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Mobility choices predicting subjective well-being

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Abstract

Transportation can be associated with well-being from many viewpoints. In the field of travel behavior, researchers have studied transport-related subjective well-being in last 10-15 years. Traditionally, the association between well-being and transportation is measured with objective criteria such as travel time costs, road safety or motorized vehicle's noise. The impact of transport on individuals' well-being is not however explained comprehensively with objective measures. The multi-discipline approach of transport-related subjective well-being has increased interest among scientists and they have found some significant associations between mobility choices and subjective well-being.

Travel behavior and subjective well-being are both a sum on many factors. Travel behavior consists of infinitive number of decisions that people do over space. Subjective well-being consists of experiences and emotions that can be linked to specific domains and activities. Results show that many factors such as travel time, travel mode and quality of travel environment can have an impact on short- and long-term subjective well-being. However, further investigation is needed to understand the impacts of mobility choices on subjective well-being more comprehensively.

In this thesis, a cross-sectional study investigates whether mobility choices and some selected socio-demographic variables can explain subjective well-being. A logistic regression model is conducted for simplified analysis of predictors. The results support that active traveling and car ownership are positively related to subjective well-being. Frequent walking and cycling predict high quality of life and self-rated health. Public transport did not show any significant results from the model but active public transport users walk more than people who use less public transport. For women, active walking predicted the highest self-rated health. More cars in a household predicted also high subjective well-being especially for men.

Keywords Mobility choices, quality of life, subjective well-being, self-rated health, travel behavior, travel satisfaction

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Abstract of master's thesis

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Tiivistelmä

Liikenteellä on monia yhteyksiä hyvinvointiin. Matka-aika ja moottoriliikenteen päästöt ovat esimerkkejä kriteereistä, joita käytetään liikenteeseen liittyvän hyvinvoinnin arvioinnissa. Kaikkea hyvinvointia ei voi kuitenkaan mitata objektiivisesti, joten tutkimuksissa ja suunnittelussa tulisi huomioida liikenteeseen liittyvä subjektiivinen, eli koettu hyvinvointi. Liikkumiskäyttäytymisen tutkimusalalla on viimeiset 10-15 kasvanut kiinnostus kulkutapojen merkityksestä koettuun hyvinvointiin. Tutkimustulosten perusteella on todettu, että ihmisten kulkutavoilla ja koetun hyvinvoinnin välillä on merkittäviä yhteyksiä.

Yksilön kulkutavat sekä koettu hyvinvointi koostuvat molemmat monista tekijöistä. Kulkutavat koostuvat loputtomasta määrästä valintoja, joita ihmiset tekevät jatkuvasti. Koettu hyvinvointi taas koostuu kokemuksista ja tunteista, jotka kohdistuvat eri hyvinvoinnin luokkiin ja toimintoihin. Aiheet mahdollistavat moniuloitteisen ympäristön, jossa niiden keskinäistä yhteyttä voi tarkastella. Tutkimukset ovat pääosin etsineet yhteyksiä työmatkojen, matkustustyytyväisyyden ja subjektiivisen hyvinvoinnin välillä. Tulokset ovat osoittaneet, että monet tekijät, kuten matka-aika, kulkuväline ja matkustusympäristön laatu voivat vaikuttaa sekä lyhyt- että pitkäaikaiseen subjektiiviseen hyvinvointiin. Tarkastelua ja tutkimusta tarvitaan kuitenkin lisää, jotta yhteys voidaan ymmärtää kokonaisvaltaisemmin.

Tässä diplomityössä tutkin logistisella regressiomallilla empiiristä aineistoa käyttäen, voivatko kulkutapavalinnat ja sosiodemografiset muuttujat selittää koettua hyvinvointia. Tulokset tukevat tutkimusta siitä, että aktiivinen liikkuminen ja auton omistaminen liittyvät positiivisesti subjektiiviseen hyvinvointiin. Usein kävely ja pyöräily ennustavat korkeaa elämänlaatua ja koettua terveyttä. Joukkoliikenne ei osoittanut merkittävää ennustettavuutta, mutta usein joukkoliikennettä käyttävät kävelevät muita useammin. Aktiivinen käveleminen ennusti etenkin naisille korkeaa koettua terveydentasoa ja usean auton omistaminen ennusti etenkin miehille korkeaa subjektiivista hyvinvointia.

Avainsanat Kulkutapatottumukset, subjektiivinen hyvinvointi, koettu terveys, elämänlaatu

Foreword and acknowledgements

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Abbrevations

AT	Active traveling
CBA	Cost-benefit analysis
GDP	Gross domestic product
GIS	Geographic Information System
HEAT	Health Economic Assessment Tool
HCR	Helsinki Capital Region
HSL	Helsinki Regional Transport Agency/Helsingin Seudun Liikenne
MAL	Land-use, housing and transport
PT	Public Transport
QOL	Quality of Life
QGIS	Quantum GIS, free and open-source geographic information system
SRH	Self-rated health
SWB	Subjective well-being
THL	Finnish institute for health and well-being
WHO	World Human Organization

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1 Introduction

1.1 Background

Subjects related to well-being such as health, happiness and life satisfaction have interest philosophers from the ancient Greek (Alatartseva & Barysheva,). Research on well-being is generally done in the fields of medical and social sciences. However, World Health Organization (WHO) and United Nations Development Programme (UNDP) promote the importance of health and well-being across all policy making. (Alatartseva & Barysheva, 2015; Marmot et al., 2008.) WHO states that policy making should consider and assess impact on well-being in society because well-being is cross-administrative matter. Political decision-making can increase or decrease the gap of well-being inside societies (Jordan, 2008). Many studies have shown that well-being have cross-sectional association with healthy behaviors, productivity and many other measures that connects well-being to all aspects in life. (Centers for Disease Control and Prevention, 2018.)

There is not a unanimously agreed definition for well-being. Well-being increases when there is presence of positive emotions and absence of negative emotions. It is also generally agreed that satisfactions with life, fulfilment and positive functioning increase well-being whether well-being is studied objectively or subjectively. (Centers for Disease Control and Prevention, 2018.)

Measuring well-being has traditionally focused on economic growth. However, high level of economic growth does not increase automatically levels of happiness and life satisfaction. Therefore, indicators regarding well-being should assess also other factors than economic level of a society. Subjective well-being adds dimensions to well-being that is measured objectively such as income level or birth-rate. Asking individual's subjective well-being is a simple method to recognize people's satisfaction on topics from many domains of life. (OECD, 2013.)

Well-being of an individual is usually measured by assessing subjective well-being, often referred also as perceived well-being. Subjective well-being (SWB) is human's individual view on their own state of well-being. SWB is defined by feelings and emotions of an individual. Overall SWB describes the combination of satisfaction in multiple domains in life. The domains such as safety, social relationships and financial security can be investigated separately. Sometimes studies use terms such as happiness, life satisfaction and quality of life as a synonym to SWB. In science, SWB is often divided in three components that are positive and negative affect and cognitive SWB based on Diener et al. studies (2009). Positive and negative affect are direct emotions and immediate experiences whereas cognitive component looks at long-term quality of life.

Travel behavior studies have recently gain knowledge about how mobility choices and travel satisfaction can have also long-term impacts on well-being. These are important to distinguish in transport-related SWB because travel behavior studies discuss often travel satisfaction which is about positive and negative affects. However, travel behavior's impact on SWB can be either satisfaction during the trip or longer-term satisfaction in life. Additionally, travel satisfaction is often linked to SWB by discussing hedonic and eudemonic happiness. Hedonic happiness consists of happy moments that relates to affective SWB and immediate reactions of travel satisfaction. Eudemonic happiness has similarities to cognitive SWB but

they are not synonyms and should not be mixed. Eudemonic happiness consists of meaningfulness and deeper purpose of life that requires behavior that has long-term positive impact on human. (Giangrasso, 2018.)

The fields of travel behavior and well-being studies are together a combination of two different thematic approaches in one framework. Terminology, study methods and discussion have different backgrounds and therefore the intersection for travel behavior and subjective well-being is very multi-discipline. First time well-being was acknowledged in the field of transportation engineering studies was in 1970's when researchers understood that exclusion, travel and inequality were interrelated to well-being (Schwanen, 2019). However, it is argued that the relationship between subjective well-being and transportation have been unclear regardless of some significant findings.

Literature regarding travel behavior and well-being is often from other fields of science. The field of travel behavior have studied subjective well-being mostly in the last 10-15 years. The literature focus on domains of travel satisfaction and health-related SWB. Travel satisfaction can be explained as a part of service-related domain. Hence it is argued, that travel satisfaction can be classified as a domain of SWB. (Ettema et al., 2016.) Travel satisfaction is not the only domain that travel behavior is connected to. Daily decisions such as which mode people take, what the purpose of the trip is or how many activities people do are complex and are related to other domains of SWB such as safety, health and income level. Studies show that travel behavior is highly connected to factors such as mood, feel of autonomy and stress. (Ettema et al., 2016.) However, the direct connection between travel behavior and SWB needs yet further studies.

1.2 Scope and objectives of the study

Mobility choices are individual decisions and people have both similarities and differences between their travel behavior. People make mobility choices daily and the main focus of this thesis is to study their impact on subjective well-being even though there is broader interconnection between the themes. For instance, Socio-demographic differences are one factor that affects travel behavior. Need for activities differ according to age, access to a car can depend on income level and so on. Research shows also top-down effect which indicates that SWB have an impact on travel satisfaction and travel behavior. According to De Vos (2013), people with higher SWB are generally more satisfied with their commute and travel. Even though there is only some evidence about the connection between travel satisfaction and travel behavior with SWB, there seems to be reliable enough evidence to suggest that the association exists.

In this thesis, I have selected some socio-demographic factors that I will investigate together with mobility choices when predicting SWB. There are also other factors that can have an influence on travel behavior such as values and culture but they are excluded from this analysis. Personal traits affect also travel behavior and subjective well-being but this study does not focus on personality factors. The other domain of SWB that is investigated further in this thesis is health. Self-rated health is an important domain that explains SWB (Steptoe et al., 2015). Perceived health is meaningful to the public because it is a valid measure for population morbidity, mortality and economic status. Self-rated health can predict several health-related outcomes such as diseases, physical functioning or mortality (Berglund et al., 2016).

Perceived health can predict future health more reliably than some objective measures because self-rated health includes often more dimensions to health such as habits, quality of life and social aspects that are more difficult to include in objective measures. (Duarte et al., 2010.)

This thesis aims to gain knowledge about the relationship between perceived well-being and travel behavior. The relationship is investigated by narrowing the scope to specific mobility choices and socio-demographic factors and their impact on self-rated health (SRH) and quality of life (QOL). Transport behavior and mobility choices can be related to many life domains of subjective well-being but the impact on domain-specific SWB is limited to self-rated health in this study. Furthermore, the literature discusses frequently travel satisfaction and other more specific domains that are related to short-term SWB. Therefore, the literature presents the association between positive and negative affects on SWB and whether short-term affects are related to long-term SWB. The literature also discusses long-term impacts and the model created for the study focus on long-term impacts by analysing domains of self-rated health and quality of life.

The core of the thesis is to find if mobility choices can predict SWB in a statistical model built in the thesis using data from the residents of Helsinki Capital Region (HCR). In the second chapter, I will study the related research from the scientific literature. I discuss the intersection between subjective well-being and transportation. The review consists of observations of both objective and subjective findings for self-rated health and quality of life. The main focus is in factor-specific findings between travel behavior and subjective well-being. Additionally, I will discuss what measuring subjective well-being usually is in science and what measuring methods are common in transport-related well-being.

The model investigates if selected socio-demographic factors and mobility choices can predict SRH and QOL. Furthermore, the same model was delivered for men and women to find if mobility choices show differences in subjective well-being according to a gender. Some other findings from the data concerning average SWB and mobility choices are also discussed. For instance, some analysis by geographic information system (GIS) was done to investigate the distribution of subjective well-being in Helsinki Capital Region.

2 Related research

2.1 State of transport-related well-being in Finland

In general, people feel healthy in Finland (THL, 2018) and in Europe (European Comission, 2011). Finnish institute for health and welfare (THL) have ongoing statistics about subjective well-being of Finnish people. Nearly 70 % of Finnish adults age 25-64 find themselves healthy or fairly healthy. Older people have lower SRH but it has increased in recent decades. (THL, 2019a) Challenges in maintaining high level of well-being in Finnish society are getting more complex. There is a risk that well-being will accumulate unevenly and polarization on well-being will increase a gap perhaps also between age groups or gender. Preventing diseases, maintaining equal health and narrowing health gaps are the challenges Finland is facing (HSL Helsingin seudun liikenne, 2016a). Other threats for health are inactive lifestyle and obesity in well-being societies. Physical activity is an important topic in transportation issues for healthy society. For instance, promoting active traveling (AT) as a transport mode increases people's physical activity and decreases risks of many diseases (Rantala et al., 2014).

Urbanization is one of the largest forces shaping our future environment (United Nations, 2018). Urbanization has created higher demand for planning complex urban structures where people and goods can move sustainably. Dense environment and urbanization have also challenged traditional transport planning. Throughout the decades, the emphasis on transport engineering have developed from designing roads to more holistic perspective of networks that fulfils society's and people's needs and enables high quality of life. In addition to traffic safety and road design, the responsibility of comfortable commuting, equally accessible services and other social factors have become basic values in transport planning. Promoting sustainable modes such as walking, cycling and public transport have become trend not only for increasing physical health but also for ecological and economic purposes. Well-being across all policy making have thus spread into transport policies.

