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Author:
Steven Repa

Course coordinator:
Daniela Müller-Eie

Supervisor(s):
Daniela Müller-Eie

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The development of this thesis has been a challenging but rewarding experience. It has provided me with deeper insight on the role of cycling and active transportation in shaping a sustainable future as well as how cycling is experienced by different sociodemographic groups. The topic choice reflected my interests in cycling and the influence of the built environment, which was acquired through my own observations and experiences of bicycle commuting in the very different contexts of Winnipeg, Canada and Stavanger, Norway.

There are many who supported me throughout this process. I would firstly like to thank my thesis advisor Daniela Müller-Eie, who provided me with both direction and feedback which was key in the successful development of my thesis. I would also like to acknowledge the great support of my girlfriend Hedda Solheim. Who seemingly had no limits in her ability to both listen and reflect on my thoughts and Ideas, as I worked through the various stages of my thesis. Lastly, I am incredibly grateful for the never-ending support of my family back home in Canada, as well as friends both here and abroad, who's support and encouragement helped in my pursuit of this Master's Degree.

Abstract

Norway has ambitious plans to reduce private car use, both for the benefits of reduced emissions and to mitigate their space consuming impacts on roadways and in cities. In conjunction with these plans, a high target has been set for increased bicycle mode share across Norway's major urban regions. In Stavanger this has translated into increased investment in the facilitation of cycling for transport, including the expansion and improvement of bicycle infrastructure. Although, what cyclists perceive as safe and attractive bicycle infrastructure can vary widely, based on factors such as experience level, age and gender. One example is, that a stronger preference towards infrastructure with a greater level of separation between motorized vehicles and cyclists, has been found in both women and older adult cyclists.

Through observations of cyclists at twelve locations and three different infrastructure typologies in Stavanger, this thesis seeks to provide insight on the possible influence of bicycle infrastructure on the proportion of cyclists of different genders and age groups. The proportion of cyclists which use safety gear, sport clothing and e-bikes are also a focus of the analysis. These variables are of relevance, as research has highlighted that cities which have safer and more separated infrastructure, often also have more normalized cycling cultures and cyclists which less often use safety gear and sport clothing. While e-bike users often have different infrastructure preference and choice than that of conventional bike users.

The infrastructure typologies which are compared, have been selected on the basis of the degree that they are separated from motorized vehicles. Although other infrastructural and environmental characteristics are also considered, including traffic volume, traffic speed, measure of centrality and density. The findings do not validate the assumptions made between the infrastructure characteristics of degree of separation and the variables considered. Although strong correlations are found between measures of traffic intensity and centrality at observation points and the proportion of women cyclists using the infrastructure. While other findings may point to a moderating effect of e-bikes on the proportion of women cyclists observed at more highly trafficked locations. Additionally, correlations between safety gear and sport clothing use and centrality are found which could be potentially related to two distinct types of cyclists found in Stavanger.

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1 Introduction

Bicycles are widely recognized as a highly sustainable mode of transport, they produce minimal amounts of greenhouse gases from a life-cycle perspective while simultaneously making limited noise and taking minimal space (Parkin et al., 2012). In addition cycling is seen to provide a range of health benefits to individuals, which can have even broader implications for societal level health, such as reduced rates of obesity and cardiovascular disease (Pucher et al., 2009). Although given these benefits, aside from a few examples such as the Netherlands, Denmark and Germany, the modal share of bicycle transport has remained relatively low in many contexts when compared to motorized vehicle transport (Pucher & Buehler, 2008).

A commonly stated reason for not cycling, is a perception of vulnerability to collisions with motor vehicles and resulting injury (Clark et al., 2019). This perception of vulnerability is also found to be more impactful to certain population groups, such as women and older adults (Aldred & Dales, 2017; Dickinson et al., 2003; Krizek et al., 2004; Van Cauwenberg et al., 2018). The presence of high-quality cycling infrastructure plays a large role on increasing this perceived safety and attractiveness of cycling, and can help facilitate cycling (Buehler & Dill, 2016; Buehler & Pucher, 2011). Therefore, this increased perception of risk can partly explain the lower proportions of these population groups in cities which lack more comprehensive or supportive bicycle infrastructure. While a key factor of bicycle infrastructure, which can contribute to the feeling of safety and reduced perception of risk is the degree of separation between motor vehicles and cyclist traffic (Aldred & Dales, 2017; Clark et al., 2019; Van Cauwenberg et al., 2019).

Additionally, in contexts which lack either supportive cycling infrastructure or a more normalized cycling culture, perceptions of cycling as being more exclusive to sporty or risk-taking individuals can be more likely to proliferate (Oosterhuis, 2016; Pedroso, 2021). Higher levels of safety gear such as helmets and high visibility gear as well as sport clothing such as tight-fitting lycra gear are shown in some cases to promote these perceptions (Aldred & Woodcock, 2015; Daley & Rissel, 2011). These images of cycling are more impactful to both less experienced cyclists as well as women, which could be attributed to often greater perceptions of vulnerability to injury from cycling amongst these groups (Aldred & Woodcock, 2015; Daley & Rissel, 2011). Although, in countries with high modal shares of cycling, the use of safety gear and sport clothing are less common, which is theorized to be related to the presence of high-quality separated infrastructure and greater feelings of safety and security (Aldred & Woodcock, 2015). These high bicycle modal share countries, such as the Netherlands, Denmark and Germany also experience greater representation of women and older adult cyclists (Buehler & Pucher, 2012; Pucher & Buehler, 2008).

In recent years the use of e-bikes has become more popular, with older adults, as well as women in some contexts, being found to use or own more often (Leger et al., 2019; Lunke et al., 2018; Wild et al., 2021). Given the increased speed and ease of effort, many e-bike users state an increased confidence in comparison to riding conventional bikes (MacArthur et al., 2014). This increased confidence and potential attitude shift may compensate for perceptions towards cycling as risky or sporty, which may be particularly prominent in contexts which lack either a more normalized cycling culture or comprehensive bicycle infrastructure.

1.1 Background for a cycling study in Norway

Norway has great ambition in obtaining the environmental and societal benefits possible through increased transportation by bicycle (Samferdselsdepartment, 2017). Where the major regions of Oslo, Bergen, Trondheim and Nord-Jæren are considered important, given their greater population sizes and levels of urbanity (Lunke & Grue, 2018). This thesis focuses on the municipality of Stavanger within the Nord-Jæren region. The cycling modal share in Stavanger was (9%) in 2018/19 and Scandinavian countries are well known for greater levels of gender equity (Grue et al., 2021; Kautto et al., 2001). This context provides an opportunity to provide insight on bicycle travel behavior across socio-demographics from a city with a modal share of cycling that could be considered moderate but growing and with a higher level of gender equity. As much of the current literature is focused particularly on regions with very low modal shares such as the USA, UK or Australia (Aldred & Dales, 2017).

In addition to increasing the bicycle modal share, the government hopes to reduce the number of road traffic deaths and serious injuries with a focus on pedestrians and cyclists (Statensvegvesen, 2017). Norway has long focused on road traffic safety and has some of the lowest rates of road and traffic fatalities in Europe. This focus has potentially created a strong road safety culture in Norway and therefore this context presents an interesting opportunity to explore relationships between bicycle infrastructure, socio-demographics and the use of safety gear and sport clothing. Lastly e-bikes are fairly common in Norway, with a study by Lunke et al. (2018) showing that they are more often used by women. Therefore, this thesis will also explore the potential behavior and infrastructure preference differences of e-bike users and possible support they can provide to typically under-represented groups in cycling.

1.2 Research questions

Within this thesis twelve observation points have been selected in Stavanger, categorized within three bicycle infrastructure typologies. The infrastructure typologies have been selected on the basis of how separated they are from vehicle traffic, ranging from the lowest, non-separated, then the next highest visually separated, and lastly, fully separated infrastructure. Through the use of a non-participant observational methodology an analysis is conducted between the degree of separation of the typologies and the sociodemographic distribution of cyclists as well as safety gear, sport clothing and bike type usage of the cyclists observed using the infrastructure. The main focus is on how cyclist preference and behavior can influence their use of infrastructure based on its degree of separation. The thesis is also exploratory in nature and considers choice based on other infrastructural and environmental characteristics, such as motorized traffic volume, speed limits and presence of hills and greenery. This has resulted in three main research questions which are presented below.

1. ***Does the degree of separation of cycling infrastructure influence the demographic composition of cyclists who use it? if so, in which ways?***

2. Does the degree of separation of cycling infrastructure influence the proportion of cyclists with safety gear and equipment who use it? if so, in which ways?

3. Does the degree of separation of cycling infrastructure influence the proportion of e-bike riders that use it? if so, in which ways?

1.3 Thesis structure

This thesis consists of seven chapters, which are presented in Figure 1.1. ***Chapter 1*** is the introduction, which attempts to provide a broad and general framing of current research that the thesis topic fits within. It also presents some background as to why such research is relevant in the context of Norway and concludes with a statement of the research questions which will be answered. ***Chapter 2*** provides a more detailed look at cycling and mobility in the Norwegian context. Including how cycling goals at the local level of Stavanger fit within the broader regional and national context. It also describes some of the measures which have been used to facilitate increased cycling uptake in Stavanger as well as graphic presentation of the current and historic modal share data for cycling across major urban regions in Norway. ***Chapter 3*** is theory, where the intent is to build a strong basis of findings and research on the areas of focus within the topic. The chapter concludes with clear summaries based on the theory, of what is hypothesized in regards to the presented research questions. **Chapter 4** is the methodology, which first describes and justifies the research design. It then provides thorough details on the process of the study, including how the locations of observations where selected, as well as how the observations were conducted. ***Chapter 5*** is the findings, which based on the research questions and hypotheses, presents and explores key findings from the analysis. Chapter 6 is the conclusion, which provides a more concise answer to the research questions. ***Chapter 7*** is the discussion and the final chapter of the thesis. The discussion attempts to further connect the findings back to the local context of Stavanger and elaborates on their possible implications, including the improvement of the infrastructure.

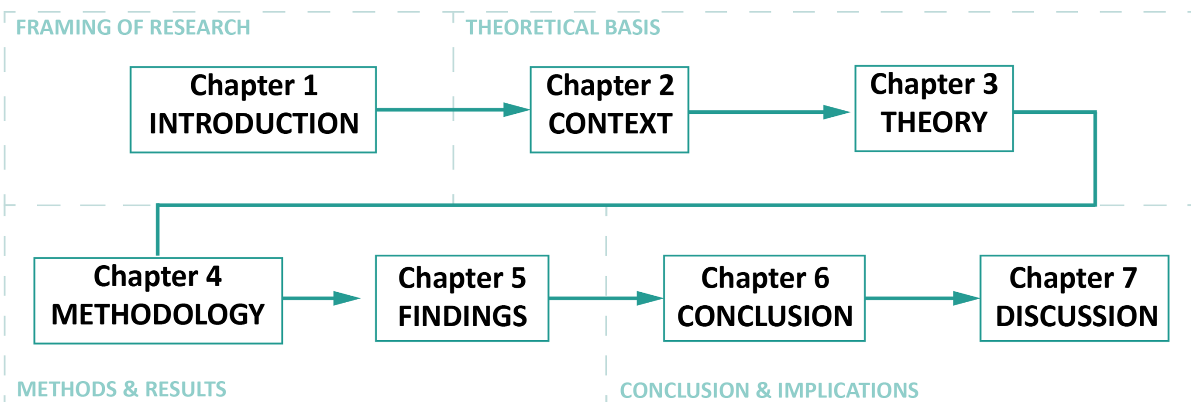


Figure 1.1 – Flow chart of thesis chapters.

2 Context of cycling and mobility in Norway

2.1 National goals for cycling and emissions reductions

In connection to the Paris climate agreement, Norway has committed to a 40% reduction in greenhouse gas emissions within 2030, compared to the levels in 1990 (Samferdselsdepartment, 2017). Which is an important step in Norway's goal of becoming a self-described, low-emission society by 2050. The national transport plan recognizes the significance of the transport sector in achieving these goals and therefore has stipulated a goal of zero growth in passenger vehicle transport. Meaning any rise in the passenger transport must not come from personal vehicles such as cars and only consist of increased usage in public transport or active traffic modes such as walking and cycling (Samferdselsdepartment, 2017).

In seek of this broader emissions reduction goal and in recognition of the importance of active modes of transport to attain them, the Norwegian government has adopted a national target of 8% bicycle mode share across the entire country, an increase of (+3%) from its 2013/3014 levels. Along with this national goal they have also stipulated a more ambitious target of 20% within the most urban areas (Lunke & Grue, 2018). The idea behind this increased target in more urban areas is, given that they consist of the highest population levels and the densest development they therefore also likely offer the best accessibility to active transport alternatives such as cycling. Correspondingly they should be easier to shift towards these more sustainable travel modes. This will then have a positive impact on the national goal of an increase to 8% bicycle share. Assuming growth in population as well as growth in the amount of transport required, this would mean that the total share of personal vehicle trips by cars needs to decrease. The goals take a particular focus on children and youth, where the government has a goal that 80% of students in school should either walk or bike (Lunke & Grue, 2018).

The urban areas which are to contribute to the more ambitious 20% bicycle modal share consists of the nine largest urban areas within Norway, that is, Oslo/Akershus, Buskerudbyen, Nedre Glomma, Greenland, Kristiansand, Nord-Jæren, Bergen, Trondheim and Tromsø (Lunke & Grue, 2018). The transport modal share of these urban areas is shown in Figure 2.1.

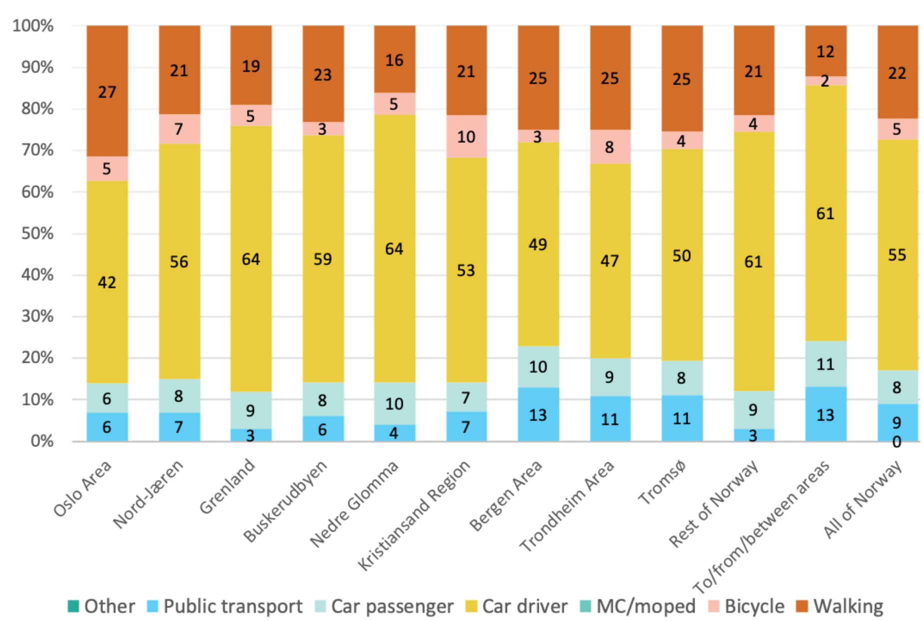


Figure 2.1 - Daily modal share of transport for trips under 100 km for different cities and regions across Norway, adapted from "sykling og sykkelmål – Analyser av sykkelandeler og ulike målsetninger for Nasjonal Transportplan" by E. Lunke and B. Grue, 2018, p.5. Copyright Transportøkonomisk institutt, 2018.

The increase in cycling required, in order to achieve the 20% goal across the urban areas is significant, given that the bicycle share as of the 2013/2014 National Transportation survey was an average of 5%. This would mean an average increase of (+15%) in these nine urban areas (Lunke & Grue, 2018). In regards to the national goal of 8% bicycle modal share, the Norwegian Transport Economics Institute Lunke and Grue (2018) has indicated that the goal could be achieved with only Oslo reaching a 20% bicycle modal share or alternatively the next three largest urban areas of Bergen, Trondheim and Nord-Jæren achieving a 20% bicycle share, given their greater population levels. Also, if these four largest regions all see an increase to the level of 13% bicycle modal share, the national goal of 8% bicycle modal share could be achieved (Lunke & Grue, 2018. There are numerous alternatives in achieving the increase in cycling required as a means to reach the emissions reductions target of 40% for 2030. Although through this analysis, it is clear the significance of the populated urban areas of Oslo Bergen, Trondheim and Nord-Jæren in reaching these goals.

2.2 Regional and municipal goals and measures for cycling and emissions reductions

2.2.1 Cycling Goals

To promote a holistic approach in achieving the national targets for emissions reductions across regional and municipal levels of government, the state government has formed agreements with local municipal and county governments as well as other local actors. Where the main goals stipulated through these urban development agreements are the zero growth in private car use and a second and corresponding goal of achieving greater mobility levels for other more sustainable modes of traffic. The local actors are incentivized through reward scheme funding, where if the goals are met, further funding for measures are provided. (Rosales, 2019; Samferdselsdepartementet, 2016). An additional factor which is important to mention, given the significant recent growth in battery electric vehicles, is that the zero growth goal in vehicle traffic also applies to these vehicles. Meaning that the governments can’t rely on the increased prominence of battery electric vehicles, and that the growth in traffic then from all personal vehicles must be considered(Rosales, 2019; Samferdselsdepartment, 2017).

The agreement towards achieving the zero growth goals in private car transport goals in Nord-Jæren is called the urban environment package. This package signifies an agreement between local actors such as Stavanger as well as the surrounding municipalities of Sandnes, Sola, Randaberg and Rogaland County Municipality as well as the other state actors of Statensvegvesen, The Norwegian Railway Directorate and the State Administrator of Rogaland (Bymiljøpakken, 2020). Various measures have been agreed upon to achieve the zero growth goal, with division of the use of funds of approximately 70% towards collective transport, walking and cycling infrastructure improvement while the remaining 30% will be road projects (Bymiljøpakken, 2020).

At the municipal level the Stavanger climate and environmental plan 2018-2030, dictates its main goal within the transport sector as reducing the direct GHG emissions in the transport sector to 80 percent within 2030 and 100 percent by 2040. They also state that 70 percent of passenger transport should take place by bike, foot and public transport within 2030, which would mean an increase of 27 percent from the 2014 level of 43 percent. These significant increases in active and collective modes of transport are to be achieved through measures that focus on both disincentivizing the use of private vehicles while making it more attractive to utilize collective and active modes of transport (Stavanger-Kommune, 2018). The key disincentivizing measures include the toll system on roadways, as well as the inclusion of increased fees for travel times during peak hours. While supportive measures for public and active transport include the development of the bus way, a dedicated bus road that is connected throughout Stavanger. In addition to the development of bicycle trunk road (sykkelstamveg), which is intended to connect cyclist commuters between the more urban areas of Stavanger and the business area of Forus (Stavanger-Kommune, 2018).

2.2.2 Measures for increasing cycling

Through a project called Bicycle in Stavanger that was operational between 1996 and 2001, a cycling network base, coherent signage systems and operational norms were established within Stavanger (Stavanger-Kommune, 2010). In addition to the national transportation plan and the aligning of goals between the state and more local actors through the urban environment package, the region of Nord-Jæren as well as Stavanger municipality have their own more detailed cycling strategic plans (Davidsen et al., 2016; Stavanger-Kommune, 2010). The consistent messaging throughout these plans highlights cycling as an important means for achieving reduced private vehicle use as well as the general societal health and environmental benefits which come from increased levels of cycling. Both at the regional and municipal levels the main instruments that are to be utilized in order to create a safer and more attractive environments for cyclists lie within three main categories: increased facilitation of cycling infrastructure, high levels of operationality, service and maintenance, as well as increasing cycling knowledge, competence and the spread of information through campaigns (Davidsen et al., 2016; Stavanger-Kommune, 2010).

In the 2019 bicycle survey completed in Stavanger nearly 35% of respondents thought that more cohesive cycle networks as well as safer cycle infrastructure were important for increasing cycling in Stavanger (Stavanger-Kommune, 2019). While the majority of respondents feel that politicians should invest more in cycling as a transportation mode (69%) and that cycling is a good solution in reducing vehicle traffic congestion (75%). Although the proportion of respondents which say that safer cycle paths and a more cohesive network will lead to more people cycling has been steadily decreasing since 2015 (Stavanger-Kommune, 2019). This information together seems to paint a picture that most people in Stavanger believe in increased investment in bicycle infrastructure, although there is possibly a growing minority who is less supportive to it.

The measures towards facilitating cycling infrastructure in Stavanger and the Nord-Jæren region that are emphasized, consist of creating a consistent main network of cycle routes, as well as well-established localized network that serves to channel cycling traffic between the main routes (Davidsen et al., 2016; Stavanger-Kommune, 2010). They also state the importance of the main network being consistent, coherent and well signed, as shifts in the typology and winding routes become unreadable and less accessible for cyclists (Stavanger-Kommune, 2010). Some of the key principals described for planning of the main network routes are: to consider separation from both vehicle and pedestrian traffic, uniform standards of routes for minimum 1 kilometer stretches, high quality paved surface, usable all year round and prioritization of cyclists at intersections. Recent infrastructure improvements in Stavanger include the addition of approximately 24 kilometers of red coloring to cycle lanes, the currently under development trunk cycle road and dedicated cycle street Møllegata (Danielsen, 2019; Laugaland & Buene, 2016).

Red painted bicycle lanes

The red colored lanes were added as a way to make the cycle lanes clearer, contrasting to the black asphalt vehicle lanes. This can then contribute to an added sense of security for the cyclists that use them. In addition, the colored lanes can delineate not only from motor vehicle traffic but also between cyclists and pedestrians. The added levels of separation and prioritization add increased awareness to vehicle traffic, while making a more attractive and coherent solution for cyclists (Statensvegvesen). A study by Bjørnskau et al. (2016) showed that having sufficient width and coloring contributes positively to cyclists perceptions of safety. The municipality of Stavanger's standards for bicycle lanes states that the typical width should be 2.2 meters wide with a minimum requirement of 1.8 meters (Stavanger-Kommune, 2021a). Although, a recent news article prompting feedback from over 1300 cyclists in Stavanger Identified key bicycle routes that were perceived as dangerous. One of the most commonly identified locations was along newly colored bicycle lane on Hillevågsveien. The cyclists were mainly concerned with the vehicle interactions that occurred due to the bike lanes going through highly trafficked round abouts (Risa, 2021).

