat rapidly as time increases. Though public transportation in the Greater Helsinki region is quite extensive and reliable, spatial accessibility even within a 30-minute radius is inadequate. There are previously identified large areas that have poor spatial accessibility by public transport to swimming facilities. Insufficient spatial accessibility is eased by metro connections in Otaniemi and Herttoniemi but highlighted to some extent in coastal areas like Laajasalo, Westend and Haukilahti which do not have great public transportation connections.

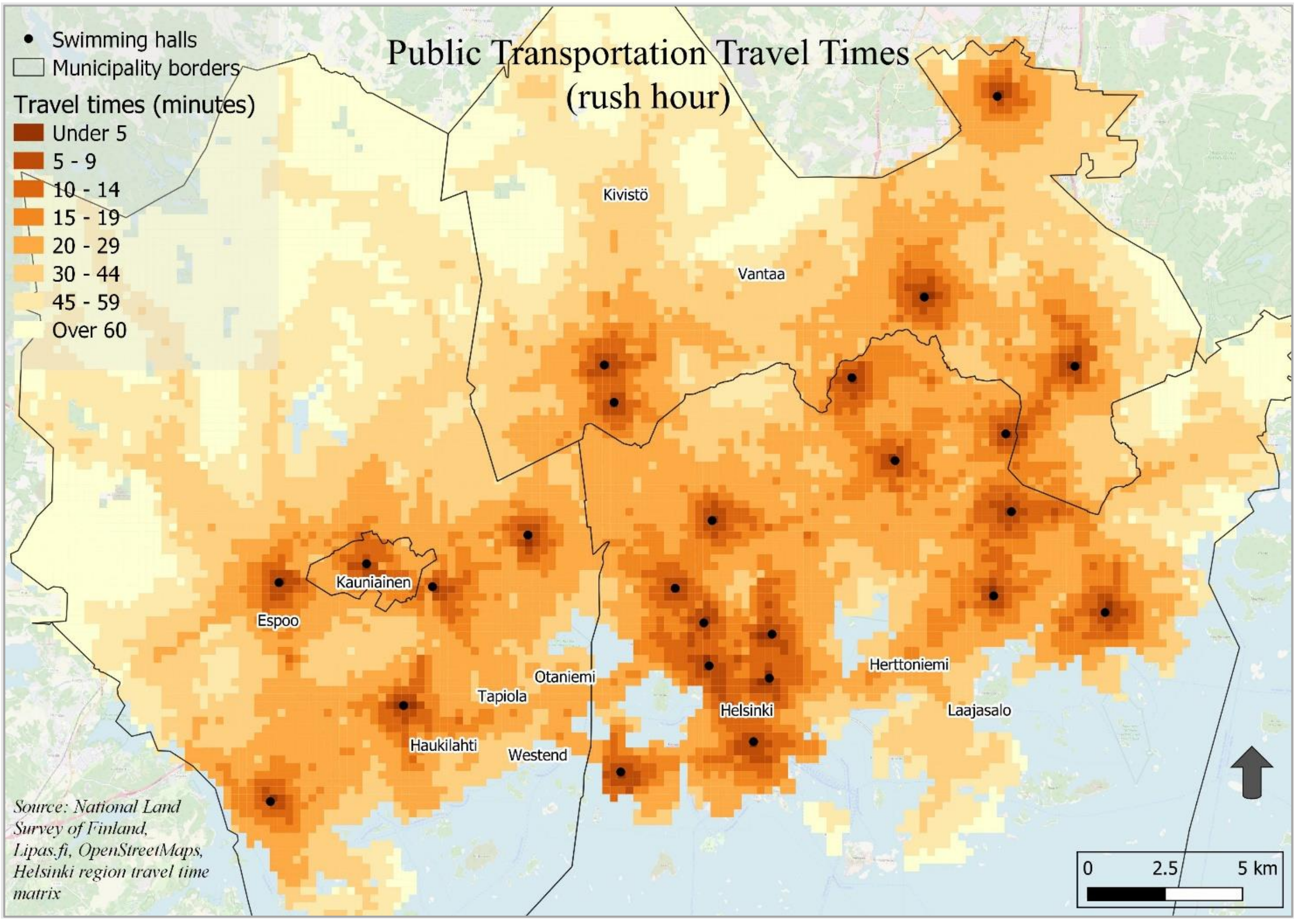

Figure 7. Travel times by public transport (rush hour) to the nearest indoor swimming hall.

Spatial accessibility by car in the Greater Helsinki region is good and is comparable to cycling when it comes to travel time to the nearest indoor swimming facility (Figures 8-9). There is not a significant difference in spatial accessibility when considering the midday and rush-hour travel times by private car. But the difference is more significant than the difference between the midday and rush-hour travel times by public transportation (Figure 3). Practically, all residents can potentially reach the nearest swimming hall by private car within 15-20 minutes during midday whereas rush hour analysis shows a little bit lower travel times. There are no significant remote locations in the Greater Helsinki region where residents living there could not access their nearest swimming hall by private car within half an hour. But certain areas have challenging geography – for example, Laajasalo has longer travel times to the nearest swimming hall than other areas nearby. Using a private car allows people to access also other swimming halls than only the nearest one, but these travel time calculations are measured to the closest one. It is people's personal choices what swimming hall they prefer. This requires an extensive survey and therefore it is not the focus of this study.

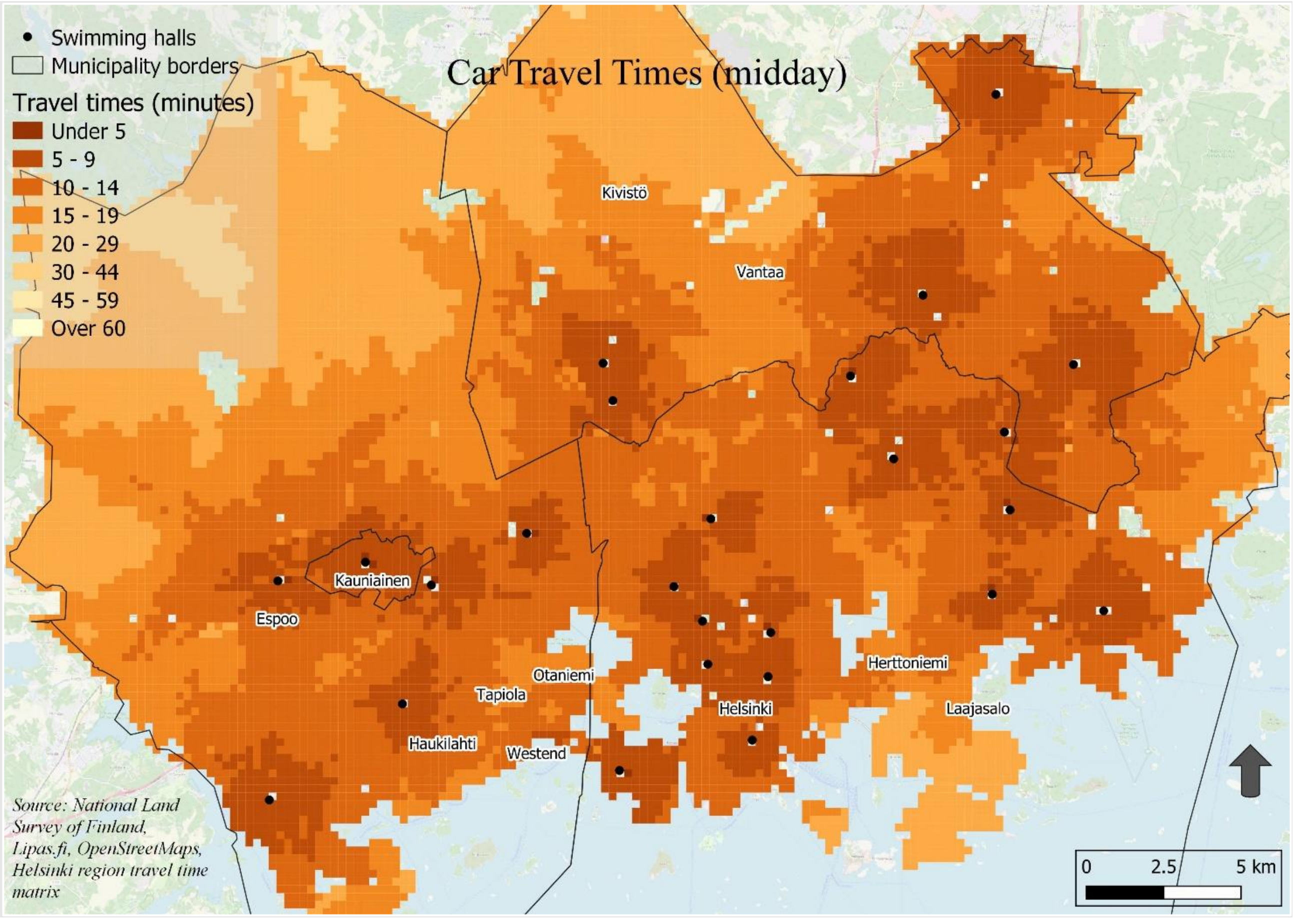

Figure 8. Travel times by private car (midday) to the nearest indoor swimming hall.

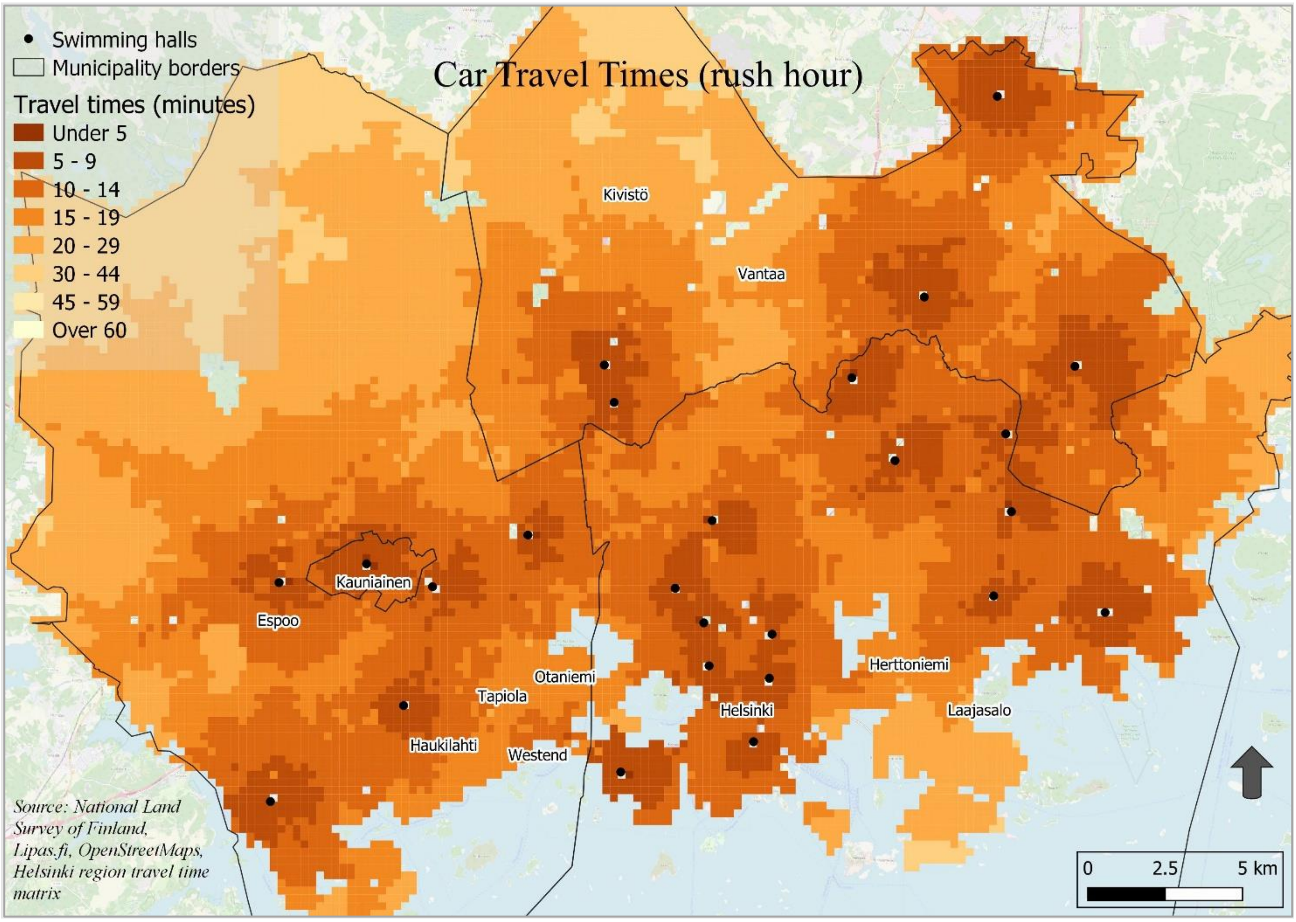

Figure 9. Travel times by private car (rush hour) to the nearest indoor swimming hall.

5.3. Segregation

Figure 10 illustrates the spatial dispersion of socioeconomic differences in the Greater Helsinki region. Values in Figure 10 are adjusted to the average of the region which is set for 100 i.e. if the value is more than 100 the cell is more subject to deprivation than average and if the value is less than 100 it is more advantaged than average. Figure 10 highlights the spatial segregation and clustering of disadvantaged residents. There are multiple clusters of disadvantaged areas but also advantaged clusters. The majority of the highly disadvantaged areas are located in eastern Helsinki but there are also some disadvantaged areas in Espoo and Vantaa that have accumulated clusters of disadvantaged residents.