There are yet challenges in including comprehensive well-being in transport planning and assessment. Assessments are traditional cost-benefit analyses that do not assess properly individuals' health or subjective well-being. (Vella-Brodrick and Stanley, 2013; Australian Transport, 2016) According to a publication by Finnish Ministry of Social Affairs and Health, health impact assessments and reporting tools do support Health in All Policies - method (Ståhl et al., 2006). However, there should be more critical analysis on how health assessment is done in transport sector. Connections between health and transportation has been recognized among policy makers and researchers but the improvements are still lacking holistic perspective that would consider well-being from broader perspective and not focus on physical and other objective measures. (Lee and Sener, 2016.)

In Finland, transport projects are assessed in national level by governmental authority. It is legally required to assess transport projects and programs according to environmental impacts if the implementation can have markable impact on people, nature and its diversity, built environment, landscape or natural resources. Additionally, authorities from Ministry of transportation and communications, provinces and municipalities provide research, programs and strategies to organize transport more sustainably. Land-use, housing and transport plan MAL 2019 is a strategic plan of Helsinki region in 2019-2050. Strategy is prepared, steered and approved in cooperation with local and state authorities. The goal is to have low-

emission, attractive, vibrant and healthy region and the strategy is a roadmap to meet these goals. MAL 2019 presents plans and actions to meet different short- and long-term goals. The goals aim at sustainable region and there are for instance measures for sustainable mode shares and accessibility. One of the four main goals is to have well-being region. In the evaluation framework of MAL 2019, health benefits and well-being are mentioned. Therefore at least on a strategic level, Helsinki region is executing "well-being on all policy making" in the field of transport. The assessment methods for well-being are however limited and measures are mostly objective. (HSL Helsingin seudun liikenne, 2019.)

Knowledge about the interaction of mobility choices and subjective well-being is rather weak which is seen as a lack of practice among strategies and assessments. This study takes a step forwards assessing SWB and transport in the same framework. This study reviews results from a survey that was conducted by Helsinki Regional Transport Authority (HSL). HSL is a local strategic partnership of nine municipalities (Helsinki, Espoo, Vantaa, Kauniainen, Kerava, Kirkkonummi, Sipoo, Siuntio and Tuusula) and in charge of public transport in these municipalities. HSL conducts also surveys, studies and publications concerning transport related issues in Greater Helsinki. In addition to the nine municipalities of HSL, Greater Helsinki includes Hyvinkää, Järvenpää, Mäntsälä, Nurmijärvi, Pornainen and Vihti that are in cooperation with HSL.

Before going into the survey, analysis and study results, a short literature review needs to take place. As mentioned, the intersection of travel behavior and subjective well-being is very multi-discipline and concepts and methods vary across different traditions and approaches. Thus, the section of related research reviews the literature and is then followed by sections introducing the framework and research questions of this thesis, methods, analysis, results and finally discussion and conclusion.

2.2 Intersection between subjective well-being and transportation

Perceived good or very good well-being requires physical, psychological, social and economic well-being. There has been a lot of scientific research and among them different study methods to understand which characters and factors can be associated with perceived well-being. (e.g. Bergstad et al., 2011; Ettema et al., 2010; Hansson et al., 2011; Martin et al., 2014.)

Transportation can affect positively and negatively direct health impacts. The most common connection between transport and well-being are health risks of road traffic and pollution. Traffic is globally one of the main reasons for deaths and diseases. Road accidents kill over one million people annually (ASIRT, 2019). Traffic related pollution such as CO2 emissions and noise are a global cause of health impairment. Studies have shown several increasing health risks such as asthma, reduced lung function and cardiopulmonary mortality that are related to air pollutants. Exposure to noise also causes mental disorder such as stress and sleep disturbance (Halperin, 2014).

Another impact of transport on well-being is related to spatial accessibility. The infrastructure defines where people can move and how. The relation to land use types is also important since it defines the distance one must travel to reach necessities and other destinations. Furthermore, traveling and mobility are closely related to physical fitness because one's physical condition is determinant factor on what and how one can move. Furthermore, traveling

can be physical exercise. Physical infrastructure and physical fitness are moreover the root for individual's possibility to move. Their relation to transportation has been understood for as long as there has been transport planning.

Social aspects and the reflection of transport network to well-being have been studied since 1970's in planning and the research have evolved since (Blau et al., 2017; Schwanen, 2019). Transportation does not only restrict people physically but also mentally. Spatial characteristics can limit people to have social interactions. Provided facilities can be financially too expensive to use. Poor accessibility to different transport modes and destinations can lead to spatial inequality and segregation that is proven to result low level of health and well-being (Stanley et al., 2011). Additionally, studies have shown that quality of access to public transportation can segregate families according to their income level. Higher quality of transport accessibility results often in higher housing prices and thus poor people have to move to areas of poor transport services (Stanley et al., 2011; Vella-Brodrick and Stanley, 2013). Transport poverty occurs in different situations that relate to spatial segregation, social exclusion and social justice (Tiikkaja et al., 2018).

High quality of accessibility not only have economic and spatial impacts but it also gives an idea of individual freedom. This freedom of choice involves freedom to choose how, when and where to travel and freedom to choose where to live and how far other needed places and relationships are located. The value and number of options is the individual capacity to be mobile. Theories of political philosophy and questions about justice and equity in transport policies has risen in transport research during past decades (Pereira et al., 2017). Classical theories of justice such as Rawls' egalitarianism and Capability Approaches by Sen have risen attention in evaluation of equity in transport policies. Researchers claim that the connection between transport disadvantage, social exclusion and individual's capabilities needs more complete understanding. Kaufmann et al. (2004) have named this concept as motility. Competency and appropriation of motility has increased researchers' interest and studies have shown their importance in transport-related well-being and health. (Jordan, 2008).

As a result, transport affects physical, psychological, social and economic well-being. The impact of travel behavior on well-being is thus evitable. However, measuring particularly perceived well-being and quality of life, the number of studies is much lower. In recent 15 years, researchers in the field of travel behavior have resulted some findings on SWB and transport that I will discuss separately in the following sub-chapters (e.g. Bergstad et al., 2011; Ettema et al., 2010; Hansson et al., 2011; Martin et al., 2014).

Adding to the factors that have an impact on well-being, some conceptual links have been created from the evidence. Ettema et al. (2010) argue that there are three ways that well-being is impacted by travel behavior. The first is positive and negative experiences during the trip. The second is a possibility to reach many trips and destinations, which increases positive emotions because one is able to reach their goal. The third is the organization of trip that affect the amount of stress if there are multiple uncertainties in a trip. Vos et al., (2013) suggest that travel behavior affects well-being from five different ways. Firstly, through experiences during (destination-oriented) travel, secondly through activity participation enabled by travel, thirdly through activities during (destination-oriented) travel, fourthly through trips where travel is the activity, and finally through potential travel (motility). Nordbakke and Schwanen (2014) have also studied the link between mobility and well-being by

framing psychological approaches of well-being through three categories of movement: potential movement (motility) and two actual movement (accessing destinations and during travel). These three frameworks structure the intersection between well-being and transportation that contribute to both objective and subjective well-being.

In summary, based on the findings, transport and travel behavior have an impact on well-being. Additionally, travel satisfaction itself can be considered as a domain of SWB. It is thus hypothetical that transport and travel behavior are associated with overall SWB indirectly or directly. Theoretical frameworks from scientists also support association between transport and SWB. Studies have also shown that SWB and travel behavior are associated with socio-demographic factors. Transport-related subjective well-being is therefore multidimensional and in the following sub-chapters I will review the most important transport-related findings and some selected socio-demographic factors that have an impact on SWB.

2.2.1 Public transport and private cars

Most studies compare the impact of public transport and private cars on travel satisfaction or subjective well-being, hence I discuss modes in the same sub-chapter. Public transport is relatively complex indicator as a factor for SWB because public transport is very heterogeneous mode and the service level vary across cities and countries. Some studies have found it hard to find correlation between use of public transport and life satisfaction but some significant associations have also been found. Public transportation can have positive and negative impacts on perceived well-being (Abou-Zeid, 2009).

The findings of public transport discuss often travel satisfaction rather than SWB. The findings often suggest actions towards attractive public transport which would then increase willingness to travel by public transport and that way increase travel satisfaction and subjective well-being. The findings include reasonable pricing, high-quality service, safety and punctuation (Abou-Zeid et al., 2012). Ettema et al. (2011) and Fordham et al. (2017) show in their studies that experienced quality of travel is related to quality of life. For instance, in a study where people shifted their commuting mode between private car and bus, mood during the day among bus users with the most attractive trip conditions was more positive than bus users with less attractive trip conditions.

Studies have found some specific details for connection between public transport and travel satisfaction. Diana, (2012) have studied travel satisfaction of multimodal travelers where the levels of satisfaction were higher in small towns than in metropolitan cities. The resulting overall satisfaction levels and frequency of use of public transport were not correlated in the study. Perceived control such as getting a desired seat was negatively related to stress according to Diana (2012). On the other hand, Chng et al. (2016) have found that in London good public transport connectivity was associated with lower mental distress. Underground commuters had higher life satisfaction than car drivers or train users. Public transport enables better productivity than other modes. However, the type of an activity during a trip can result different travel satisfaction. According to a study by Ettema et al. (2016), productive activities resulted positive travel satisfaction whereas relaxing activities did not. Additionally, measures show that talking to other passengers increases travel satisfaction.

Use of public transport expose people to daily active traveling when a person must walk to and from a station. People who use public transport tend to walk more and have lower risks

of diseases related to inactivity. In the United Stated, physical activity between car and public transport commuters have been found to be significant. Many achieve recommended 30 minutes a day physical activity from the walking to and from the transit alone. Additionally, light-rail users have been associated with lower likelihood of obesity and lower BMI compared to non-users. (Beirão and Sarsfield Cabral, 2007; Delvin et al., 2009; Lee and Sener, 2016) Physical activity is naturally linked to well-being and better health but there is limited evidence if the use of public transport can increase subjective well-being or more specifically self-rated health because of required physical activity.

Studies have also compared satisfaction levels of commuting by car and by public transport. Abou-Zeid and Ben-Akiva (2011) have shown that commuting by car expose commuter to higher stress, anxiety and impatience than commuting by public transport. Duarte et al. (2010) show that satisfaction is higher when commuting by metro or train than by bus or car. Transfers during public transport trip also increases stress and decreases predictability which leads to negative travel satisfaction. Then again, an analysis by Gatersleben and Uzzell (2007) shows that public transport users had the most negative attitudes toward their travel mode and car drivers were the most stressful commuters.

Since 1979, Novaco et al. (1979) have examined personal control expectancies as a personality variable and situational control dimensions, finding strongest support for the situational control variables on task performance. Later, other researchers have also found positive affections for same reasons from traveling by car. Psychological (such as feeling of freedom or excitement) and symbolic (identity or status) motives have been related to car ownership for long. (Jakobsson et al., 2011; Steg, 2003.) Additionally, Eriksson et al. (2013) have analyzed that emotions such as fun, lifestyle match and security affect travel satisfaction by car and public transport. Car showed higher satisfaction than public transport. The results showed that the mode affected on the mood but not satisfaction in longer period of time.

In addition to mode choices, some studies have shown that dynamics in mode shift can predict life satisfaction. Abou-Zeid and Ben-Akiva (2011) had an experiment where a group travelled the first period by car and the second period by public transport. A week of commuting by car showed significantly greater life satisfaction than a week of travelling by public transport. Expectations for public transport were more negative than evaluation after the travel period. Other findings have shown that higher subjective wellbeing increases the willingness to shift towards sustainable mode (Höysniemi and Salonen, 2019). However, forced reduction of car ownership may have a negative impact on SWB (Bergstad et al, 2016).

2.2.2 Active traveling

“Active traveling” or “active transport” (AT) is a common term for mobility that is a form of physical activity. Active traveling produces energy exposure of muscular movement. Litman (2003) has stated that “active transport” is preferred term for that mode of transport but also many other terms are used for same purpose such as “walking and cycling” or “non-motorized transport”.

Active traveling is a primal solution to obesity and other population health risks mostly because active traveling is an easily accessible mode of physical activity. Aggregate research at the international level has demonstrated an inverse relationship between AT and rates of

obesity (Pucher and Buehler, 2010). Studies almost explicitly show that people from all demographic groups who use active travel report higher total physical activity than those who did not (Sahlqvist et al., 2012). Some studies have shown significant health benefits of AT and there is direct association to diseases such as cardiovascular risk and type 2 diabetes. AT can prevent from health risks that are associated with physical health. However, some studies have not been able to report significance between AT and health-related effects especially with risks of all-cause mortality. (Lindström, 2008; Pucher and Buehler, 2010; Sahlqvist et al., 2012.)

There are unique health threats for physical exposure when traveling. Many studies show that active travelers have higher injury risk than automobile travelers (Elvik, 2009; Reynolds et al., 2009; Teschke et al., 2012). Pedestrians and cyclists are not protected in road accidents as well as drivers. Additionally, pedestrians and cyclists are exposed to air pollution more than drivers. Teschke et al. (2012) have calculated that ratios for benefits and risks of cycling often yield for higher benefits than risks for cyclists. Additionally, studies have shown that safety of pedestrians and cyclists often increase the more there are pedestrians and cyclists. Elvik (2009) have shown that reduction of accidents is possible if trips are transferred from motor vehicles to walking and cycling.