Bicycle priority streets

Another improvement was the designation of Møllegata, a street approximately 800 meters in length near the Sentrum of Stavanger, into a bicycle priority street. The transformation includes coloring of the roadway red, signage and traffic calming measures, which all contribute to the prioritization of the cyclist over vehicles. The vehicles must yield to cyclists along this stretch of road and thru traffic for vehicles is not allowed (Laugaland & Buene, 2016). The municipality of Stavanger states that the measure is applicable to sections of the bike network with mixed traffic between cyclists and vehicles, where the volume of vehicles is less than 4000 AADT and with speed limits of 30 km/hr or less (Berg, 2017; Laugaland & Buene, 2016). This measure, as well as other improvements such as the red colorings of bike lanes in Stavanger and across Norway, have been shown to increase the number of cyclists that use the infrastructure (Fyhri et al., 2019). The designation of Møllegata as a bicycle priory street was determined to be the most successful improvement measure across Norway, where the levels of cyclist passes grew by (167%) considering pre and post improvement cyclist counts (Fyhri et al., 2019). This increase was also seen to be in excess of the general increase in volume of cyclists within Stavanger. Further development of bicycle priority streets are to be pursued, with the addition of Kannikgate and Tjoldolvsgate in Stavanger (Stavanger-Kommune, 2021b).

Bicycle trunk road

One of the most extensive measures undertaken in Stavanger is the development of the cycle trunk road (sykkelstamveg). This cycle road is intended to be a high quality, direct and coherent route option between the municipalities of Stavanger and Sandnes (Grønnestad, 2020). Connecting them both with high employment density area of Forus. One of the main goals of its development is to promote a shift in travel behavior of commuters between Stavanger, Sandnes and Forus, from private vehicle use to cycling (Bymiljøpakken, 2020). The bicycle road follows along the E39 highway and consists of a wide (approximately 4 meter), consistent path way with lanes dictating directional flow and dedicated connections and intersections for cyclists. This dedication towards cycling transport means minimal interference between cyclists and pedestrians or vehicle traffic. The development of the bicycle road has been controversial with opponents largely being against the high costs involved in the project, dedicated solely to cyclists (Ellingsen, 2020). Proponents feel that the high level of dedication and separation of the cycle road is necessary. As significant strides towards reduced private vehicle commuting and an increased cycling are needed while stating the additional socio-economic benefits of such a transition to more active modes of transport (Ellingsen, 2020; Stokka, 2020). The bicycle trunk road does not currently connect all the way to central areas of Stavanger, as it is being implemented in stages. The more southern section closer to Forus has been completed as well as a segment in the more central area of Stavanger, although the middle section which will connect the two is still in progress.

2.3 Norwegian cycling statistics and demographics within a broader context

This section will introduce how cycling is spread across various demographics such as age and gender both in Stavanger, as well as some of the larger and comparable cities within Norway and how this has changed over time. Additionally, it seeks to provide some context on the commonality of safety gear usage and various bike types within Norway in comparison to other European countries.

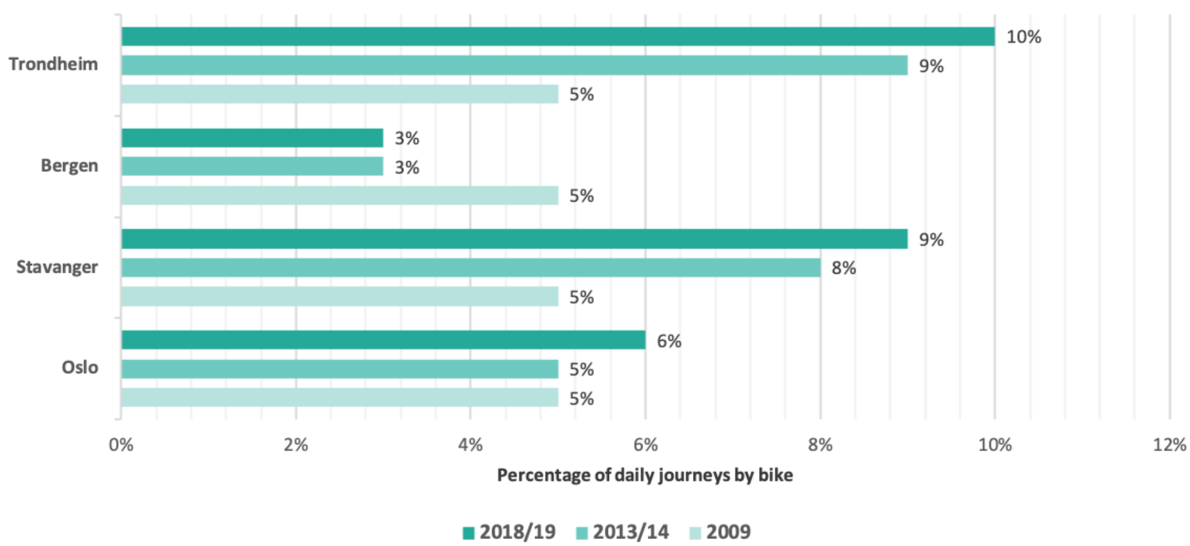


Figure 2.2 - Percentage of daily journeys by bike in major Norwegian cities, based on data from the national transport surveys 2009, 2013/14 and 2018/19 (Grue et al., 2021; Hjorthol et al., 2014; Vågane et al., 2011).

Figure 2.2 shows the proportion of daily journeys completed by bicycle across Norway's four most populous cities and how they have changed between 2009 and 2018/19, the data is collected from the National Transportation Survey in Norway. Trondheim has the greatest bicycle share with (10%), although Stavanger is close behind with (9%), while the capital of Oslo and the city of Bergen are further behind with shares of (6%) and (3%) respectively. In comparison to cycling modal shares across the world, Norway's major cities levels could be said to be moderated. Pucher and Buehler (2008) compiled a large set of data comparing the bike modal share in cities around the world, Norway lies far below other leading cities such as Copenhagen (29%), Amsterdam (27%) and Münster (27%) but also far above some of the cities in more car dependent countries with lower modal shares, such as Chicago (0.7%), Toronto (0.8%) and Sydney (0.6%). In general, the modal share of bicycles is increasing within these cities, with near doubling of the amount in the cities of and Stavanger, between 2009 and 2018/19. Although, this is not the case in the city of Bergen, where the modal share of bicycles has decreased by two percent over the same period.

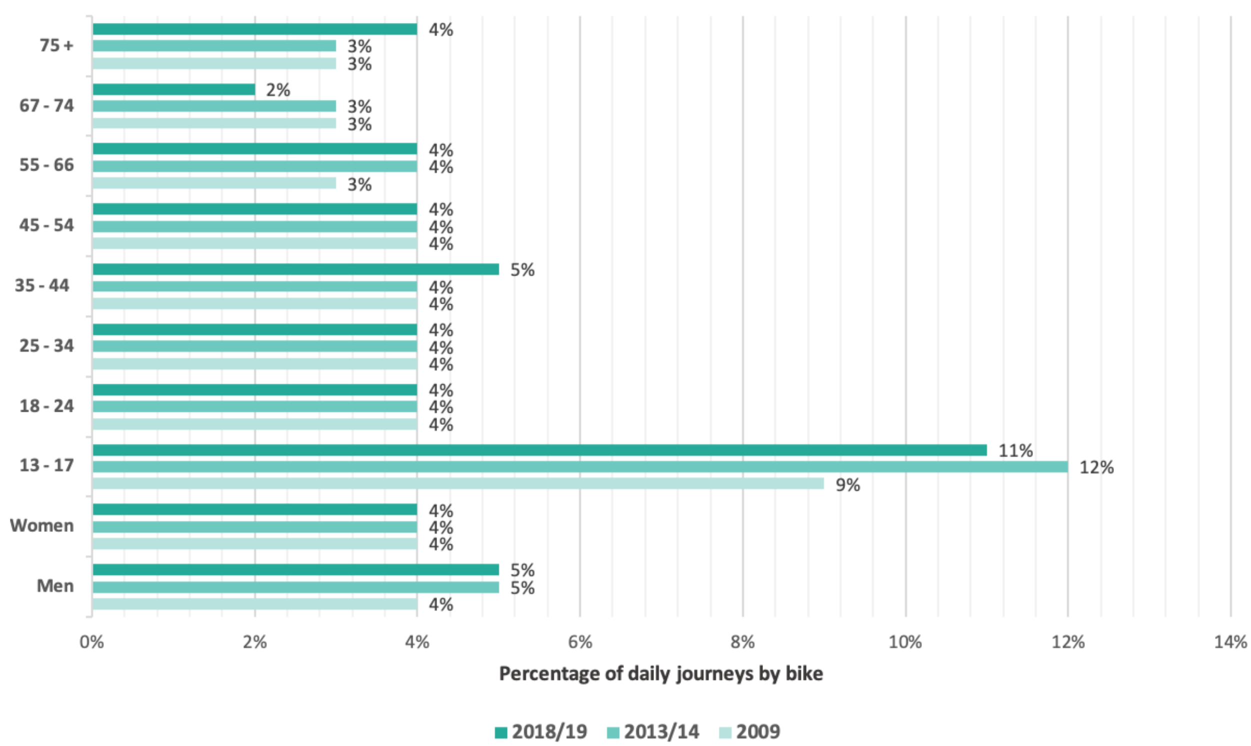


Figure 2.3 - Percentage of daily journeys by bike in major Norwegian cities, based on data from the national transport surveys 2009, 2013/14 and 2018/19 (Grue et al., 2021; Hjorthol et al., 2014; Vågane et al., 2011).

When the same data is compared but across the entire country and split amongst the demographics of age and gender (Figure 2.3), in every survey year the greatest proportion of cycling trips comes from the 13 to 17 year age group. The remaining age groups have a pretty similar proportion of trips completed by bike, with a slight decrease beginning over the age of 54. There are no significant shifts in the demographics over time, the greatest change is of a (2%) increase in the 13-17 year age group between 2009 and 2018/19. Additionally, there is a net increase of about 1% in the age groups beyond the age of 54 over the same time period. The shifts in the 13- 17 year age group could be related to the active focus the Norwegian government has on encouraging children and youth to walk or bike to school. While the slight increase in percentage of cycle trips completed by people over the age of 54 could possibly be related to the increasing popularity and use of e-bikes, which has been shown to be even more so popular with older adult demographics (Leger et al., 2019; Van Cauwenberg et al., 2019). The modal share of bicycles is fairly evenly divided between men and women although the increases which have occurred over the last ten years have been amongst men, with an increase of (1%) within that period. Nordic countries, have higher levels equity across genders, "often looked upon as pioneers in the promotion of equal opportunities for women and men" with both a strong representation of women in political positions of power and high participation levels in education and the labour market (Kautto et al., 2001, p. 66). Which could contribute to the nearly equal proportions of women and men cycling, while the increase in men's cycling compared to women between 2013/14 and 2018/19 could possibly signal that more recent efforts to increase cycling in Norway have been disproportionately influential to men cyclists. Additionally, given that this data is at a quite aggregate national level, there is likely more significant differences between various ages and genders cycling proportions at more localized levels.

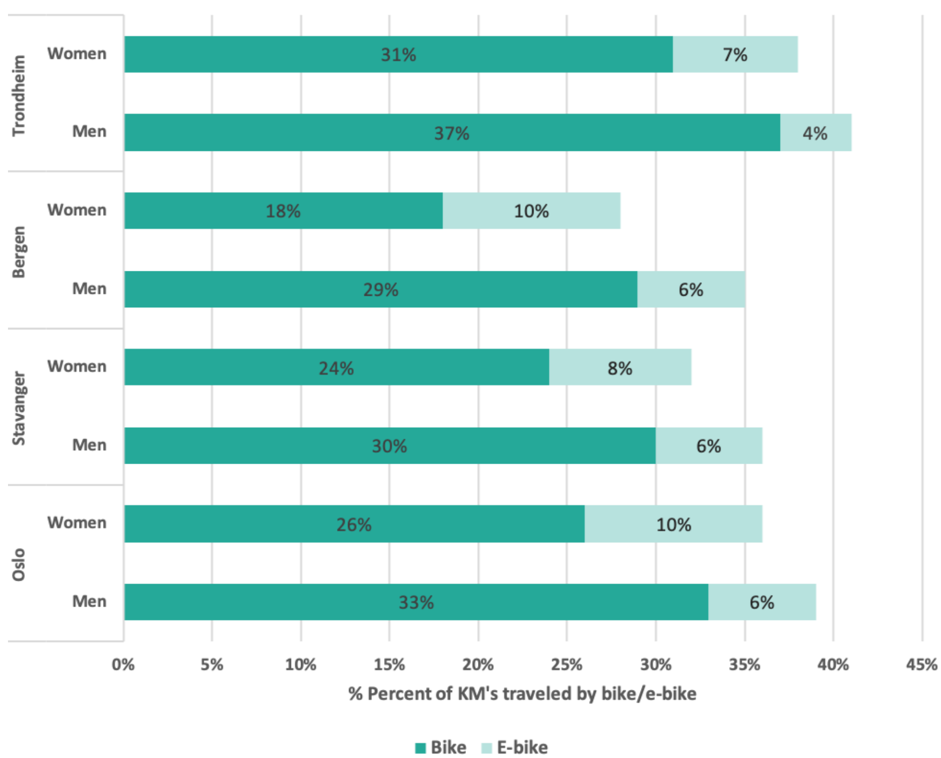


Figure 2.4 - Percentage of kilometers traveled by bike and e-bike across gender in major Norwegian cities, adapted from figures in "Cycling in Oslo, Bergen, Stavanger and Trondheim" by E.B. Lunke, J.Aarhaug, T.De Jong, A.Fyhri, p.16, p.29, p.42, p.53. Copyright Institute of Transport Economics, 2018.

A more local context of cycling across some of Norway's largest cities, has been studied through a survey of cyclists supplemented with use of GPS app data (Lunke et al., 2018). The findings on the proportions of trip kilometers traveled by both conventional and e-bike, across men and women is presented in Figure 2.4. The levels of cycling across the sample are much higher than what is found in the national transport survey, which the researchers acknowledge is likely due to a sample skewed towards cyclists, as the majority of participants were found through a register of bicycle owners called falck's register (Lunke et al., 2018). Again, when comparing across genders, similarly to the national transport survey, we see that the proportion of cycling is relatively equal with a slightly higher proportion of men. Although, when trips that are only completed by a conventional bike are considered, there are greater gaps between the proportions of cycle trips by men and women then when considering both e-bikes and conventional bikes (ie. An 11% gap when only considering conventional cycling in Bergen becomes a 7% gap when considering e-cycling, or a 7% gender gap in Olso becomes 3% when considering e-cycling). The use of e-bikes, given that they are more popular amongst women, seems to reduce the inequality between the proportion of cycling completed by men and women (ie. Nearly 50% reduction in the gap between cycling by men and women in each city when e-cycling is considered)

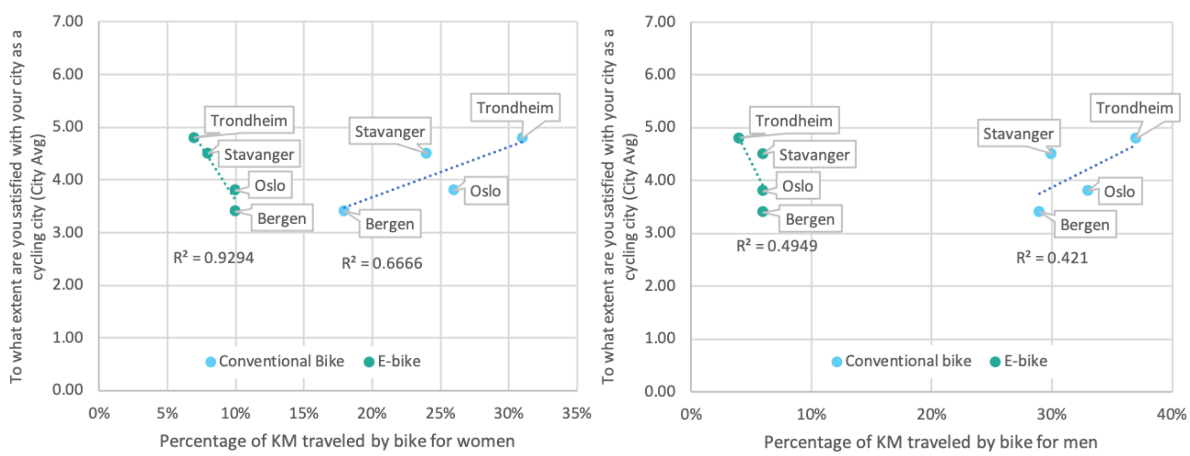


Figure 2.5 - Percentage of kilometers traveled by bike and e-bike across gender compared to rankings of the extent cyclist consider their city a "cycling city", adapted from figures and tables in "Cycling in Oslo, Bergen, Stavanger and Trondheim" by E.B. Lunke, J.Aarhaug, T.De Jong, A.Fyhri, p.16, p.29, p.42, p.53, p.21, p.34, p.46, p.57. Copyright Institute of Transport Economics, 2018.

The study by Lunke et al. (2018) also had the participants rank their city on a scale from 1 to 7 in terms of cyclability or quality of infrastructure. The average ranking of the question "to what extent are you satisfied with your city as a cycling city" seems to have a correlation with the proportion of cycling done by conventional bicycle within the city (ie. Where cities with higher average satisfaction levels have higher proportions of cycling). Interestingly, when only considering cycling by e-bike, the relationship is in the other direction (ie. Lower satisfaction levels result in a high proportion of cycling with e-bike). Furthermore, these relationships are stronger amongst women then with men, which could be related to greater sensitivity to safety and risk related barriers women face in cycling. Such barriers which could be overcome through greater quality and safer infrastructure, or possibly through the use of e-bikes.

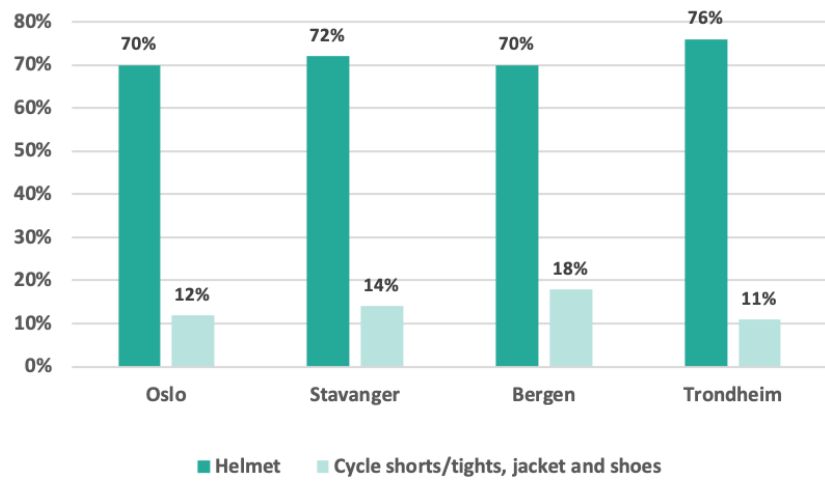


Figure 2.6 - Percentage of cyclists which use helmets and cycling sport clothing in Norwegian cities,, adapted from table in "Cycling in Oslo, Bergen, Stavanger and Trondheim" by E.B. Lunke, J.Aarhaug, T.De Jong, A.Fyhri, p.11. Copyright Institute of Transport Economics, 2018.

Figure 2.6 shows the proportion of cyclists which use helmets across the major Norwegian cities, as well as the proportion of cyclists who ride with a full set of cyclist specialty gear (Includes the use of cycle shorts/tights, cycle jacket and cycle shoes). The levels are generally consistent across the cities, with a slightly greater proportion of helmet use in Trondheim and an increased proportion of specialist gear in Bergen. The higher levels of specialty cyclist gear in Bergen could be related to the larger proportion of cyclists which own a road bike there. Road bike ownership in Bergen is (29%) compared to the next highest proportion of the four cities in Trondheim (16%). A recent survey of helmet use across some European cities found great variation, Amsterdam had the lowest percentage with (1.1%) of cyclists using one, while more moderate levels were found in Copenhagen (19.9%) and Berlin (24.3%). The highest percentage was in London, where (60.9%) of cyclists used a helmet (Dekra, 2020). Set within this context, the level of helmet use could be interpreted as quite high in Norway, with an average use of helmets of (72%) for cyclists within the four major cities. The high use of safety gear in Norway could also potentially extend to high visibility clothing as well, although this data is not available for comparison.

Norway has a strong culture surrounding road safety which can be connected to the governments vision of zero serious injuries or deaths in road traffic accidents. While the goal is to eventually reduce the number to zero, the current National transportation plan stipulates that by the year 2030, they want to achieve a reduction in the yearly number of serious injuries and deaths to 350. While the zero-vision goal is more recent, being adopted in 2002, the Norwegian government has long targeted reductions on traffic related deaths, resulting in a steady decline in road traffic death and injuries since the 1970's.

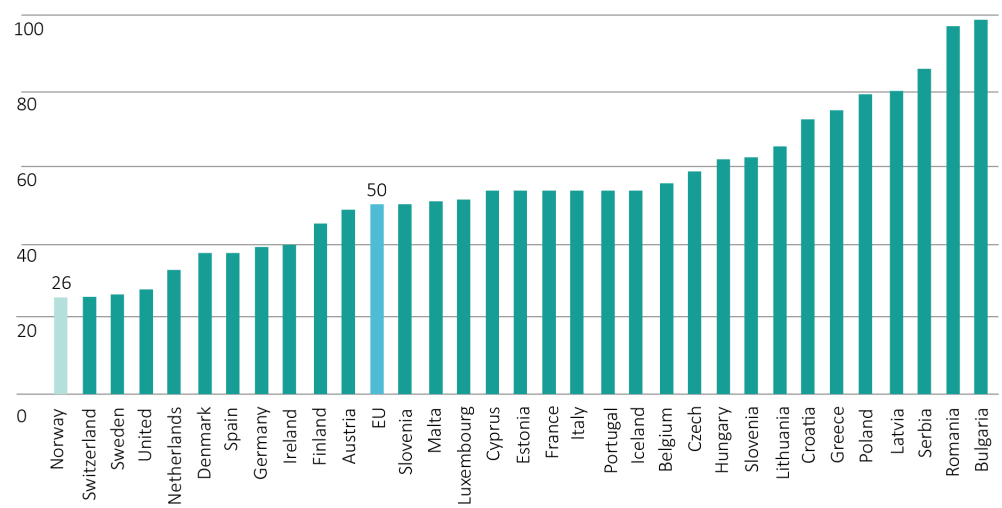


Figure 2.7 Number of road traffic fatalities per million inhabitants in 2016 in Norway and other European countries, adapted from "National Plan of Action for Road Safety 2018-2021" by Statensvegvesen, p.11. Retrieved from: (https://www.vegvesen.no/globalassets/fag/fokusomrader/trafikksikkerhet/nasjonal-tiltaksplan-for-trafikksikkerhet-pa-veg-2018-2021.pdf).