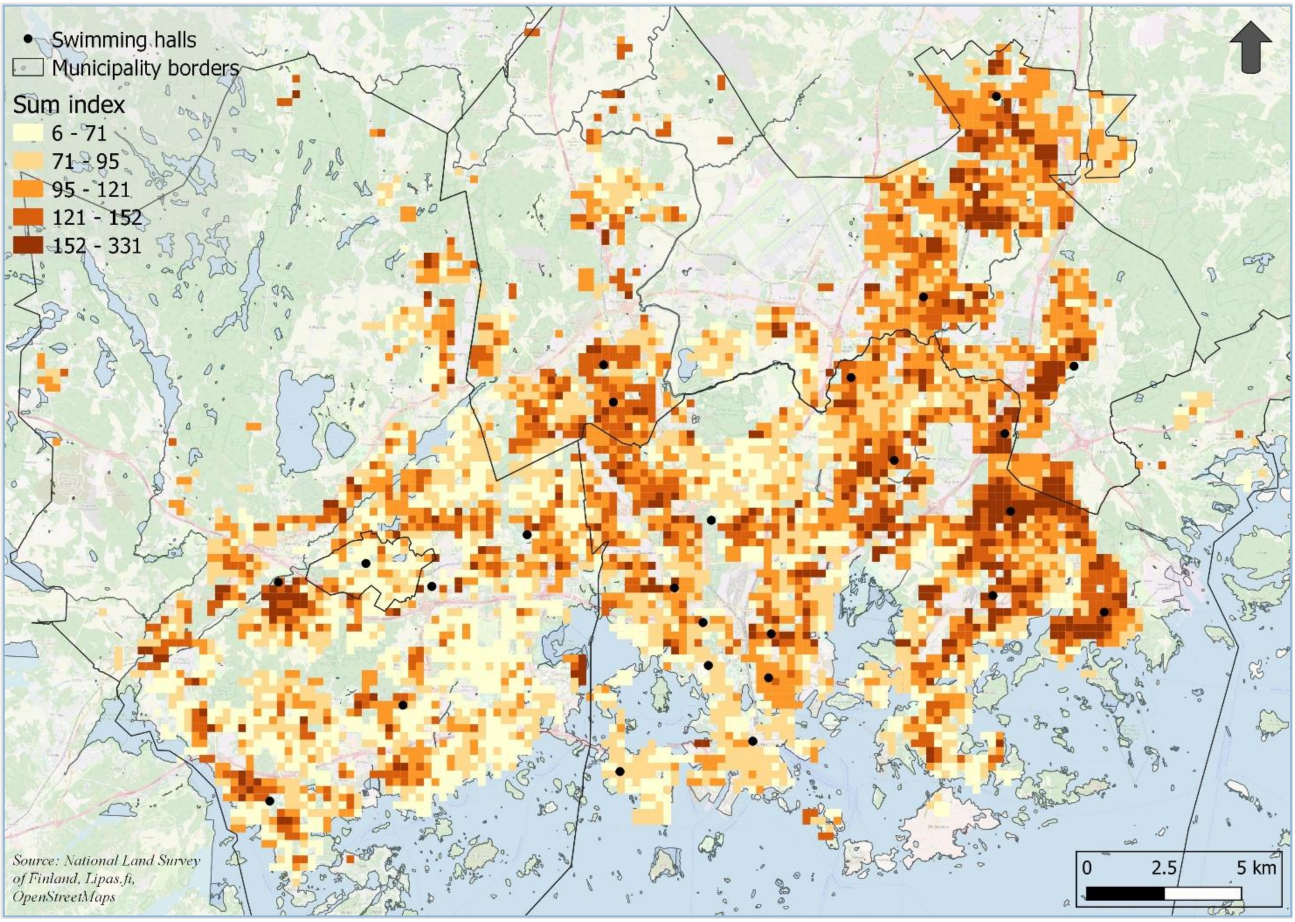

Figure 10. Disadvantage sum index values in the Greater Helsinki region adjusted to an area mean of 100.

Based on the disadvantage sum index (Figure 10) population grid cells were classified into quintiles. Figure 11 shows all quintiles based on the disadvantage sum index in the Greater Helsinki region. Classification into quintiles highlights spatial segregation as the dataset is divided into five categories with an equal number of cells. Interpreting figure 11 there are some clear clusters of blue (advantaged) and red (disadvantaged) clusters around the region. To generalize, western areas are more advantaged and eastern areas more disadvantaged with some pockets of the opposite socioeconomic clusters here and there.

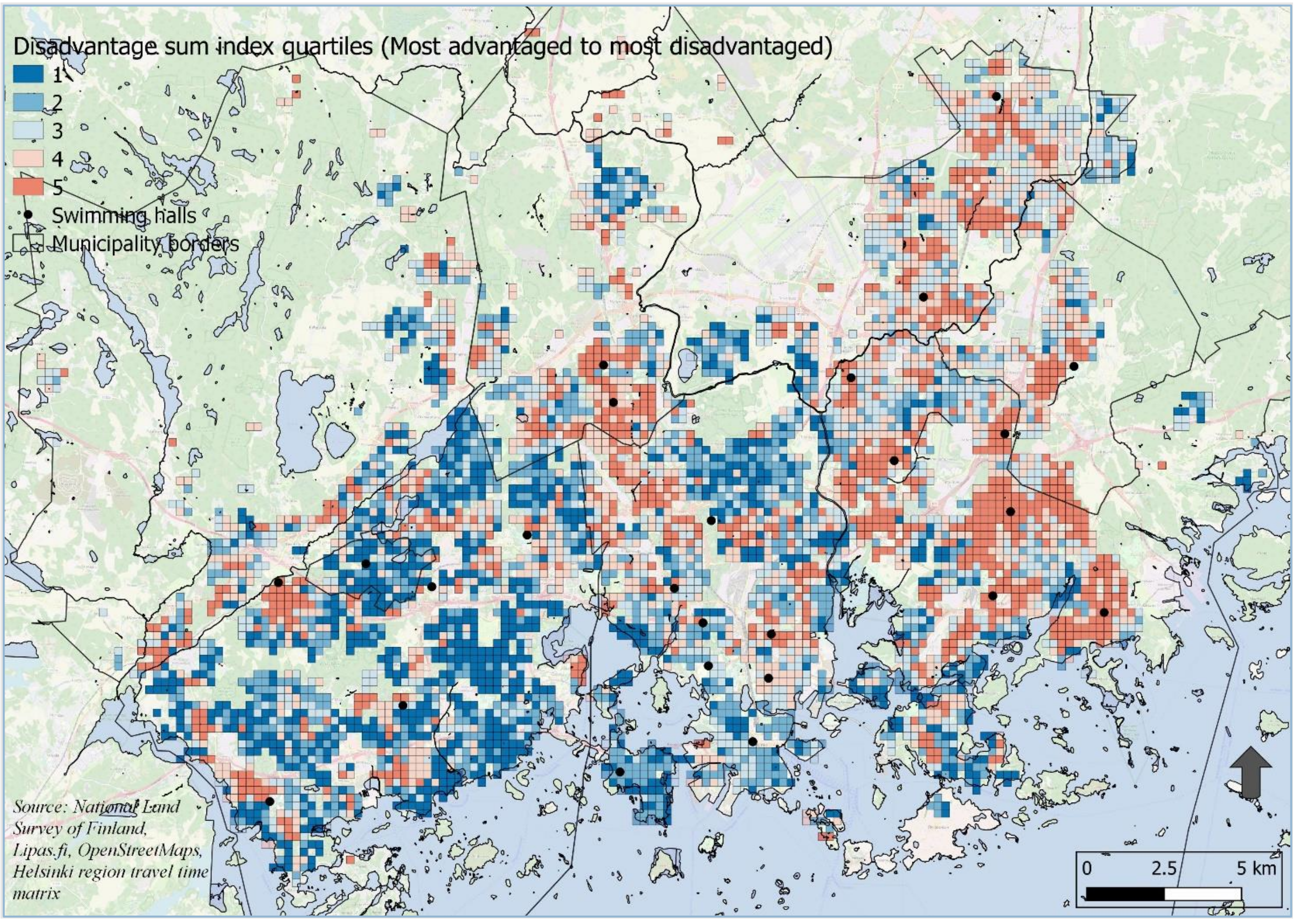

Figure 11. Disadvantage sum index quintiles (from a totally of 4963 grid cells) in the Greater Helsinki region.

Figure 12 illustrates the most advantaged and most disadvantaged quintile cells in the Greater Helsinki region. The majority of most advantaged quintile cells are located in Espoo, namely in the southern and eastern parts of Espoo. On the other hand, there are vast concentrations of the most disadvantaged quintile cells in Eastern Helsinki. Smaller clusters of most disadvantaged quintile cells can be found in each city that seems to have concentrated around connection corridors such as railway stations and the metro line.

The map that includes all the disadvantage sum index quintiles in the Greater Helsinki region (Figure 11) underlines the location of residents above and below-average socioeconomic status in the region. Figure 12 shows only the most advantaged and the most disadvantaged cells, which will be used for analysis later, but figure 11 draws a more realistic picture of segregation in the Greater Helsinki region. For example, central Helsinki consists mostly of advantaged or very advantaged residents as does Espoo in large areas. Kauniainen itself is in a different category compared to other cities in the areas in terms of socioeconomic status.

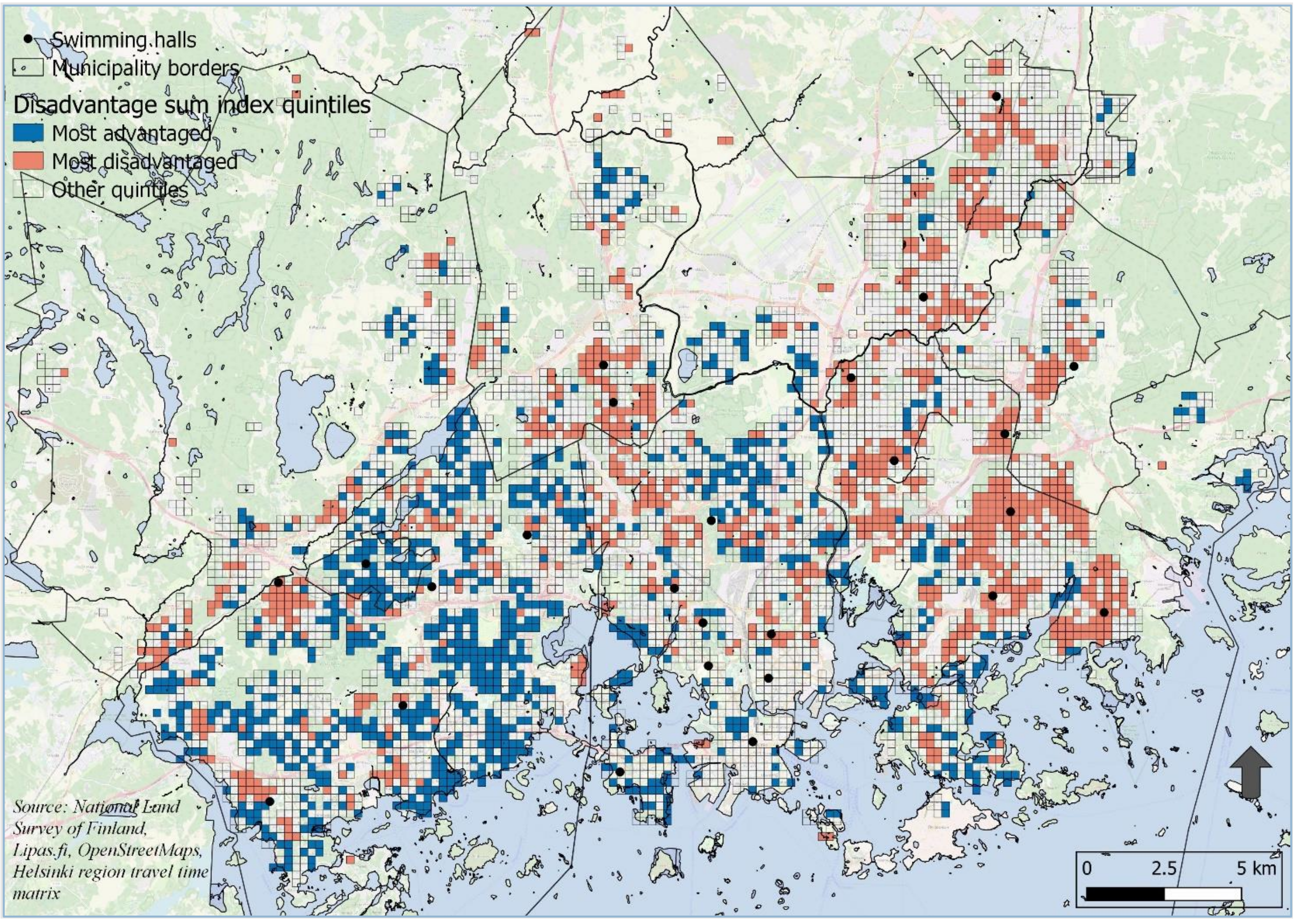

Figure 12. Location of most advantaged and most disadvantaged quintile cells (from a totally of 4963 grid cells) in the Greater Helsinki region.