Hence, there are many statistics that active traveling affects health objectively. Many studies have also shown that when comparing travel modes, active traveling has the highest travel satisfaction (Abou-Zeid, 2009; Duarte et al., 2010; Olsson et al., 2013). De Vos et al. (2013; 2019) have studied the connection between travel satisfaction of AT and life satisfaction. They state that hormonal stimulation and diminish of health risks that physical exercise causes might reflect to travel satisfaction. Some other studies have also shown that travel satisfaction of AT is related positively to overall life satisfaction.

Distinctions between walking and cycling have not been studied much. Most studies emphasize the impact of active traveling in general on subjective well-being. However, a study from the Netherlands (Lancée et al., 2017) show that biking is the least negative option for being at home when comparing commuting modes. The study suggest that people feel less well when commuting than at home but commute by bike or foot can affect mood positively. A study from Portland (Singleton, 2019) also shows positive affect of cycling compared to car or public transport. The study suggests that better cycling infrastructure could decrease negative emotions such as fear during cycling. A study that investigates mode choices and life satisfaction in London did not find same results. Only walkers reported higher life satisfaction than car drivers, not cyclists (Chng et al., 2016). Common factors for the studies was that they mentioned the importance of cycling infrastructure and its impact on travel satisfaction and cycling. The studies also show results that walking has more positive effect on mood than commuting by car or public transport.

Active traveling may not directly lead to well-being and higher quality of life even though they often correlate together. According to some studies, mandatory activity such as chores are less enjoyable than activity of which purpose is leisure. Some factors such as lack of options and financial status also change the meaning and travel satisfaction of traveling because people do not have an option always to choose their destination-oriented mode of transport. These are only some examples of how mobility choices differ according to its obligatory and freedom of choice (Bavetta and Navarra, 2011).

Measuring the affection of active traveling on SWB is challenging. De Vos et al. (2019) have shown that AT has a cyclical process that positive travel satisfaction causes positive effect to choose the mode again. Cycle of positive emotions often lead to higher life satisfaction also. However, mobility choices are complex part of travel behavior. For instance, a trip made by public transportation can include a considerably big amount of active traveling by foot or cycle but only the use of public transport is reported. Additionally, public transport has factors that impact travel satisfaction which can impact individual's emotions and travel satisfaction of the whole chain of traveling. Furthermore, only a few studies have shown interest in resolving the causality of AT and SWB. Thus, studies have varying results but overall AT predicts higher SWB.

2.2.3 Travel time

Time use is an important factor on subjective well-being. Job satisfaction is highly meaningful in well-being and work hours affects SWB differently (Dolan et al., 2008). Furthermore, household work and time left for leisure have an impact on well-being (e.g. Vos et al., 2013). Time use plays also an important role in transport assessments. Travel time reduction is in core of utility-maximization in transport research and traditionally, the benefits of reduced time use is considered as savings. The benefits of time use measures more economic well-being than individual or perceived well-being in transport assessments. (Metz, 2008.)

The impacts of daily travel to individuals are also studied. Generally, Travel-to-work is not appreciated and commuting is often perceived as unpleasant activity. (Kahneman and Krueger, 2006; Wheatley, 2014). Studies have shown that longer commuting time usually predicts lower life satisfaction (e.g. Ettema et al., 2011; Lancée et al., 2017). However, it is challenging to find the net effect of commuting on well-being because there are many types of commuting. A mode, reliability, predictability, congestion and comfort of the trip are some factors that can increase or decrease the impact of travel time on well-being. It is also noted that longer travel time is not seen that negative if there is a possibility for useful activities such as work or reading. (Ettema et al., 2016.) Choi et al. (2013) have studied that commuting time is significant and negatively related to SWB. The study shows similar results for two different indicators: global well-being definition (WBI score) and perceived well-being which was measured by asking how happy respondent felt the day before. The results indicate that commuting has both long-term impacts on well-being and momentary negative feelings such as stress during the trip.

Even though negative feelings are exposed during traveling and commuting, impact on well-being is negative mostly in longer trips. Many individuals want to commute and many find their commute satisfactory. According to a study by Langer (2007), most people enjoy their commute if the trip is less than 15 minutes long. When travel time exceeded 30 minutes 42 % enjoy their commutes. Novaco and Gonzalez (2009) have studied broadly commuting and stress while traveling. According to their studies, the greatest impedance on well-being results from traveling long distances slowly and the least impedance occurs when short trips are travelled in small amounts of time. Gottholmseder et al. (2009) also resulted that commute duration is associated with increased stress and diminished life satisfaction after controlling for individual and work-related characteristics.

Commuting duration and its relation to stress and well-being is broadly studied. However, many activities are not only for commuting and there are also other factors that are related to travel time. Mode, trip purpose, travel environment and possibility to spend travel time usefully are some factors that can shift the attitudes towards better levels of satisfaction.

2.2.4 Age and gender

Differences in perceived well-being have been found between age groups (Clark, 2019; Clark and Oswald, 2006; Steptoe et al., 2015). Older people experience fewer negative emotions and older people tend to be happier than others. Most studies find that age have U-shaped curve in perceived well-being so that not only old people are satisfied with their life but also the youngest age groups.

Literature about happiness and quality of life is extensive and statistical analysis have results about SWB in age groups. Furthermore, there is literature about the impact of transport connections to different age groups. Especially among older people, there are statistically significant studies. In ageing society there are both increasing number of healthy older people but also more people with physical and psychological mobility challenges. (e.g. Gilhooly et al., 2002; Spinney et al., 2009). According to Banister and Bowling's study (2004) about QOL and mobility of older people in the UK, older people who have more activities during a day have higher QOL. Furthermore, if a car or a van is available, more activities are made. The study also states that even though about 63 % of the respondents have long-term illness it does not impair mobility.

A few studies have also discussed older people as a more heterogeneous group, which can give more detailed results about mobility and life satisfaction of older people. A Canadian study shows that older people have decreasing exposure to the benefits of transport mobility for psychological, exercise and community-socializing domains. However, the study did not find reliable results between the exposure of transport mobility to quality of life. (Spinney et al. 2009.) Other studies have shown that older women tend to take less trips than men. One reason that explains findings is also accessibility to transport resources such as car ownership (Hjorthol, 2013).

Men and women in general have also different travel behavior and it affects SWB differently. Most studies find for example that women use more frequently and are willing to use AT modes and public transport (e.g. Bergstad et al., 2011; Steg, 2003). However, Spinney et al. (2009) show that men have higher exposure to benefits for transport mobility than women in Canada.

Wheatley's (2014) study about travel-to-work and subjective well-being has also findings that travel behavior in households supports traditional gender roles. According to the study, women find car more necessary for chauffeuring children. The study implies also that stress during longer trips is higher for women due to many activities. Sweet and Kanaroglou (2016) also support this because the number of trips increases for women but not for men in households where there are children compared to household without children. Additionally, women travel more for errands such as doing household responsibilities and take care of children whereas men travel for leisure purposes such as sports and hobbies. Furthermore, many other studies have found that gender affects travel behavior (e.g. Ettema et al., 2010; Sheldon et al., 1996; Stronegger et al., 2010).

Even though results according to gender show that women's travel behavior affects negatively SWB, statistics show that women are relatively happier than men for example in Finland (THL, 2019b). Broader investigation about SWB between genders show supportive results but there are also findings of differences that are either very small or men are happier. Furthermore, sometimes studies have been unable to find any significance according to life satisfaction between genders.

2.2.5 Spatial characteristics

Spatial characteristics in this context are land-use conditions that create physical environment. These characteristics can have both direct and indirect associations with well-being. Transport-related SWB is affected by factors such as travel time, mode of transport, accessibility, safety and social connections. The factors are dependent on spatial characteristic that can restrain or enhance the impact on SWB. Spatial characteristics are often the measures that will lead to changes in travel behavior. For instance, changes in infrastructure requires changes in travel behavior and shifting origins or destinations will change traveling routines because the physical environment is different.

There is plenty of research that transport and accessibility are linked to well-being and quality of life. In Finland, the Finnish Environment Institute produces Residents' barometer survey that investigates the quality of Finnish housing areas (figure 1). Survey done in 2016 shows that location and transport connections is the most important contentment factor (Finnish Environment Institute, 2017). 54 % of respondents found it to be an attraction of a residential area. Furthermore, many other quality factors such as nature and services are important.

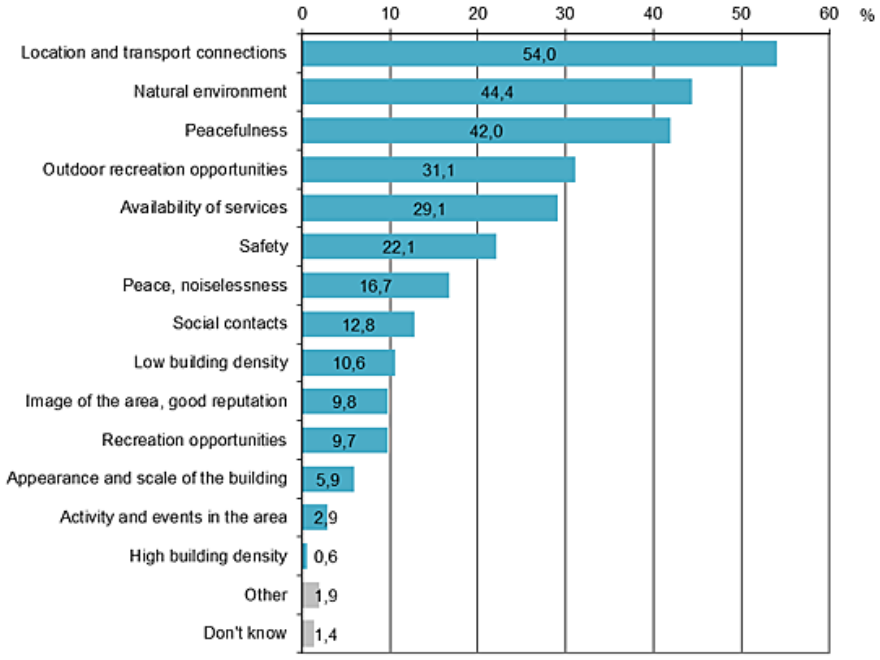

Figure 1. The most important attractiveness factors of the residential area (Finnish Environment Institute, 2017)

People value good transport connections but spatial characteristics of high-volume roads and rails have also negative impact on people's SWB. Infrastructure can make activities more unpleasant and create physical barriers. (Lee and Sener, 2016.)

Spatial characteristics are shown to have an impact on transport-related well-being. People who live in more walkable neighborhoods are more likely to walk more and drive less (Delvin et al., 2009; Laatikainen et al., 2019). Enjoyable active traveling is affected by land use and infrastructure (Barton, 2009). In the field of architecture and city planning there have been discussion about walkable cities for decades. Many researchers agree that active traveling play an important role in sustainable urban structure. When services are located in walking distance, there is less inequality issues such as travel affordability. In walkable areas there is less transport-related pollution, and space can be used more effectively when there are no cars or parking. Active street life keeps businesses busy and public places seem more attractive when there is social communication. (Pedia, 2017; Rantala et al., 2014.) According to Rantala et al., attractive landscape without cars can increase acceptable walking distance by 70 %. Mixed land-use is one attraction for positive associated walking. Some results have also shown that mixed land-use may not show associations with PA due to its weaknesses as a measurement (Laatikainen, 2019).

Transport options of urban and rural environment have different impacts and strengths on SWB. Rural landscape has most likely better connections to natural environment and outdoor recreation opportunities and it is usually more peaceful than urban environment. These are factors that Finnish people find the most contenting feature in their housing area right after location and transport connections (Figure 1). Rural environment is often promoted for its positive impacts on both physical and mental health (Pretty et al., 2005). However, the other side of peacefulness and nature is often lack of employment opportunities, services and transport connections that are qualities of an urban structure. Some studies have tried to find whether urban or rural dwellers are happier. The findings are not directly agreeing because some studies provide higher level of subjective well-being for urban residents and some for rural residents. (Gilbert et al., 2016.)

Spatial characteristics that affect travel behavior are connected to many domains of SWB. Safe environment and access to transport resources are directly related to domains such as feelings of safety and autonomy. According to Ettema and Smajic (2015) locations that are perceived as safe for walking do not increase the affect level of well-being but they make people feel more active.

Objectively measured qualities in spatial environment seem to be less influential on happiness and quality of life than subjectively measured qualities. Safety and trust in neighborhood are associated with life satisfaction according to Ettema and Schekkerman (2016) study about spatial characteristics and SWB. Furthermore, Ala-Mantila et al. (2018) have studied urban environment in light of well-being and results were mostly contradictory. For example, central pedestrian zones flourish in terms of quality of life, whereas happiness is highest in car-oriented zones. Another study results that density in neighborhood has negative effects on health but positive effect on SWB in Sydney (Ma et al., 2018). The results would indicate that subjectively measured qualities define the effects better than objective ones.

2.2.6 Social exclusion and accessibility

Accessibility is an evitable feature of transportation equality. Planning processes discuss often social exclusion and accessibility as primarily issues. Accessibility defines how much effort one must make to reach activities. Higher accessibility enables better opportunities to for instance higher number of services, job opportunities and modes of travel with higher variety. Different types of mobility needs are fulfilled when accessibility increases. (Bocarejo and Oviedo, 2012; Vella-Brodrick and Stanley, 2013.) ZOTERO Measuring individual's mobility levels increases understanding of accessibility needs in society. Furthermore, findings should also increase the awareness of which characteristics have an impact on accessibility and how it affects individuals' well-being.