Comparisons across Europe show that Norway has some of the lowest number of traffic related deaths (Figure 2.7). The Norwegian government attributes their success to having coherent and consistent national transport plans and national safety plans as well as creation of a safety culture in Norway. Although it is acknowledged that a key area of improvement is in the reductions of pedestrian and cyclist injuries as these make up one third of the 2016 total and have had a smaller reduction compared to car drivers and passengers over the past 30 years (Figure 2.8). The high level of helmet wearing, even though helmet use is not mandated by law could be related to this long history of road safety targeted reduction measures and safety campaign.

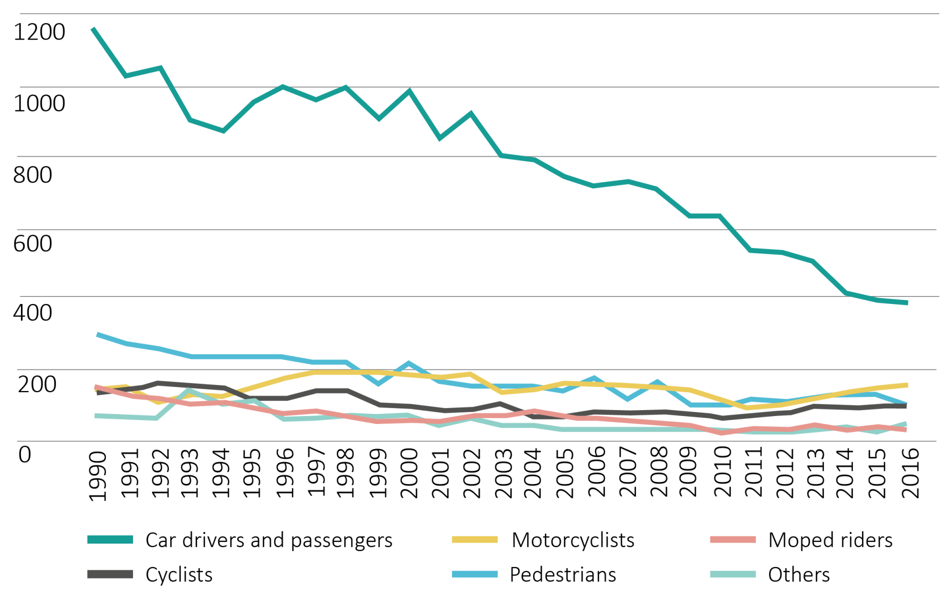


Figure 2.8 - Development in number of people killed or seriously injured for different road user groups adapted from "National Plan of Action for Road Safety 2018-2021" by Statensvegvesen, p.20. Retrieved from: (https://www.vegvesen.no/globalassets/fag/fokusomrader/trafikksikkerhet/nasjonal-tiltaksplan-for-trafikksikkerhet-pa-veg-2018-2021.pdf).

3 Theory

Research has highlighted the many factors which can either promote or provide barriers to cycling for transport. These include distances, costs/access to bikes, bike infrastructure/facilities, use of bikes and equipment, individual and social environment (Handy et al., 2014). While not a main focus of this thesis it is important to acknowledge the important influence of distances on cycling (Handy et al., 2014). Distances between common destinations are largely dictated by land use patterns, where higher levels of density, both residential and employment, as well higher degrees of mixes between land uses, have positive associations with more active modes of transport such as cycling (Leck, 2011). In this thesis the promotion of cycling is mainly covered within one aspect, which is bicycle infrastructure. This has led to the development of a theory section beginning with a focus on the types of bike infrastructure and preference of cyclists in general, as well as how these shift, across the individual factors of gender and age. Next the usage of safety gear and bicycle types and its relationships with level of perceived comfort and safety of bicycle infrastructure is explored.

The sections on gender and safety gear/equipment also provide some insight on how the social environment can influence cycling uptake, through cultural norms and proliferating images of cycling.

3.1 Bike infrastructure

The types of bike infrastructure that exist can typically be broken down into two broader categories the first being on-road infrastructure and the second, separated infrastructure. On road infrastructure makes efforts to facilitate for cycling while still having it mix with vehicle traffic (Buehler & Dill, 2016). Measures can range from more simplistic, including signage designating that a road be shared with cyclists, having extra wide vehicle lanes or shoulders on the roadway to accommodate for cyclists to more extensive, such as giving bicycles priority over motorized vehicles or the use of vehicle traffic calming (Buehler & Dill, 2016). The main commonality between all these various types of on-road infrastructure is that there is no clear delineation between the space that is to be used by motorized vehicles and cyclists, meaning that in many cases there is more interaction between the vehicle traffic and cyclists. These types of infrastructure are not necessarily less enjoyable for cyclists, provided they are placed on local roads with lower traffic volumes or speed limiting motor vehicle calming they can be considered high comfort (Winters et al., 2020).

Figure 3.1 – Examples of on-road infrastructure, bicycle priority street in the Netherlands (left), from "Sykkelstrategi for Nord-Jæren 2017-2032" by R.Davidsen, I.Undheim, C.Berg, T.Dahl, R.Børresen, T.Gøtterup, pg.26, (Davidsen et al., 2016). Mixed traffic street (right), from "The Canadian Bikeway Comfort and Safety (Can-BICS) Classification System: a common naming convention for cycling infrastructure" by M.Winters, M.Zanotto, G. Butler, p.290, Health Promotion and Chronic Disease Prevention in Canada

The second broad category is separate infrastructure, although these can be further subdivided based on the degree that they are separated from motorized traffic. At the lowest degree are bike lanes which typically are separated from motorized vehicles with white painted lines (Buehler & Dill, 2016). Although there is not one consistent type of bike lane, as they can vary in width, where they are positioned in relation to parked vehicles and sidewalks, and the use of different colorized surfacing (Buehler & Dill, 2016). The next higher degree of separation, is protected bike lanes. They differ from bike lanes in that they have some form of physical barrier between the bicycle lane and vehicle traffic. Typical barriers can consist of curbs, heavy planters or concrete barriers as well as the use of bollards with distance buffers (Buehler & Dill, 2016). The highest degree of separation is considered to be bicycle paths. Along this infrastructure there is no presence of motorized vehicles as they often go through park and green spaces (Buehler & Dill, 2016). Furthermore these bicycle paths could be solely dedicated to cyclists or more multipurpose paths which are combined with pedestrian traffic and other modes of active transport (Winters et al., 2020).

Figure 3.2 - Examples of separated infrastructure at varying degrees, bicycle lane with lane marking (visual separation) (left), bicycle path (fully separated) with designated bicycle and pedestrian travel (right), from "The Canadian Bikeway Comfort and Safety (Can-BICS) Classification System: a common naming convention for cycling infrastructure" by M.Winters, M.Zanotto, G. Butler, 2020, Health Promotion and Chronic Disease Prevention in Canada, p.290,p.291.

In regards to the infrastructural preference of cyclists, Studies seem to show that there is a general leaning towards separate forms of infrastructure (Buehler & Dill, 2016). Additionally, a comprehensive review by Buehler and Pucher (2011) showed positive correlations between the amount of bicycle infrastructure and the rates of cycling commuting across 90 American cities. While within another study, which was conducted in Portland (a city with one of the more developed cycle infrastructure networks within America). It was found that approximately 50% of the total kilometers cycled by participants were on separate or designated cycling facilities. This was despite the fact that this type of infrastructure only accounted for 8% of the total usable bike network (Broach et al., 2012). Although some studies have also found that the preference of cyclists can relate to their level of experience with cycling or what kind of rider type they are. Clark et al. (2019) found that while cyclists of all experience level stated increased comfort on infrastructure with greater levels of separation. The group which cycled most often, had an even greater increase in comfort levels for each added degree of separation. Although, there is not a clear unanimous preference for more separation, and in some cases it has been shown that cyclists, particularly ones with greater levels of experience actually dislike separated facilities such as bike paths (Buehler & Dill, 2016; Fyhri et al., 2012). A study conducted in Olso by Fyhri et al. (2021) found that more experienced cyclists were not in favor of the addition of temporary physical barriers along bicycle lanes (previously only separated with painted lines and coloring) as they believed this led to being confined within a lane which was too narrow, impacting the ability to pass cyclists. Whereas those with potential to become cyclists, as well as cyclists carrying children saw the measures more positively.

3.2 Gender equity in cycling

Cycling is a critical form of mobility that has been tied to empowerment and gender from as early as 1900 or the advent of cycling (Hanson, 2010; Willard, 1895). The theory presented in this chapter mainly focuses on the influence of gender on mobility, although acknowledges research by Hanson (2010) that highlights the two sides of the research agenda, that both gender influences mobility patterns but that also mobility can influence gender. The former tends to prioritize mobility aspect over gender while the latter prioritizes gender over mobility (Hanson, 2010). Additionally, when researching the influence of gender on mobility, it is important to not just focus on patterns of mobility but to more fully understand the underlying gendered processes shaping the patterns (Hanson, 2010; Law, 1999; Ravensbergen et al., 2019). “Gender is the process through which differences based on presumed biological sex are defined, imagined, and become significant in specific contexts” (Nightingale, 2006, p. 171). In this quote gender is depicted as socially constructed and is therefore construed as being unique within certain cultural contexts. This view of socially constructed gender roles needs to be balanced or coexist with a view that sees gender as “an innate source of fixed and universal male/female difference” (Hanson, 2010, p. 8) Understanding this complexity, the theory will examine further the swath of research that looks at gender and its influence towards cycling mobility.

Research has shown that in certain contexts women are less likely to cycle then men. Contexts which validate this statement are the US, UK, Canada and Australia, where women make up between 21 to 31% of the total portion of cycling trips (Figure 3.3)(Pucher & Buehler, 2008). Although this is not always the case and in specific contexts such as within the countries Denmark, Germany and the Netherlands, women make up 45%, 49% and 55% of all cycling trips respectively (Figure 3.3). These large differences in the proportion of trips by gender, is often stated by scholars to be related to built environment factors, as well as the impacts of cycling culture (Aldred & Dales, 2017; Heesch et al., 2012; Heinen & Handy, 2012). In regards to cycling culture, these countries with greater modal shares are often said to have reached a state of so-called cycling “normalization” which contributes towards these equalized or even greater (in the case of the Netherlands) cycling modal shares for women (Aldred & Dales, 2017; Heinen & Handy, 2012).

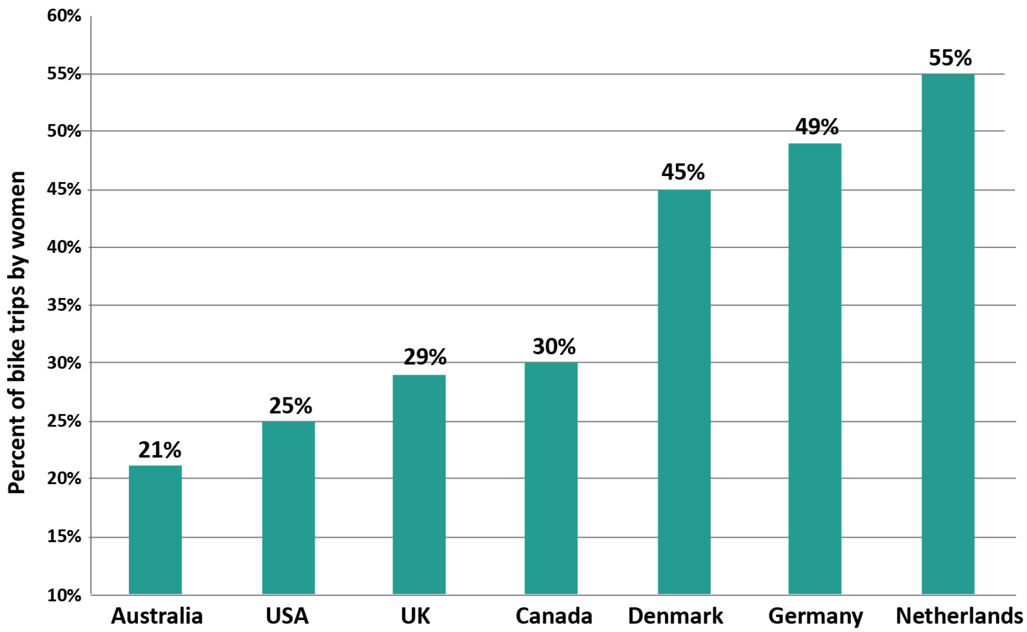


Figure 3.3 Percent of bike trips by women in various cities, adapted from “Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany” by J.Pucher and R.Buhler, 2008, Transport Reviews, p.504. Copyright Taylor & Francis, 2008.

Recent research into gender and cycling, depicting differences in the amount of cycling and in the way individuals amongst different genders cycle, has solidified into two strands. These strands highlight the gender differences through, varying trip characteristics as well as by differences in aversion to risk. In regards to the area of research focusing on trip characteristics, it was found that women more often have shorter trips or trips with more complex characteristics such as chained/multipurpose journeys. This includes trips carrying heavy loads or for care purposes such as dropping off children that are cited to be taken more often (Dickinson et al., 2003; Emond et al., 2009). Literature states that the increased occurrence of these types of trips and trip characteristics are closely related to the division of household labour, where women often share un unequal burden of such household tasks as shopping or caregiving (Prati, 2018). Considering this, it is not difficult to understand, why such an increase in trip complexity is correlated with less women choosing cycling as a mode of transportation, given the increased difficulty in achieving such complex trips on a bike.

In a study by Akar et al. (2013) that looked at cycling behavior of students and staff at a university, some insights on how gender can shape transport behavior were found. In a survey sent to both students and staff of Ohio University, they noticed that women Faculty and Staff were more likely to answer survey's with the response "not having option" as a reason for using a car to get to the university, then any other group (Men-Faculty and Staff, Women/Men -Students). Using data from the survey they were also able to see that there were no significant differences between the distances to school for the men or women in the study and that many women lived within a feasibly cyclable distance. This leads Akar et al. (2013) to state that the survey question could have been interpreted more so as "considering that alternative options are unfeasible" as a possible reason why more women chose to say they had no other options of transport other than a car. This could then be related back to the greater likelihood of increased complexity of trips for women. Which in the typically very vehicle-oriented context of the United States, could be said to make such complex (caregiver/encumbered) trips very unfeasible for women to complete by bicycle. Aldred et al. (2016) highlight that these types of encumbered or caregiver trips are often seen to be as generally less cyclable then other journey types and therefore cycling authorities in some countries may not design or accommodate for them. Alternatively, within the Netherlands, such trip types are commonly depicted and accounted for within the national design manual (Aldred et al., 2016). Given the 55% share of women cyclists in the Netherlands it is clear the ramifications that such a supportive design system can have towards cycling equality and general positive impacts to cycling uptake as a whole.

Figure 3.4 - Image depicting encumbered/caregiving trips from "We are Groningen cycling city - bicycle strategy 2015-2025" by the City of Groningen, 2015, p.22. Retrieved from: (https://groningenfietsstad.nl/friksbeheer/wp-content/uploads/2016/05/Groningen_CycleCity_Strategy_2015-2025.pdf)

The other commonly cited gender influence on cycling mobility regards a difference in attitudes on safety between men and women, where it is found that women more often state a concern for safety as a reason for not cycling, this concern is both directed towards driving a bicycle near vehicle traffic as well as fear over their own personal safety (Akar et al., 2013; Dickinson et al., 2003; Krizek et al., 2004). This finding is also exhibited within stated and revealed preference type studies. Within such studies, it is found that women prefer routes that are off-road, separated or some type of dedicated bicycle facility, more so than men (Aldred & Dales, 2017; Heesch et al., 2012; Krizek et al., 2004). In the stated preference survey study by Krizek et al. (2004) various types of cycling facilities were compared ranging from roadways with parking and no lanes to infrastructure that was completely off-road and separated from infrastructure. The amount of time that respondents were willing to detour in favor of preferred alternate routes were examined. The study revealed that women on average were willing to take longer trips in order to utilize their preferred cycling infrastructure type. Considering a 20 min commute journey, on average men were willing to diverge 5.43 minutes less than women for their preferred facility type. While studies that compare the travel distances for men and women cyclists have concluded both that the trip distances are longer for men (Dickinson et al., 2003; Heesch et al., 2012) as well as finding that there are no significant differences, or that women cycled further (Krizek et al., 2004; Wuerzer & Mason, 2015).

It also is important to broaden the frame of understanding on cycling behavior differences across genders, exploring some of the possible reasons for differences in risk aversion. Waengnerud et al. (2019) explain an increased aversion to risk and threat in women through the perceived vulnerability hypothesis, which links it to elevated anxiety levels, as they often feel more vulnerable in society, particularly towards violence and crime, which can then lead to greater sensitivity to risk in general. While gender scholars highlight new concepts of gender as a spectrum or having more fluidity (Monro, 2005), studies have shown that children can already identify themselves within binary categories of boy or girl by around the age of three (Egan & Perry, 2001; Waengnerud et al., 2019). This leads Waengnerud et al. (2019) to hypothesize that the increased vulnerability is not just developed through women's own personal experiences, but by societal norms and expectations, which is propagated throughout culture and media. These norms and expectations, set for any particular context a limited number of gender "boxes" which an individual can fit into, and can influence attitude and behavior through self-categorization. Waengnerud et al. (2019) then found that women who considered themselves to have greater level of feminine characteristics or more so fit into the more feminized gender category, also had greater levels of anxiety which corresponds to greater risk aversion.

3.3 Age equity in cycling

"Mobility is fundamental to active aging and is intimately linked to health status and quality of life". (Webber et al., 2010). Additionally, benefits of environments conducive to active mobility and correspondingly healthy ageing, will only rise in significance in the coming years. A European union report on Ageing states that as of 2019 (20.3%) of the total European population was of older people – which they define as 60 yrs or older. This proportion is expected to rise with an expected peak in 2050, when (29.4%) of the population is expected to be of older age (60 yrs +) (EU, 2020). This increasing proportion of older aged individuals will lead to certain challenges, including a potential strain on long term health facilities, given the reduced labor force from increased proportion of older aged and retired persons and subsequent reduced social funding towards these systems (EU, 2020). Additionally, longer life expectancies as a contributor to the increasing proportion of older aged individuals, will not necessarily lead to the later stages of these individuals lives being healthier more active and independent (EU, 2020). This further stresses the importance of an increased focus on promoting physical activity in ageing and creation of urban environments which are conducive to such healthy ageing.

A comprehensive study looking at environmental correlations and physical activity in older adults, found strong links between neighborhoods with a higher quality physical environment and increased levels of physical activity (Cerin et al., 2019). They specify that this link was especially strong regarding the environment and aspects of active travel based physical activity, in contrast to leisure based physical activity. This is accredited to a wide variety of factors which may influence one to participate in physical activities in their own leisure time such as the manifestation of will required to participate in recreational physical activity and other social factors which are less present in physical activity related to travel (Cerin et al., 2019). Therefore, creating physical environments which are conducive to active transportation can have great impacts towards healthy ageing in older adults.

Considering the potential positive health benefits to older adults and the proliferation of e-bikes in recent years, the proportion of older adults who cycle for transport is still low (Van Cauwenberg et al., 2019). Although, this proportion shifts depending on the country examined, where in the USA or the UK, which have generally low cycling modal shares, the proportion of cyclists slightly decreases between middle aged to older adults (Figure 3.5). This contrasts with countries with higher modal shares such as Germany, Denmark and the Netherlands, where the proportion of cyclists is approximately equal or slightly higher between the middle-aged groups to the older adult age groups (Buehler & Pucher, 2012; Pucher & Buehler, 2017).

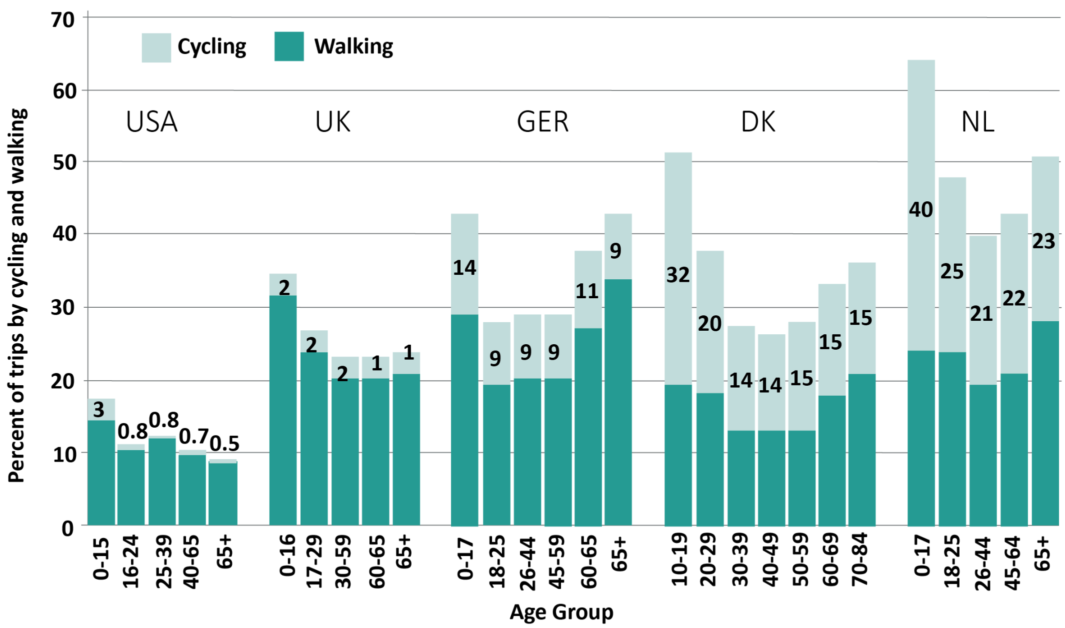


Figure 3.5 Cycling and walking share of trips across age groups in various countries, as percent of trips by all modes for all trip purposes, adapted from figure in "Walking and Cycling in Western Europe and the United States" by R.Buehler and J.Pucher, 2012, TR News, p.36. Retrieved from: (https://onlinepubs.trb.org/onlinepubs/trnews/trnews280westerneurope.pdf) (Buehler & Pucher, 2012).