Based on map analysis (Figure 12) majority of the most advantaged quintile cells in proximity to the swimming hall seem to concentrate around swimming halls in Kauniainen, Kilo, Lauttasaari, and central Helsinki. In addition, Olari swimming hall also has a lot of very advantaged living areas in proximity. The rest of the swimming halls are located in and around the most disadvantaged residents, the population in proximity is mixed or there are neither or the extremes in immediacy to the swimming hall.

The aim of the thesis is not to study the location of spatial accessibility of individual swimming halls but the overall spatial accessibility pattern of swimming halls in the region between the two socioeconomic extreme quantiles, but it should be noted how public sports facilities, for which swimming halls are a case study, in the area a located.

5.4. Comparative statistics between most advantaged and most disadvantaged living areas

When comparing travel times for most advantaged and most disadvantaged quintiles we can get an understanding about residents' equal opportunities to access swimming halls, which are places for the most common types of sports that suit well for example to different age groups and physically disabled people. In this study, mean and median travel times have been calculated for all transportation modes. Travel times, both mean and median, to the nearest swimming hall are slightly significantly smaller for the most disadvantaged quintiles than for the most advantaged. In general, the analyses show shorter travel times for the most disadvantaged areas in comparison to the most advantaged areas (see Figure 13).

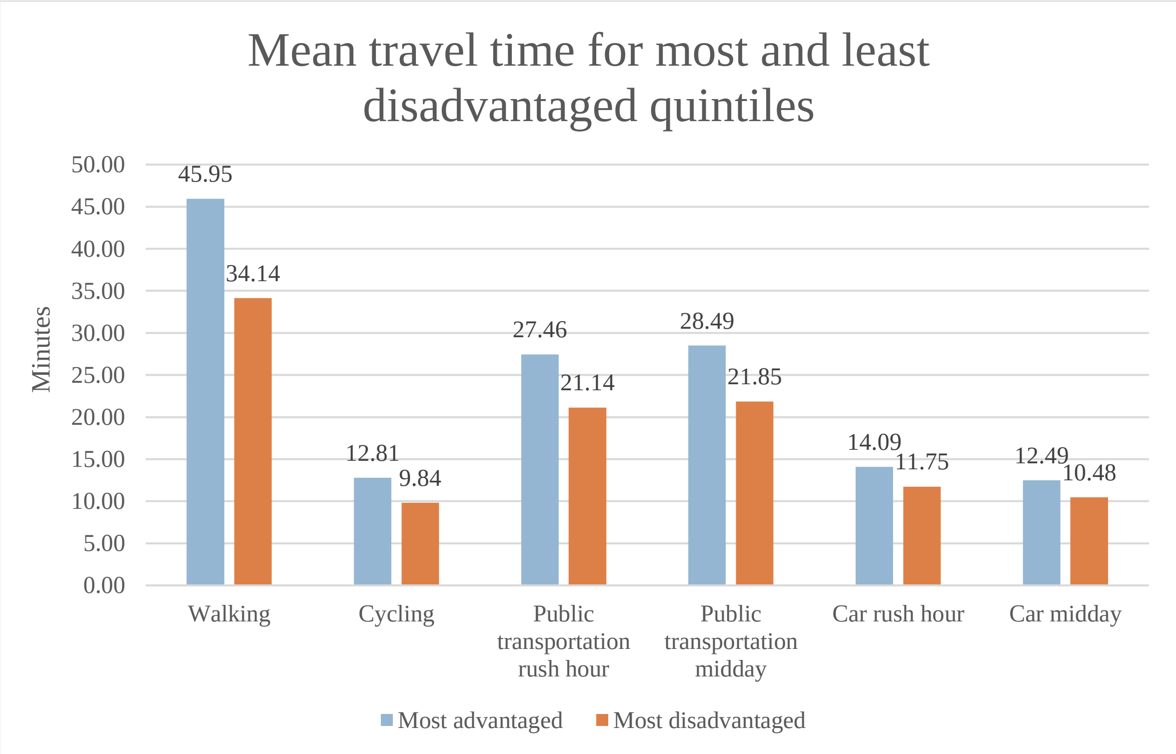

Figure 13. Mean travel times in the Greater Helsinki region for most advantaged and most disadvantaged quintiles (form total of 4963 grid cells) by each transportation mode.

Figure 13 illustrates the mean travel times for most advantaged and most disadvantaged quintiles by each transportation mode. Travel times for the most disadvantaged quintile were shorter across the board. The difference in mean travel times varies between the two compared groups to some extent and is quite extreme at times. The shortest travel times for the most advantaged quintiles to swimming halls are on all types of transportation less than 20% shorter than residents living in the most advantaged quintile areas. The most drastic difference between travel times is for walking which is 34,6%. It does not come as a surprise since looking at the locations of the most and the most advantaged quintile cells in Figures 11-12, a lot of the highly disadvantaged cells are concentrated around swimming facilities and advantaged areas further away from swimming halls.

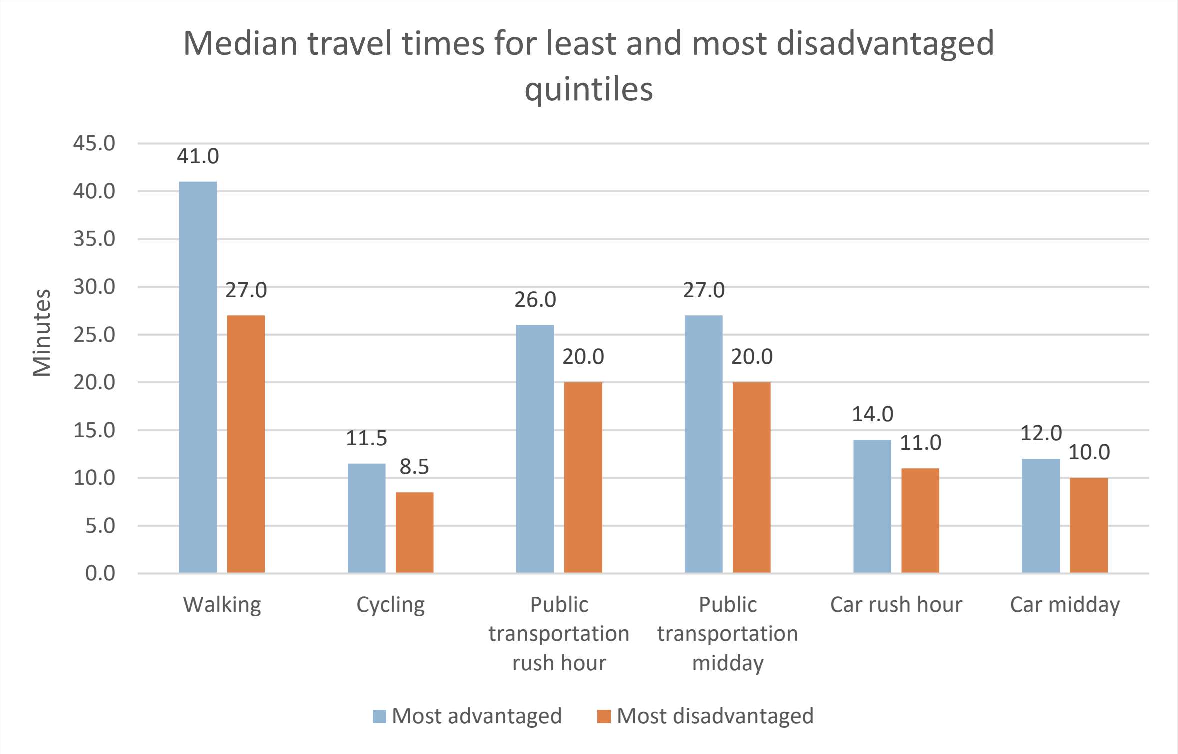

Figure 14. Median travel times to the closest swimming facility for the least and the most disadvantaged quintiles (from a total of 4963 grid cells) in the Greater Helsinki region.

On average, the best mode of transportation in the Greater Helsinki region to access swimming halls is cycling. Residents that live in the most disadvantaged quintile areas can access a swimming hall on average under 10 minutes. Cycling and driving for both the most advantaged and most disadvantaged quintiles are well within the maximum travel time that people are willing to spend commuting for recreational activities as discussed earlier. Worryingly, public transportation travel times are over 20 minutes for most disadvantaged quintile cells and barely under 30 minutes for most advantaged quintile cells. Mean travel times are slightly inflated by some cells that are located very far away from swimming halls so it might be more meaningful to look at media travel times (see Figure 14).

Median travel times are likely to give a more realistic view of differences in travel times between most advantaged and most disadvantaged quintiles. Median travel times in Figure 14 are shorter than in the graph illustrating mean travel times (Figure 13). The median travel time graph highlights the fact that bicycle is the best mode of transportation in this study to access a swimming hall. The most disadvantaged areas can access a swimming hall in 8.5 minutes and for the most advantaged areas, the fastest way is also by cycling in 10 minutes. Driving by private car is still a very competitive mode of transportation, in comparison to cycling, both during the day and during rush hour as a swimming hall can be accessed within 15 minutes in both cases.

Median travel times on public transportation do not make a great difference in comparison to mean travel times. Travel times by public transportation are still 20 minutes for the most disadvantaged quintile and over 25 minutes for the most advantaged quintile. Travel times closer to half-hour are still within the range for decent spatial accessibility but are quite high compared to cycling or driving by which travel times are less than half what it is by public transportation. Travel times by foot are still very high, although, they are lower than mean values.

In figures 15-16 there are cumulative shares of living areas that can be reached in different travel times when considering population catchment areas around the swimming halls by each mode of transportation for the most advantaged (figure 15) and most disadvantaged (figure 16). Spatial accessibility to a swimming hall by these types of transportation, according to the results, fall into two categories; cycling and private cars have great accessibility whereas public transportation and walking have significantly worse spatial accessibility.

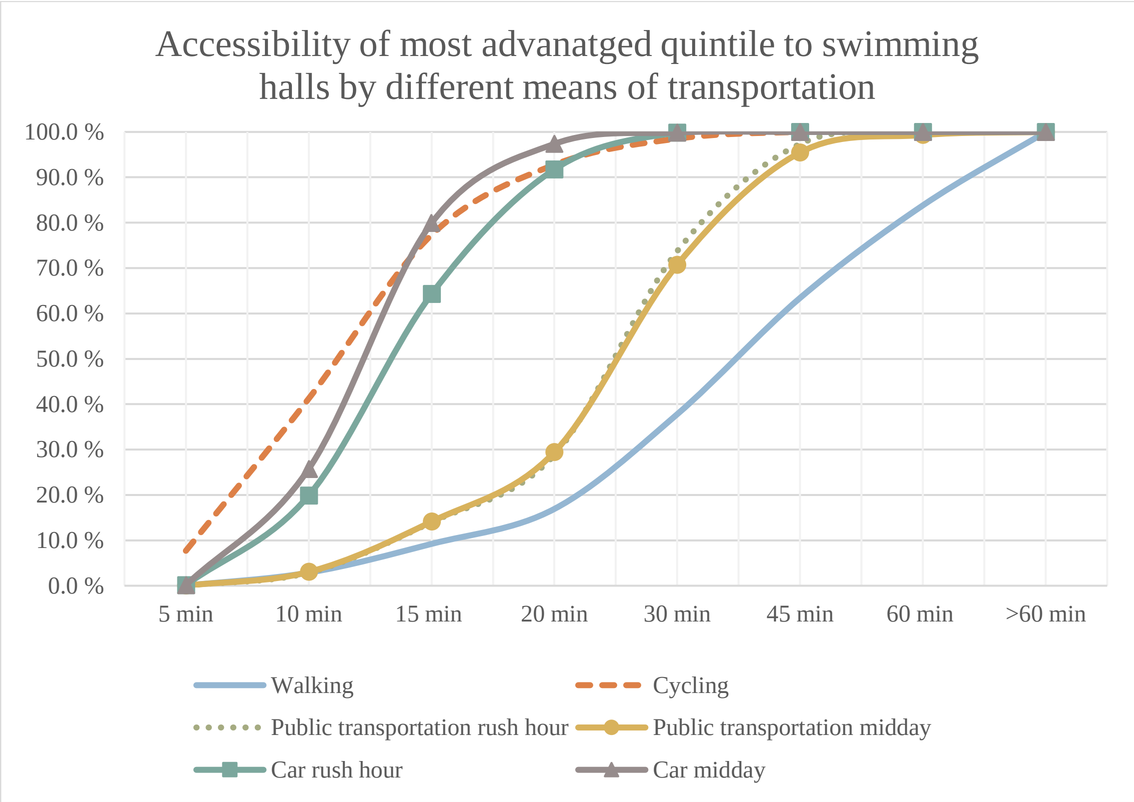

Figure 15. Cumulative share of most advantaged quintile cells by each mode of transportation.