From mobility point of view, social exclusion means that the access to social contacts is poor. The term of social exclusion has been used since 1974 but some find social exclusion as a process and some as an end-state. Therefore, there is not an agreement on the actual meaning. (Preston and Rajé, 2007.) Social exclusion is a multi-disciplinary problem that requires policy work in many fields and transport is one of them. People are at risk of social exclusion if there are mobility challenges and transport services do not meet with people. (Stanley et al. 2013.) According to the studies transport-related social exclusion can be physical exclusion, geographical isolation, exclusion from facilities, economic exclusion, time-based exclusion, fear-based exclusion or space exclusion.

Few studies have tried to investigate which transport-related factors of accessibility and social accessibility have an impact on well-being. Delbosc and Currie (2011) have studied the impact of transport disadvantages and social exclusion on well-being. Among the other findings, they found that people with transport disadvantages and social exclusion had lower well-being. Furthermore, lack of social support was the greatest influencing factor on well-being compared to transit disadvantage, general transport disadvantage and vulnerable traveler. Additionally, people who face transport disadvantages are more likely to not own a car. Similarly, other results show that poor and physically disabled people have higher risk of social exclusion than others (Stanley et al., 2011).

Other findings have shown that transport opportunities affect employment, and transport barriers challenge people's ability to have a job. (Social Exclusion Unit, 2003, p. 8.) Studies by Ravulaparthy et al. (2013) show that people who are socializing more and have more activities out of home have shown higher subjective well-being.

2.3 Measuring subjective well-being

Perceived well-being is dependent on context to some extent. Some of the factors defining SWB are for instance in cultural and geographical framework. SWB is defined by feelings and emotions but at the same time international studies show that the content of some positive and negative emotions varies across cultures and societies (Diener, 2009; Kankaanpää, 2017). Additionally, some emotions are understood differently in other cultures and societies. Culture can also change people's understanding of what they want or should pursue to become happy and satisfied with life. According to some studies, demographic factors have only 15-20 % coefficient of determination of a model on SWB (Kankaanpää, 2017).

Experience and interpretation of subjective well-being is an individual decision. Well-being is often studied in a numeric scale where low number indicates poor well-being and higher number indicates higher well-being. Surveys explain sometimes the numbers with words that have meaning so that people would interpret the numbers of the scale more unanimously (Kahneman and Krueger, 2006). Measuring scales and methods for both SWB and transport-related SWB are mostly psychometric. Studies use single-item question that covers overall happiness or multi-item questionnaires that define comparable value for SWB by asking separate questions from different domains such as perceived health and safety. (Stanley et al., 2011).

Psychometric indicators have raised some doubts among scientists because the method has information gaps. Variables that affect perceived well-being are not discrete which means that evaluation cannot be quantified. Therefore, it is challenging to measure well-being because there can be infinite number of factors that explain perceived well-being. (Berglund et al., 2016.)

One traditionally used and developed measure for SWB is Personal Well-being Index (PWI) (International Wellbeing Group, 2013). This index consists of questionnaire of seven or eight questions about different domains of life. The answers are given in 11-point satisfaction scale from 0 (No satisfaction at all) to 10 (Completely satisfied). The core set of items that form the PWI consider standard of living, personal health, achieving in life, personal relationships, personal safety, community-connectedness and future security domains. The PWI also offers additional optional items that discuss general life satisfaction and spirituality or religion. The scores from the questions are added to get a final score for the index.

A part of the evaluating process is also to compare the final score to question about overall SWB which validates the answers. The item about general life satisfaction should not be however included in the mean because this item does not have a domain and it only validates the other questions. PWI has shown validity in many studies globally and it is rather simple instrument. PWI measures perceived well-being of adults in general and it is not personalized for certain groups such as children or older people who have different needs and capabilities. It is suggested that similar instruments should discuss different profiles and specific situations in future research (Giangrasso, 2018).

2.4 Measuring transport-related well-being

Transportation network has a big impact on national economy. Infrastructure and vehicles cost and exchange of goods define most national wealth. Therefore, economic evaluation has a long history in transport investments (Metz, 2008). Modern version of Gross Domestic Product (GDP) was developed in the 1940s and it has been a dominant indicator of national economy since. National economy is considered as a synonym for national well-being although wealthier nations are not generally happier than nations with poor GDP. It has been shown that decades of increasing GDP or average per capita income does not correlate with increasing happiness of nation. (Dutt and Radcliff, 2009.) However, higher per capita income is generally associated with higher quality of life and life expectancy. Nowadays GDP is rarely used as measurement of well-being in society. Other indicators such as Human Development Index (HDI) and Gross Domestic Happiness (GDH) are developed to evaluate national well-being and happiness. However, GDP keeps its dominant role when assessing wealth and economy. (Bates, 2009.)

Utility-maximization is seen as an indicator to measure travel satisfaction in classical transport research. The method investigates the consequences of people's travel choices and thus create models from observed choices. This method observes that people appear to have average daily travel patterns that are then used in planning. Theoretical framework of utility maximization is based on microeconomics, which means that every decision done in traffic is rational and optimized and preference is minimum travel time. (Golob et al., 1981.) As a result, travel satisfaction is completed because everyone makes their trip rationally so that travel time and travel cost are minimized. The application of utility theory in transport planning is questioned by many researchers because utility-maximization discusses travel behavior in a one-sided way.

Cost-benefit analysis (CBA) has been a dominant assessment process in transportation projects since the 1960's. CBA's assessment criteria for traveling are traditionally based on utility-maximization that put weight on trip-optimization and minimizing travel time. Utility theory is valued in CBA because travel time equals travel cost unit that should aim lowest possible value. CBA was a great leap for understanding and justifying major investments. CBA considers economic savings, safety and environmental impacts. CBA quantifies these factors and document them in monetary values which makes it understandable and efficient tool. However, there has come up many limitations throughout decades. The analysis is criticized for lack of multi-level assessment such as distribution of benefits. (Metz, 2008; Nahmias-Biran et al., 2017.)

A study of OECD (2016) about economic benefits of transport accessibility argues that benefits of accessibility are often overlooked. Traditional evaluation practices have clarity with the costs but benefits are lacking clear definitions, quantities and documentation. However, instead of changing assessment methods, organizations and researchers are trying to find economic value of indirect and other overlooked benefits of transport related issues.

The WHO Regional Office for Europe announced HEAT (Health Economic Assessment Tools) for walking and cycling in 2007 to calculate economic benefits of active traveling (WHO, 2013). HEAT is based on calculations of assessing all-cause mortality that derives from physical activity. HEAT calculations have shown that direct costs of inactivity cause approximately 1.5-3.8 percent of total costs in health care. (Pedia, 2017.) Additionally, inactivity can have a lot higher costs for society indirectly. On the other hand, HEAT is criticized for not considering the needs of special groups of people. For instance, calculations are not suitable for assessing mobility of children or older people because travel behavior and physical limitations are different and therefore the risks for health and traveling are different. HEAT for walking and cycling has evolved in last years and some differences between modes are acknowledged. (Kahlmeier et al., 2013.)

Interest of hedonic importance of traveling and mobility have highlighted subjective well-being in transport-related evaluation. Furthermore, the discussion should also challenge what sort of well-being or happiness is needed for research. (Kahneman & Krueger, 2006.) Gao et al. (2017) have gathered methods and scales that are used for measuring transport-related subjective well-being. They are using scales that ask about positive and negative affects and experiences. The affects are studied in retrospective view concerning traveling that a respondent have done.

Other than psychometric methods are rare but their incapability to measure well-being at the moment is acknowledged. In laboratory, it is possible to monitor moment-to-moment emotions and stimulus of events and their impact on well-being. (Kahneman & Krueger, 2006.) This requires however a lot more work than surveys. Additionally, a laboratory would have very limited possibilities to study travel behavior. Travel satisfaction is traditionally studied as a travel survey that has theoretical background on psychometric study regarding perceived well-being but the questions ask about satisfaction of a trip (Bergstad et al., 2011). This is the most common study method in the field of travel behavior. However, retrospective study method can create distortions because some emotions concerning the trip can be forgotten.

Real-time measures are rather limited. Experience Sampling Method is developed to gather information about occurring event (Larson and Csikszentmihalyi, 2014). This phenomenological approach can be applied to subjective well-being in travel behavior. A study by Ettema & Smajic (2014) investigated places that make pedestrians happy. Smartphones were used to collect the data. Participants filled a questionnaire about place characteristics and experiences after each walk after walking for five minutes. Additionally, SoftGIS methodology can be used as a tool to evaluate location-related emotions (Kyttä, 2012). Online mapping has been tested to understand also activity spaces and results have been able to recognize significantly different types of mobility and well-being (Hasanzadeh et al., 2019). The results indicate that new methods such as real-time information and mapping have an important role in understanding the connection of mobility and subjective well-being.

3 Framework and research questions

The conceptual framework of this thesis is presented in figure 2. The aim for this thesis is to study whether travel behavior can explain subjective well-being. Individual's travel behavior consists of activities one does over space and time and many factors have an impact on it. This study investigates the intersection between travel behavior and subjective well-being with selected mobility choices and socio-demographic factors.

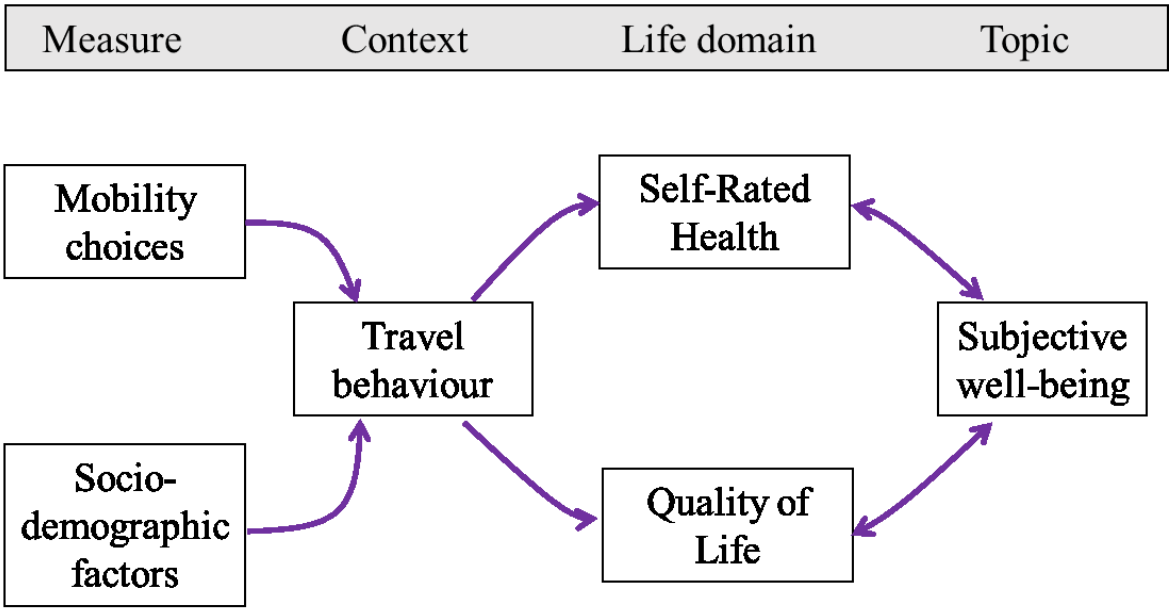

Figure 2. Conceptual framework of the study.

Even though the causality between subjective well-being, travel satisfaction and travel behavior is not always clear, this study will focus on travel behavior affecting subjective well-being and not vice versa. The arrows in the conceptual framework illustrate that relation. Subjective well-being is also a broad topic and individual's subjective well-being consist of satisfaction in different life domains. This thesis focuses on overall SWB that I call quality of life (QOL). Domain for self-rated health will be discussed separately.

Inside of this framework, I have four research questions for my thesis that are the following:

1. What is the association between subjective well-being and travel behavior?
2. Can mobility choices predict subjective well-being?
3. What is the impact of socio-demographic factors on subjective well-being and are they related to mobility choices?

4 Method

4.1 Data

4.1.1 Data collection and survey

To collect the data, an Internet survey was carried out for registered HSL users. The survey was sent to one quarter (approximately 250 000) of registered users in March 2019 and another quarter in June 2019 via email. Sample size in March was 22 304 and in June 6 961 which is in total 29 265.

The survey targeted all users of HSL services. The survey comprised of 23 customer satisfactory questions with open comments about the HSL service, five socio-demographic questions, three questions about mobility choices and four questions related to subjective well-being. This study does not analyse customer satisfactory questions concerning HSL services thus they are excluded from the study.

In the questionnaire (Appendix 1) the socio-demographic questions concerned

- Age
- Municipality and postcode
- Gender
- Number of cars in a household.

In the questionnaire, the following questions concerned mobility choices:

- How often have you walked over 400 meters at a time in last three months?
- How often have you cycled in last three months?
- How often do you travel by HSL public transport?

In the questionnaire, the following questions considered subjective well-being:

- How satisfied are you with your life?
- How happy are you?
- How good do you perceive your physical health?
- How good do you perceive your state of health?