It may be easy to assume that increasing modal shares will lead to increasing gender and age diversity amongst cyclists. Although, Aldred et al. (2016) found that regions in UK experiencing increases in bicycle modal shares did not always lead to increases in representation of older aged cyclists amongst older aged commuters. In addition, Grudgings et al. (2021) found that although more supportive cycling environments led to more cycling in older adults in the UK, the influence was much greater towards increasing cycling rates in women than in the older adult population groups. Many adults may start or stop to cycling throughout their life course and these shifts are often connected to big transitions in life such as the ending or beginning of partnerships, moving and or starting new jobs (Janke & Handy, 2019). Older adults may be more likely to be well established, given their later stages in life, whether it be in a career or retirement, relationship or community. This could be a possible reason why Aldred et al. (2016) found that a modal share increase did not always lead to an increased proportion of older adult cyclists and highlights a potential challenge in increasing older adult cycling levels.

In order to promote cycling, safe and well-maintained infrastructure is a necessity and generally applies to all cyclist groups. Although, for a few reasons, it could be said to be even more critical for promoting cycling within more vulnerable or risk averse groups such as older adults (Pucher & Buehler, 2017). Firstly, older adults are more susceptible to falls that result in injury (Ikpeze et al., 2018). While In countries that lack safe cycling facilities and have lower cycling modal shares, the amount of injuries per km traveled by bike is significantly higher (Buehler & Pucher, 2012). Additionally, with age comes the increased possibility of functional and sensory impairment (Spirduso et al., 2005; Van Cauwenberg et al., 2018). This increased impairment can lead to more difficulty in navigating the built environment where encountering complex traffic situations, hills and uneven terrain can be big barriers to mobility (Van Cauwenberg et al., 2018). Given the increased likelihood of mobility challenges in this older adult age group it is understandable why countries with lower modal shares and which are less likely to have supportive built environments for cyclists, also have lower proportions of cyclists when progressing into the older adult age categories

Understanding the types of environments which older adults believe is supportive to cycling could then be considered and important aspect of increasing the representation of older adult cyclists. Qualitative research utilized in the forms of ride along interviews with older adults, found that the riders had a great preference to dedicated and separated cycle routes, separated both from vehicle traffic and pedestrians (Van Cauwenberg et al., 2018). In addition, they enjoyed wider infrastructure as this also allowed for group riding, allowing for a social environment as well as physical activity (Van Cauwenberg et al., 2018). Through the use of a quantitative stated preference study, Van Cauwenberg et al. (2019) also identified the three most important environmental characteristics for older adult Flemish cyclists as: the type of cycle path, traffic density and the evenness of the cycling path. The majority of cyclists indicated the highest degree of importance to the type of cycle path (degree of separation) including groups which had the greatest limitations on their mobility and lowest levels of cycling.

Figure 3.6 - Example of manipulated images of infrastructure and environment, demonstrating comfortable infrastructure for older adults, from "Older adults' environmental preferences for transportation cycling" by J.Van Cauwenberg, I. De Bourdeaudhuij, P.Clarys, B. De Geus, B. Deforche, 2019, Journal of Transport & Health, p.188. Copyright Elsevier Ltd 2019.

3.4 Usage of safety gear and equipment

In a recent review study by Olivier and Creighton (2017), it was found that the use of helmets can reduce the risk of head injury by (51%). Although this has very clear implications towards the protection of the individual user of the equipment, the discussion surrounding how best to get cyclists to wear them is complexified through a wider body of literature. Some advocate for the promotion of helmet use through mandatory helmet legislation, where countries such as Australia, New Zealand, Canada and the USA, have either partly enacted (region dependent) or created blanket legislation applying to the entire country (Dennis et al., 2013). While many studies reveal a reduced level of head injury following mandatory helmet legislation (Hoye, 2018; Walter et al., 2011) , with in many cases, even greater impacts towards the reduction of severe head injuries amongst cyclist head injuries (Hoye, 2018; Kett et al., 2016). Another study conducted in Canada, found that it was difficult to link the reduction in injuries to the mandatory helmet legislation, stating that in many cases the base line trends for injuries were already going down prior to the enactment of the law (Dennis et al., 2013). A difficulty which can be worsened through the challenge of separating helmet legislation from the impacts of other measures being implemented along the same time line, such as better cycling infrastructure, vehicle calming as well as other safe cycling programs and legislations (Teschke et al., 2015). Additionally, theories exist that speculate helmets may cause cyclists to ride more riskily or that mandatory helmet legislation can shift the cyclist population (Fyhri et al., 2012). From a questionnaire of 1504 bicycle owners in Norway, Fyhri et al. (2012) examine the cycling behavior, safety equipment use, sport clothing use, accident involvement and risk perceptions of these cyclists, they conclude that the cyclists could be divided into two distinct groups. They summarize the first group as "speed happy" cyclists which are more likely to be wearing safety gear, sport clothing and cycle for training purposes and have higher risk of accidents. The second group is described as more "traditional" using limited safety gear and equipment, cycling slower with a lower risk of accidents (Fyhri et al., 2012, p. 622). Regarding the lack of findings that mandatory helmet legislations results in reduced levels of cyclist injuries, they Fyhri et al. (2012) state that one of the likely contributing factors is the disproportionate disincentivizing impact on cycling within this more traditional cyclist group. Which then counter-acts the impacts of the helmet legislation, given that the population shifts towards the more accident inclined "group. This can also have impacts on the general uptake of cycling, resulting in decreased safety through decreased number of cyclists, where higher cycling modal shares have been related to reduced risk of injury (Jacobsen, 2003; Teschke et al., 2015).

Helmets are found to have large impact on individual safety, although more controversy surrounds the best ways to advocate for their usage. In contrast more recent research on conspicuity aids (high visibility gear or clothing) has largely questioned its effectiveness in decreasing risk of injury and crashes (Aldred & Woodcock, 2015; Miller et al., 2017; Walker et al., 2014). Its ineffectiveness is exhibited in a study by Walker et al. (2014) examining the impacts that the visual appearance of a cyclist would have on the distance at which a vehicle would overtake a rider. The study revealed that the appearance, determined by the rider's outfit, had very little impact on the overtaking distance. The outfits used in the study ranged from very casual attire without the use of a helmet, to more extensive levels, including the use of reflective vests and helmets. While the mean passing distance of vehicles in general deviated very minimally depending on the outfit, there was one outfit which did produce some differences, that was when the rider wore a helmet and a reflective vest with the Statement in bold "POLICEWITNESS.COM" with bold text below that saying "MOVE OVER" and "CAMERA CYCLIST" (Figure 3.7). Given that vehicles reacted to this one outfit, that included very specific text and warnings, it shows that the motorists were to an extent aware and able to shift their passing behavior based on what the rider attire was. Although given the similar average passing distance for the majority of rider attire, the motorists often chose not to shift the passing distance (Walker et al., 2014).

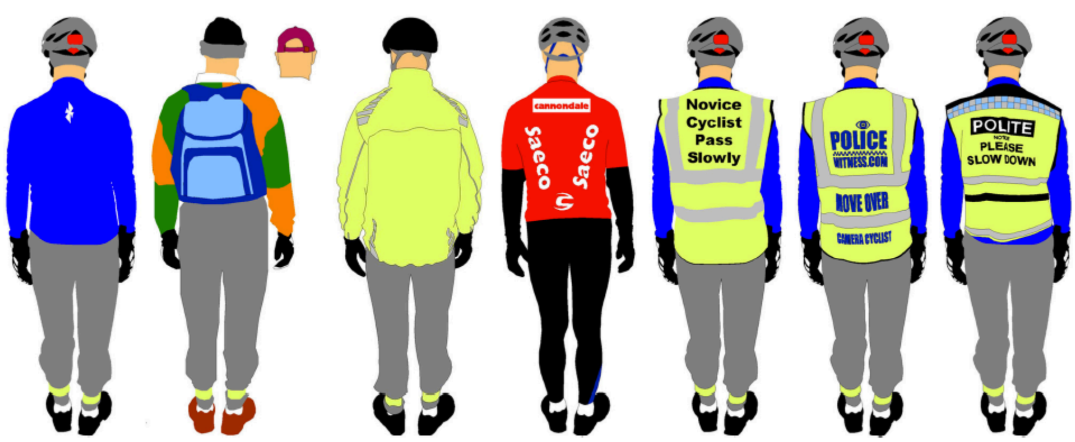


Figure 3.7 - The seven outfits used to test passing distance of vehicle traffic, with the second from the right being the outfit which led to slightly increased passing distances, from "The influence of a bicycle commuter's appearance on drivers' overtaking proximities: An on-road test of bicyclist stereotypes, high-visibility clothing and safety aids in the United Kingdom" by I.Walker, I.Garrard, F. Jowitt, Accident Analysis and Prevention, 2014, p.71. Copyright Elsevier Ltd 2013.

These arguments are elaborated on by Aldred and Woodcock (2015), where they state, given that many people may wear safety gear when they feel cycling conditions are more dangerous, an increased amount of users wearing helmets and reflective gear may signal to the larger population that cycling has a much higher risk level. The perception of cycling as an un-safe activity coupled with increased difficulty through either a societal expectation or mandated legislation of safety gear could be said to lead to a decrease in cycling uptake. In this sense, the mandatory legislation of safety gear could be seen as negative towards the larger goal of increasing cycling modal shares which in turn, can make cycling safer. Such argumentation leads to a suggestion that the responsibility of keeping cyclists safe is to a minimal extent in the hands of the cyclists themselves (what they wear/if they use a helmet). Measures such as the separation and segregation of cycle ways from vehicle traffic, improvements towards driver education or other legal system improvements towards greater enforcement on dangerous driving could be more effective and provide a broader benefit to society (Aldred & Woodcock, 2015; Walker et al., 2014) .

The perception of cycling as an unsafe activity for the wider and non-cycling public is corroborated by Daley and Rissel (2011), where qualitative interviews with cyclists and non-cyclists revealed that the non-cyclists and less experienced cyclists were more likely to have perceptions of cycling as dangerous. This perception of risk also seemed to decrease with increased experience level in cycling. The participants also had differences between their perceptions of recreational cycling, bicycle commuting or sport focused cycling. Bicycle commuting was perceived as more dangerous then cycling for recreation. This could be due to the reduced ability to ride where you would prefer when cycling for transport, as it becomes necessary to choose between a limited number of route options to get between start point and destination, which may put you in adverse riding conditions which are beyond your level of comfort. They also perceived recreational cycling as a form of cycling feasible by anyone but cycle commuting or sport cycling were considered a more serious type of cycling. Non-cyclists associated this serious image of cycling with cyclists who chose to where lycra or tight-fitting sport cycling clothing and believed that this image was generally unflattering and lead to alienation of the average person.

The fall of the bicycle as a popular mode of transport occurred with the dominance of the personal vehicle in the late 1950’s (Oosterhuis, 2016). Since, there has been a diverging of cultures surrounding bicycle riding. In countries with well-established cycling cultures, such as Denmark and the Netherlands this dominance of cars was somewhat mitigated and a culture revolving around bicycles as a very normal and everyday utilitarian form of transport are still held. This is in clear contrast with other western countries such as the United States, Canada and Britain where utilitarian cycling is often seen as " abnormal, eccentric, inferior, unsafe, uncomfortable and (too) strenuous abound" and recreational and sporting forms of cycling is more common (Oosterhuis, 2016, p. 245). In such countries, with an absence of a more normalized cycling culture, the images of cycling as "gentleman-amateur sportiness" have proliferated (Pedroso, 2021, p. 3).

The way that the public perceives cycling is important, as this perception can either negatively or positively influence the uptake of cycling, particularly amongst people with limited cycling experience (Daley & Rissel, 2011). Additionally, there is debate around how best to protect cyclists while encouraging a greater number of people to begin cycling. The creation of more separated and dedicated cycling facilities is a critical measure to increased growth in cycling transportation. Although can these facilities also help in creating a more normalized cycling culture through decreased proportions of cyclists using extensive safety gear or sporty tight-fitting equipment, shifting the general perceptions towards cycling from risky, strenuous sporting activity to everyday casual mode of transportation? Aldred and Dales (2017) have observed the influence of such separated and protected infrastructure in impacting the use of helmets, high visibility gear and sport clothing. They compared the usage of this specialist gear by cyclists on a newly implemented bike lane considered to have light physical separation from vehicle traffic with that of two nearby less separated bike infrastructure controls (Figure 3.8). The findings revealed some small variations of gear usage between the two infrastructure types, the separated infrastructure had the greatest proportion of cyclists that did not use any kind of safety gear or sport clothing (27.8%) compared to (24.4%) at the control sites.

Figure 3.8 - The physically separated infrastructure (left) and the less separated control site (right), from "Diversifying and normalizing cycling in London, UK: An exploratory study on the influence of infrastructure" by R.Aldred and J.Dales, Journal of Transport & Health, 2017, p.352, p.356. Copyright Elsevier Ltd 2017.

3.5 Usage of e-bikes and e-cycling

E-bike usage theory within this section will follow along two pathways, the first being that E-bikes have the potential to provide population groups who in some contexts cycle less or are underrepresented, to adopt mobility patterns involving cycling. Research shows that they are popular with older adults and women cyclists, which are often underrepresented in cycling modal shares. Secondly by observing different infrastructure types and environmental differences in conjunction to E-bike usage, it reveals how the patterns of usage shift, between conventional bike riders and e-bike riders.

Research completed in the US, identified travel pattern differences via online surveys of e-bike users, 45% of respondents of the survey stated that they take a different route using their e-bike then the route they would take on their conventional bike (MacArthur et al., 2014). The different types of routes e-bike users may take, are further detailed through open ended questions. The responses varied from not avoiding hills, taking more direct or routes with higher traffic levels, taking a less trafficked or less direct routes and finally that some users choose to avoid off-street or multiuse pathways due to possible confrontations with pedestrians (MacArthur et al., 2014). E-biking can also result in riders taking commuting paths which are longer then may be considered necessary (Plazier et al., 2017). Which could be in part due to the ability to drive further distances then what may be achievable given the same physical exertion on a conventional bike (Plazier et al., 2017). This could possibly amplify the many other benefits of biking as a commute mode, such as being exposed to your surrounding environment, taking in fresh air, being able to use the time to clear your mind or prepare for the day ahead. Understanding this, there could be increased importance of not only considering directness of a route but also the routes quality, especially when considering e-bike traffic (Plazier et al., 2017).

The shifting of route choice by e-biker users is exhibited in a revealed preference study completed in Switzerland. The tracking of e-bike riders and conventional cyclists via GPS revealed that there was a tendency for e-bike riders to utilize routes which had higher exposure levels to vehicle traffic. This finding was supported with a few results from the study, the first being that in interviews E-bikers ranked the factor of “low vehicle traffic volume” as less critical in their route choice than conventional cyclists. Additionally, e-bike users were found to have varying route choice (Figure 3.9), where they more often rode on streets which had no cyclist measures but were official routes. The streets in this category more often had greater traffic volumes and a greater proportion of traffic signals. In contrast, conventional bike users were found more often on streets which had traffic ban and in general much higher degrees of separation from vehicle traffic (Allemann & Raubal, 2015).

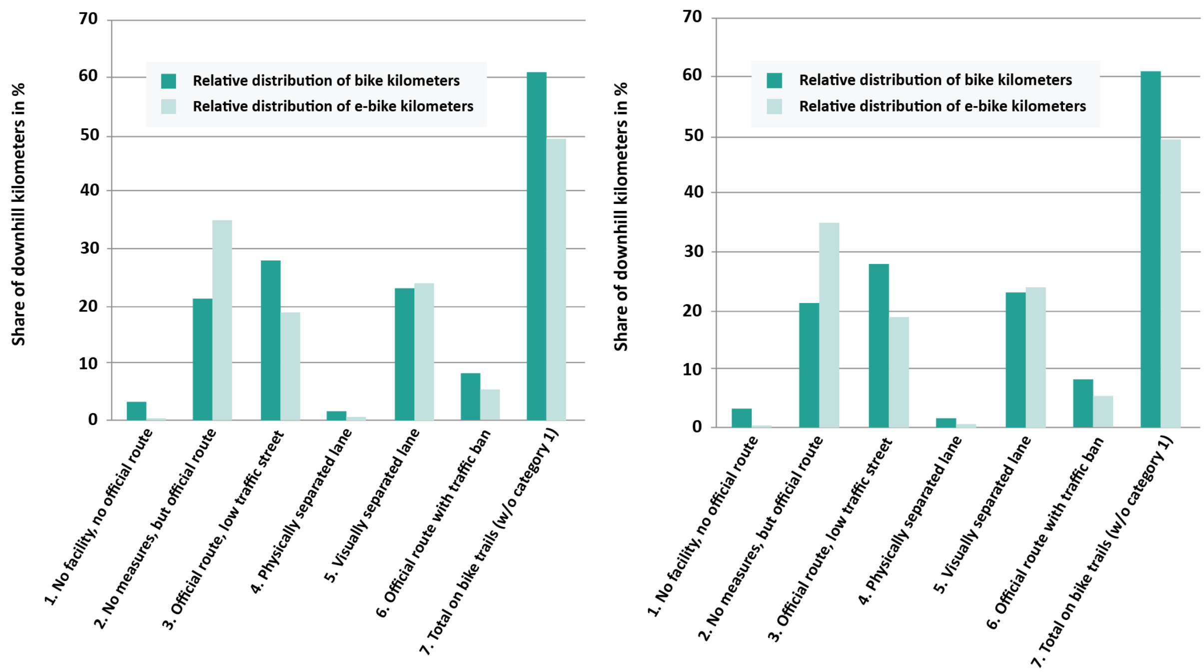


Figure 3.9 - Proportion of study participants distance traveled by e-bike vs conventional on different infrastructure types (Uphill & Downhill), adapted from "Usage Differences Between Bikes and E-Bikes" by D.Alleman and M.Raubal, 2015, pg.210-211. Copyright Springer International Publishing Switzerland 2015.

Although, the researchers acknowledge that their study sample was small and that more research is needed from other cities, to affirm whether the riders choices are reflective of their preferences, or were influenced by the local street layout of the study location (Allemann & Raubal, 2015). This preliminary finding could possibly signal that e-bike users are somewhat less disincentivized by risk, particularly in traffic situations, which may be attributed to the increased speed and potentially confidence. This is corroborated in an online survey of e-bike users where the majority (60%) agreed, or strongly agreed that they felt safer on their e-bike then a conventional bike, which seems to be due to the increased speed levels (MacArthur et al., 2018; MacArthur et al., 2014). Alternatively, it could be that the most unrestrictive way to travel is to use shared roadways with vehicle traffic. So therefore e-bike users less often choose more separated infrastructure, due to potential encounters with slower cyclists or pedestrian traffic and the increased sensitivity to this by e-bike users.

E-bikes seem to shift the travel behavior and infrastructure preferences of its users, but also certain demographics seem to be more inclined to using e-bikes. Within a region of Belgium, the proportion of bike trips that were done on an e-bike were much greater for the older adults (25%) then that of the population in general (7%) (Van Cauwenberg et al., 2019). Additionally, nearly half the respondents to a survey of 1700 e-bike users in north America were 55 or older (Leger et al., 2019; MacArthur et al., 2018). While in an Australian survey with 478 e-bike riders, 70% of the respondents were 50 or older (Johnson & Rose, 2015; Leger et al., 2019). This greater amount of older adult e-cyclists could be partly explained by the greater distances that e-bikes enable its users to cover, with reduced amounts of efforts (Mac Arthur, 2014). MacArthur et al. (2014) have also identified that e-bikes allowed some people with physical disabilities, to overcome limitations to their mobility, making cycling the best form of transportation for them. “I cannot drive due to epilepsy. I cannot bus due to severe motion sickness. Biking is my only way to work other than getting a ride. Bike commuting maintains my fitness level. I can ride even when I don’t feel physically well or am overtired. I get to work faster than it takes when I get a car ride. I love the time outdoors, seeing the city and feeling like part of the bike community” (MacArthur et al., 2014, p. 129).

Women are more likely to be impacted by the perceived riskiness of cycling and are often more burdened by increased trip complexity (Such as caregiver and other encumbered journeys) (Akar et al., 2013; Dickinson et al., 2003; Emond et al., 2009; Krizek et al., 2004). Additionally, the sporting and recreation history of cycling could be said to have reinforced gendered roles and corresponding barriers to cycling for women (Oosterhuis, 2016; Pedroso, 2021). Given the increased feelings of safety and confidence for e-bike riders, the typically longer distances that can be covered by them, as well as reduced exertion (MacArthur et al., 2014; Wild et al., 2021), e-bikes could then be seen as a way for mitigating some of these typical barriers to cycling for women. A recent review study concluded that e-cycling is generally more common amongst men (Bourne et al., 2020). Although, in certain contexts e-bikes are more likely to be owned by women and more likely to be used by them also (Wild et al., 2021). Research from Norway found that within some of its major cities, the proportion of km’s cycled on e-bikes was always greater for women than men. Which was in contrast to conventional cycling, where men cycle more than women within the same cities (Lunke et al., 2018). Wild et al. (2021, p. 14) argue that the e-bike is a technology which can challenge the gendered norms of cycling by “opening up more empowering and enjoyable opportunities for physical activity to a wider group of women”. Although the high costs of e-bikes can be a barrier to their use and this high cost is more likely to impact low income and even middle income households (Wild et al., 2021). Barriers to cycling are also seen to be greater to people from non-western cultures, which is often related to the greater likelihood of them to view cycling as culturally unsuitable, partly due to associations with poverty (Wild et al., 2021). Women from non-western backgrounds are exposed to even greater barriers to cycling, given their often increased likelihood of having responsibility for care giving family roles, and therefore increased complexity of trips (Wild et al., 2021). Wild et al. (2021) therefore also highlight the potential importance of subsidy support for e-bikes, given that some demographics which could benefit most greatly from them are those which may have most difficulties in purchasing them.

3.6 Main assumptions

Three research questions have been posited in the introduction of this thesis, which ask if the degree of separation of bicycle infrastructure is influential towards the demographic composition of the cyclists, as well as the proportion of cyclists using safety gear and equipment and the proportion of cyclists using e-bikes. The theory in this section is used as a basis to form some main assumptions on these relationships and is supplemented by the section on the context of cycling within Norway. The assumptions are categorized within the three broader research questions and are presented below.