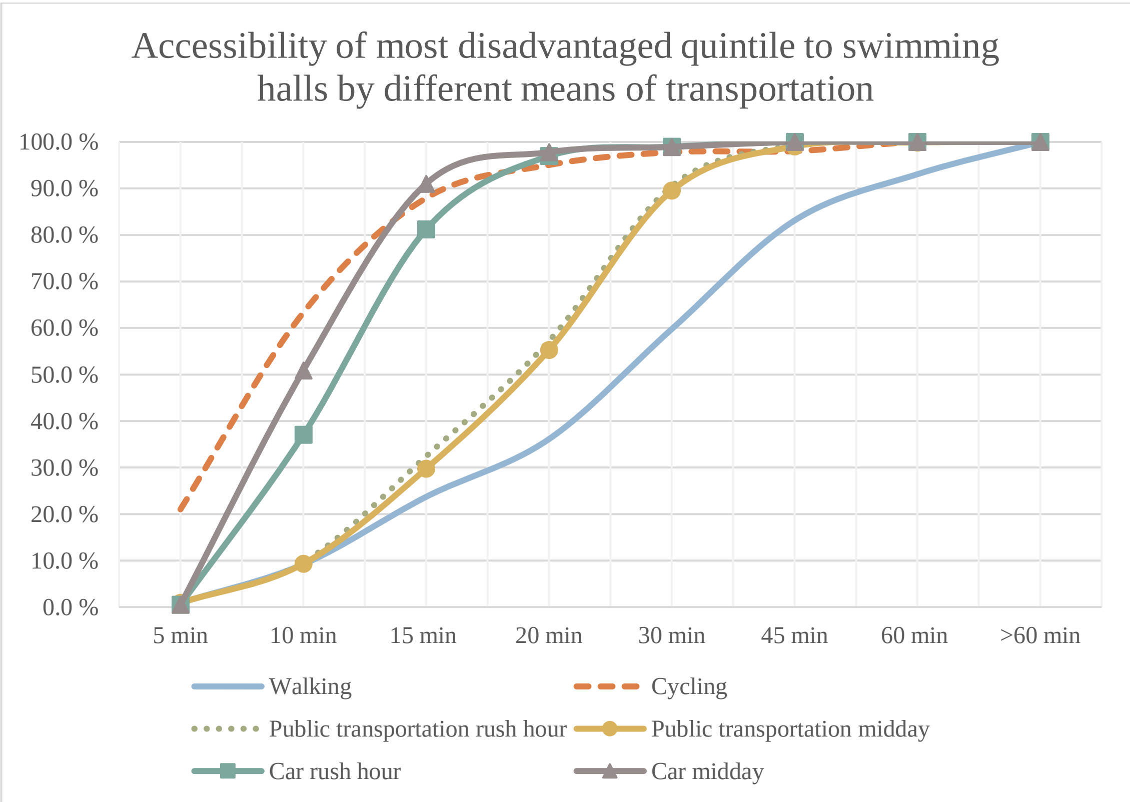

Figure 16. Cumulative share of most disadvantaged quintile cells by each mode of transportation.

Comparison between each mode of transportation for most advantaged and most disadvantaged cells is found in Figure 17 (blue for most advantaged and orange for the most disadvantaged). It is evident that travel times for each mode of transportation modes are shorter for the most disadvantaged than they are for the most advantaged. Differences between the travel times are not significant but they are still significant and follow a similar pattern. Travel time differences are the most drastic in the short distances, under 20 minutes travel times and even out after that. Larger graphs of individual travel times can be found in Figures 18-23 in Appendix 1.

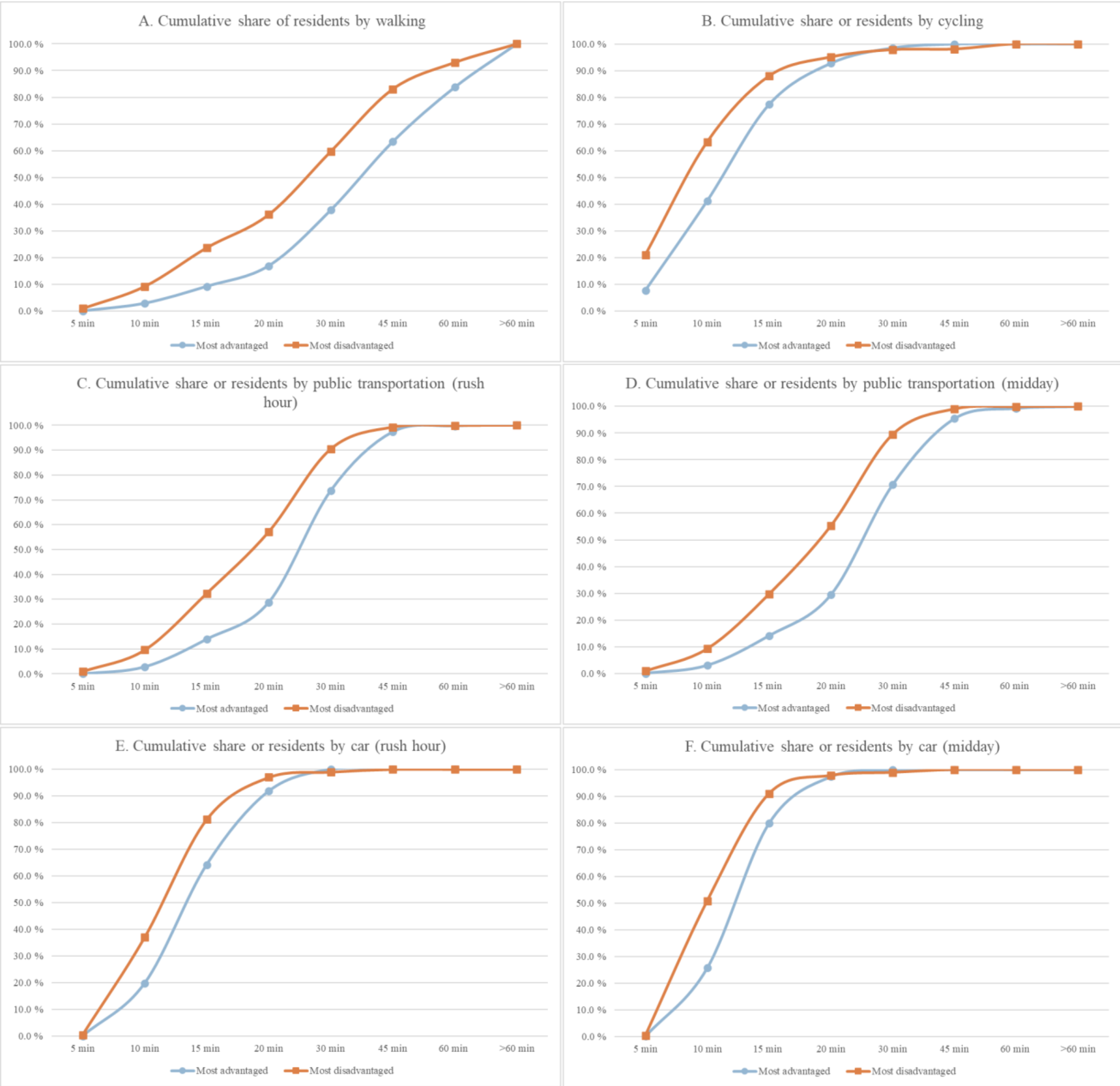

Figure 17. Cumulative share of living areas when considering travel times to the nearest indoor swimming facility for all means of transportation by most and least disadvantaged quintiles. Types of transportations in the Figure are: A) Walking, B) Cycling, C) Public transportation (rush hour), D) Public transportation (midday), E) Car (rush hour) and F) Car (midday).

Student’s t-test was conducted to verify the statistical significance between the travel times for the most advantaged and the most disadvantaged cells in the Greater Helsinki region. Student’s t-test was carried out in all the cities in the study area in addition to the Greater Helsinki region to see if travel times vary within each city. Results for the Student’s t-test are in Table 5.

Table 5. Student’s t-test results for each area of interest and all types of transportation.

	Independent Samples Test														
	Helsinki metropolitan region			Helsinki			Espoo			Vantaa			Kauniainen		
	t	df	p-value	t	df	p-value	t	df	p-value	t	df	p-value	t	df	p-value
Walking	9.769	1 980	**<0.000**	9.624	800	**<0.000**	-0.098	643	0.922	8.312	508	**<0.000**	-1.920	31	0.064
Cycling	9.661	1 963	**<0.000**	9.701	802	**<0.000**	0.666	638	0.505	8.408	501	**<0.000**	-1.244	31	0.223
Public transport (rush hour)	13.857	1 983	**<0.000**	12.284	804	**<0.000**	3.198	643	**0.001**	8.852	508	**<0.000**	-2.021	31	0.052
Public transport (midday)	13.410	1 983	**<0.000**	11.812	804	**<0.000**	2.267	643	**0.024**	9.735	508	**<0.000**	-1.820	31	0.079
Car (rush hour)	11.770	1 970	**<0.000**	9.773	798	**<0.000**	2.301	642	**0.022**	10.568	506	**<0.000**	-0.668	31	0.509
Car (midday)	11.928	1 969	**<0.000**	10.177	798	**<0.000**	2.109	642	**0.035**	10.679	505	**<0.000**	-0.536	31	0.596

Student’s t-test was conducted for the study to see if there are statistically significant differences looking at the travel times to swimming halls from most advantaged quintile cells and most disadvantaged quintile cells. In the whole study area, the Greater Helsinki region, it is evident that there are clear statistically significant differences in travel times between the most advantaged and the most disadvantaged quintiles. Statistically, significant differences applied to all types of transportation, but the most significant difference was with public transportation. In the city of Helsinki, the results of the Student’s t-test were similar. Statistically significant differences were found for each mode of transportation with public transportation having the highest differences. Statistical significance was also found in Vantaa where the strongest difference was for private cars instead of public transportation.

However, the statistically significant differences did not apply to all areas of interest. In Espoo, the threshold for statistically significant differences was not exceeded for walking and cycling. The threshold for statistical significance is p=0.05 which all the rest of the types of transports comfortable fall below. This means that there is less than a 5% chance of being wrong to claim that there is a statistically significant difference in travel times between the compared groups. statistically, significant differences were not found in Kauniainen, but the analysis would not be valid since the sample size in the area is too small and the city has such a high socioeconomic among its population that this type of analysis would not apply.

6. Discussion

Based on the results of the study, it can be said that the spatial accessibility to swimming halls is generally adequate. Swimming halls are expensive and demanding to develop and maintain so it is reasonable that the number of swimming facilities is limited. The limited number of facilities is bound to create gaps in the service network which might be problematic in terms of equality and equal spatial accessibility.

6.1. Travel times and location of swimming halls

Travel times people are willing to spend commuting for swimming facilities have been studied and based on these studies we can consider 30 minutes to be sufficient and 15 minutes to be in proximity (Apparicio et al., 2007; Kenworthy & Laube, 1999; Spinney & Millward, 2013). Since these thresholds are gathered from various sources there will be some generalization and these thresholds will be considered for all types of transportation analysed in the study. 30 minutes by walking and driving is a significantly different commute so applying justified travel time thresholds for different types of transportation will have to be done.

As I have discussed earlier in the thesis, a connection between lower socioeconomic status and health issues and lack of physical activity has been shown. Mixed results have been given about the spatial accessibility to sports facilities between different socioeconomic groups (Estabrooks et al., 2003; Lamb et al., 2012; Powell et al., 2006), but the results of this study are evident that spatial accessibility to swimming halls is quite significantly better for most disadvantaged people in the Greater Helsinki region than for most advantaged. It was shown that the most disadvantaged residents have access to a swimming hall by bicycle or by car in 15 minutes and 90% can access a swimming hall in 30 minutes. Travel times to the nearest swimming hall fit comfortably within the thresholds established so swimming halls can be claimed to be located well.

Swimming halls in Finland are owned almost exclusively by the public sector which means that the owners of the facilities are obligated to perform the duties addressed by the Act on the Promotion of Sports and Physical Activity (390/2015). One of the main goals and purposes of the Act on the

Promotion of Sports and Physical Activity is to promote equal sports opportunities for everybody. Public investments are always a trade-off between resources and setting locations (Owen & Daskin, 1998, 425). As Delafontaine et al., (2011, 278) proposed there are multiple approaches to provide accessible public services that emphasize different things. Trade-offs in public investments constantly face the issue of allocating resources for which there are a few different ways that apply to swimming halls. Delafointe et al. (2011, 278) continues that approaches are the following: utilitarian, egalitarian, and distribute. The utilitarian approach maximizes accessibility whereas the egalitarian approach treats all the people the same. The distributive approach on the other hand aims to weigh certain sociodemographic groups differently i.e., it is based on the idea of allocating resources where they are the most needed. The distributive approach is especially important in public investments as libraries or sports facilities for people that potentially rely on public facilities.

A relatively sparse network of swimming halls in the Greater Helsinki region is bound to create gaps for the public. Although the spatial accessibility in the Greater Helsinki region is generally good, some areas have below average spatial accessibility to swimming halls. In terms of absolute spatial accessibility, especially northern Espoo, northwestern Vantaa, and eastern Helsinki have significant challenges to access a swimming hall. Most of these are not major issues though since these areas are quite sparsely populated. In Espoo, there is a small gap around Tapiola and Otaniemi as both areas have had a swimming hall shut down in the 21st century. In Helsinki, the easternmost part of the city, Östersundom, is currently on hold in terms of development but in the future, there might be potential pressure for further public sports facility investments. The gap that affects most people is the southeastern Helsinki archipelago. The Island of Suomenlinna is an extremely challenging place for spatial accessibility, as the only way to the island is by ferry. Accessing any more special service or facility from the island will require the ferry trip which alone takes about 20 minutes. Areas around Herttoniemi and Laajasalo, and if Santahamina gets planned in the future, there will most certainly be increasing pressure around the area for a swimming hall. There are already a significant number of residents living in the area and current developments will increase the population on the island even more.

6.2. Difference between the cities

Cities in the Greater Helsinki region, all act as their individual cities and municipalities even though they form one unified urban area. Different history and planning policies in the cities have created unique cities compared to one another with different demographics and spatial structures. One of the research questions for the study was to see how the cities varied from one another in most advantaged and most disadvantaged mean travel times.