4.1.2 Missing and rejected data

The final number of respondents was 25 495 after uncompleted responses were deleted from the sample. For spatial analysis, the data was narrowed down to Helsinki Capital Region (Helsinki, Vantaa, Espoo and Kauniainen) because vast majority of the respondents lived there (90% in March and 80% in June). Some data was rejected due to low aerial representativeness in some postal code areas. The postal code areas were investigated so that every postal code area would have at least 30 responses. This excluded sporadic responds. Additionally, some sets of 10-29 responses in a postal code area were combined with the nearest postal code and thus were not excluded from the data set.

This study does not have information about respondents financial or socio-economic status. Higher income level usually predicts higher car ownership due to high prices of cars and cultural reasons such as status or emotional attachment (Belgiawan et al., 2014). Therefore, car in a household can indicate higher income.

4.1.3 Independent variables

Postal code area variable was used only in spatial analysis but not in the regression models. Postal code area and place of residence variables had multicollinearity which is not accepted in logistic regression. Postal code areas had small sample sizes and as a variable it had over 100 categories which made it less attractive to study. Therefore, place of residence was clearly more convenient background variable to study spatial differences for the model.

There are categorical and continuous covariates. Place of residence has three categories "Helsinki", "Espoo and Kauniainen" and "Vantaa". Kauniainen was added into "Espoo" category in Place of Residence variable, because Kauniainen is a small municipality inside of Espoo. Rest of the responses that had some other municipality for place of resident were excluded. Additionally, gender has also three categories "Female", "Male" and "Other". This covariate was not modified or rejected.

Number of cars is discrete numeric variable that has three categories in the model that are "0", "1" and "2 or more". Option "3 or more cars in a household" was combined with "2 cars in a household" because 3 or more cars in a household is a relatively small group in Finland and they are similar enough with 2-car-households to be statistically significant (HSL Helsingin seudun liikenne, 2016b).

Rest of the independent variables were not modified. Age is expressed in 7-point scale. Variables for mobility choices were expressed as nominal categorical variables. Use of public transport and cycling have same scale for answers, that are 1 = "Less than once a month", 2 = "2-3 times a month", 3 = "once a week" and 4 = "Many times a week". Furthermore, questions about cycling and walking consider time frame of past three months.

Additionally, walking has the same scale as cycling and public transit with one more option 5 = "many times a day". Walking is asked not only from past three months but also minimum distance of 400 meters. In scientific research threshold value of 400-800 meters is used for people's willingness to walk somewhere, for instance, to a bus station. (Mavoa et al., 2011.)

4.1.4 Dependent variables

One purpose of this study is to analyse the impact of travel behavior and socio-geographic information on subjective well-being. The respondents of the survey were asked to rate their well-being in four questions on scale 0-10. The best model for this analysis was binary logistic model that requires dichotomous outcome variable. As a result, the dependent variables needed to be investigated to find the best fit from 11-category scale variable to binary variable.

Subjective Well-being Index suggests to compose a sum variable from many questions that together gives a value for subjective well-being rather than ask it directly. The survey in this study is based on questions that are not however identical to the index or any other example. Therefore, some tests and analysis were made to study the four well-being-related questions to form the best possible outcome variables for the model but the method of WBI was used as a basis for creating the dependent variable. After some correlation analysis, factor analyses were conducted between SWB variables and to the best fitting combinations.

Questions “how satisfied are you with your life?” and “how happy are you?” showed the highest correlation and questions “how good do you perceive your physical health?” and “how good do you perceive your state of health?” had also high correlation. Additionally, factor analyses showed that factor loading was high especially between those two variables. Moreover, the distributions of the values were rather small. Therefore, I created two sum variables named quality of life (QOL) and self-rated health (SRH). The averages of these two variables are reliable and do not hide any big leaps. The contents of the questions are rather supportive than overlapping. Factor analysis was conducted also for all four questions together which resulted good variance. Therefore, significant result could have been found by having just one sum variable. Two separate outcome variables give however more detailed analysis in this case.

Logistic regression analyses were carried out for life satisfaction and self-rated health. The dependent variables have good psychometric properties relating to internal consistency. Additionally, the questions have scales that are easy to understand (International Wellbeing Group, 2013). Having more than one question concerning life satisfaction validates the questions due to their high correlation. In both cases, the dependent variable was dichotomized with the score 0-8 coded ‘0’ (low or average QOL or SRH) and score 8.5-10 coded as ‘1’ (higher than average QOL or SRH).

In this study, the dependent variable was not dichotomous by its nature so some adjustments had to be done to perform binary output variable. There are two dependent variables both with scale 0-10. The responds were given in integer numbers but since the dependent variables were sum variables, they were either integer or halves that are not rounded. The means of each variable is presented later in the results. Life satisfaction had an average of 7.75 and SRH 7.99. Additionally, medians of the variables were a little bit higher than means (median = 8) but means round up to the same value as median. Standard deviation was quite small (1.9).

I carried out Hosmer and Lemeshow test to find the best binary variables. Hosmer and Lemeshow test is frequently used in risk predictions but it was also applicable for this analysis because it tests the goodness of fit for logistic regressions. The test evaluates probabilities of cases between observed and expected ones. In other words, the test assess percentages of dichotomous values and how many observed cases match with predicted ones. (Hosmer et al., 2013.)

Based on descriptive statistics, I tested two different threshold values between 0-10. The threshold value indicates line between higher than average SWB and average or lower SWB. Hosmer and Lemenshow test is a contingency test that shows how cases distribute for dichotomous output. The tests were conducted with the following adjustments from 0-10 scale to dichotomous:

1) 0-7.5 = 0 and 8.0-10 = 1
2) 0-8.0 = 0 and 8.5-10 = 1

If the value for both observed and predicted values have approximately half of the cases, the overall percentage would be closer to 50 % and then cases are distributed evenly for options

"higher than average SWB" and "average or lower SWB". Overall percentage closer to 50 % increases significance of the logistic model. Classification table 1 shows that the model classifies only 4.6 % of QOL and 18.4 % of SRH correctly for people with average or lower SWB with threshold values 0-7.50 and 8.0-10 (option 1). The percentage is too low because desired output would give overall percentage closer to 50 %.

The overall percentages for QOL is 70.5 % and for SRH 64.6 % with threshold adjustment option 1 (table 1). When the threshold is 8.00 rather than 7.50 (option 2) for "average or lower SWB", table 2 shows that the classification is more even. The overall percentage of correct classification is 57.9 % for QOL and 60.6 % for SRH (table 2). Overall percentages of the test for option 2 can be considered good because perfect classification of 50 % is near but also demanding to achieve.

Table 1. Classification table of option 1.

		Predicted sum variable		**Percentage Correct**
Observed sum variable		*Not Selected*	*Selected*	
QOL values 8.00-10.00	*Not Selected*	*336*	*6990*	*4.6*
	Selected	*305*	*17292*	*98.3*
Overall Percentage				70.5
SRH values 8.00-10.00	*Not Selected*	*1698*	*7549*	*18.4*
	Selected	*1268*	*14376*	*91.9*
Overall Percentage				64.6

Table 2. Classification table of option 2.

		Predicted sum variable		**Percentage Correct**
Observed sum variable		*Not Selected*	*Selected*	
QOL values 8.50-10.00	*Not Selected*	*8935*	*4238*	*67.8*
	Selected	*6253*	*5497*	*46.8*
Overall Percentage				57.9
SRH values 8.50-10.00	*Not Selected*	*12201*	*2476*	*83.1*
	Selected	*7335*	*2879*	*28.2*
Overall Percentage				60.6

As a result, based on the model tests, descriptive statistics and the literature about scale answering, the most logical and best fitting threshold was number 2 (Hosmer et al., 2013; Institute for Digital Research & Education, 2019). Values 8.5 and above are not only higher well-being than average but also higher than good well-being. Thus, logistic regression does not make distinction between answers that have had good well-being and bad well-being (values 0-8) but a distinction between average or lower well-being and higher than average well-being is done in the model. Additionally, the median value of 8 can be seen as the average level of life satisfaction in this study. The scale of 0-10 can be interpreted easily as school grade scale of 4-10 where 8 translates to "good" and 7 as "satisfactory". (Statistic Finland, 2011.)

4.2 Data validation

All data were cleaned and analysed using Microsoft Excel and IBM SPSS Statistic version 25. Table 3 shows means, standard deviations and scales for variables that have some scale. From the table 3 we can see that the average response for walking and public transport were very close to the highest value that indicate frequent use of the mode, whereas the average response for cycling was close to the low value.

In the survey, the mean for SRH was 7.99 with standard deviation of 1.56 in range of 0-10. In the survey, the mean for life satisfaction was 7.71 with standard deviation of 1.67 in a scale of 0-10. These results indicate a little bit higher evaluation of perceived well-being and self-rated health than Finnish national surveys (THL, 2019a, 2018).

Table 3. Descriptive statistics of variables with scale.

Variable	Mean	Standard Deviation	Scale
Age	4.27	1.60	1-7
Number of cars	0.74	0.68	0-2
Public transport	3.47	0.91	1-4
Walking	4.42	0.79	1-5
Cycling	1.40	0.94	1-4
QOL	7.75	1.67	0-10
SRH	7.99	1.56	0-10

Validation included also investigation about representation of Helsinki Capital Region demographics. Table 4 summarises sample sizes and shares of each category for the socio-demographic variables of the model. The analysis was also conducted for women and men to find out if distinctions between genders could be found from statistics. Municipalities of Helsinki Capital Region were represented evenly according to their population and Kauniainen is included in Espoo (Kuntaliitto, 2019). Each age group except ‘under 18’ was represented well in data. Respondents were mostly women (63.9%).

Table 4. Frequencies of socio-demographic information in total, for women and for men.

Variable	Total N	Total %	Women N	Women %	Men N	Men %
Place of residence	25495		16299		8658	
Helsinki	16381	64.3	10502	64.4	5506	63.6
Espoo	5536	21.7	3447	21.1	1986	22.9
Vantaa	3578	14.0	2350	14.4	1166	13.5
Age	25495		16299			
Under 18	350	1.4	246	1.5	92	1.1
18-29	4120	16.2	2812	17.3	1176	13.6
30-39	4592	18.0	2772	17.0	1659	19.2
40-49	4407	17.3	2680	16.4	1619	18.7
50-59	5418	21.3	3659	21.9	1763	20.4
60-69	4362	17.1	2853	17.5	1478	17.7
Over 70	2246	8.8	1367	8.4	8658	10.1
Number of cars	25495		16299		8658	
0	10079	39.5	6817	41.8	2980	34.4
1	11907	46.7	7353	45.1	4360	50.4
2 or more	3509	13.8	2129	13.1	1318	15.2
Total	25495	100	16299	63.9	8658	34.0

Since the survey was sent only to people who are registered HSL users, it is possible that more active users of public transport were more willing to respond to HSL survey. Among all the respondents 39.5 % did not have a car in their household. 70.5 % said that they use public transport many times in a week (table 5). Thus, frequent public transport users were represented in this survey more than non-public transport users. Additionally, car ownership was a little bit lower among the respondents than in HCR in general (HSL Helsingin seudun liikenne, 2016b). Women had also a little bit higher representation in the study than in the region. Representation of all the categories was however high in number and did not cause issues with significance. Furthermore, the bias was small enough that the model can be considered as general sample of the HCR as far as we can interpret from the explanatory variables.

Table 5. Frequencies of mobility choices and subjective well-being in total and according to gender.

Variable	Total N	Total %	Women N	Women %	Men N	Men %
Public transport	25495		16299		8658	
Less	1355	5.3	642	3.9	688	7.9
2-3 times in a month	3264	12.8	1712	10.5	1502	17.3
Once in a week	2899	11.4	1689	10.4	1156	13.4
Many times in a week	17977	70.5	12256	75.2	5312	61.4
Walking	15495		16299		8658	
Less	388	1.5	240	1.5	136	1.6
2-3 times in a month	450	1.8	280	1.7	166	1.9
Once in a week	1159	4.5	715	4.4	416	4.8
Many times in a week	9678	38.0	6129	37.6	3360	38.8
Many times in a day	13820	54.2	8935	54.8	4580	52.9
Cycling	25495		16299		8658	
Less	21105	82.8	13911	85.3	6759	78.1
2-3 times in a month	1039	4.1	593	3.6	244	4.9
Once in a week	942	3.7	531	3.3	396	4.6
Many times in a week	2409	9.4	1264	7.8	1081	12.5
QOL	24891	97.6				
SRH	24923	97.8				

According to the analysis, walking was the weakest predictor due to homogenous responds. Categories “walking once a week”, “walking 2-3 times a month” and “less” could have better fit if they were combined as one category. However, a change could also increase bias. Furthermore, questions about cycling and public transport had same scales so the model and results are easier to follow with similar categories.

4.2.1 Differences between data sets

The results of two data sets were very similar. The second data set had smaller sample size and relatively more respondents lived outside of Helsinki Capital Region. Cycling showed most change due to increasing cycling. Results of March and June data were compared with SPSS cross tables and correlation tables.

Table 6. Change in cycling between data sets.