Bicycle infrastructure with higher degrees of separation will have greater proportions of women cyclists who use it. Research shows that there are often lower proportions of cycling trips completed by women compared to men, within certain country contexts (Aldred & Dales, 2017; Heinen & Handy, 2012; Pucher & Buehler, 2008). This gender inequity has been theorized to relate to two factors, first that women are more likely to have complex trip characteristics due to an unequal burden of household labor and secondly, that they are more likely to be averse to risk, which can be attributed to both the result of biological differences between sexes and socialized gender roles (Aldred & Dales, 2017; Dickinson et al., 2003; Emond et al., 2009; Heesch et al., 2012; Prati, 2018). The levels of household labor distribution are more even across genders in Norway then many other western countries and the country is thought to have some of the greatest levels of gender equity. Although given the increased likelihood to risk aversion in women and the continued prevalence of socialized gender roles, it is assumed that the proportion of women cyclists will be greater on bicycle infrastructure with a higher degree of separation from vehicle traffic. This finding would highlight the importance of focusing on supportive and safe infrastructure, as an important measure to the inclusion of women in cycling, even in countries with a greater levels of gender equity, and growing cycling modal shares, such as Norway.

Bicycle infrastructure with higher degrees of separation will have greater proportions of older adult cyclists who use it. Within countries with low modal shares of cycling, research shows that the proportion of cyclists often is less within the older adult age group then middle-aged adults (Buehler & Pucher, 2012; Pucher & Buehler, 2017). This is in contrast with countries that are known to have more supportive cycling infrastructure, such as the Netherlands, Denmark and Germany, where the proportion of cyclists in the older adult age groups are often greater than that of middle-aged adults (Buehler & Pucher, 2012; Pucher & Buehler, 2017). This difference can possibly be attributed to increased risk aversion in the older adult age group due to the increased possibility of severe injury from falls (Ikpeze et al., 2018; Van Cauwenberg et al., 2018). Additionally older adults are more likely to experience functional and sensory disability or impairment which can lead to increased difficulties in cycling mobility, especially in situations around heavy traffic and with more complexity (Spirduso et al., 2005; Van Cauwenberg et al., 2018). The theory points towards the increased importance of safe and well-maintained infrastructure in promoting cycling within the older adult age group. Therefore, it is assumed that the proportion of older adult cyclists will be higher on bicycle infrastructure with higher degrees of separation from vehicle traffic. The health benefits of cycling rise with age and there can be great benefits in enabling cyclists to continue cycling or even begin cycling at older ages.

Bicycle infrastructure with higher degrees of separation will have lower proportions of cyclists with safety gear and equipment that use it (casually dressed cyclists). There is debate around most effective means for ensuring safety for cyclists, with some scholars highlighting that protection is best achieved through some form of mandate on safety gear use for individual cyclists (Hoye, 2018; Olivier & Creighton, 2017; Walter et al., 2011). While others believe the benefits of such legislation is more complex and more difficult to isolate from other safe cycling measures, or that such mandates could inhibit cycling from reaching a broader base, which could in turn make cycling less safe through being a smaller and therefore less visible group (Dennis et al., 2013; Jacobsen, 2003; Teschke et al., 2015). When there is greater levels of safety gear as well as more use of specialty sport gear for cycling, Aldred and Woodcock (2015) state that this could lead to a perceived image of cycling as dangerous or requiring high levels of fitness or sportiness. Such an image could be more impactful to less experienced or non-cyclists, creating a barrier to increased growth in cycling (Daley & Rissel, 2011; Rissel et al., 2002). Through creating safer, more separated and cohesive networks, cycling would likely be attractive to a wider range of cyclist with varying experience levels and demographics, this increased level of safety could also lead to a more relaxed approach to cycling, with less safety gear and specialty sport equipment use (casually dressed cyclists). In a small scale study, Aldred and Dales (2017) found that this increased facilitation of safety through separated infrastructure development resulted in an increased proportion of cyclists with no safety or specialty sport equipment. Therefore, it is assumed that the proportion of cyclists using safety gear and specialist sport equipment will be lower on bicycle infrastructure with higher degrees of separation from vehicle traffic.

Bicycle infrastructure with higher degrees of separation will have lower proportions of e-bike riders that use it. E-bikes are increasing in popularity and commonality and many scholars have identified shifting travel patterns for users of e-bikes in comparison to conventional bikes (Bourne et al., 2020; MacArthur et al., 2014; Plazier et al., 2017). Given their increased speeds and reduced levels of exertion required, e-bike users tend to travel greater distances, are less deterred by hills, while appreciating uninterrupted and flowing segments of infrastructure (Plazier et al., 2017). In addition, e-bike users can be discouraged from routes which may have slower traffic such as pedestrians or slower cyclists (MacArthur et al., 2014). This could be why Allemann and Raubal (2015) found that e-bike riders traveled more along routes that were mixed with vehicle traffic, rather than separated infrastructure. Considering these behaviors and preferences of e-bike riders, as well as that many of the fully separated infrastructure points observed in this thesis are shared with pedestrians, *it is assumed that the proportion of cyclists riding e-bikes will be greater on bicycle infrastructure with a lower degree of separation from vehicle traffic.*

Bicycle infrastructure which leads to underrepresentation of women or older adults, will have a smaller influence on the proportion of women or older adult cyclists which use an e-bike, in comparison to the same groups using conventional bikes. E-bikes are common amongst older adults, they have also been found to be more commonly owned and used by women in certain contexts (Leger et al., 2019; Lunke et al., 2018; MacArthur et al., 2018; Van Cauwenberg et al., 2019; Wild et al., 2021). Earlier sections of theory have shown how these demographic groups can have increased barriers to cycling, with one barrier being their increased likelihood of risk aversion. This perceived risk of cycling is often found to be greater towards cycling environments with less separation or physical protection from vehicles or with more complex interactions with traffic. Research has shown that riders feel safer and can have greater confidence when using an e-bike, which could be associated with the increased speed and ability to accelerate (MacArthur et al., 2018; MacArthur et al., 2014; Wild et al., 2021). *The assumption, given the increased confidence and safety provided from the e-bikes, is that on infrastructure that women or older adults are underrepresented, this underrepresentation will be less for e-bike riders that are women or older adults compared to that of conventional bike users that are women or older adults*

4 Methodology

4.1 Research design

Literature on cyclists' infrastructure preference and usage is wide ranging. Although many studies reviewed as a part of this thesis could be categorized into two broad categories, that is, revealed or stated preference studies. Stated preference studies can involve the use of surveys to determine the preferred infrastructure types of its participants. These may include for example, the presentation of manipulated images of various infrastructures and environmental surroundings and have participants select their preferred images/infrastructure types (Krizek et al., 2004; Van Cauwenberg et al., 2019). Alternatively, surveys are completed which reveal deterrents or enablers to participants cycling, these deterrents or enablers are also often compared across gender and age groups (Akar et al., 2013; Emond et al., 2009; Heesch et al., 2012).

The other category is revealed preference, where the actual infrastructure and routes that are taken by cyclists are studied. Common revealed preference methods which study the entire journey of a cyclist included the use of app-based GPS, GPS units mounted to participants bicycles, participant recalled routes (Allemann & Raubal, 2015; Lunke et al., 2018). While other revealed preference studies focus not on the entire route but select locations along particular infrastructure types. In the case of Aldred and Dales (2017) cyclist demographics and safety gear use is compared at a location with a newly installed separated bicycle lane to that of two adjacent observation locations on infrastructure where cyclist are mixed with vehicle traffic. While Debnath et al. (2021) uses video recordings of cyclists across 17 locations comparing the proportion of women cyclists to various environment and infrastructure characteristics (path or road, speed limits, number of lanes) at the observation locations.

Aldred and Dales (2017) proclaim that stated preference surveys typically show strong preferences for separated types of infrastructure for women and older adults, while revealed preference do not as often show such a strong preference. They believe this could be associated with the widespread large lack of coherent and well-developed separated infrastructure systems, in many contexts. Therefore, cyclists lacking their preferred more separated infrastructure, or where it is sparse enough and too difficult to incorporate into their route choice, will alternatively choose the most direct route (which may actually not reflect their stated preference).

This thesis will use an observational non participant methodology which has been structured similarly to that of Aldred and Dales (2017) and Debnath et al. (2021). Different types of cycling infrastructure have been chosen, based upon the degree of separation and their locations along what are thought to be key travel axis in Stavanger. The cyclists observed at each location are registered into a number of categories based on gender, age, the type of bike used and their wearing of safety gear or sport clothing. The observational non-participant methodology is different than many of the above-described methodologies in that there is no participation required by the cyclists observed.   In a review of revealed preference route choice studies, Pritchard (2018) found that the participants in many of the studies were not statistically representative, citing claims that found the respondents were for example more often older, had higher income or more educated in comparison to regular cyclists. Studies which require larger amounts of the participations time in order to be involved such as the physical carrying of GPS units and recording of their own daily travel behaviors, could possibly exclude lower income cyclists who need to spend more of their time focusing on having steady and sufficient income and therefore may be less likely to participate. While recruiting participants from bicycle forums or registers could exclude more novice and beginner cyclists, which are often the target demographic of such studies (given that the goal is often to attract more people to cycling) (Pritchard, 2018). Understanding this, the observational non-participant methodology used in this thesis could provide some advantages regarding the presentiveness of the sample. This may be especially pertinent given its focus on the typically underrepresented groups of women and older adults.

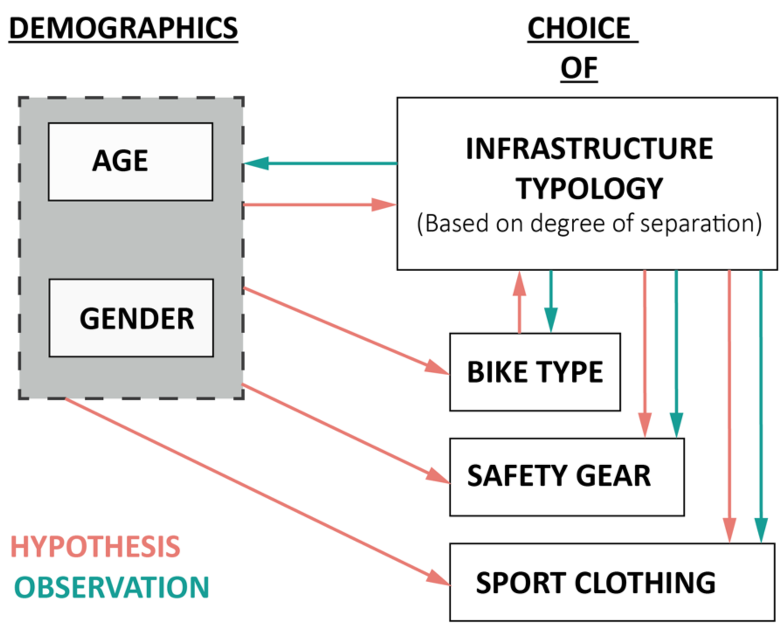


Figure 4.1 - Research design with direction of assumed relationship and from which direction the relationship is observed.

The structure of the research is shown in Figure 4.1, it includes both the direction of influence of the hypothesis which is based on the reviewed theory but also the direction that the relationship is observed and analyzed. In some cases, the relationships are analyzed from a different direction, which is due to the observational methodology.

The theory section begins with the topics of gender and age and how certain characteristics of these populations may lead to them having stronger or different preferences for cycling infrastructure then other groups. The independent variable in this case is the gender and age as it is hypothesized to lead to a greater proportion of cyclists in these population groups on infrastructure typologies with higher degrees of separation. In regards to bike types the focus is mainly on e-bikes. Through the theory it is understood that given the reduced efforts provided and greater speeds achievable with e-bikes, that the use of e-bikes influences the riders preferred infrastructure and route choice, in comparison to if they were using a conventional bike. The independent variable in this case is the e-bike user, and their changed behavior while using e-bikes is hypothesized to lead to a greater proportion of e-cyclists along typologies with lower degrees of separation. In the case of safety gear and sport clothing the theory implies that through a greater sense of safety and security, the use of separated infrastructure by cyclists leads to less use of safety gear and sport clothing. The independent variable in this case is the degree of separation of the infrastructure typology and it is assumed that greater separation will lead to lower proportions of cyclists using safety gear or sport clothing.

Within most hypothesis the dependent variable is the degree of separation, with the lowest degree being the non-separated typology, then the visually separated and lastly the fully separated. This thesis is also exploratory in nature and therefore considered other infrastructure and environmental characteristics, analyzing the possible influence of gender, age and e-bike use on the proportion of cyclists across observation points based on these characteristics. Additional infrastructural and environmental characteristics considered were traffic intensity, population density and how central the observation points were (distance between Stavanger Sentrum and observation point). The influence of age and gender alone on the use of various bike types, safety gear and clothing were also analyzed. All analyses have been conducted with the use of excel, including the use of linear regressions for select variables, while the majority of findings are presented using descriptive statistics.

4.2 Location of observation points

4.2.1 Stavanger

The locations for the observations are all within the borders of the municipality of Stavanger. Stavanger has a topography and urban layout which is dictated largely by its surrounding fjords, interior lakes and elongated land mass in the north and south direction. The lower lying sea shores are contrasted by numerous hills and areas of higher elevation on the interior. The pattern of urban development is scattered in a somewhat linear nature across this topography, this linear nature is also seen to occur within the main transport corridors. Population and employment density are higher within the central area of Stavanger (Stavanger Sentrum) but development also extends northwards to the tip of the landmass, southwards to the neighboring municipality of Sandnes, as well as directly westward towards the western shoreline of the landmass.

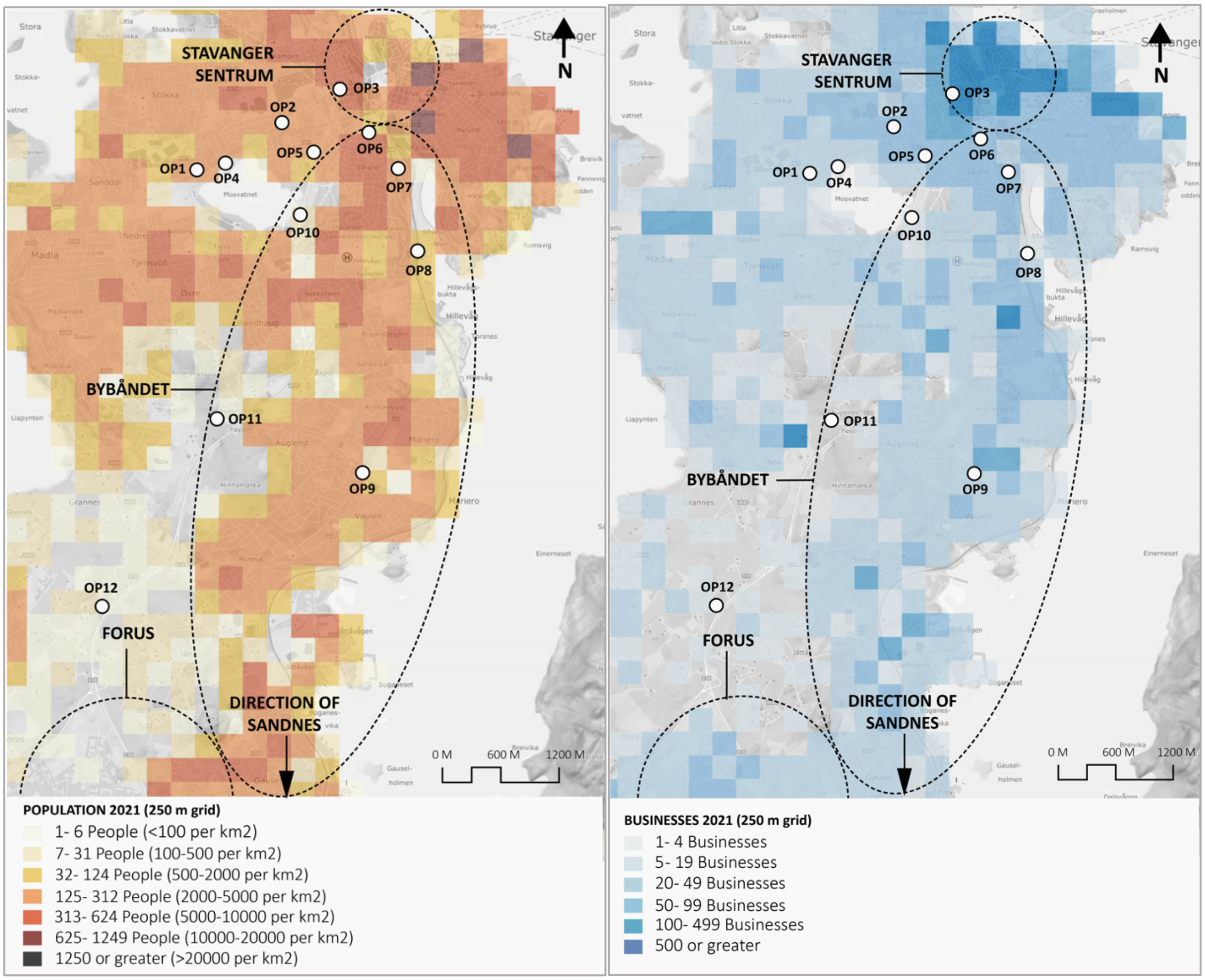


Figure 4.2 Maps of Stavanger Population density on 250 m grid (left) and business density based on 250 m grid (right), based on map data from "statistics on maps" by Statistics Norway. Retrieved from: (https://kart.ssb.no/).

Expanding outwards from Stavanger Sentrum, the urban development patterns are characterized by a slow transition to more suburban and then rural development with decreasing population density. A commonly referred to axis of development is the bybåndet or city band which is the north-south axis of urban development between the municipalities of Stavanger and Sandnes. Between the urban and central areas of Sandnes and Stavanger is the Forus business area. Forus is a common place of employment and consists of a higher business density then its adjacent suburban and rural surroundings (Figure 4.2) this means that journeys into Forus are typically longer and for cyclists beginning their journey from the Sentrum in Stavanger, the trip distance can be greater than 10 km. While the density of businesses does not appear to be substantial (Figure 4.2) this could be due to the presence of a greater number of larger businesses (both in physical size and volume of employees), meaning a greater number of employees without needing a larger number of businesses. Additionally, cyclists traveling within Stavanger can be constrained by numerous hills, such as Ulandhaug and Vålandshaugen, as well as within Hinnamarka and lakes, such as Mostvatnet and Stokkavannet (Figure 4.3). This reduces the options of travel paths which require shorter distances or limited physical exertion, creating a few optimal corridors of travel. In the Nord-Jæren cycle strategy, Stavanger is described as a city with a good climate and terrain layout to allow for cycling (Davidsen et al., 2016). Although, given the aforementioned linear development axes and topographic constraints to travel, there are some challenges. One challenge could be summarized as, a lack of options for the shortest and least exertive travel paths between destinations. Given this it could be said that there is an increased importance of having good cycling infrastructure solutions along the options that do exist. Although this can be difficult to achieve given a recent dominance of car transport and narrow road widths. The inclusion of adequate facilities on some of these main routes is challenging given the space constraints and the uphill battle required in reclaiming that space for more bicycle and pedestrian oriented facilities.

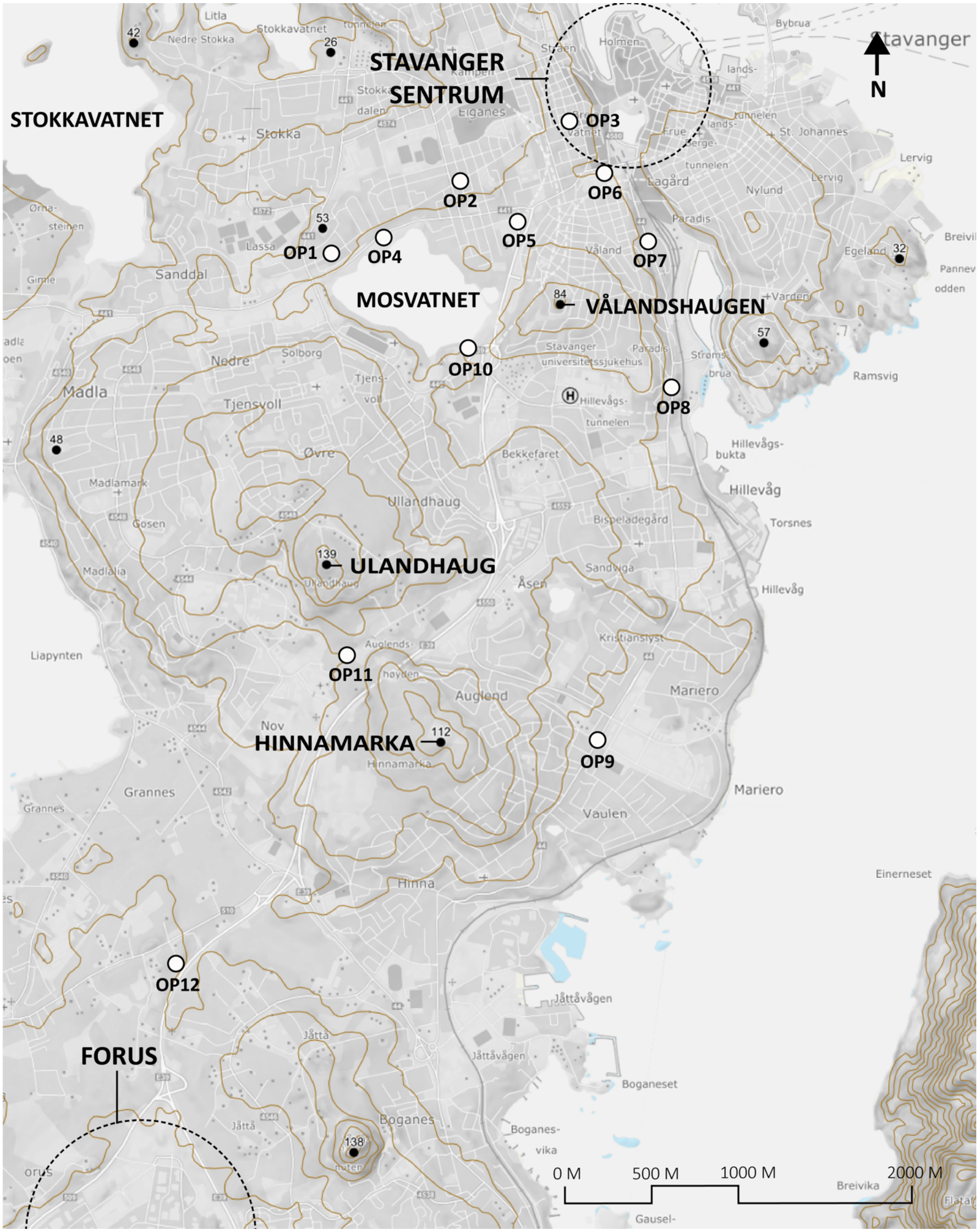


Figure 4.3 - Map of terrain with hill and lake formations in stavanger, based on elevation data and maps provided from dataset "Inspire Elevation WMS" by Geonorge. Retrieved from: (https://kartkatalog.geonorge.no/metadata/inspire-elevation-wms/3389a1c5-3093-44a0-9d2b-1e6c1b4f8944)

4.2.2 Axes of development

The observation points for this study were selected based on their degree of separation (typology) in order to analyze the different proportions of demographic groups, bike type use and gear use of the cyclists that utilize them. It was highlighted that the development pattern of Stavanger is somewhat linear in nature and this also corresponds to a limited set of route options along these axes of development. These factors were also considered in the selection of the observation points. Therefore, the total twelve observation points are not only divided amongst the three typologies selected but also between the north-south and east-west urban axes in Stavanger. Within each of these axes of analysis, there is one set of three observation points that is along a fully separated typology but also another set of three observation points which is along another typology, which has a lesser degree of separation. Therefor the analysis can occur more generally across the three typologies of non-separated, visually separated and fully separated infrastructure but also at more detailed levels within each axes of development/travel, or furthermore detailed across all the individual observation points themselves.