Statistical analysis on mean travel times found in Table 5 and the difference of mean travel times to swimming halls (Figure 25 in Appendix 2 in each study area highlights the difference between the cities. Though results in the City of Kauniainen alone are inconclusive there is a pattern visible for other study areas. Travel times for all types of transportation are significantly shorter for the most disadvantaged in the Greater Helsinki region, Helsinki, and Vantaa. These results were also validated by the Student's t-test which showed statistically significant differences for all types of transportation in these areas. Espoo on the other hand has by far the smallest travel time differences between the most advantaged and the most disadvantaged cells to a swimming hall and there was no statistical significance shown for the difference for cycling and walking.

The reason for such a drastic difference between the City of Espoo and other cities might lie in the urban structure and planning policies of the cities. In Helsinki and Vantaa, the highest population concentrations are in the central areas. In Helsinki highest population densities are found close to the Centre and around metro and train stations which is a similar case to Vantaa. Conversely, in Espoo population density is much more evenly distributed around the city area. There are some more densely populated areas, but the population density is not as polarized as it is in other cities. One explanatory factor might be the housing stock in the cities. Espoo has relatively much more detached housing and row houses in comparison to Vantaa and Helsinki. The common opinion about the City of Espoo is that the urban structure there can be described as a "city without a centre" or "a collection of suburbs". Vast areas of Espoo consist of low-rise housing and services are centralized for traffic junctions.

6.3. Swimming hall locations in urban population structure

A key factor to explain the significant difference in travel times to swimming halls is the location of the swimming facilities in relation to population. Swimming halls, as they are sparse due to the expensive nature of the facilities, are often located in a central location to be in proximity to as many people as possible. Often these moderately high population areas are also traffic junctions or other transportation nodes that are easily accessible for as many people as possible. Many of the swimming halls in the study area are in the suburban areas in Helsinki, Espoo, and Vantaa. These suburb centres where the swimming halls are located have a higher concentration of disadvantaged people due to the price of housing and housing stock.

The preferred form of living is often being near the centre in Helsinki whereas it is more popular in Espoo to live in a suburban setting (City of Helsinki, 2019b).In Espoo, patterns of living are different and detached housing and rowhouses are more common than in Helsinki. Different housing standards can also be noticed from the number of cars that residents in Espoo have in comparison to Helsinki (Helsingin Sanomat, 2019). In 2019, households in Espoo have 0.83 cars in use on average whereas the number in Helsinki is 0.5. These statistics point to the fact that residents in Espoo are more reliant on private vehicles and housing is more scattered than in Helsinki. Even though the population in Espoo might be more scattered than in Helsinki, travel times were on par with Vantaa (Figure 25 in Appendix 2). The travel time difference between the most advantaged and the most disadvantaged cells was significantly smaller than in other study areas, almost non-existent (Figure 24 in Appendix 1). Results of the Student's t-test also confirm that in Espoo, socioeconomic status does not make as much difference in spatial accessibility to swimming halls as in other cities in the study.

6.4. Spatial differentiation

In addition to travel time analysis, Population grid database was used to study segregation and spatial differentiation in the Greater Helsinki region. The disadvantage sum index was used to locate the most advantaged areas as well as the most disadvantaged areas and identify potential clusters or patterns. Spatial segregation patterns (Figures 10-12) show similar results to findings by Vilkama (2011, 103). It is evident that in Eastern parts of Helsinki there are clusters of a cumulative disadvantage. Similar clusters can be found around metro and train stations in other cities of the study.

It is unlikely that there is causality in more disadvantaged people living closer to swimming halls than the advantaged people, but it can be considered to be potentially a good thing. More disadvantaged sociodemographic groups tend fewer options in terms of mobility. Disadvantaged sociodemographic groups rely more on public transportation, walking and cycling compared to more advantaged sociodemographic groups that have a higher probability of having access to private cars as transport.

This study has focused solely on the spatial accessibility of swimming facilities but that is just one aspect of accessibility-related to physical activities. It has been shown that even though certain demographics would have access to physical activity facilities in terms of travel times, lower socioeconomic status people are less likely to facilities that charge an entrance fee (Giles-Corti &

Donovan, 2002, 608). Results of this thesis indicate similar outcomes based on prior literature. In the Greater Helsinki region residents living in the lower socioeconomic areas have better accessibility to swimming halls than those living in more advantaged areas. Assuming based on international studies that lower socioeconomic classes in Greater Helsinki region tend to engage less in physical activity as well, it might be worth pondering how swimming hall accessibility could be increased for disadvantaged residents.

6.5. Study evaluation

Overall, I think that the data, especially travel time analysis, is quite solid and holds for a type of analysis that was conducted in this thesis. Data is comprehensive and available for quite a large area, that covers the whole population of the Greater Helsinki region, almost a fifth of all the Finns. It is great that the data covers all the main types of transportation as well as rush hour and midday travel times for public transportation and cars which allows comparative analysis between the transportation modes.

LIPAS sports data, as it is updated by municipalities or other sports facility operators, might be out of date to some extent. In this study, the most important information about the dataset was the location of the swimming halls and the ownership, two things that rarely change when it comes to swimming halls. In addition, the number of swimming halls was considerable low so that manual checking could be done. This might not be the case if there would be more points of interest in the study where manual validation of the data is either not possible in a reasonable time or due to lack of information about the study subjects.

The disadvantage sum index was calculated using the Population grid database from Statistics Finland which is quite comprehensive but lacks some information due to privacy reasons increases the chance of inaccuracy. If there are less than 3 or 10 objects in the cell, depending on the sensitivity of the topic, the data is set as *NODATA*. Protecting data might turn out to be more significant as data is generalized. Generalizing the disadvantage sum index into quintiles, without considering the number of residents at all, could potentially have skewed the results. The risk lies in both the population grid database and the generalization of data as we produce the data further the more chances there are for data to be incorrect. The way the analysis was done in this thesis only a few subjects could potentially distort the data one way or another if in some cells there happens to be only a handful of very advantaged or very disadvantaged people.

The data and the equation used for the disadvantage sum index should also be a potential liability. The equation that was before used in other studies and for example City of Helsinki's reports measures accumulative disadvantage but fails to be exact. For example, the unemployment percentage takes into account only working-aged residents and thus does not factor the elderly into the equation. Data protection for cells with a low sample size poses the same threat as previously mentioned. That being said, the population grid database suits quite well to study high or medium dense areas but fails to at rural areas where the sample sizes are small.

6.6. Suggestions for future research

Accessibility in this study was examined by travel times to public indoor swimming halls. Although the data to study travel times was quite comprehensive, it could also be described one-dimensional as the grunt of the analysis was based on spatial accessibility. There is very little data available on swimming hall visitors which makes evaluating allocating the facilities hard. User surveys and background information of the visitors could potentially make the analysis more detailed as there is further information on who are the actual users of the swimming halls instead of who has the potential to use swimming halls. More detailed user data in addition to the gravity model would help researchers understand the spatial patterns in the city and how far people are willing to travel for a certain, potentially bigger, swimming hall.

Adding a social dimension to the accessibility analysis could turn out useful for identifying the obstacles people face using sports facilities. The topic was briefly touched on in this study but studying why people do not want to use a given sports facility in the Greater Helsinki area has potential.

Spatial accessibility and travel time analysis can potentially provide a piece of further information on planners and when allocating future swimming hall developments. Spatial accessibility analysis combined with allocation approaches proposed by Delafontaine et al., (2011), can help to recognize the demand or need for a public sports facility investment where it is most dire.

7. Conclusions

The goal of the thesis was to study statistical differences in travel times to the nearest public indoor swimming hall between the most advantaged and the least advantaged quintiles in both the Greater Helsinki region as well as each city individually.

The results show a strong statistically significant difference between the most advantaged and the most disadvantaged mean travel times to public indoor swimming halls. The study results show that the most disadvantaged areas had better potential spatial accessibility to swimming halls than the most advantaged areas. The difference was especially statistically significant in the Greater Helsinki area, Helsinki, and Vantaa. In the City of Espoo, statistically, significant differences were not found in either public transportation nor private car methods but for walking or cycling. Results in the City of Kauniainen was inconclusive due to the small sample size. Based on prior literature and map analysis, spatial differentiation in the Greater Helsinki region has increased and occurs as clusters around the study region. The most notable spatial differentiation clusters were disadvantaged clusters in the eastern part of Helsinki and vast advantaged areas in Espoo, but smaller clusters of advantaged and disadvantaged cells were found around the area.

Results and the produced materials such as figures and graphs can be used to identify gaps in the Greater Helsinki region network of public swimming halls. Further analysis on the accessibility of the extreme quintiles might help allocate public resources in the future in terms of providing equal spatial accessibility to swimming halls for the ones that need it the most.

To complement data, methods, and the results of the study, a more detailed approach to swimming hall users will come in handy. Visitor surveys, more data on visitors' home city/area or spatial mobility data can reveal spatial patterns of swimming hall visitors in more detail. This study only considered residents' travel times to the nearest indoor swimming facility but that might not always be the case as people might visit the swimming hall while commuting to work or school. Further data into visitors' background and swimming hall experience could give an insight on who the visitors are and why certain sociodemographic groups might not visit as often as other groups do and if the location of the facilities is successful in what it tries to achieve.

8. Acknowledgements

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Appendix 1. Cumulative share figures

Figure 18. Cumulative share of living areas by walking to the nearest swimming hall for the most advantaged and the most disadvantaged quintile cells in the Greater Helsinki region.

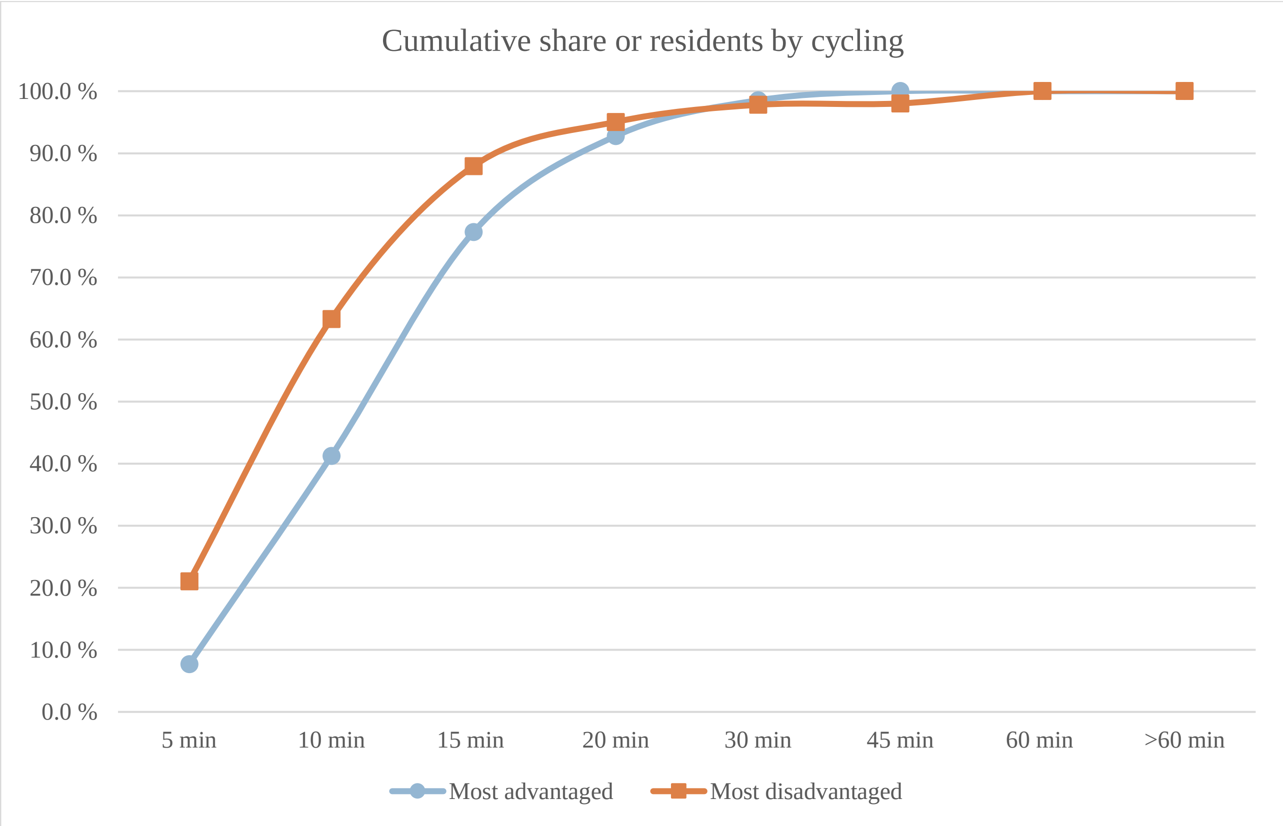

Figure 19. Cumulative share of living areas by cycling to the nearest swimming hall for the most advantaged and the most disadvantaged quintile cells in the Greater Helsinki region.