How many times have you cycled during the last 3 months?	March		June	
	N	**%**	**N**	**%**
Less than once in a month	18257	91	2932	53
2-3 times in a month	463	2	581	10
Once in a week	346	2	599	11
Many times in a week	967	5	1460	26
Total	20033		5572	

Table 6 shows that 82,8 % of the respondents said they had cycled less than once a month during last three months and 9,4 % of the respondents had cycled many times a week. For validation, I searched for studies that supports the statistics and therefore are reliable. According to the City of Helsinki, the mode share of cycling in 2017 was 9 %. According to the data from 12 counting points of cycling in Helsinki, cycling is a lot more popular during summer than winter. (City of Helsinki, 2019.) Most of the responses of the dataset are from March where most of the respondents are expected to be non-cyclists. 93 % of the respondents of the first part cycled 3 or less times a month which support the validity of the data. Data set from June adds sample size for frequent cycling which increases the significance of the variable.

4.3 Statistical methods and models

This study aims to create a model about travel behavior and its effects on subjective well-being, more precisely mobility choices on quality of life and self-rated health. The goal was to describe prediction in a model and not testing the model that was created. The model predicts subjective well-being from socio-demographic information and mobility choices. The model tries to explain relationships between different factors with interactions between input variables and prediction of output variables. The relationships and conclusions can be formed by analysing the model.

As models especially among social sciences, the model is built using abstract and common factors that define the basis of the model and statements that determine the interactions between the factors. The model is built using statistical methods in IBM SPSS Statistics 25.

Logistic regression determines which independent variables have stronger and weaker qualities for prediction. Additionally, the model indicates which independent variables have interactions and which of them are required for predictability. (Pyke and Sheridan, 1993.) Logistic regression forms predictive equations to understand complex relationships between variables. Furthermore, logistic regression is an approach that can have more than continuously or categorically scaled independent variables in the model. (King, 2008.) That is also a reason that logistic regression has increased its popularity among social sciences.

According to Pyke and Sheridan (1993) logistic regression is flexible, easy and it gives straightforward answers. The model is two-level logistic regression model. The estimate for logistic regression is a method of maximum likelihood. Among regression models, logistic one is natural choice for SBW study because of the distribution of self-rated well-being. As

figure 3 shows, the responses are not evenly distributed for scale 0-10 and therefore the values do not fit in normally distributed model. Logistic function is a common s-curve function. The values in the study are also distributed cumulatively nearest to logistic function which enables reliable probabilities and model fit. The graph below shows an example of the SWB distribution. The graph has cumulative values for quality of life -variable in 0-10 scale (figure 3).

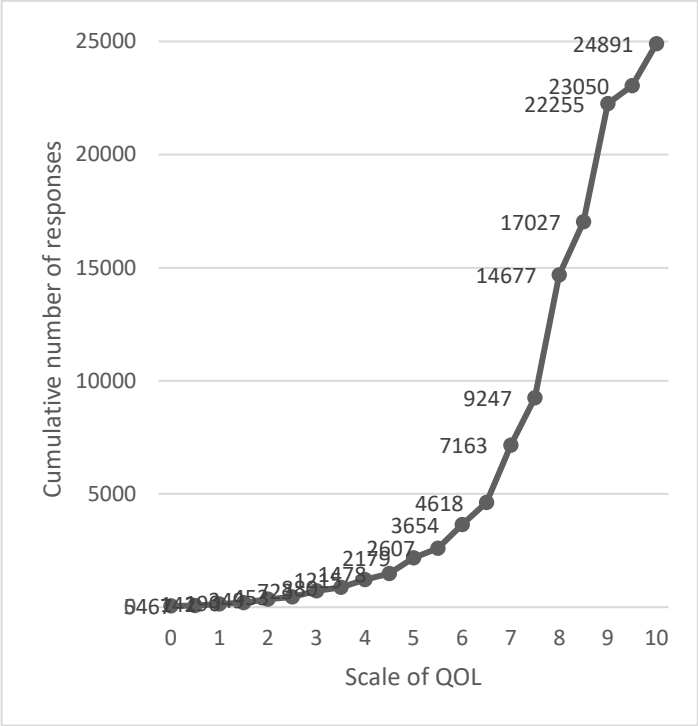

Figure 3. S-curved distribution of respondents' quality of life on scale 0-10.

The equation 1 is the prediction of logistic regression model that is formed in the following way:

$$p = \frac{e^{\beta_0+\beta_1 x_1+\cdots+\beta_k x_k}}{1+e^{\beta_0+\beta_1 x+\cdots+\beta_k x_k}} \quad (1)$$

Where p is an estimate of a probability
β_0 is the constant term
$\beta_{1\ldots k}$ are coefficients of an explanatory variable
$x_{1\ldots k}$ are predictors (independent variables)

This equation satisfies also the constraint of the conditional mean bounded between 0 and 1 since the model is binary and outcome should not give coefficient values outside 0 and 1. Equation 2 shows the logarithmic regression model that uses the prediction equation (equation 1) for final probabilities of predictors.

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k \quad (2)$$

This formulation is called logit transformation that is defined in terms of p. On the other side of the formulation, β's are the coefficients of explanatory variables that explain the predictability in terms of the binary variable.

Logistic regression was also chosen for this study because of the characteristics of independent variables. The variables fit well for the regression model because they are mostly evenly distributed between categories. The model also benefits from big sample size and low number of predictors. Additionally, covariates have variance in same scale. These factors will increase significance and reliability. Logistic model can be built by choosing all the independent variables to the model at the same time or by different stepwise methods that add or remove variables according to coefficient of determination. This model was built on the former method because reliability of coefficient of determination were investigated with variance and correlation analyses.

The binary logistic model was also conducted for standardized coefficients to ascertain the relative performance of predictors. The model included variables that are not in natural metric but rather different interval scaled which makes standardization useful and the strength of prediction can be compared. When standardized, all variables have a mean of 0 and a standard deviation of 1. SPSS does not offer standardized coefficients for logistic regression but computing is possible with existing materials. For the model, I created standardized odds ratios. First, I studied partially standardization, where only predictor variables were standardized. Fully standardized model required standardization for also dependent variables which I ended up using for the results. (Crowson, 2019; King, 2007.)

5 Results

5.1 Association between subjective well-being and travel behavior

The tables 7 and 8 show descriptive statistics of respondents according to the dependent variables QOL and SRH. Values for mean, sample size and standard deviations are presented in the tables. The total average of QOL was 7.99 and SRH was 7.75. Low values of standard deviations show that respondents inside each category rated their quality of life and health mostly homogenously. The highest standard deviations are in categories with the lowest sample size.

The table 7 shows that the average QOL or SRH do not vary much (7.60-8.24) between categories in socio-demographic factors in a scale of 0-10. Average QOL and SRH are the highest for people who have at least one car in a household. The average QOL is the lowest in categories under the age of 18 and gender marked as "other". The lowest average SRH is in categories age of over 70 and gender marked as "other".

Mobility choices show higher variation between the categories than socio-demographic factors (tables 7 and 8). Cycling many times in a week has highest mean for SRH (8.24) and QOL (8.21) out of mobility choice variables. Walking at least 400 meters less than two times in a month has the lowest mean of 6.18 for SRH and 7.27 for QOL. Average SWB between categories of use of public transport are more even than averages of walking and cycling categories.

5.1.1 Connections between mobility choices

The table 7 shows that most of the respondents are active users of public transport (PT). According to the observed results, whether people use public transport frequently or once or less in a month, QOL is rated the same. However, people using PT once or less in a month have significantly lower mean for SRH than others. Furthermore, people who use PT more than once in a week also walk more than people who use less PT. Younger respondents use more PT than older respondents and public transport is more popular in smaller postal code areas. Those areas are also usually denser and have more PT connections.

Most of the respondents do not cycle more than once in a month. However, cycling is a lot more popular in the second data set (June) compared to the first set (March). Averages of QOL and SRH increase relatively linearly from a scale not cycling to frequent cycling. Additionally, the more respondents cycle the more they also walk. Most of the respondents evaluate that they walk at least 400-meter distances many times in a week. Walking 400 meters less than many times in a week indicates evidently lower SRH whereas QOL decreases more moderately.

Table 7. Descriptive statistics of QOL by independent variables and categories.

Variable QOL	Mean	N	Std. Deviation
Place of residence			
Helsinki	7.98	16012	1.56
Espoo and Kauniainen	8.04	5392	1.51
Vantaa	7.91	3519	1.64
Age			
Under 18	7.60	342	1.97
18-29	7.71	4064	1.68
30-39	7.94	4486	1.55
40-49	7.99	4301	1.55
50-59	8.06	5270	1.59
60-69	8.18	4257	1.42
over 70	8.05	2203	1.45
Gender			
Female	8.06	16004	1.49
Male	7.87	8433	1.66
Other	7.53	486	1.94
Number of cars			
0	7.72	9843	1.69
1	8.12	11645	1.45
2 or more	8.24	3435	1.42
Public transport			
Less	7.98	1317	1.78
2-3 times in a month	8.06	3195	1.55
Once in a week	8.03	2853	1.51
Many times in a week	7.96	17558	1.56
Walking			
Less	7.27	381	2.21
2-3 times a month	7.75	447	1.74
Once a week	7.64	1125	1.73
Many times in a week	7.88	9455	1.57
Many times in a day	8.11	13515	1.50
Cycling			
Less	7.95	20622	1.59
2-3 times in a month	8.02	1010	1.51
Once in a week	8.09	925	1.42
Many times in a week	8.21	2366	1.42
Total	7.99	24923	1.56

Table 8. Descriptive statistics of SRH by independent variables and categories.

Variable SRH	Mean	N	Std. Deviation
Place of residence			
Helsinki	7.74	15999	1.68
Espoo and Kauniainen	7.84	5386	1.59
Vantaa	7.65	3506	1.72
Age			
Under 18	7.77	342	1.84
18-29	7.78	4056	1.59
30-39	7.86	4484	1.56
40-49	7.87	4296	1.61
50-59	7.74	5265	1.73
60-69	7.67	4246	1.70
over 70	7.41	2202	1.81
Gender			
Female	7.81	15991	1.61
Male	7.66	8414	1.72
Other	7.36	486	2.15
Number of cars			
0	7.54	9841	1.80
1	7.86	11621	1.57
2 or more	8.00	3429	1.51
Public transport			
Less	7.61	1316	1.94
2-3 times in a month	7.76	3195	1.70
Once in a week	7.75	2847	1.67
Many times in a week	7.76	17533	1.64
Walking			
Less	6.18	383	2.65
2-3 times a month	7.04	444	2.03
Once a week	6.96	1119	2.01
Many times in a week	7.56	9447	1.67
Many times in a day	8.01	13498	1.50
Cycling			
Less	7.67	20603	1.70
2-3 times in a month	7.90	1006	1.53
Once in a week	8.07	922	1.38
Many times in a week	8.24	2360	1.43
Total	7.75	24891	1.67

5.1.2 Spatial distribution of SWB

Figures 4 and 5 show spatial distribution of SWB inside Helsinki Capital Region. Average QOL and SRH are distributed mostly evenly according to the postal code areas. Maps show little bit lower average QOL and SRH in Vantaa and the eastern part of Helsinki. The averages of QOL and SRH according to postal code areas show also low variation. Hence, the difference of the lowest and the highest average SWB are small.

Furthermore, socio-economic statistics were added for postal code areas concerning education level and income level. Analysis was mostly conducted by comparing average values of variable according to the postal code area. However, analysis did not have any supportive results for the study and there were two main reasons for weak analysis. Firstly, the differences between postal code areas were small when sample size increased its reliability. Secondly, in small scale examination, these statistics and the scope of the study did not offer enough reliable information about examining differences between postal code areas.

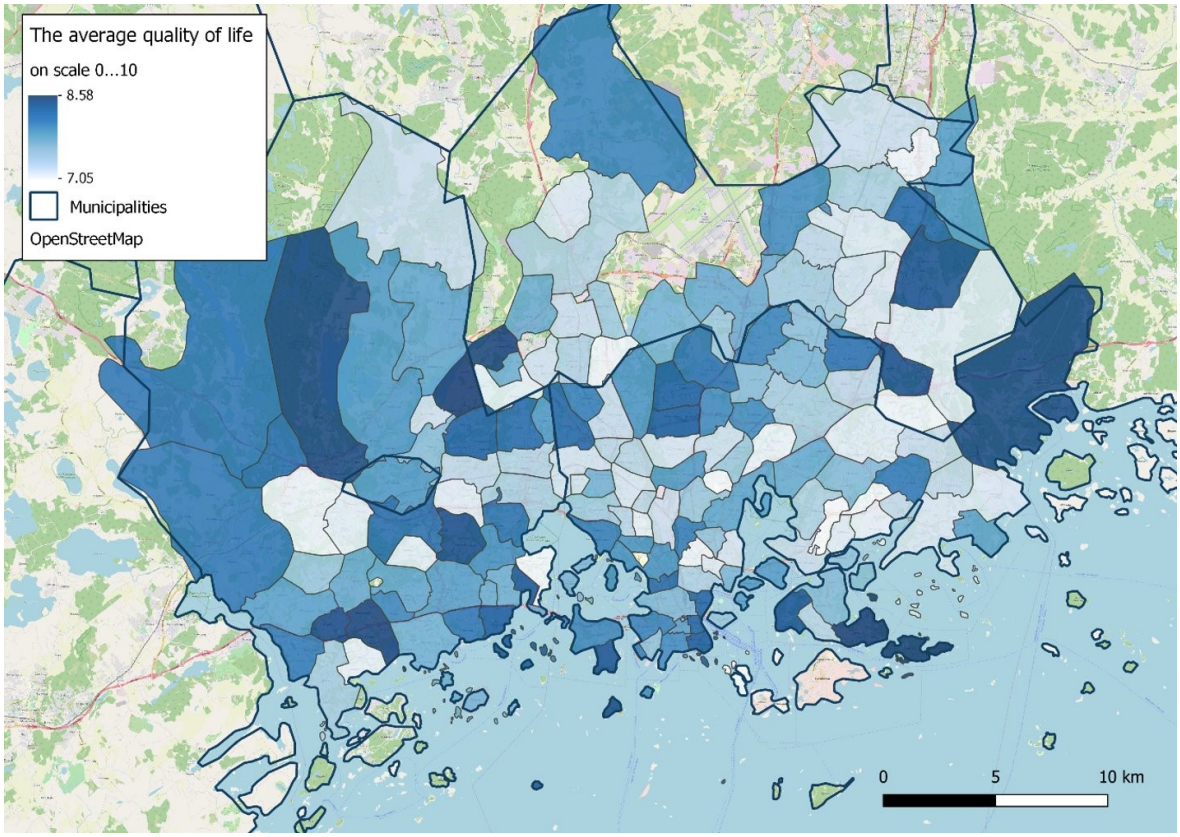

Figure 4. Distribution of QOL by postal code areas.