East-west axis

The observation points 1 to 6 are along the east - west axis of development, spanning from the urban/suburban areas of Madla, Eiganes and Tjensvoll towards the more urban area of Stavanger Sentrum. This east-west axis of development is characterized by more consistent and higher levels of urbanity and population density, while the west end is somewhat lower than that of the eastern Sentrum area. The Sentrum area clearly has a greater number of businesses and correspondingly employees, the observation points have been selected to potentially capture cyclists who are traveling to or from this Sentrum area. Although, the observation points are all within a relatively close distance from each other. The observation points 1 to 3 are along a non-separated typology and within this axis they are compared to points 4 to 6, which are along a fully separated typology.

North-south axis

The observation points 7 to 12 are along the north-south axis of development, starting from the Sentrum of Stavanger and extending south towards Forus and the border of Stavanger municipality. This development axis and observation points along it span a much greater distance than that of the east-west axis. Along this axis there are a few pockets of higher population density often corresponding to locations of mid to high rise multifamily housing complexes. While in general, there is a slowly decreasing population density and urbanity as the observation points progress south towards Forus. The spread of businesses is more even with generally greater density between points 8 and 9. The observation points 7 to 9 are along a visually separated typology and within this axis are compared to points 10 to 12, which are along a fully separated typology.

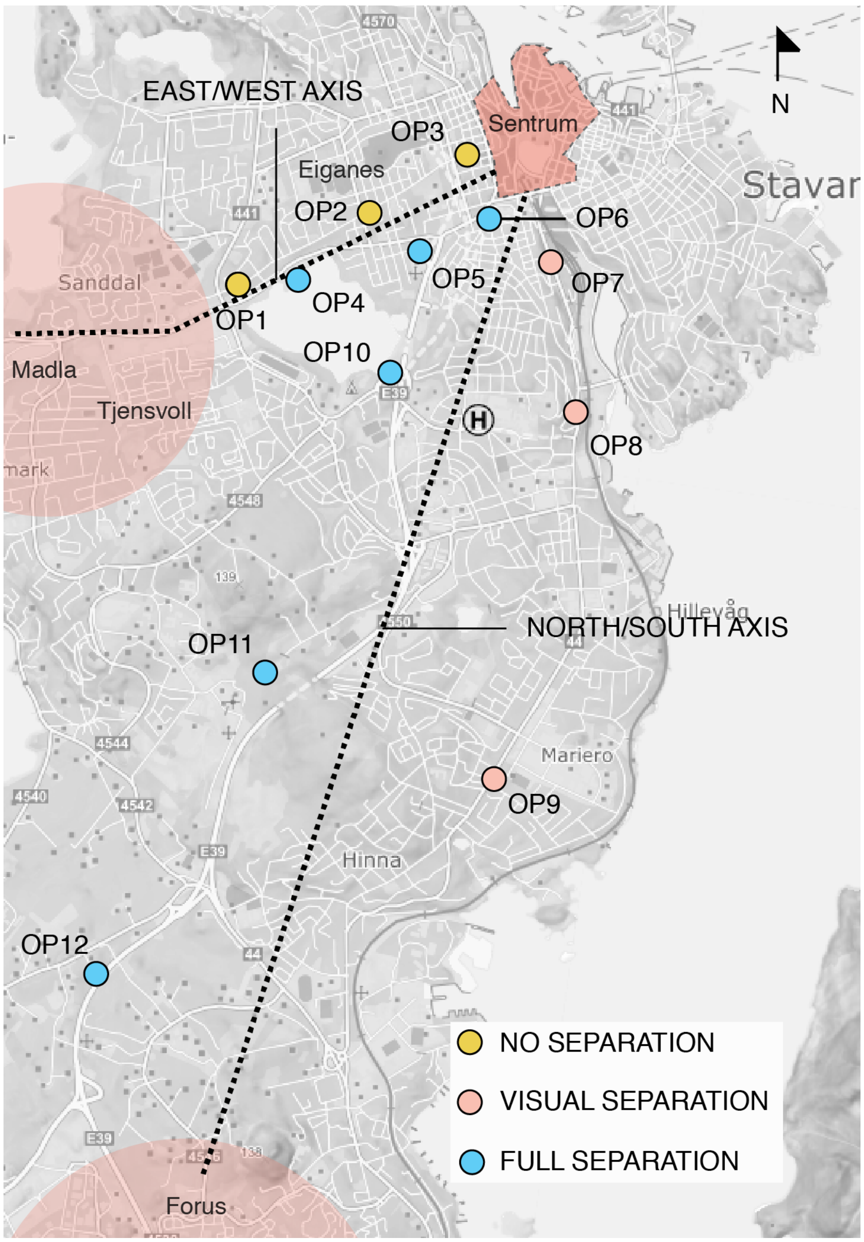


Figure 4.4 - Map of observation point locations, overlaid on background map "graatone" from Norgeskart web map service. Retrieved from: (https://www.norgeskart.no/#!?project=norgeskart&layers=1002&zoom=3&lat=7197864.00&lon=396722.00).

4.2.3 *Infrastructure typologies* [1]

Non-separated (east-west axis)

The observation points (1-3) are categorized as non-separated in this thesis. This typology also more broadly falls under the on-road infrastructure classification and since there is no physical or visual delineation between vehicles and the cyclists, it could further be refined as mixed traffic. Typical for this category of infrastructure, these observation points are located along roadways with speed limits ranging between 30 km/hr – 40 km/hr, the use of traffic calming such as speed bumps and chicanes are common and they have generally lower traffic volumes (approximately 1800 AADT). Given these lower traffic volumes and speeds the observation points typically have narrower roadways and contain lower levels of heavy traffic (busses, freight trucks). Their surroundings are urban with a higher degree of residential generally lower degrees commercial or retail uses. Although this shifts towards a more equal distribution between residential and commercial at observation point 3.

Figure 4.5 - Non-separated cyclist infrastructure at observation points 1 to 3 from left to right.

Visually separated (north-south axis)

Observation points (7-9) are categorized as visually separated in this thesis. This typology also more broadly falls under the separate infrastructure classification, as there is a form of separation (visual) between space allocated for motor vehicles and that of cyclists. At these locations cyclists have a designated lane which is identifiable visually with painted separation line and red coloring to make it stand out even further. The lanes range in width from 1.3 m to 1.7 m. These observation points are located along roadways with speed limits ranging between 40 km/hr – 50 km/hr and they also contain round abouts where the roads intersect with other larger roadways. The roads are wider, with up to two lanes in each direction and correspondingly have generally higher levels of traffic volume (9,000 – 22,000 AADT). With the higher volumes comes a larger

[1] See Appendix 11.1 for a detailed written description of each individual observation points environmental surroundings and infrastructural characteristics or Appendix 11.2 for similar information in table form.

proportion of heavy traffic (freight trucks and busses) although public transit has its own designated lane and at observation point 9 public transit exists within its own designated corridor, separated from both personal vehicles and pedestrian/cyclist traffic. Given the larger road way with higher traffic the property surrounding has larger setbacks and is more often mixed use with higher proportions of commercial or public service oriented land uses.

Figure 4.6 - Visually separated cyclist infrastructure at observation points 1 to 3 from left to right.

Fully separated (east-west & north-south axis)

Observation points (4-6) and (10-12) are categorized as fully separated. This infrastructure is also referred to as bicycle paths, when is are dedicated to bicycle usage or multi-use path, when it is shared with other users such as pedestrians. At these observation points the cycling infrastructure is completely separated from vehicle traffic, and often has a large distance between the road way and the infrastructure itself and in some cases (OP11) no vehicle roadways are visible from the observation point. Therefore, it is assumed that cyclists should not be impacted in any way by vehicle traffic and it is not considered (speed limits, traffic volumes) in the description. Given that these points are distanced from vehicle roadways, they are often located within green spaces and parks with have surroundings that are rich in trees and green qualities. In the case of observation points (5-6) the infrastructure is part of dedicated underpass for pedestrians and cyclists and in that case, they act as a bridge connecting other fully separated and mixed traffic infrastructure typologies crossing under roadways with higher levels of vehicle traffic.

Figure - 4.7 Fully separated cyclist infrastructure at observation points (4-6) top left to right, (10-12) bottom left to right.

4.3 Observation

The observations of the cyclists were taken over 38 individual observation sessions which were each thirty-minutes long. All of the twelve observation points were observed for at least three of these 30-minute sessions each. While the observation points 1 and 3 required four sessions each, as the sample sizes were inadequate with only two. The sessions occurred throughout the summer over three somewhat separated rounds of collection, with the first round taking place late June, the second round late August (Between 17 and 28) and the third at the start of September. The rounds were spread intentionally across the summer months to mitigate the potential impact of any one-off events, or weekly trends which could shift the demographic or equipment/gear use of the cyclists. All the observation sessions took place between the time periods of (6:30 – 9:30 am,) and (2:30 – 5:30 pm) with a distribution of 17 morning periods and 19 in the afternoon. These time periods were chosen as the sample for this thesis is targeted towards commuter cyclists and these are the periods of time which correspond to the morning and afternoon commuter rush. All the observation sessions were completed during periods of relatively fair weather, the range of temperatures was between +12 to +21 C while the wind speed ranged between 2 and 7 m/s.

The observations were taken from a position at each location, which attempted to maximize the view of cyclists passing in both directions along the infrastructure. As cyclists passed by the observer, a standardized form was used to record characteristics of the passing cyclists, these forms included categories for, direction of travel, age, gender, bike type, speed as well as yes or no boxes for the use of bike trailers/cargo bike/child carriers, high visibility gear, helmets and sport clothing (see Appendix 11.3). In addition, it was also recorded if the cyclist was using the infrastructure as intended, an example of not using the infrastructure as intended would be a cyclist using the adjacent sidewalk instead of the red colored cycle lane along the roadway. The characteristic of speed was only recorded during the first round of observations, therefor 12 of 38 of the observation sessions include this characteristic. This is due to the requirement of an additional observer in order to record speed due to its increased complexity, which was difficult to acquire given the time periods and large number of observation sessions completed. The speed recordings are more complex as they require the observer to mark two locations at a set distance from each other (typically 30 M) and record the time with a stopwatch that it takes the cyclist to cycle between the points. The category of high visibility gear and sport clothing requires more clear definition due its subjectivity from the observer. High visibility gear has therefore been defined to include the use of fluorescent colors or reflective strips, which can either be part of the cyclists clothing or gear (helmet, gloves and cycling baggage). Sport clothing includes the use of spandex shorts, leggings or shirts, that does not appear to be clothing which the cyclist would continue to wear when they were no longer cycling. In addition, cyclists which walked by with their bike and were not cycling at the point of observation were not recorded.

4.4 Categories of observed cyclists

4.4.1 Bike types

In this thesis, bikes are described more broadly in two categories, that is of conventional bicycles and e-bikes. To be considered an E-bike they must meet the definition of electrical motor assisted bicycles, which still require its rider to pedal in order to get assistance from the motor (Bourne et al., 2020). While conventional bicycles are considered to be all other bicycles that are used, which do not have electrical motor assistance. The conventional bicycle has a range of styles which have been differentiated between in this thesis and each style (mountain bike, hybrid bike, classic bike and road bike) is categorized and further detailed below in Table 4.1. The styles are mostly described in the way they vary in the position that the rider sits on the bicycle, which is impacted by the structure of the frame and type of handlebars (upright or leaning forward). Additionally, the width and diameter of the wheels and the type of tires dictates the type of terrain and riding the bike is best oriented towards. The described characteristics provide visually identifiable differences which help to sort the observed cyclists amongst the bike type categories. While e-bikes also exist in a range of styles, the overriding feature of them being electrically power assisted is the main focus around e-bikes in this thesis, therefor they are not detailed further into the various styles which they are manufactured in.

CONVENTIONAL BIKES	
Hybrid bike These bikes have a more multifunctional purpose and are considered “hybrid” due to their blended characteristics between a range of bike styles including touring, road and mountain bikes (Nævestad et al., 2014). They provide the rider with a more forward leaning stance, typically have flat handlebars, light frame and tires suitable for both gravel and asphalt pavement (Nævestad et al., 2014; Rabben et al., 2021).	 *Figure 4.8 - Hybrid bike example, retrieved from: (https://mtnweekly.com/reviews/best-hybrid-bikes-for-men/)*
Classic bike These bikes have a more “traditional” or “classic” appearance, including a simple frame and can also be referred to as city bikes or utility bikes. They will often have limited number of gears or none at all, often include carriers for baggage and splash guards and have an upright sitting position is upright (Nævestad et al., 2014). They therefore are often described as a more practical everyday bike type, usable for a variety of trip type, although this practicality often comes with a tradeoff for added weight and reduced speeds.	 *Figure 4.9 - Classic bike example, retrieved from: (https://www.bikester.no/ortler-van-dyck-cargo-M909202.html?vgid=G1301395&cgid=36903)*
Mountain bike These bikes are designed for usage off road, they therefore typically have wide tires with large treads for added traction. In addition they have strengthened frames, which provide a forward leaning position and usually have suspension for dampening of impacts (Nævestad et al., 2014). The suspension is typically on the front tire but can be placed at the back wheel as well, for higher intensity conditions. While	

their intended use is for off-road purposes, they have been common in the city scape of Norway (Rabben et al., 2021).	*Figure 4.10 - Mountain bike example, retrieved from: (https://www.rei.com/learn/expert-advice/mountain-bike.html)*
Road bike These bikes are lightweight and designed for highspeed riding or racing competition and can therefore also be referred to as racer bikes (Nævestad et al., 2014; Rabben et al., 2021). They typically have thin tires which restrict riding to smooth paved surfaces and dropped handle bars which provides the rider with a more aggressive forward leaning position (Nævestad et al., 2014).	 *Figure 4.11 - Road bike example, retrieved from: (https://www.wiggle.co.uk/brand-x-road-bike)*
E-BIKES AND BIKE SHARING	
E-bikes The use of e-bikes in Norway falls under the European Union's requirements for Electric Pedal Assisted Cycle or (EPACs). These requirements dictate that the user must pedal to gain electrical assistance and that engine performance cannot exceed 250 watts or propel to speeds beyond 25 km/h (Fyhri et al., 2017). If the bike exceeds these maximum limits, then the it is considered an electric moped and also subject to registration and fees (Rabben et al., 2021). E-bikes come in a range of styles and types and therefore can look similar to a range of conventional bikes, although they are usually noticeable due to the inclusion of a large battery pack located typically on the frame or above the rear wheel.	 *Figure 4.12 - E-bike example, retrieved from: (https://www.mhw-bike.com/kalkhoff-endeavour-3-b-move-smokesilver-glossy-diamond-2021-touring-e-bike-men-156387)*
Bike share Bike sharing schemes are bicycle rentals which are short term and allow the users to pick up and drop off the bicycles again at various self-served docking stations across an urban area, with payment often through IT based solutions (Chen et al., 2020). Within Stavanger the bicycle sharing system is operated	

by the public transit company Kolumbus, therefore the same app-based system which is used for ticketing on public transit functions with the bike share system. The Kolumbus system consists of e-bikes which are allocated at docking stations across Stavanger, as well as other municipalities in the county (Fylkeskommune, 2020). The bikes have a frame in the classic bike style, including baggage carrier, splash guards and a very upright sitting position.	 *Figure 4.13 – Kolumbus bike share example, retrieved from: (*https://www.kolumbus.no/globalassets/ images/imagegallery/ p1030014-2.jpg?w=1200&h=630&mode=max)

Table 4.1 – Categories of bike types used by cyclists.

4.4.2 Age groups

The age groups were based on the ten-year age ranges which are used within the Norwegian National Transportation survey. These ten-year age ranges have then been merged into groupings, which are thought to represent potential behavioral differences through varying stages of life (Table 4.2). Although given the observational methodology, the exact age of cyclists is unknown and the categorization of cyclists is only an estimate. Exact age ranges that define the below categories of child/youth, young adult, adult and older adult do not exist but these groupings (particularly that of older adults, due to a larger focus on them in this thesis) has been based on similar studies completed on cycling across age groups.

Child/youth This age grouping is an estimate of cyclists who are under the ages of 18 years old. The age grouping is intended to reflect cyclists which will still likely be attending school.
Young adult This age group is an estimate of cyclists who are between the ages of 18 and 34 years. The age group is intended to reflect the earlier stages of adulthood, where it is assumed cyclists in this group may be more likely to be attending post-secondary education, in earlier stages of a career, to be single and or to have no children/younger children.

Adult This age group is an estimate of cyclists who are between the ages of 35 and 54 years. The age group is intended to reflect the middle stages of adulthood, where it is assumed cyclists in this group may be more likely to have more developed families with older children, to be settled into a career or long-term relationship.
Older adult Across studies this age group often begins between the ages of 50 and 65 years (Aldred et al., 2016; Grudgings et al., 2021; Van Cauwenberg et al., 2019). In this thesis the older adult's category represents an estimated age of cyclist of over 55 years. Where it is assumed cyclists beyond this age may begin to be more likely impacted by increased risks of injury or issues with mobility.

Table 4.2 – Age categories for the observed cyclists.

4.4.3 Safety Gear and sport clothing

How the various categories of safety gear and sport clothing have been defined is shown in Table 4.3. What is considered sport clothing or high visibility gear can be somewhat subjective, so the following categories were created to describe how they were recognized. Images below the table show some examples of what typical cyclists looked like with different combinations of safety gear and sport clothing.

SAFETY GEAR
Helmets Bicycle helmets are used to protect the head from impact injuries by acting somewhat like a shock absorber (Walker, 2005). There are many different forms of helmets although in this thesis, there was no differentiation between styles. If a cyclist was observed wearing some type of helmet while cycling, they were recorded as a helmet user. In some cases, helmets were observed to be strapped around handle bars and not on the head of the cyclist, these were not recorded as helmet users.
High visibility gear High visibility gear, also referred to as conspicuity aids is considered to be any clothing or accessories that a cyclist can use which is incorporated with either retro-reflective or fluorescent colors (Miller et al., 2017). This includes a variety of configurations including incorporation within jackets, pants, gloves, helmets and bike bags or as a separate layer which is worn over top of clothing such as in the case of vests or "snap-

wraps" around the body (Miller et al., 2017). In this thesis, If a cyclist was observed with any of the above-described configurations whether wearing as clothes or attached to their bike, they were considered a user of high
SPORT CLOTHING
This category provides more subjectivity, due to the varying types of clothing which could be considered sporty. This was mitigated by adhering to a standard as to what would be considered sport clothing. This category included any cyclist who was wearing tight fitting clothing which is typically made from materials such as spandex or lycra. They could be shorts, or full-length pants, t-shirts or full sleeve shirts. Cyclists who wore this type of clothing were discernable from others, as the clothing is not typically something a person would wear as their everyday attire.

Table 4.3 – Categories of safety gear and sport clothing for the observed cyclists.

Figure 4.14 - Cyclist wearing no safety gear or sport clothing (left), retrieved from: (http://www.sfu.ca/~kristyh/iat339/P02/Final%20Deliverables/img/ridercategory_casual.jpg). Cyclist wearing sport clothing & helmet (middle), retrieved from: (http://www.sfu.ca/~kristyh/iat339/P02/Final%20Deliverables/img/ridercategory_sports.jpg). Cyclist wearing high visibility gear and helmet (Right), Retrieved from: (https://www.canberratimes.com.au/story/6149045/high-visibility-clothing-wont-help-cyclists/)

5 Findings

5.1 General observations of cycling in Stavanger

Before elaborating on the findings related to the influence of infrastructure on cyclists' socio-demographics, bike types and gear use, some more general findings will be presented. The findings will include the total proportions of the sample across the age groups, genders, bike types, gear type of comparisons as well as interesting trends that are exclusive from the impacts of infrastructure, such as relationships between the socio-demographics of cyclists and the type of bikes, or gear most commonly used.

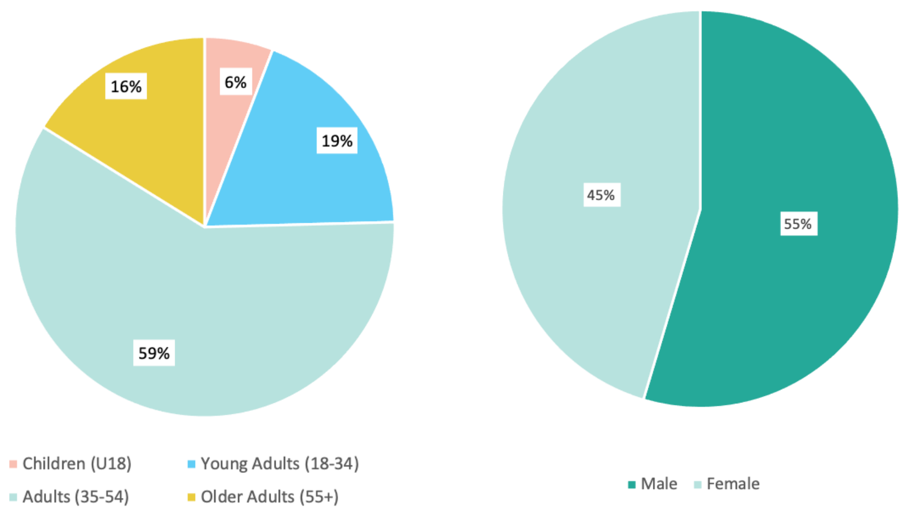


Figure 5.1 - Proportion of cyclists by age group and gender (N=1558)

38 separate observation periods were completed of half hour length each, resulting in a total of 19hrs of observation. This resulted in a total registration of complete data sets for 1558 cyclists. Across this entire sample, the majority of cyclists are within the adult age group (59%), which in this thesis is described as people between 35 and 54 years of age. The remaining cyclists are made of young adults aged between 18 and 34 (19%), Older adults aged 55 and over (16%) and the smallest proportion was of children /youth (6%) which consists of cyclists under the age of 18. The gender division across the sample is relatively equal but with a slightly lower representation of women (45%) compared to men (55%).