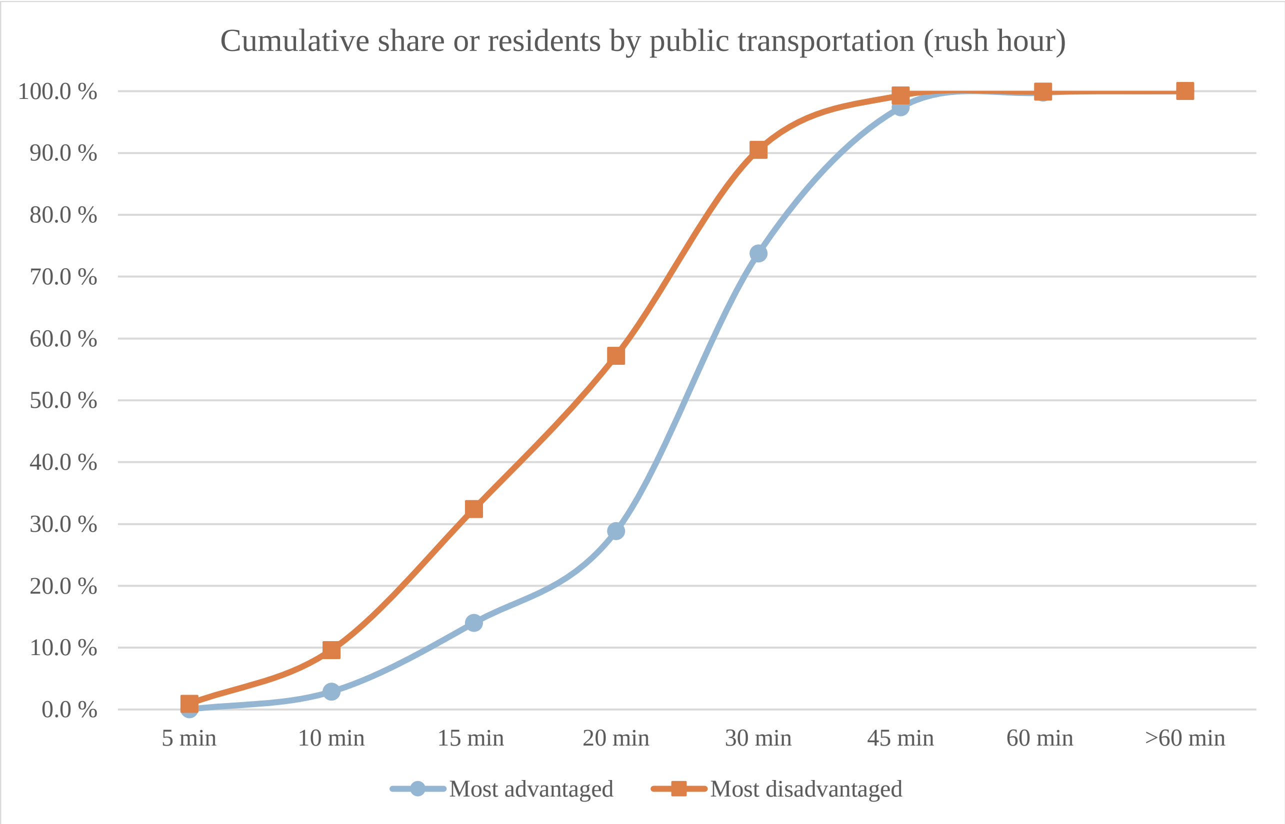

Figure 20. Cumulative share of living areas by public transportation (rush hour) to the nearest swimming hall for the most advantaged and the most disadvantaged quintile cells in the Greater Helsinki region.

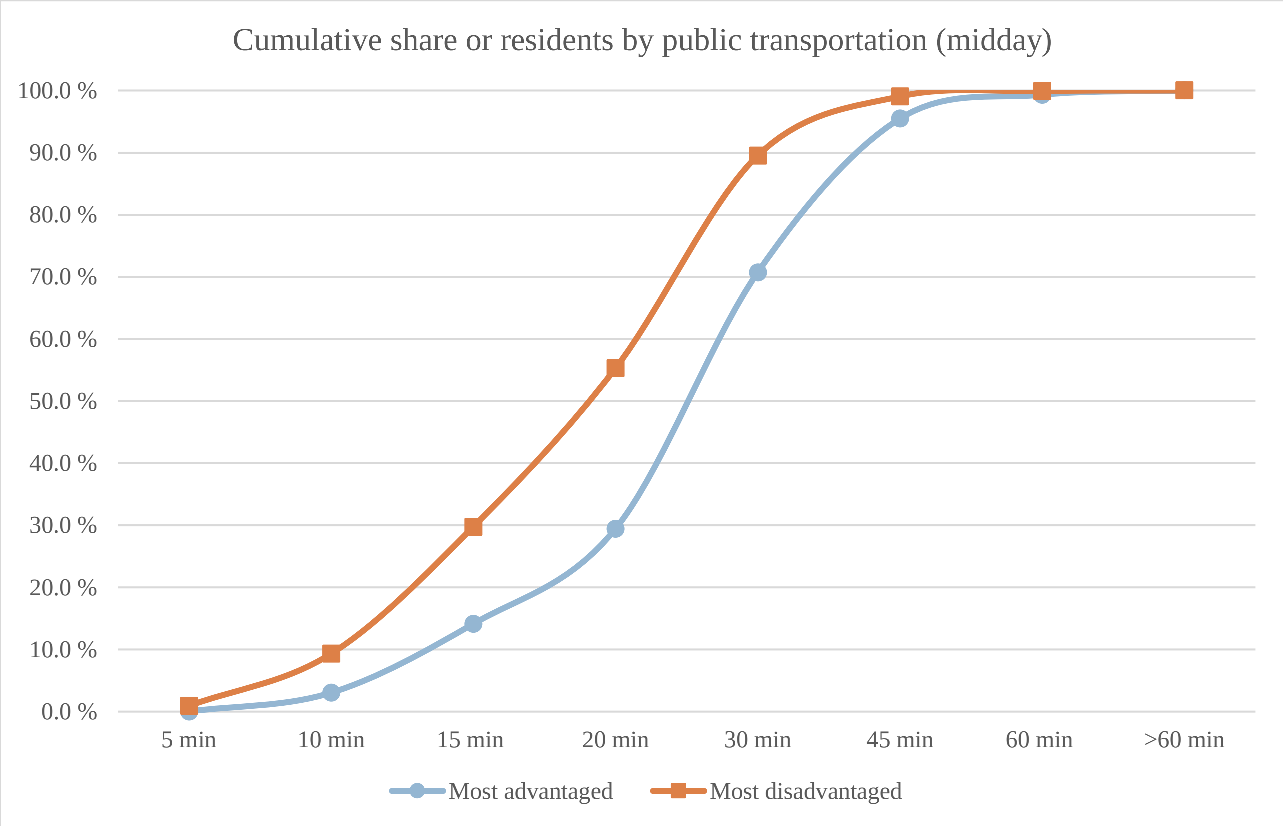

Figure 21. Cumulative share of living areas by public transportation (midday) to the nearest swimming hall for the most advantaged and the most disadvantaged quintile cells in the Greater Helsinki region.

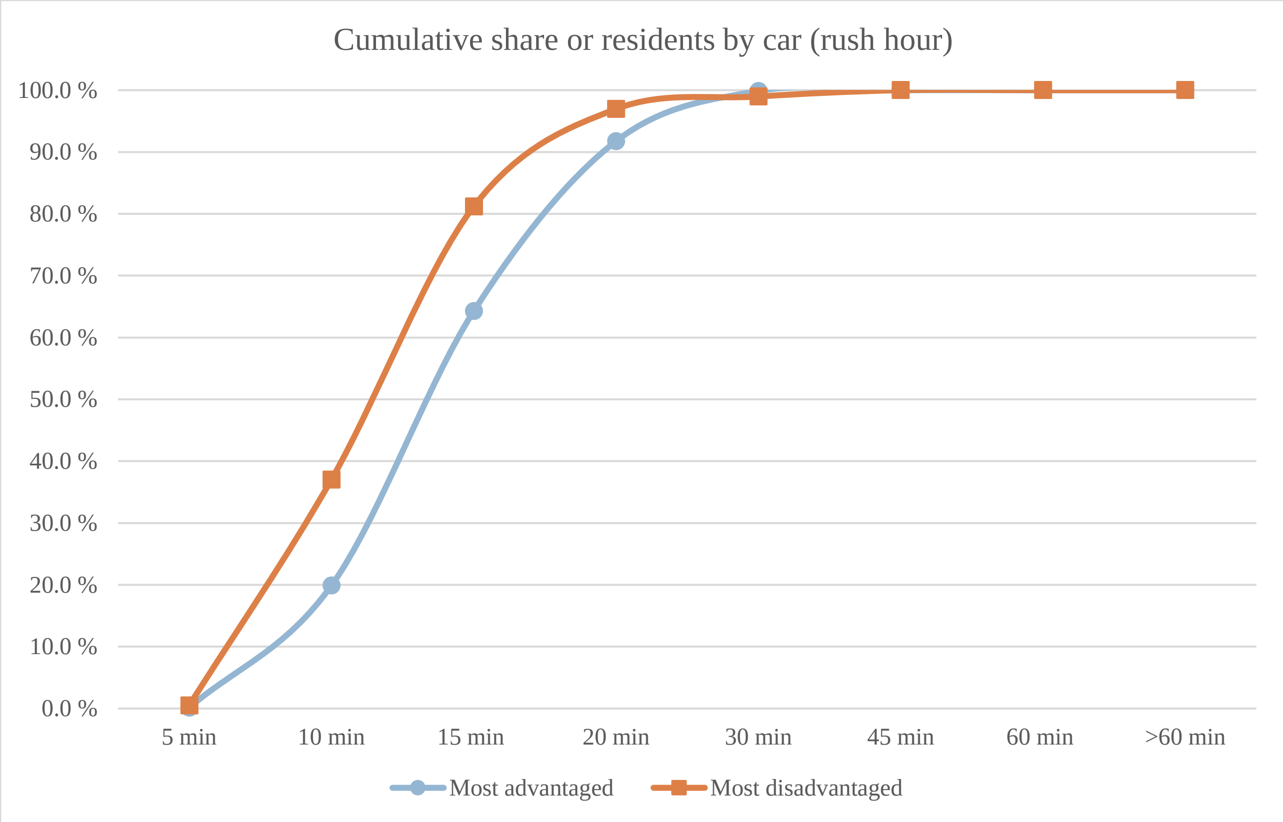

Figure 22. Cumulative share of living areas by private car (rush hour) to the nearest swimming hall for the most advantaged and the most disadvantaged quintile cells in the Greater Helsinki region.

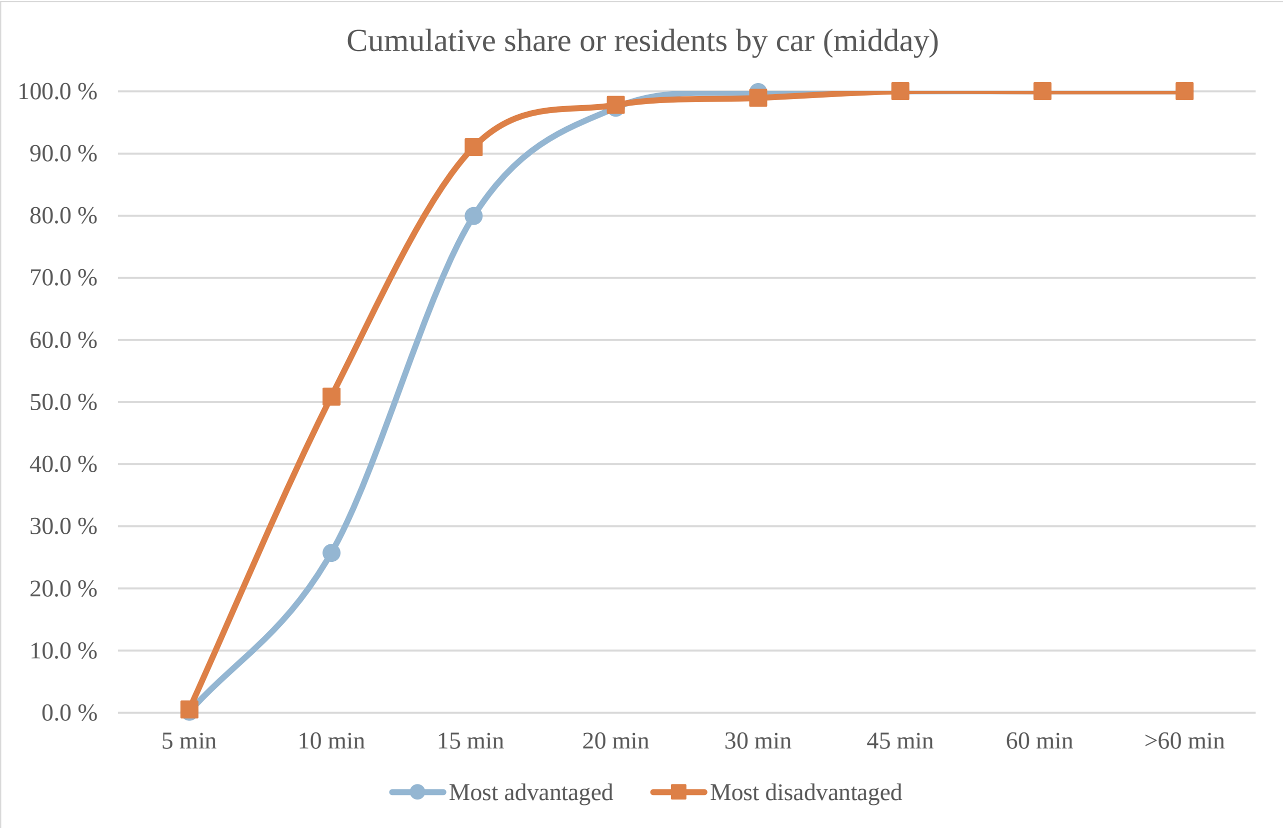

Figure 23. Cumulative share of living areas by private car (midday) to the nearest swimming hall for the most advantaged and the most disadvantaged quintile cells in the Greater Helsinki region.