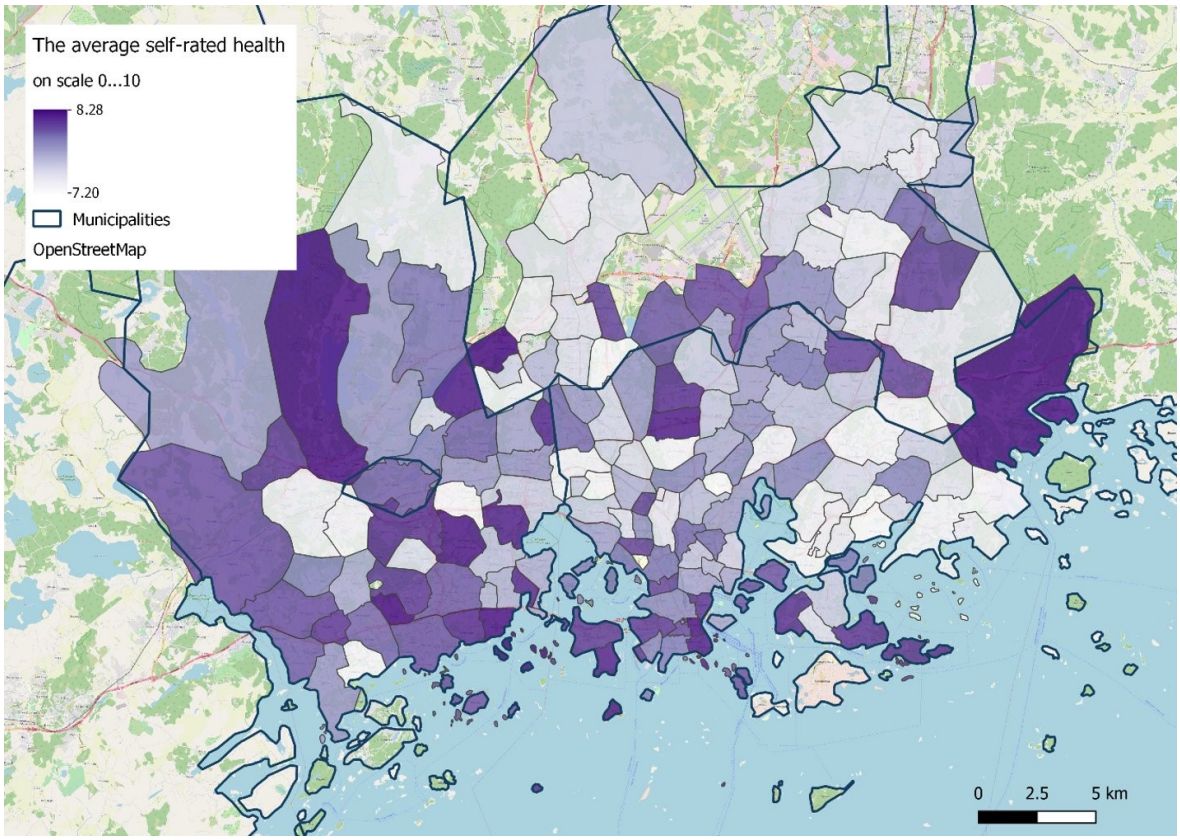

Figure 5. Distribution of SRH by postal code areas.

5.2 Socio-demographic factors and mobility choices predicting SWB

QOL and SRH models are estimated for un-standardized and standardized socio-demographic factors and mobility choices. Each of the unique model results are displayed in tables 9 and 10. The tables present the predictability of each category for the predictors of QOL (table 9) and SRH (table 10). The value of an OR is an exponentiation of a coefficient that determinates the direction and the size of the relationship between the independent and dependent variable. One category of an independent variable is a response category that other categories are compared to OR of the response category has always a value of 1.00. ORs that are higher than one, predict better odds for having higher than average SWB. ORs lower than one predict odds for having lower than average SWB compared to the response category. In the table, significance is marked with "*" when the result is significant in 0.05 significance level.

Standardized results decrease the effect of all of the categories. Both partially and fully standardized results were investigated and they had similar impact. Fully standardized ORs give 40-55 % smaller impact for the categories. Standardization did not show for example any shifts between the impact of categories. The following results discuss odds ratios of un-standardized model which is the original model that SPSS conduct from the variables.

Compared to residents of Helsinki, residents of Vantaa have 13 % lower chance of having higher than average QOL and 17 % lower chance for SRH. There were no statistically significant results for residents of Espoo compared to Helsinki. Additionally, the model predicts different SWB for genders. Men and other genders have 20-30 % lower chance of having

higher than average QOL or SRH compared to women. After standardization, the difference is only 10-15 % lower for men and other genders.

According to the model, younger people feel healthier than older people. Compared to the response group of over 70-years-olds, age between 18-29 predicts 40 % higher chance of having higher than average SRH. On the other hand, QOL is higher for older people. People under 18 years have 40 % lower chance of having higher than average QOL compared to people over 70 years. The highest odds are for people between 60-69. They have 11 % higher chance of having higher than average QOL than people over 70 years. The model explains well that quality of life increases when people get older until in the 70's quality of life turns back lower. Self-rated health on the other hand decreases when people get older.

At least one car in a household increases the odds of having high subjective well-being. Until some extend, the results show that more cars predict higher QOL and SRH, since category "2 or more cars" has the highest ORs. Compared to households without car, the odds of having higher than average SRH is 40 % higher for households with one car and almost 70 % for households with two or more cars. Odds for QOL is even higher: 54 % for households with one car and 89 % with two or more cars.

Use of public transport does not show significant associations with SRH or QOL. However, frequent walking and cycling predict higher SWB than small amount of active traveling. Odds for higher than average SRH is almost two times higher when cycling many times in a week compared to cycling once or less in a month. Odds for higher than average QOL increases also but only 40 % when cycling many times in a week. Comparing to people who walk once or less in a month, odds for higher than average SRH doubles when walking many times in a week and triples when walking many times in a day. Odds for higher than average QOL increases 48 % when walking many times in a week and 98 % when walking many times in a day.

Table 9. The odds ratios of the logistic regression model of quality of life.

Variable QOL	OR Unstand.	OR Stand.
Place of residence		
Helsinki	1.00	1.00
Espoo and Kauniainen	0.94	0,97
Vantaa	0.87*	0,94*
Age		
Under 18	0.59*	0,77*
18-29	0.73*	0,86*
30-39	0.88*	0,94*
40-49	0.85*	0,92*
50-59	0.97	0,99
60-69	1.11*	1,05*
Over 70	1.00	1.00
Sex		
Female	1.00	1.00
Male	0.77*	0,88*
Other	0.73*	0,85*
Number of cars		
0	1.00	1.00
1	1.54*	1,24*
2 or more	1.89*	1,37*
Public transport		
Less	1.00	1.00
2-3 times a month	1.00	1,00
Once a week	0.95	0,97
Many times a week	0.98	0,99
Walking		
Less	1.00	1.00
2-3 times a month	1.37*	1,17*
Once a week	1.15	1,07
Many times a week	1.48*	1,21*
Many times a day	1.98*	1,40*
Cycling		
Less	1.00	1.00
2-3 times a month	1.05	1,03
Once a week	1.15*	1,07*
Many times a week	1.42*	1,19*

Table 10. The odds ratios of the logistic regression model of self-rated health.

Variable SRH	OR Unstand.	OR Stand.
Place of residence		
Helsinki	1.00	1.00
Espoo and Kauniainen	0.96	0.98
Vantaa	0.83*	0.92*
Age		
Under 18	1.37*	1.16*
18-29	1.41*	1.17*
30-39	1.42*	1.18*
40-49	1.40*	1.17*
50-59	1.31*	1.13*
60-69	1.22*	1.10*
Over 70	1.00	1.00
Gender		
Female	1.00	1.00
Male	0.80*	0.90*
Other	0.79*	0.90*
Number of cars		
0	1.00	1.00
1	1.39*	1.17*
2 or more	1.68*	1.27*
Public transport		
Less	1.00	1.00
2-3 times a month	0.98	0.99
Once a week	0.94	0.97
Many times a week	0.94	0.97
Walking		
Less	1.00	1.00
2-3 times a month	1.36	1.16
Once a week	1.08	1.04
Many times a week	1.85*	1.33*
Many times a day	2.96*	1.66*
Cycling		
Less	1.00	1.00
2-3 times a month	1.1	1.04
Once a week	1.34*	1.15*
Many times a week	1.93*	1.36*

5.3 Gender differences in SWB by mobility choices and car ownership

The descriptive statistics for genders show that 64 % of the respondents were women (16 299 in total) and 34 % men (8658 in total). Mobility choices between genders were mostly similar. Half of both men and women walk over 400 meters more than once in a day according to the results. Men cycle a little bit more frequently than women. 12 % of men cycle many times in a week as for women the share is 8 %. The largest difference between mobility choices was the use of public transport. Three quarters of women responded that they travel by public transport many times in a week as 61 % of men responded that. According to the results, 65 % of men live in a household with at least one car. Women live less often in a household with one or more car (58 %).

Women and men had a lot of similarities in the models for mobility choices and car ownership. The models are built using the interactions of the same socio-demographic factors as in the previous model, but this analysis investigates only results concerning unstandardized mobility choices and car ownership. The use of public transport did not have any significant predictions.

The table 11 shows that frequent cycling affects similarly for women and men but the odds of higher than average QOL increases more for women. Odds for having higher than average QOL is 54 % higher for women and 30 % higher for men compared to cycling once or less in a month. Walking over 400 meters many times in a day predicts high QOL and SRH for both genders. For men, odds for having higher than average QOL and SRH is 2.3 times higher when walking many times in a week compared to walking less than once in a month. For women, odds for having higher than average QOL is 1.7-times higher when walking many times in a day. Odds for higher than average SRH is 3.4-times higher when walking many times in a day compared to walking once or less in a month.

Table 11. The odds ratios of the logistic models by gender.

Variable	Quality of life OR		Self-rated health OR	
	Women	Men	Women	Men
Cycling less than once in a month	1.00	1.00	1.00	1.00
Cycling 2-3 times in a month	1.06	1.04	1.17	1.02
Cycling once in a week	1.24*	1.08	1.44*	1.29*
Cycling many times in a week	1.54*	1.30*	1.90*	1.95*
Walking over 400 m less than once in a month	1.00	1.00	1.00	1.00
Walking over 400 m 2-3 times in a month	1.29	1.62	1.57*	1.05
Walking over 400 m once in a week	1.06	1.41	1.11	0.99
Walking over 400 m many times in a week	1.42*	1.69*	2.12*	1.43
Walking over 400 m many times in a day	1.87*	2.35*	3.44*	2.27*
No cars	1.00	1.00	1.00	1.00
1 car	1.61*	1.42*	1.36*	1.52*
2 or more cars	1.79*	2.02*	1.58*	1.96*

Car ownership predicts higher QOL and SRH for both genders but the odds ratios increase differently. Comparing to having zero cars in a household for men, odds predict higher than average QOL and SRH by 42-52 % when having one car in a household and. Odds increase to 95-100 % when having two or more cars compared to having zero. For women, one car increases the odds of having higher than average QOL by 60 % and the second car only by 80 % compared to not having a car. Odds of having higher than average SRH is 36 % higher for having one car and 58 % for having two or more cars. In summary, one car in a household predicts higher QOL for women than for men. Two or more cars in a household predicts higher QOL and SRH for men than for women.

6 Discussion

6.1 Mobility choices and subjective well-being

According to the model, active traveling predicts especially high self-rated health. Literature regarding active traveling and subjective well-being show physical and psychological connections to well-being. There is a lot of research about health benefits of active traveling. The relationship between active traveling and health is broadly acknowledged. For instance, higher stress levels are commonly found from car commuting rather than active traveling. The association between congestion and negative SWB also supports active traveling being the best option when traveling. Furthermore, longer commuting distances that require car or public transport have most likely more negative impact on SWB than shorter commuting trips (Halperin, 2014; Novaco and Gonzalez, 2009.)