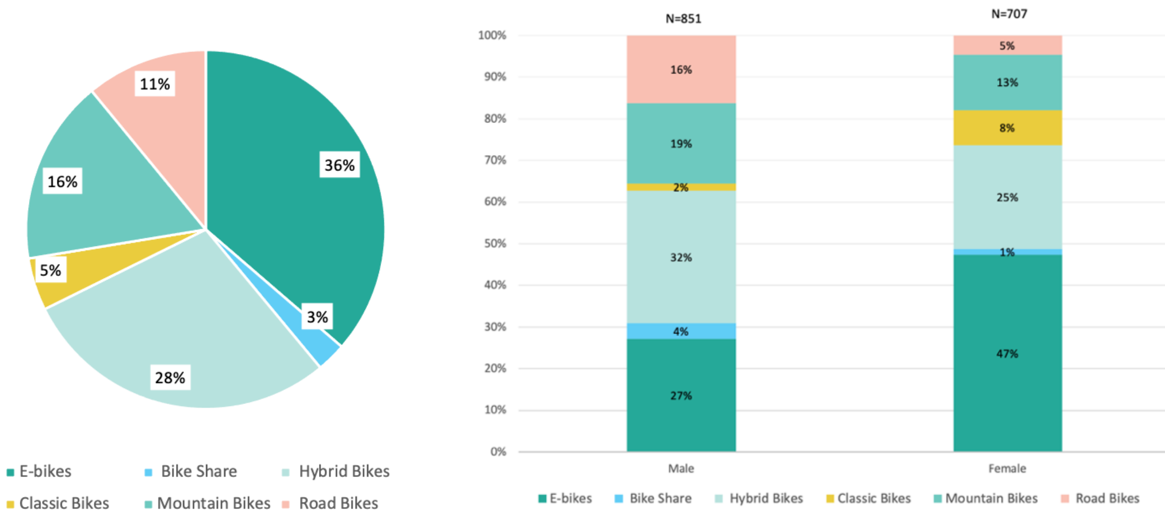


Figure 5.2 - Percentage of bike types usage across entire sample (right) (N=1558), and by gender (right).

Examining the bike type usage across the entire sample, e-bikes were the most common of the six types (Figure 5.2 - Left) (36%), which is surprising given the high costs of owning as well as that they are a relatively new technology. The next highest proportion was of the hybrid bike type (28%), which could be due to its versatility, making it suitable for a variety of rider types as well as terrain. There were smaller proportions of the remaining categories (approximately 15% or less) of mountain bikes, road bikes, classic bikes and bike shares. In regards to age and bike types, one varying trend was that bike share use was most common amongst the young adult age group (7%), constituting more than a doubling of the percentage across the entire sample. This could relate to the tech-savvy nature of bike share systems, which require the use of mobile apps, or possibly that this younger demographic seems least inclined to use helmets, (64% use helmets compared to the sample average of 79%) while bike share use was also associated with less helmet use (15% of users wore a helmet).

Comparing the use of bike types across gender, some clear contrasts are also observed (Figure 5.2 - Right). One of the most notable is the proportion of women who use e-bikes (47%) in contrast to men, which only (27%) use. This fits well with the understanding that e-bikes can provide added confidence and rider support which can assist in overcoming some barriers to cycling for women. In addition, it was found that men are 3x more likely to use road bikes (16%) in contrast to women (5%). Theory found that certain sport-oriented images of cycling promoted through more extensive use of sport clothing (tight fitting lycra clothing), were perceived negatively by women and less experienced cyclists. Given that road bike users were most commonly found using sport clothing (69%), these negative perceptions could be extended to road bikes and be related to the lower proportions of women road bike users. Alternatively, within the classic bike type, women are 4x more likely to use them with a total proportion of (8%) in contrast to men's (2%). This bike type is described as more comfortable and practical providing a higher level of utility, therefore the increased use by women could be associated with the greater diversity of trip types (encumbered, caregiver journeys) that they often have. Lastly, men are 4x more likely to use bike shares, with a total proportion of (4%) in comparison to women's (1%). A pattern which has been seen in other countries and has been associated with the general varying trip characteristics of women due to unequal division of labor and greater likelihood of risk aversity. Although given that gender equality in general cycling levels is much greater (55% men to 45% women) in Stavanger. The 4x more men using the bike share system compared to women is quite significant although this proportion is likely swayed by the very small sample of bike share users (n=41). Although, similar inequalities have been found in the Oslo bike sharing system with nearly 2x as many bike share trips completed by men (Böcker et al., 2020).

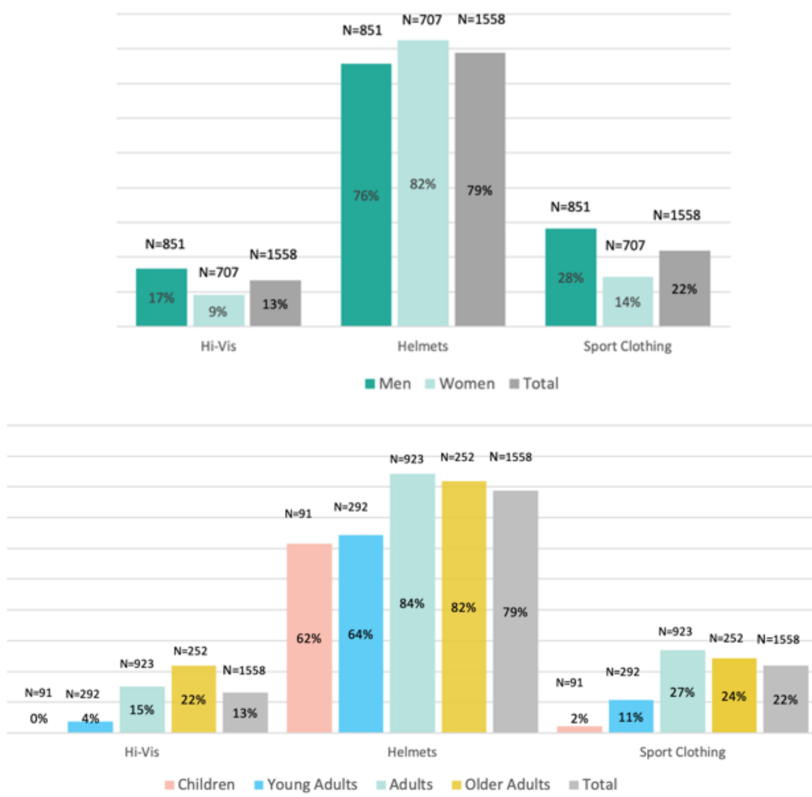


Figure 5.3 - Percentage of cyclists using safety gear and sport clothing by gender(top) and age (bottom).

Across the gear usage categories (Figure 5.3), helmet use is the most prevalent with (79%) usage in total across the sample. This is higher than the (72%) which was identified by Lunke et al. (2018) in a survey of cyclists in Stavanger. It is also greater than the majority of countries in the European union (Dekra, 2020).

Stavanger is more comparable to percentages of helmet use that occurred in regions of Australia (75%) after the legislation of mandatory helmet use (Robinson, 1996). It could be posited that the Norwegian governments heavy focus on reducing traffic related deaths and injuries for pedestrians and cyclists has led to a deeply engrained safety culture. Which supports these high proportions of helmet use, even without mandatory helmet use legislation. Furthermore, given that mandatory helmet legislation has been theorized to lead to a cyclist population shift, where the legislation disincentivizes cycling in certain population groups (which are typically more risk averse and therefor cycle more cautiously). It is possible that this deeply engrained culture of safety exerts such a strong cultural expectation, that it acts almost as an unspoken mandatory legislation. Where the penalty for not following the legislation is not a fine, but a feeling of being socially outed and stigmatized for not fitting the norm. This could possibly be impacting the uptake of cycling, hindering the possibility of cycling reaching a broader population base and greater modal shares and orienting it more towards faster moving and riskier cyclist types.

In contrast sport clothing and high visibility gear use is less common with (22%) using sport clothing and (13%) using high visibility gear. This is lower than what Aldred and Dales (2017) found for London cyclists, where (35.7%) of cyclists used sport clothing and (26%) some type of high visibility clothing. This is interesting given that helmet use was much higher in Stavanger then was found in London. This could be due greater subjectivity in determining what is high visibility or sport clothing, and more objectivity with helmet use, where Aldred and Dales (2017) possibly had a lower threshold of what they considered to fall in the more subjective categories. Another possibility could be the range of infrastructure locations observed in this thesis (ie.12 observation points over a large variety of infrastructure typologies, with varying traffic intensities and degrees of centrality within Stavanger), as the different observation points contrasted each other significantly in the amounts of safety gear and sport clothing use, leading to a more moderate average across the entire sample. In contrast Aldred and Dales (2017) only examined three locations which were all within proximity of each other, meaning less variation in the results and a possible swaying of results based environmental characteristics of the location.

Notable differences across gender include men being about twice as likely to be users of high visibility gear (17%) and sport clothing (28%) in contrast to women (9%) and (14%) respectively. Although the trend is reversed and not as significant in regards to helmet use, with (82%) of women wearing one compared to (76%) of men. When considering age, it is most notable that both safety gear and sport clothing use tends to increase with age with a particularly large increase between the young adult and adult age groups (ie 64% of young adults wear helmets compared to 84% of adults, a 31% increase). The actual number was not recorded in this study but many of the non-helmet wearing children/youth had a helmet with them, although they were not wearing it, as it was either strapped around their handlebars or fastened to their back pack.

5.2 Influence of infrastructure and environmental characteristics

5.2.1 Gender

The main assumption regarding gender was that the degree of separation would influence the proportion of women cyclists that use it. Meaning that the fully separated typology (highest degree of separation) should have the greatest proportion of women while the non-separated should have the lowest proportion. The analysis did not show such a relationship between degree of separation and the proportion of women cyclists, as the non-separated typology (least separated infrastructure) had the highest proportion of women (52%), while the visually separated had the lowest proportion (39%) and the fully separated was in the middle with (46%)(Figure 5.4).

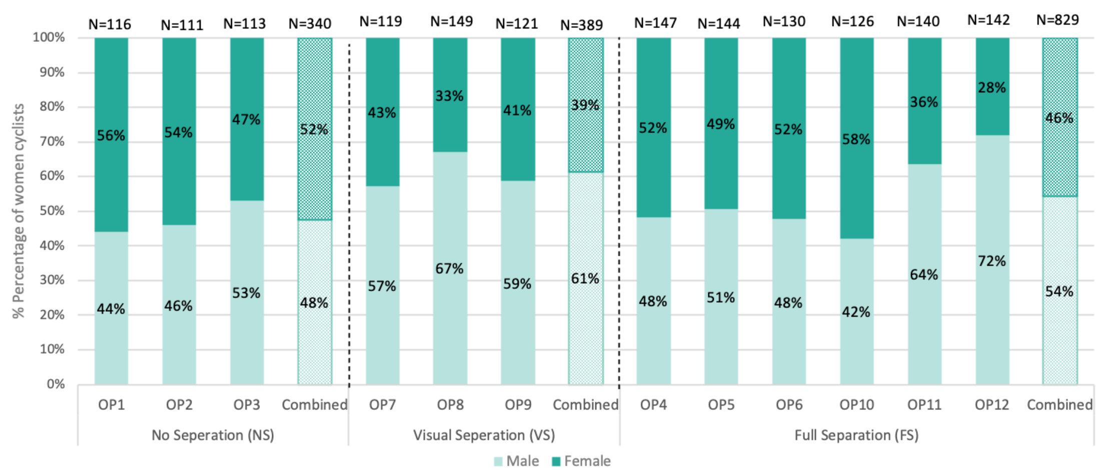


Figure 5.4 - Percentage of women cyclists by typology and observation point

Although, given the lower proportion of women cyclists along the visually separated infrastructure (Difference of 7% from the next lowest proportion of 46%), other potential relationships with the infrastructure characteristics of these visually separated observation points were explored. Correlations were found when the proportion of women cyclists is compared to infrastructure characteristics related to traffic intensity such as the posted speed limits, road widths and traffic volume (Average Annual Daily Traffic). The strongest is between the proportion of women cyclists and the vehicle traffic volume, this correlation is shown in Figure 5.5. for all the observation points which are adjacent to vehicle traffic (non-separated and visually separated typologies) The basis of the hypothesis: the degree of separation will influence the proportion of women that use it, is that, due to women's greater likelihood to risk aversion a greater amount of separation between vehicles and cyclists will lead to greater perceptions of safety, which in turn would lead to a higher usage by women. Based on this analysis it seems more likely that there is a stronger relationship between the proportion of women cyclists and the intensity of the vehicle traffic (measured here as the annual average daily traffic volume) rather than the degree of separation itself. It could be described as an interactive effect between levels of vehicle traffic intensity and how separated the infrastructure is from it. Where not considering other environmental factors, a given level of traffic intensity (contributed to both by speed and volume of vehicles) has a certain degree of separation which would best mitigate the additional perceived risk by cyclists from the traffic. Therefore, given the lower proportion of women cyclists on the visually separated infrastructure, it could be said that the degree of separation is not sufficient in mitigating the impact of the higher traffic levels along this infrastructure. Additionally, given that people who are in the category of potential cyclist or less experienced cyclist may also be perceive risks in cycling more greatly (Clark et al., 2019; Daley & Rissel, 2011). It is also possible that this degree of separation could be considered insufficient in supporting modal shifts to more cycling. In contrast, along the non-separated typology, where the AADT is lower (approximately 1800) and the proportion of women cyclists high (52%). The low degree of separation seems to be sufficient enough to not negatively impact the proportion of women cyclists and possibly also potential cyclists.

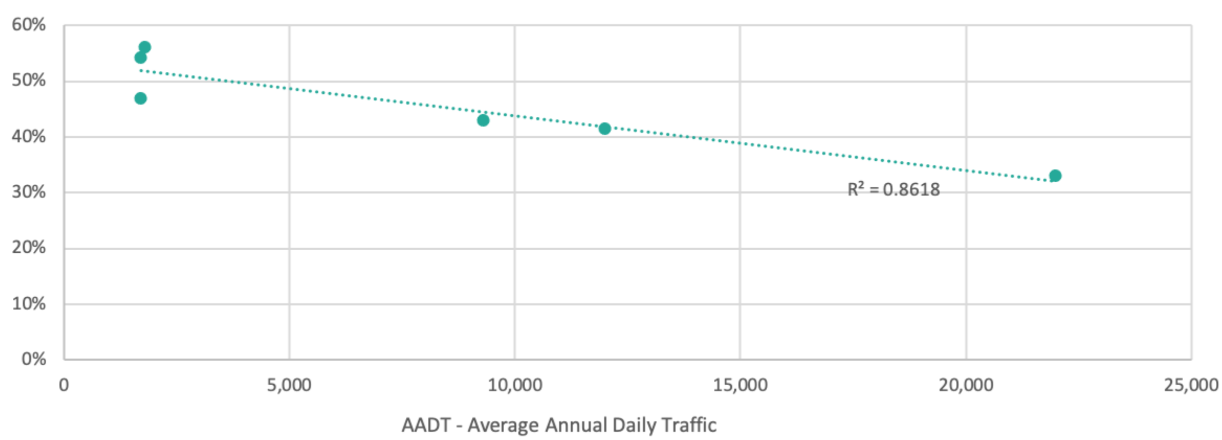


Figure 5.5 - Percentage of women cyclists compared to traffic volume across non-separated and visually separated observation points.

It was also noted that the observation points 11 and 12 had sequentially lower proportions of women cyclists (36%) and (28%) respectively. In addition, the proportion of women at observation point 12 (28%) was the lowest across all observation points. Given that these observation points are within the fully separated typology, the low proportion cannot be due to a relationship with the infrastructure characteristics like road width, speed limits and traffic volume. The proportion of women cyclists was then compared to the environmental characteristic of centrality, measured both as distance from the Sentrum area in Stavanger to observation point as well as population density of the area surrounding the observation point. The strongest relationship was with the population density (Figure 5.6).

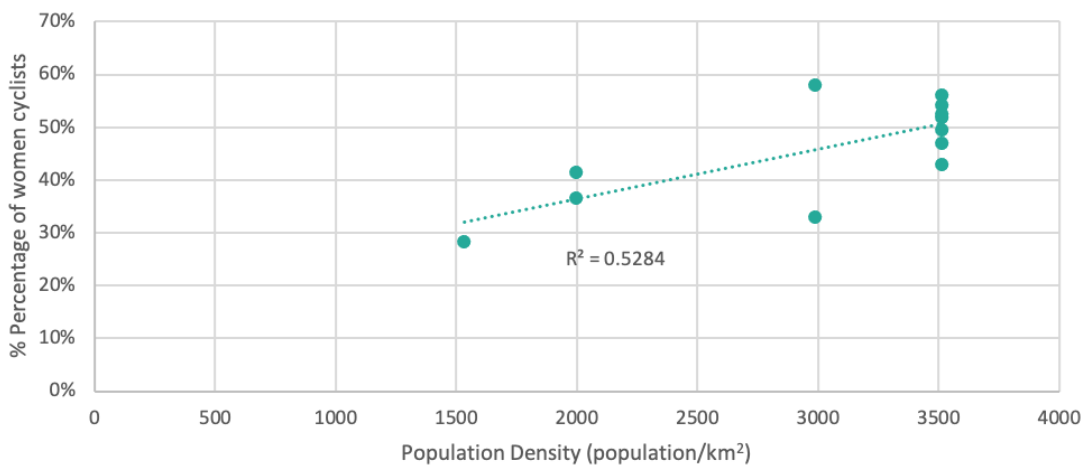


Figure 5.6. Percentage of women cyclists compared to population density across all observation points.

This relationship could be possibly explained through research that finds in some cases women are less likely to cycle longer distances (Dickinson et al., 2003; Heesch et al., 2012). Since as the population density around observation points decreases, the likelihood that an observed cyclist will be completing a longer journey should increase. Meaning, that it would then be less likely to observe women cyclists at these less central observation points. Although the evidence on women cycling less than men in general is quite divided, with many finding that they cycle similar or longer distances (Krizek et al., 2004; Wuerzer & Mason, 2015). Another possibility could be that it is related to the employment demographic within Forus. The observation points along the North-South axis (7-12) have been selected along two routes that attempt to form the most direct options of travel for cyclists between the more populous areas of Stavanger and the business area Forus. Additionally, aside from the Forus business area, there are limited destinations for a cyclist to be going, it is therefore possible that the observation points that are less central and also closer to Forus, may have a greater proportion of cyclists which are employed at businesses within Forus. This could be contributing to the low and decreasing proportions of women as the observation points get closer to Forus. The gender distribution of employees across different sectors within Forus as well as Stavanger Sentrum has been approximated and are shown in Figure 5.7. It is approximate because data limited to the geographic area of Forus, was found only in the form of distribution of employees across sector of employment and not across genders. This business sector distribution in Forus is then used together with more aggregate level data for all of Stavanger, where the gender distribution of various employment sectors exists. The gender distribution across sectors for Stavanger is then used to calculate the proportion of men and women in those sectors working within Forus.

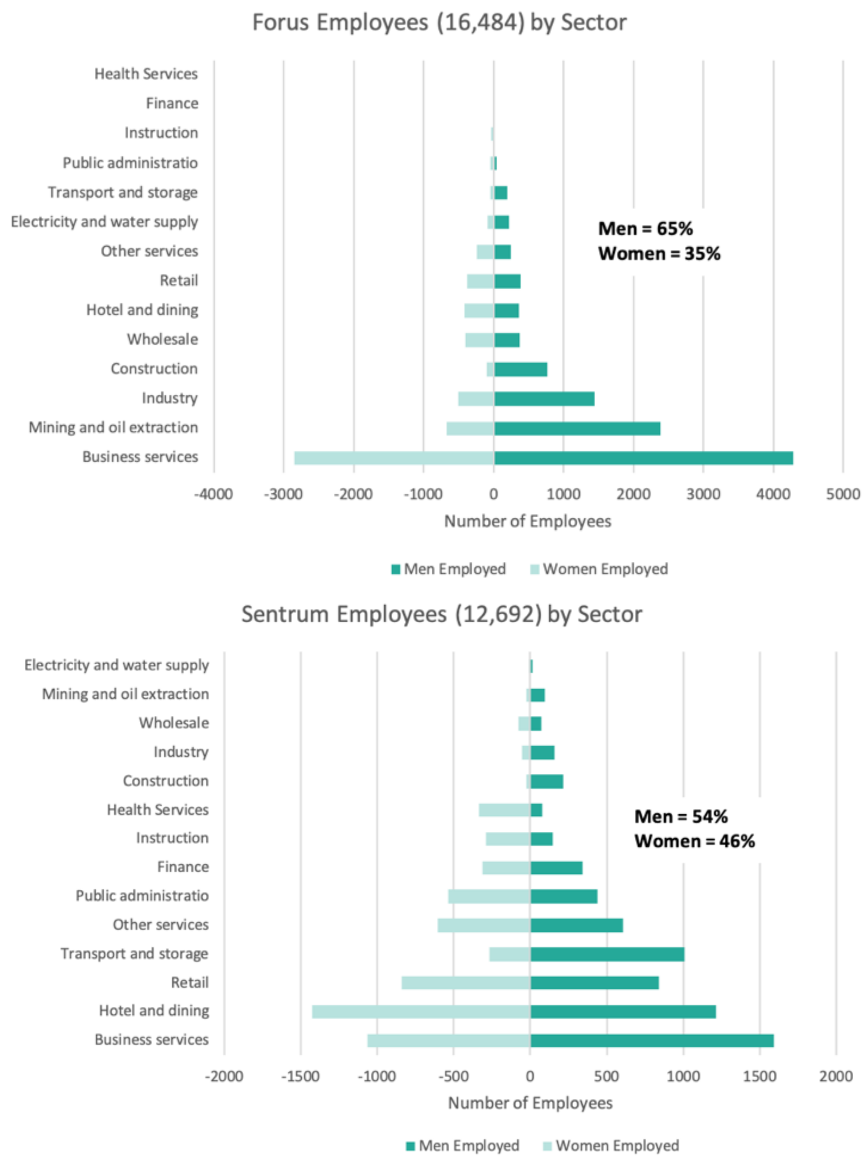


Figure 5.7 - Distribution of employment across sectors in Forus (top) and Stavanger Sentrum (bottom), based on data from Stavanger statistikken public tableu and Statistics Norway (Statistics-Norway, 2020; Stavanger-Statistikken, 2019)

From Figure 5.7, we can see that Forus has a greater number of employees working in sectors that are skewed towards employment by men. Additionally, the employment is across a smaller and less diverse range of sectors, where the top three sectors employ 75% of the workforce. This is in contrast to Stavanger in general, where the same 75% is spread across seven sectors, and the Sentrum area, where it is spread across five sectors. The approximate proportion of women employed in Forus is (35%) compared to that of Stavanger Sentrum area (46%) and across all of Stavanger (48%). This means that there is approximately 1.8 times the amount of men working in Forus than women, while at observation point 12 (fully separated and nearest to Forus) the proportion of men cyclists was nearly 2.5 times that of women. The proportion of women cyclists is even lower than the approximate proportion of women employed in Forus (28% compared to 35%), it is likely that the skewed employment demographic is not the only contributing factor. Other possible contributing factors could be that a more male oriented, masculine and therefore more sport oriented cycling culture could also provide a greater disincentivizing impact on women, who could be considered potential cyclists to Forus. Additionally, it could be that the less central location of this observation point also makes it less likely for women to be observed there, given the further distance likely required to cycle there.