Appendix 2. Mean travel times and shares of each quintile cells from swimming halls

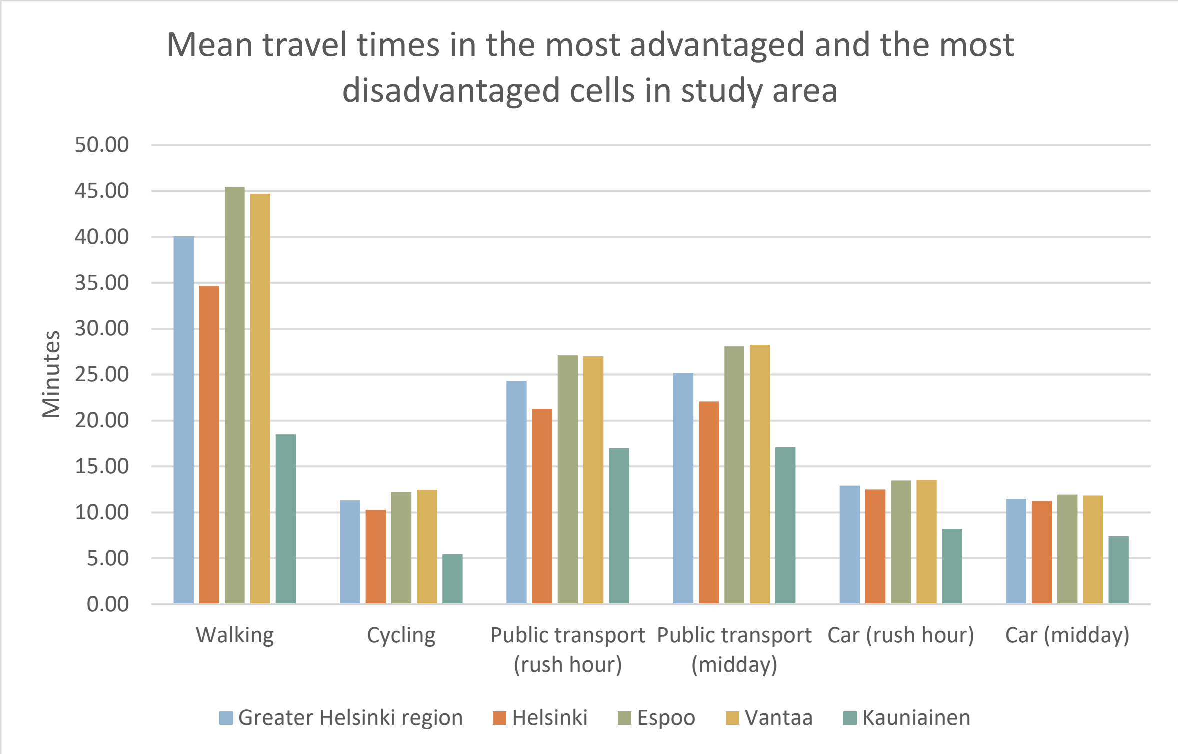

Figure 24. Average travel time in the most advantaged and the most disadvantaged cells in different cities of the study area.

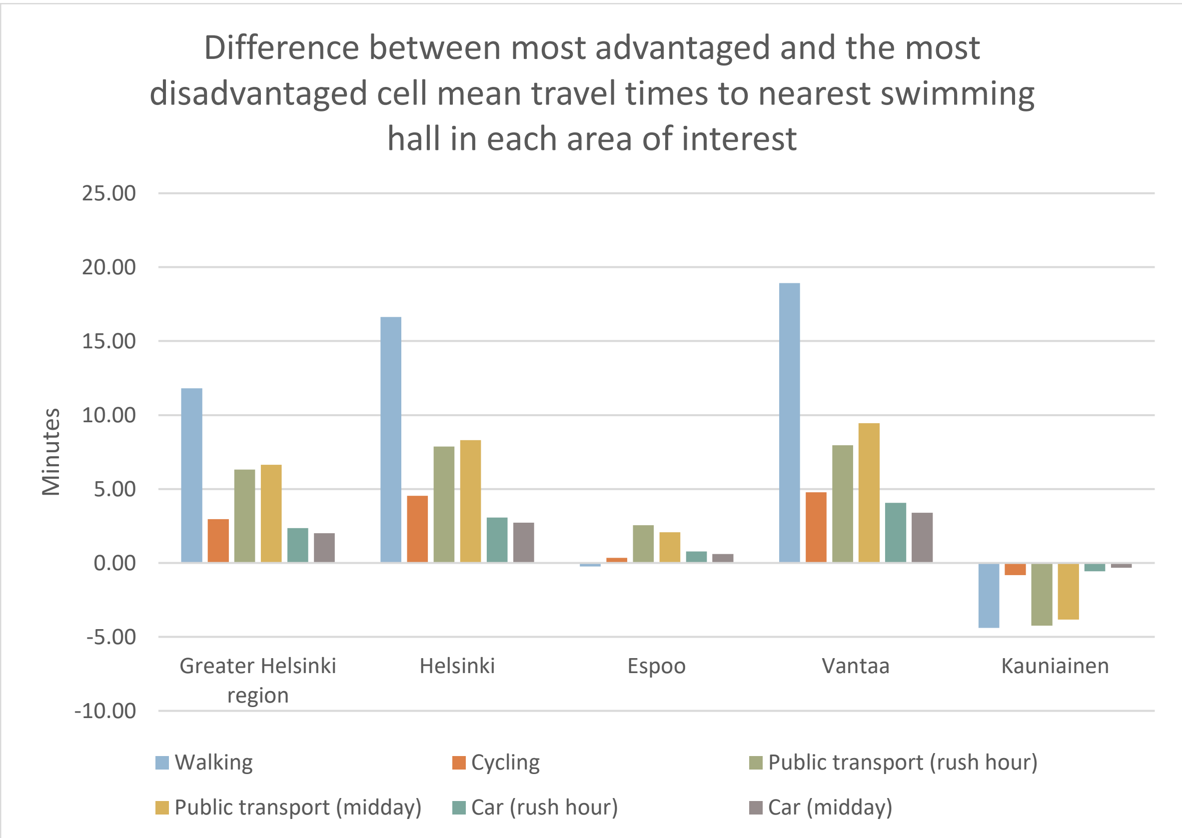

Figure 25. Mean travel time differences to nearest swimming hall in all the areas of interest.

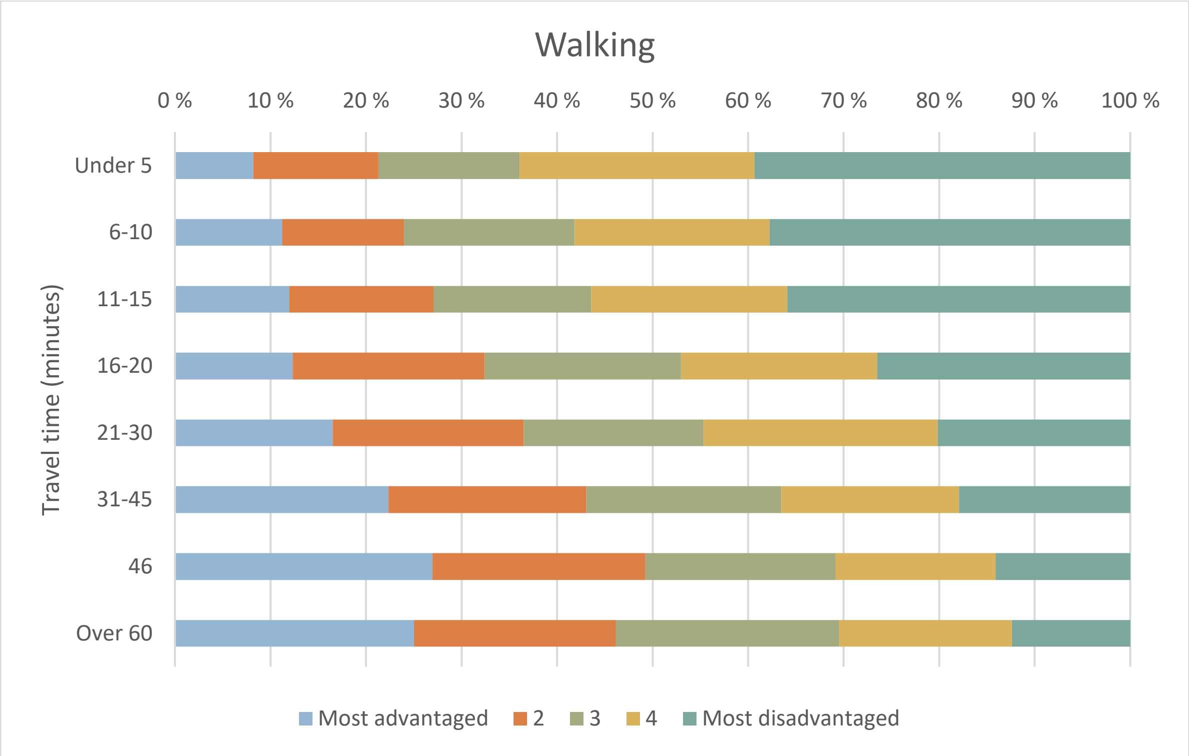

Figure 26. Disadvantage quintiles per travel intervals from swimming halls in the Greater Helsinki region.

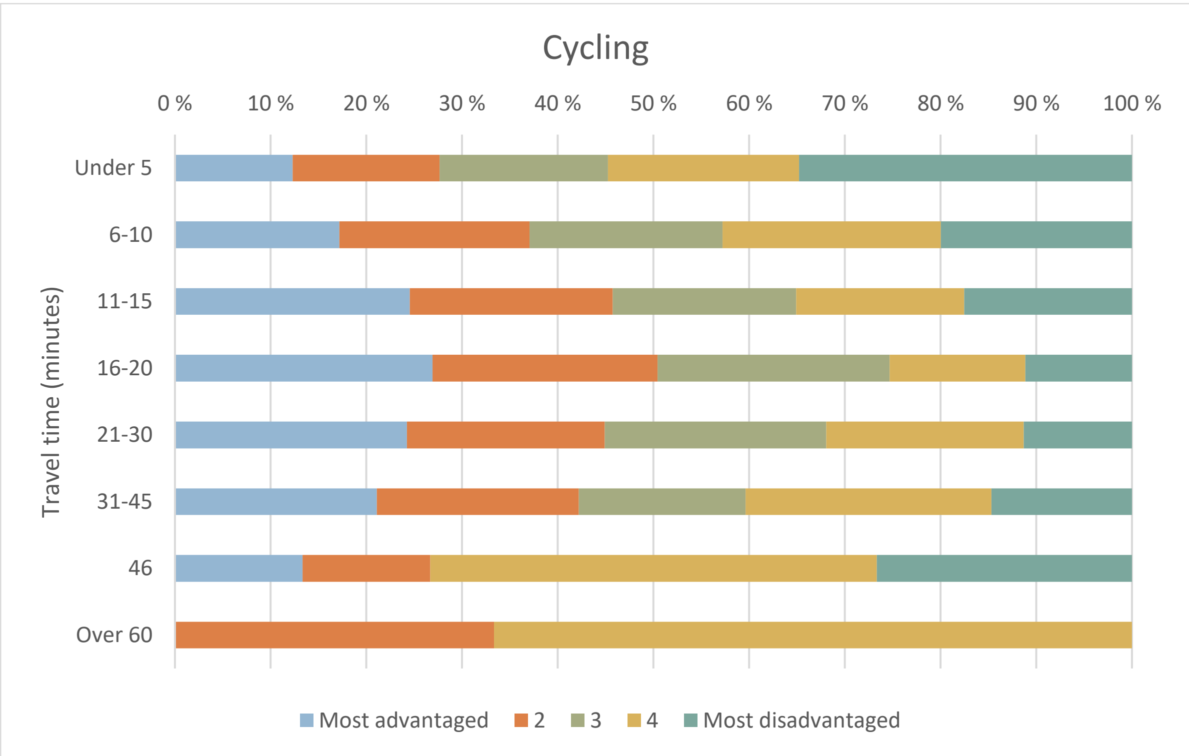

Figure 27. Disadvantage quintiles per travel intervals from swimming halls in the Greater Helsinki region.