Most of the respondents walk at least 400 meters many times in a week but it is yet less than recommendations for daily physical activity (Lee and Sener, 2016). Only about half of the respondents walk at least 400 meters many times in a day. The model showed that walking 400 meters many times in a day increases the odds for higher than average SWB more than for walking 400 meters many times in a week. The difference between categories does not only show that active walking is associated positively to SWB but also daily activity.

Additionally, the model predicts higher subjective well-being the more one cycle. Most of the respondents do not cycle much especially in wintertime. Cycling is considered rather seasonal mode in Helsinki Capital Region according to the results. Thus, a question arises that should winter cycling be promoted more to increase transport-related subjective well-being? It is uncertain if promoting cycling in winter would increase the level of subjective well-being because the causality of mobility choices and subjective well-being is not studied here. However, better cycling infrastructure is shown to have a positive impact on number of cyclists and travel satisfaction. (Chng et al., 2016; Singleton, 2019.)

The model does not show significant association between public transport and subjective well-being. According to the literature, public transport has an impact on SWB but the results are mostly different to each other due to various reasons. Some literature compares public transport to car commuting whereas only few studies show results for public transport and SWB without specific trip purpose or comparison to private car. Additionally, different modes such as bus and train show nearly always different results. Geographic differences such as density and land-use may also have an impact on varying results. Service level and other quality measures of public transport have shown to have an impact on travel satisfaction and mood during a trip yet it has been difficult to show if there are long-term impacts. Conditions are dependent on planners and decision-makers who can promote certain modes and increase attractiveness. (Abou-Zeid, 2009; Chng et al., 2016; Diana, 2012.)

The study results show that public transport does not predict negative or positive association with quality of life or self-rated health. However, active users of public transport evaluate that they walk more than others. Many studies show that frequent public transport use indicates expose to active traveling. Some public transport users reach minimum walking recommendations from using public transport alone and there are associations with lower BMI and obesity risks for public transport users compared to non-users (Lee and Sener, 2016). Physical activity can thus increase when choosing public transport but the connections to

self-rated health or quality of life are unclear. The challenge is to find whether the use of public transport can benefit from positive impact of physical activity and increase SWB.

6.2 The impact of socio-demographic factors on transport-related SWB

Car ownership's relation to subjective well-being and health can be discussed from an assumption that the respondent travels by car or from socio-economic perspective. Car ownership can explain some mobility choices of the respondent. The amount of walking and cycling does not change much whether there are 0, 1 or 2 or more cars in a household according to the results. However, public transport correlates negatively with car ownership as they are usually substitute modes. According to the model, if there is one car in a household, the odds of having higher than average QOL are 50 % higher than not having a car. Owning a car means more transport options, autonomy and freedom of choice that have been found to increase SWB (Jakobsson Bergstad et al., 2011). Car ownership enables leisure trips in a unique way that has been shown to have impact on increasing happiness (Duarte et al., 2010). On the other hand, traveling by car expose commuter often to high stress which usually relates to congestion, other unpredictable factors or long driving distances (Abou-Zeid, 2009; Choi et al., 2013).

Car ownership has historically increased there where income level also increase (Belgiawan et al., 2014). Therefore, in this study car ownership is rather a socio-demographic and -economic than mobility related factor because there is a clear relationship to income level. According to the model, owning two or more car predicts clearly better SWB than not owning a car. Many would argue that higher income respondents rate their quality of life and health higher than others. (Belgiawan et al., 2014; Duarte et al., 2010.) As a result, the reason behind the predictability of QOL and SRH by car ownership is not completely straightforward but connections to income-level and autonomy can explain it.

The categories for the place of residence are municipalities and each municipality has many types of land-use and housing. The model shows that quality of life and self-rated health are a little bit lower in Vantaa. The spatial distribution according to the postal code areas shows that the lowest average values of SWB are mostly in Vantaa and the East Helsinki. However, the differences are small and there are low values for SWB around the capital region. The impact of spatial characteristics on SWB were not investigated further and therefore this study did not find any significant results. Spatial characteristics such as safety, amount of green area or accessible pathways require usually more specific or detailed analysis for finding relationships or associations to SWB. However, the results show that there are more public transport users in smaller postal code areas that are mostly more densely built and have more PT connections.

Spatial characteristics as physical environment are associated with subjective well-being according to the literature. For instance, location and transport connections are shown to be the most important in terms of contentment for housing area in Finland. Approximately one out of three Finnish people find also natural environment, recreation opportunities or service availability important contentment in their housing area (Finnish Environment Institute, 2017). Studies have also recognized spatial characteristics that increase directly and indi-

rectly walking and cycling. Furthermore, attractive characteristics for an individual vary according to other socio-demographic factors such as age or neighborhood (Laatikainen, 2019).

Age has traditionally shown to have a u-shaped curve in relation to subjective well-being (Clark, 2019). The model predicts however higher quality of life for older age groups but lower self-rated health. Amount of walking and use of public transport also decrease throughout age. Impairment of walking is however not the reason to inactivity for older people according to some studies and therefore spatial characteristics and activities should attract older people to be more active. (Banister and Bowling, 2004; Spinney et al., 2009.)

The impact of active walking and cycling on SWB is stronger among women than among men. Frequent cyclist are however mostly men. According to the literature, women are more attached to home chores and being responsible to children which leads in some occasions to limiting the commuting mode and distance (Sweet and Kanaroglou, 2016; Wheatley, 2014). Some research indicates that shorter trips are more meaningful to women than for men which could explain the impact of walking and cycling results if women value them more. However, same studies show that women are more attached to cars because they are chauffeuring children and doing chores. On the contrary, results from the models of this study find that car ownership increase SWB on men more than on women. The dynamics of travel behavior by gender is multi-dimensional and the connection to subjective well-being can be different for genders.

Socio-demographic factors of an individual are shown to have an impact on mobility choices and subjective well-being. Transport-related subjective well-being is thus multi-dimensional and understanding the impacts of socio-demographic factors is required for comprehensive analysis. Socio-demographic factors are related to multiple domains of SWB that are not discussed in this thesis. Feelings regarding autonomy or safety might play an important role when discussing mobility decisions of certain socio-demographic group. Some of the relationships can be measured objectively but some have stronger connections to subjective well-being. Safe, aesthetic and livable environment can increase the number of pedestrians and cyclists. Additionally, short distances and urban structural characteristics promoting AT can decrease the threat of social exclusion and transport poverty. Studies also show that difference in mobility between genders.

6.3 Limitations of the study

The study includes limitations that result mostly from the methodology. Firstly, the data is from public service provider and the study was sent only to people who are registered to HSL. This can exclude some groups of people from the data set. Furthermore, people who use HSL services seldom are less likely to response to the questionnaire. The questionnaire had also many other questions related to customer satisfactory and services that could have brought more information about the respondents but they were not included in the study. There were approximately 15 000 open answers about service improvement. According to the literature, public transport can have positive impact on SWB if service and quality is good and therefore the analysis of the answers could have been valuable for the study.

The logistic regression model was used as a statistical method in this study. Model required dichotomous dependent variables which they were not in nature. This mean that changes

inside a dichotomous variable were simplified. For instance, the differences inside “average or lower SWB” that was coded as 0 were not studied and some information is therefore lost. Cut offs for categories of independent variables also lost some information. For instance, would mobility choices had different results for some other cut off -values? In addition, the analysis must be careful because the odds ratio describes only the relationship between the categories according to the binary predictor. Therefore, the causality of the relationship is not possible to recognize from the model.

The questions about mobility choices and subjective well-being were also limited in the study. Some factors that the literature from the subject suggest playing an important role were not asked in the questionnaire. Travel time and trip purpose are shown to have an impact on transport-related subjective well-being. Additionally, there were no questions concerning traveling by car which is one of the most popular mode of travel. Public transport did not result either any statistical predictions but as separate modes there could have been different outcome.

There were four questions about subjective well-being. All four correlated together highly. Domains such as travel satisfaction could have been covered for more information. The literature discusses a lot about short- and long-term impact but this study had results that are related to long-term SWB. Both travel behavior and SWB are a sum of many factors thus the impact of one factor is rather limited. Factors have also many spill-over effects because they are interrelated to each other.

The methodology of this study limited also other information concerning the relationship between travel behavior and subjective well-being. Some theories would imply the importance of the top-down effect, and causality of positive and negative affects requires also research. (Vos et al., 2013.) People with higher life satisfaction feel their experiences more positively than others and thus rate higher travel satisfaction. As mentioned, the causality of subjective well-being and mobility choices is not always clear and the empirical part could not explain the causality. Furthermore, quantitative methods have limitations when measuring well-being and human behavior.

7 Conclusion

The health benefits of active traveling are significant and the promotion of active traveling is important for health threats that inactive lifestyle is causing. This study supports the importance of walking and cycling because daily walking and weekly cycling predicted high quality of life and self-rated health. The model showed that not only frequent but also occasional walking and cycling are positively associated with subjective well-being. Especially for women, daily walking explained high SWB. The literature supports the relationship and furthermore, studies show that active traveling has more positive impact on SWB than trips done by public transport or car. The attractiveness of active traveling and the impact on short- or long-term perceived well-being is however a multi-dimensional issue.

In the model, the standardized odds ratios decreased the values of predictors meaning that other variables also explain the outcome. There are constantly other impactors such as spatial and temporal characteristics and individual's socio-demographic information that have an impact on subjective well-being. Walking and cycling can create value for an individual and for society and increase subjective well-being but to measure how and for whom, further investigation needs to take place.

The empirical part could not find significant results for public transport predicting SWB. However, the use of public transport increases active traveling according to the results and literature review. The quality of public transport has an association with experiences, mood and attitudes towards public transport. Attractive trip conditions increase travel satisfaction and willingness to travel by public transport. Hedonic happiness can be reached from using public transport but eudemonic happiness is yet more difficult to distinguish. Research show that some public transport services are associated with higher perceived well-being than traveling by car. According to the literature and the observed results, public transport can have direct and indirect association to SWB.

The results showed that car ownership predicted high SWB especially for men. Car ownership is related to higher income-level, autonomy, cultural status and increase in transport benefits that all have been found to affect different domains of SWB positively. However, car drivers expose to stress usually more than other mode users and risk of inactive lifestyle is high when travelling by car.

According to the literature, short commuting distances can increase quality of life and self-rated health. Short trips are associated with higher travel satisfaction which is one reason for active traveling being associated with high SWB. Furthermore, short trips can also have higher share of sustainable modes and AT that usually predicts higher quality of life and SRH due to physical activity. The interaction between active traveling and public transport could result positive affects towards public transport if the conditions of modes are experienced positively. According to the hedonic approach, it is important that people find positive emotions while they travel. Positive affects of a travel mode also increase the possibility to take the same mode again. Travel satisfaction measurements such as satisfaction with travel scale (STS) can find significant results about travel satisfaction which can be used as a tool to increase attractiveness of a mode and therefore have an impact on mobility choices.

Subjective well-being consists of multiple domains which have different associations to travel behavior. This study focused on overall quality of life and domain-specific self-rated health. Travel satisfaction was the link between travel behavior and subjective well-being in many studies. Findings show that mobility choices and socio-demographic factors can predict subjective well-being but the causality cannot be assured. More research could provide comprehensive understanding for the causality and the dynamics of mobility choices and subjective well-being.

The interconnection between travel behavior and subjective well-being is important to acknowledge if decision-makers and planners want to develop transport networks and assessment methods. It is however multi-discipline field of study which requires researchers from many fields to achieve comprehensive analysis. To meet strategic goals of increasing health and well-being impacts of transportation, this study is important step towards measuring transport-related well-being. For further studies, the scope should be narrowed down for more specific outcomes. Comprehensive transport-related perceived well-being study could have significant findings on SWB if trip purpose, mode choices or travel times were measured. Investigation of how factors such as gender and spatial characteristics impact on transport-related well-being objectively and subjectively should also take place.

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Appendix

Appendix 1. The questionnaire (in Finnish). 2 pages.

Appendix 1. The questionnaire (in Finnish)

	Vastaukset, joita käytetty aineistona
Asuinpaikkakunta	Helsinki Espoo Vantaa Kauniainen (yhdistetään Espooseen)
Postinumero	[avoin]
Ikä	alle 18 18-29 30-39 40-49 50-59 60-69 70 ja vanhempi
Sukupuoli	Nainen Mies Muu / en halua vastata
Kuinka monta autoa kotitaloudessasi on?	Ei autoa 1 auto 2 autoa 3 tai enemmän (yhdistetään 2 autoa -kanssa)
Kuinka usein olet käyttänyn joukkoliikennettä viimeisen 3 kk aikana?	Harvemmin kuin kerran kuukaudessa 2-3 kertaa kuukaudessa Kerran viikossa Useita kertoja viikossa
Kuinka monta kertaa olet pyöräillyt viimeisen 3 kk aikana?	Harvemmin kuin kerran kuukaudessa 2-3 kertaa kuukaudessa Kerran viikossa Useita kertoja viikossa
Kuinka monta kertaa olet kävellyt yli 400m viimeisen 3 kk aikana?	Harvemmin kuin kerran kuukaudessa 2-3 kertaa kuukaudessa Kerran viikossa Useita kertoja viikossa Useita kertoja päivässä

	asteikko
Kuinka tyytyväinen olet elämääsi kaiken kaikkiaan tällä hetkellä?	0-10
Kuinka onnellinen olet?	0-10
Kuinka hyväksi koet fyysisen terveytesi?	0-10
Kuinka hyväksi koet yleisen terveydentilasi?	0-10