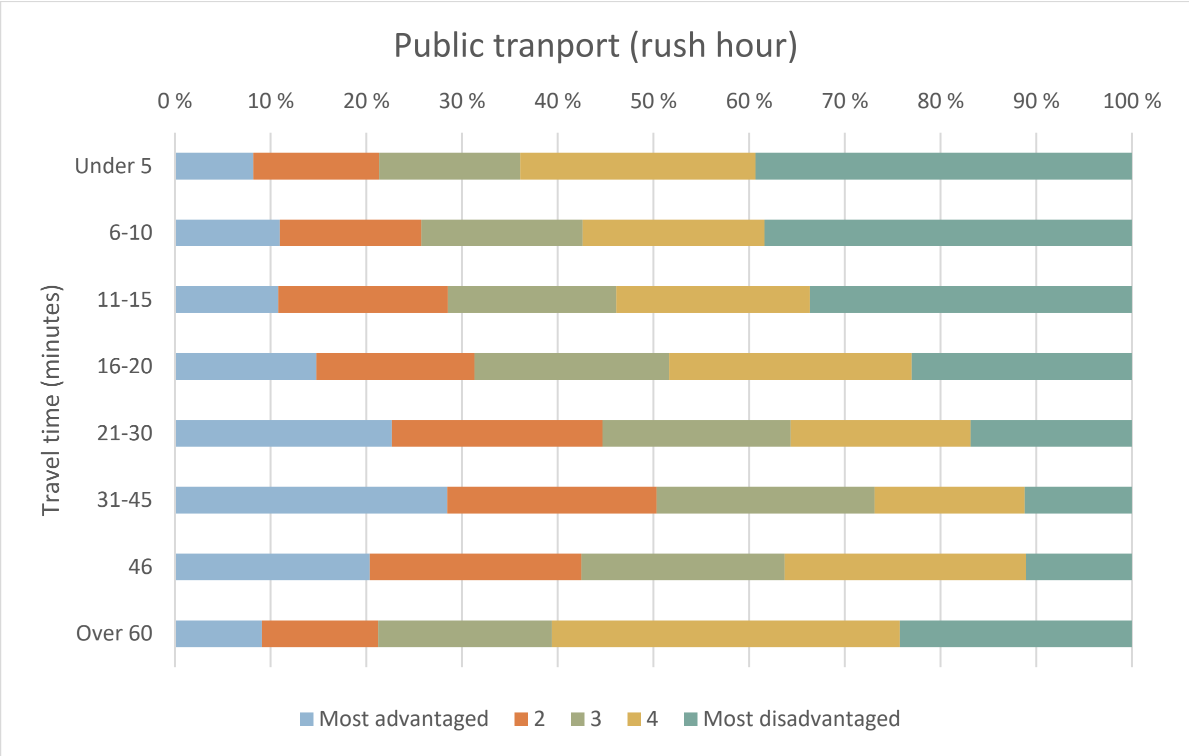

Figure 28. Disadvantage quintiles per travel intervals from swimming halls in the Greater Helsinki region.

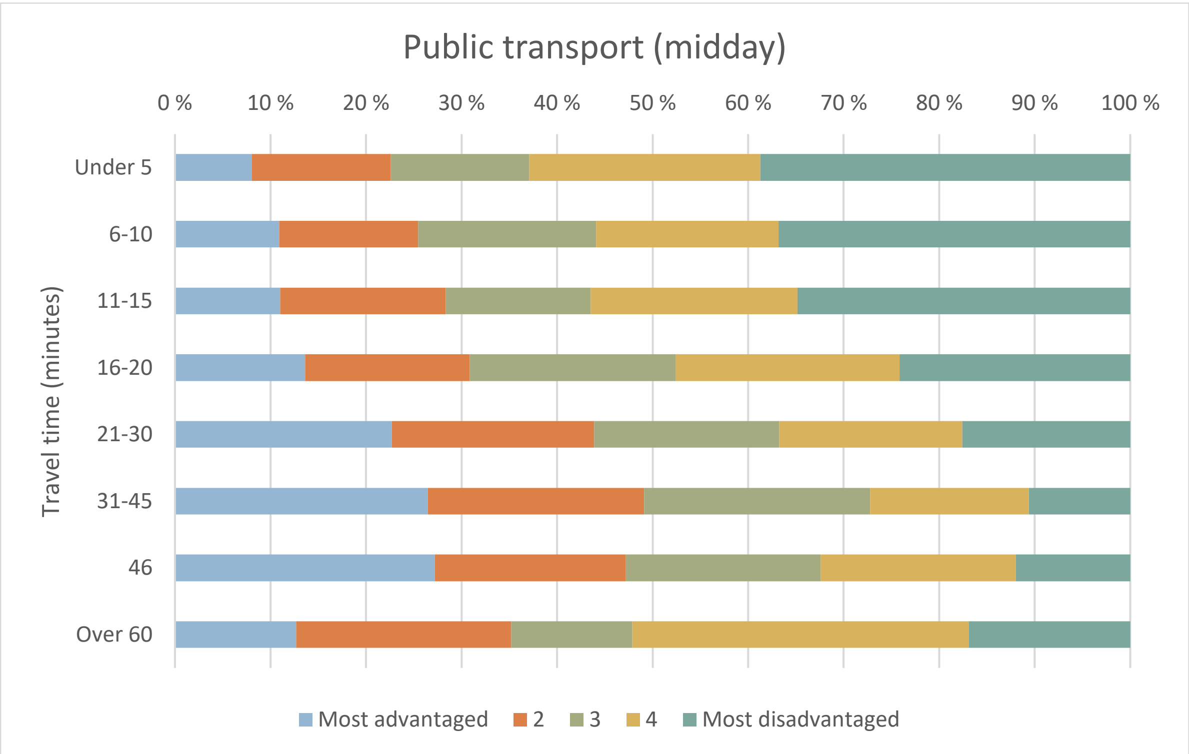

Figure 29. Disadvantage quintiles per travel intervals from swimming halls in the Greater Helsinki region.

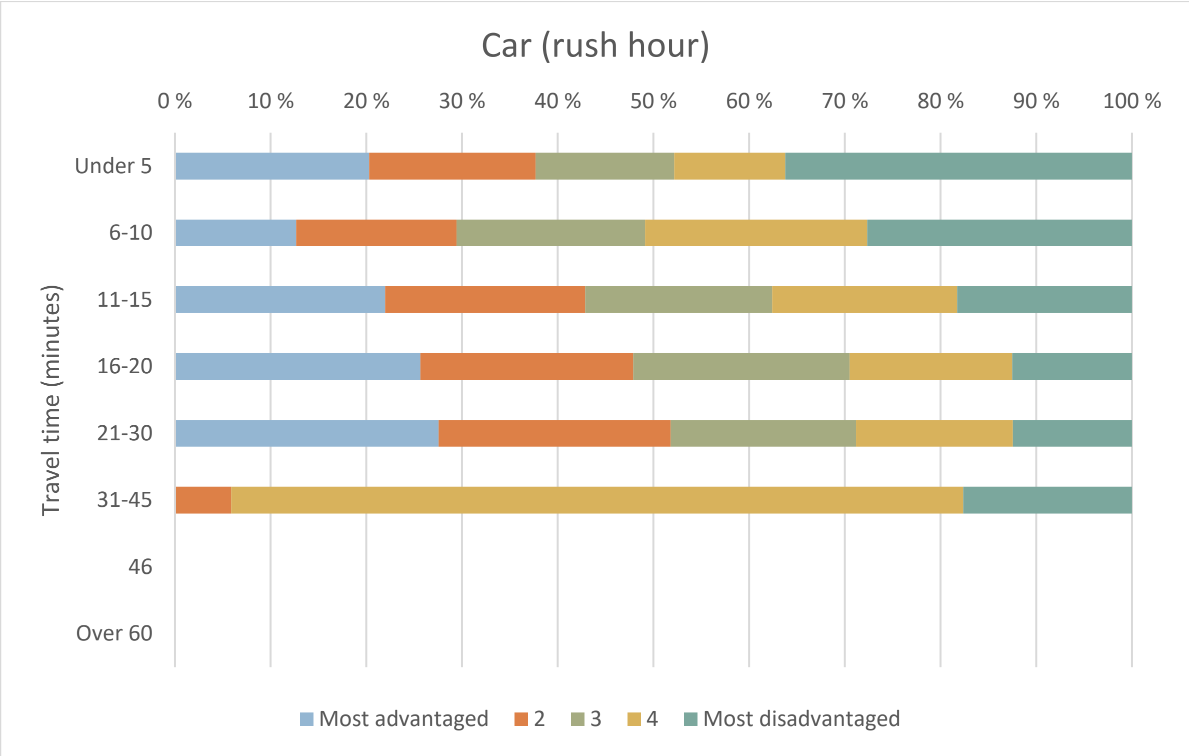

Figure 30. Disadvantage quintiles per travel intervals from swimming halls in the Greater Helsinki region.

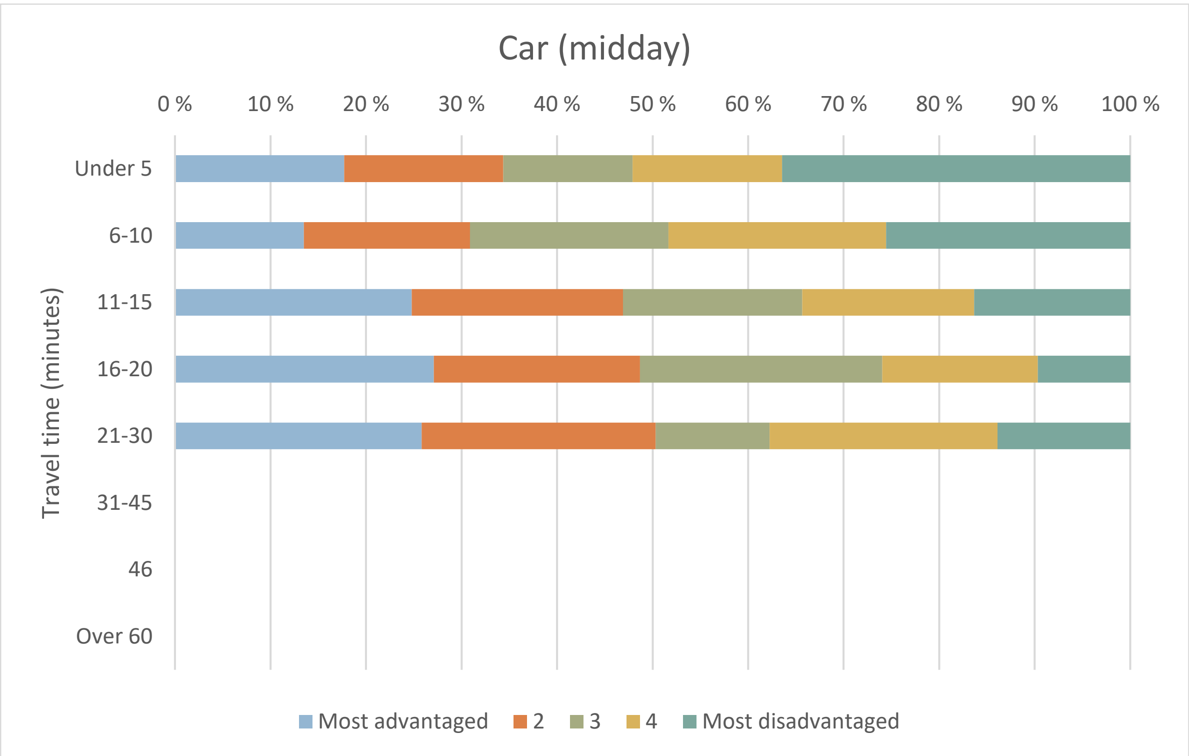

Figure 31. Disadvantage quintiles per travel intervals from swimming halls in the Greater Helsinki region.

Appendix 3. List of swimming halls in the study

Table 6. List of Swimming halls in the study with information of municipality, administrator and owner.

Name	Municipality	Administrator	Owner
Hakunilan uimahalli	Vantaa	Kunta / liikuntatoimi	Kunta
Malmin uimahalli / UH & FIX Malmi	Helsinki	Kunta / muu	Kuntaenemmistöinen yritys
Espoonlahden uimahalli	Espoo	Kunta / liikuntatoimi	Kunta
Pirkkolan liikuntapuiston uimahalli	Helsinki	Kunta / liikuntatoimi	Kunta
Haagan Uimahalli	Helsinki	Yksityinen / yritys	Säätiö
Leppävaaran uimahalli	Espoo	Kunta / liikuntatoimi	Kunta
Vuosaaren uimahalli / UH & FIX Vuosaari	Helsinki	Kunta / muu	Kuntaenemmistöinen yritys
Kontulan uimahalli / UH & FIX Kontula	Helsinki	Kunta / muu	Kuntaenemmistöinen yritys
Itäkeskuksen uimahalli	Helsinki	Kunta / liikuntatoimi	Kunta
Helsingin urheilutalo / UH & FIX Kallio / Uimahalli	Helsinki	Kunta / muu	Kuntaenemmistöinen yritys
Yrjönkadun uimahalli	Helsinki	Kunta / liikuntatoimi	Kunta
Invalidisäätiö Orton / Uimahalli	Helsinki	Yksityinen / yritys	Säätiö
Martinlaakson uimahalli	Vantaa	Kunta / liikuntatoimi	Kunta
Tikkurilan uimahalli	Vantaa	Kunta / liikuntatoimi	Kunta
Siltamäen uimahalli / UH & FIX Siltamäki	Helsinki	Kunta / muu	Kuntaenemmistöinen yritys
Keski-Espoon uimahalli	Espoo	Kunta / liikuntatoimi	Yritys
Olarin uimahalli	Espoo	Kunta / liikuntatoimi	Kunta
Korson uimahalli	Vantaa	Kunta / liikuntatoimi	Kunta
Kilon Sporttaamo / Uimahalli	Espoo	Yksityinen / yritys	Yritys
Jakomäen uimahalli	Helsinki	Kunta / liikuntatoimi	Kunta
Myyrmäen uimahalli	Vantaa	Kunta / liikuntatoimi	Kunta
Mäkelänrinteen uimahalli / UH & FIX Mäkelänrinne	Helsinki	Kunta / muu	Kuntaenemmistöinen yritys
Kauniaisten uimahalli	Kauniainen	Kunta / liikuntatoimi	Kunta

Lauttasaaren uimahalli	Helsinki	Yksityinen / yhdistys	Rekisteröity yhdistys