5.2.2 Age

The main assumption regarding age was that the degree of separation of cycling infrastructure would influence the proportion of older adults that use it. This would mean that observation points (4-6) and (10-12) which are categorized as having the highest degree of separation (fully separated) should have greater proportions of older adults. Examining the average proportion of older adults that used the different typologies, the observation points within the typology non-separated (lowest degree of separation) had the smallest proportion of older adults (14%) while both the visually separated and fully separated typologies had an average proportion of (17%) older adults. Therefore, there isn't a clear relationship between the degree of separation of the infrastructure and the proportion of older adults that use it. As was done for women, the proportion of older adult cyclists was also compared to the traffic intensity of the observation points, in this case there was no strong correlation. While the theory shows that older adults are also more likely to be averse to risk and situations with a large degree of interaction with vehicle traffic, one possibility could be that older adults have a more complex geographic distribution. When the proportion of older adult's geographic distribution is examined in urban districts across Stavanger (Table 5.1), it could be considered less even than between that of the male and female population[2]. A clearer result could possibly be given if this geographic distribution was controlled for, something which is outside the scope of this thesis. In addition, given that the more elderly of the age group, who are also more likely to have greater risk perceptions, may be retired and therefor have differing travel characteristics. The sample time period of morning and afternoon rush hour commute times could have led to not adequately capturing the more elderly and potentially more risk averse portion of the age group.

Area of Stavanger	% Population that is Female	% Population that is over 60
Hundvåg	50%	20%
Tasta	50%	19%
Eiganes og Våland	50%	21%
Madla	50%	22%
Storhaug	48%	16%
Hillevåg	51%	21%
Hinna	50%	20%
Min	**51%**	**22%**
Max	**48%**	**16%**
Range	**3%**	**6%**

Table 5.1- Percentage of population that is female compared to over the age of 60 across the urban districts which the observation points are located around, based on data collected from statistics Norway (Statistics-Norway, 2021b).

Although not part of the main assumptions there were other noted trends with the age groups of children/youth as well as young adults. Firstly, Figure 5.8 shows that there was an increased number of children and youth that used the non-separated typology (12%) compared to the visually separated (3%) and the fully separated (4%).

[2] See Appendix 11.5 for map based geographic distribution of older adults

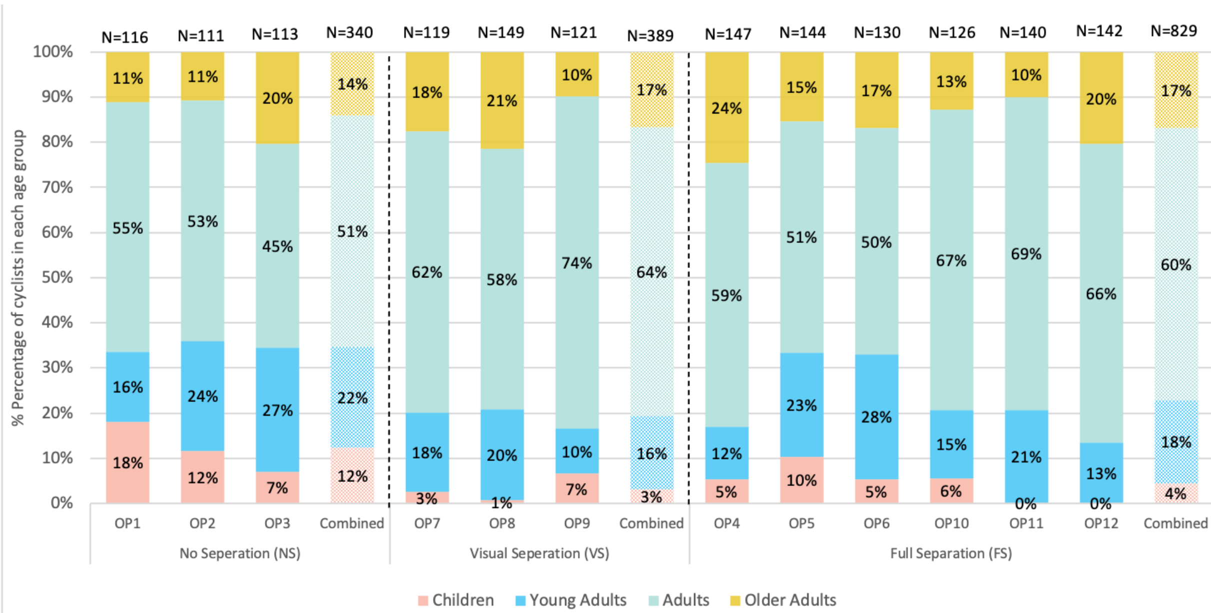


Figure 5.8 - Percentage of cyclists within age groups by typology and observation point.

Given that children/youth are an age group where much attention is focused on their safety and well-being, a larger amount of children/youth here could indicate that the perceived risk of the non-separated infrastructure is not as great as anticipated. The impacts on perceived safety of the mixed traffic between bicycles and vehicles could be lower given there is minimal traffic and lower speed limits in addition to traffic calming features as well as narrower road widths. Although this possibly related to an increased number of schools which are accessible on this corridor. Additionally, the non-separated observation points are located within an area with a higher degree of urbanization and greater population densities, this could also contribute to making the area more conducive to cycling trips given the increased likelihood of decreased trip distances in more dense urban areas. While there does not seem to be a relationship between the degree of separation and the proportion of children/youth from this data, it could be said that the lack of separation between vehicle traffic and cyclists does not seem to greatly inhibit the travel of children/youth, given the greater proportion of them that use this non-separated typology. This could also be related to the large number of children/youth which cycle along the sidewalk (45%) instead of the roadway along this typology (meaning that they are likely less impacted by the lack of separation, since they more often choose to use the sidewalk which is separated with a curb from vehicle traffic). The proportion of youth/children which cycle along sidewalks instead of roadways is high (45%) given that next highest proportion is (14%), which is for the young adult age group.

In regards to the young adult age group, they also had the greatest proportion along the non-separated infrastructure (22%) compared to visually separated (16%) and fully separated (18%). In addition, the proportion of young adults increases as the non-separated observation points (1-3) get closer towards the Sentrum area of Stavanger with the lowest proportion at OP1 (16%), then OP2 (24%) and finally closest to the Sentrum OP3 (27%). In Figure 5.9 the proportion of young adults across all observation points are plotted against their centrality (measured as distance between the observation point and closest edge of the Sentrum area) there is a strong correlation (greater proportions of younger adults at more central locations).

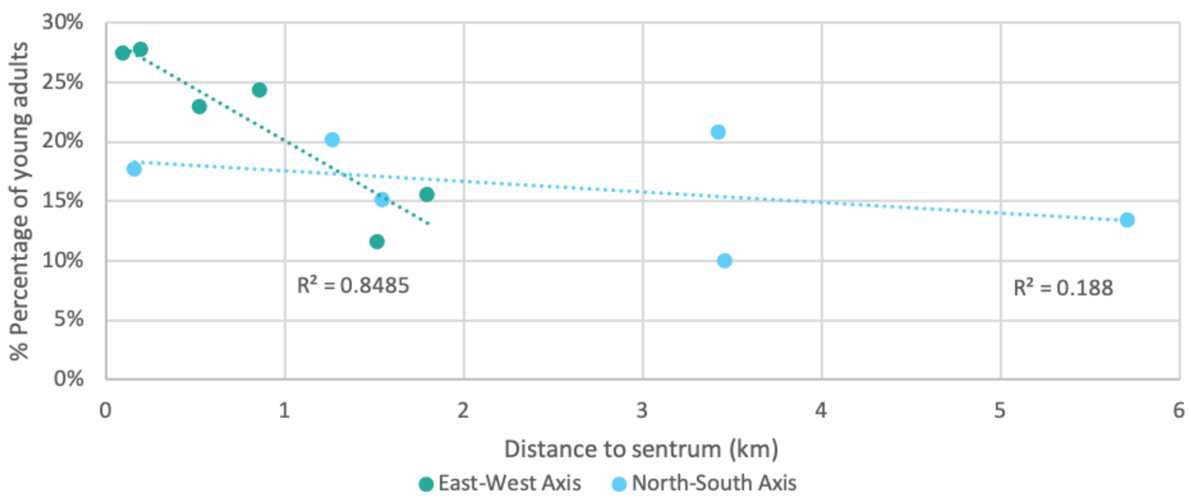


Figure 5.9 - Percentage of young adult cyclists compared to distance to Sentrum of the observation point.

The increased proportion of young adults is not only found along the non-separated typology but also the three fully separated observation points (4-6), these points are also along the east-west axis, like that of the non-separated typology. Therefore, the correlation between centrality and proportion of young adults is likely related to some geographic difference along this east-west axis. When this finding is compared to the demographic distribution of young adults (Figure 5.10), there is a geographic pattern of an increasing number of young adult residents in areas closer to the Sentrum along this east-west axis. The greater proportion of young adults along these observation points and typologies is then likely be more related to the geographic distribution of young adults and not due to any relationship with the infrastructure typologies themselves.

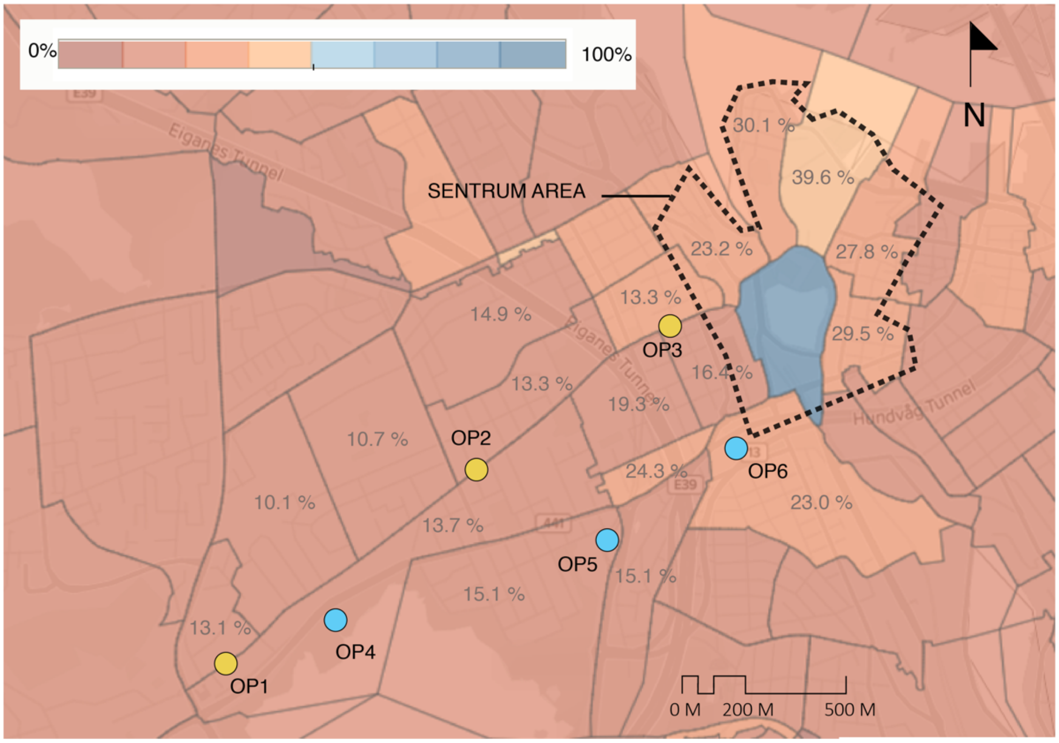


Figure 5.10 - Geographic distribution of 16 – 29 year old age group along east-west axis in Stavanger, based on map data from Stavanger statistikken public tableu (Stavanger-Statistikken, 2020).

5.2.3 Safety gear and sport clothing usage

The main assumption regarding safety gear and equipment was that the degree of separation of cycling infrastructure would influence the proportion of cyclists wearing it. Meaning that the infrastructure typology that had the highest degree of separation (fully separated typology) should have the highest proportion of cyclists not wearing any safety gear or sporty equipment such as lycra tights (casually dressed cyclists), while the least separated (non-separated typology) should have the smallest proportion. While it seems counter-intuitive, safety and sport gear has been reported in terms of non-usage in order to be comparable to findings of Aldred and Dales (2017). There was no indication of the hypothesized relationship seen across the observation points (Figure 5.11), as the fully separated typology actually had the lowest proportion of casually dressed cyclists (12%) (ie. Not wearing helmets, sport clothing (Lycra tights or shirt), high visibility clothing). Also, the same proportion was found along the visually separated typology (12%) while the non-separated typology had more than double that proportion (28%). These findings contradict that of Aldred and Dales (2017) where they found that separated infrastructure had approximately (4%) more of these casually dressed cyclists when compared to two control non-separated infrastructure typologies nearby. This does not necessarily mean that the degree of separation doesn't influence the use of safety gear and sport clothing, just that in this thesis the use of such equipment likely has a stronger relationship with other factors.

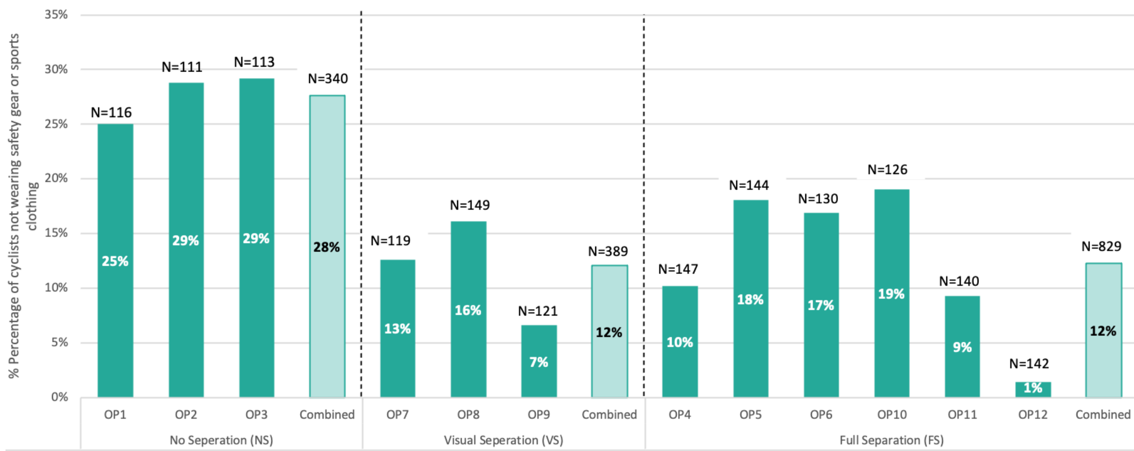


Figure 5.11 - Percentage of cyclists that were casually dressed (no helmet, no high visibility gear and no sport clothing)

In the safety gear theory section, two groups of cyclists which have been categorized by Fyhri et al. (2012) are described. The first being a more traditional cyclist which is less inclined to wear safety gear or sport clothing, is slower moving and more risk averse and therefore is less at risk of accidents. The other is of a speed happy cyclist which is faster riding and wears more safety gear or sport clothing, they cycle for training purposes and have greater risks of accidents. Some findings point to a similar variation in the cycling population in Stavanger. Where it seems that more central locations have higher proportions of a cyclists which fits the "traditional cyclist" category. This is noted when the proportion of safety gear and sport clothing at the observation points is plotted against measures of their centrality (distance between the observation point and the Sentrum) Figure 5.12.

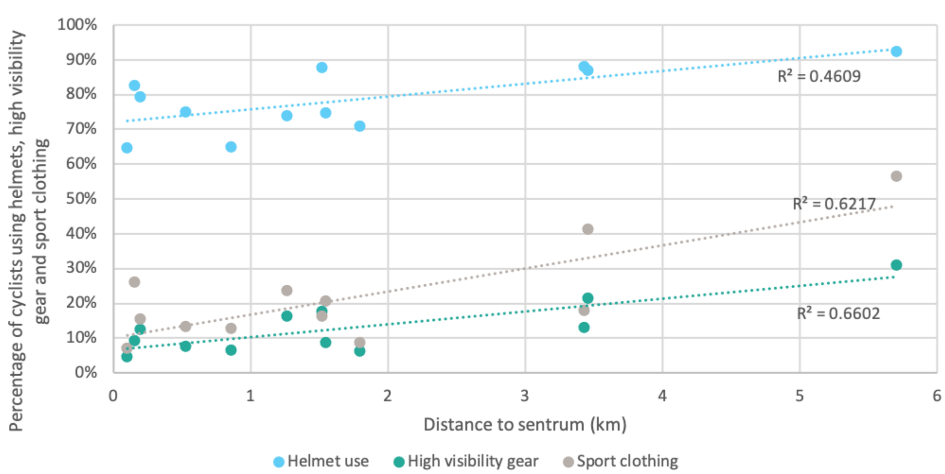


Figure 5.12 - Percentage of safety gear sport clothing use compared to distance to Sentrum of the observation point.

Where lower proportions of the use of safety gear and sport clothing are seen at more central observation points and higher proportions at less central ones. Additionally, higher proportions of women cyclists are found at the more central observation points, a demographic which could be said to be more likely to fit the traditional cyclist category due to often greater risk aversion tendencies. Women were also more likely to be slower cyclists in this sample, with an average recorded speed of (19.2 km/hr), compared to that of men (21.6 km/hr). The speed happy training cyclist's presence is corroborated in this thesis through the finding that cyclists using sport clothing traveled nearly (3 km/hr) faster than non-sport clothing wearing cyclists. This speed happy group could also be more attributed to road bike users, as they were most likely to use sport clothing, with (66%) of road bike riders wearing it (2x more than the next highest, mountain bikes). This sport clothing wearing, road bike using group, is also the fastest riding, with an average speed of (26.2 km/hr). One possible explanation of the divide between these categories of cyclists based on centrality, could be that these speed happy cyclists are more likely to travel further distances, due to the serious and often training like purposes they associate to cycling. While the distances that these observed cyclists have traveled is unknown, an assumption could be made that the cyclists at the less central observation points are more likely to have traveled a longer distance. This is because as the observation points become less central the population density also decreases meaning there is a greater chance that the cyclists have arrived from further away and more populated areas. Although, as the observation points decrease in centrality, they also increase in proximity to Forus and they have been placed along what was thought to be potential routes for cyclists to Forus. Therefor as speculated in the findings on gender it could also be that the less central observation points are more likely to be skewed towards the Forus demographic of cyclist. Where possibly the demographics and corresponding cultural norms of the employment sectors in Forus could be influencing the more common presence of speed happy training-oriented type of cyclist at observation points that are less central.

When the use of only sport clothing is analyzed in Figure 5.13, the proportion of its usage by cyclists was actually greatest along the visually separated typology (30%) compared to the non-separated typology (9%) and the fully separated typology (23%). This could be related to the lower proportion of women that use this typology, which is correlated to the higher intensity of traffic. Although the elevated amount of sport clothing still exists within this typology when the sample is isolated only to men. Another possibility could be that it is related to this speed happy training cyclist category, as given their faster speeds and lower perceptions of risk they could be less deterred by the higher traffic volumes along this typology and lower levels of separation. Which is why higher levels of sport clothing are found on this typology.

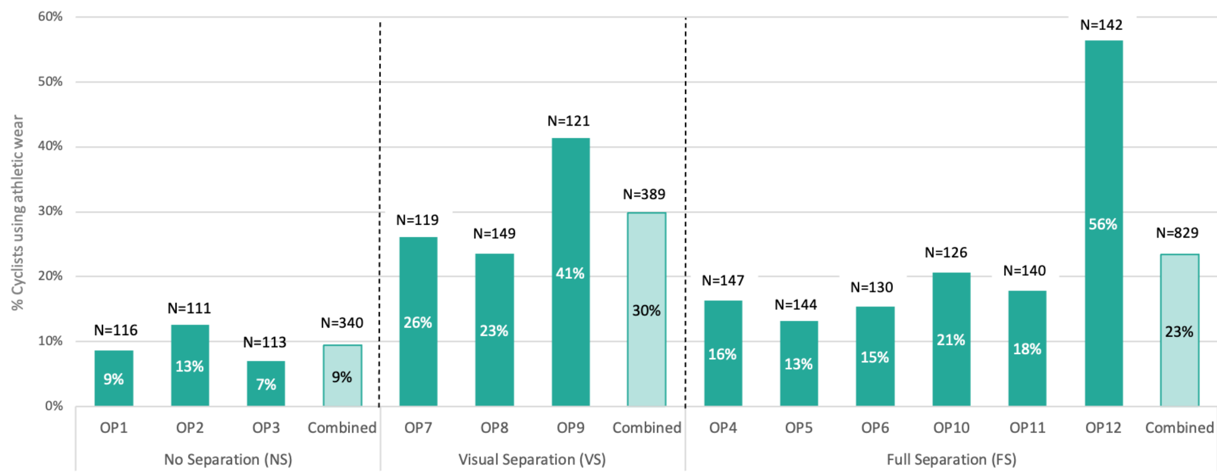


Figure 5.13 - Percentage of sport clothing use by observation point and typology.

5.2.4 *E-bike usage*

The main assumption regarding e-bike usage was that lower degrees of separation would lead to higher proportions of their use. Meaning that the non-separated infrastructure typology should have the highest proportion of e-bikes and the fully separated the lowest. This relationship was not found, as the fully separated infrastructure had the highest proportion (40%) while the non-separated and visually separated had the same proportion (32%) (Figure 5.14).

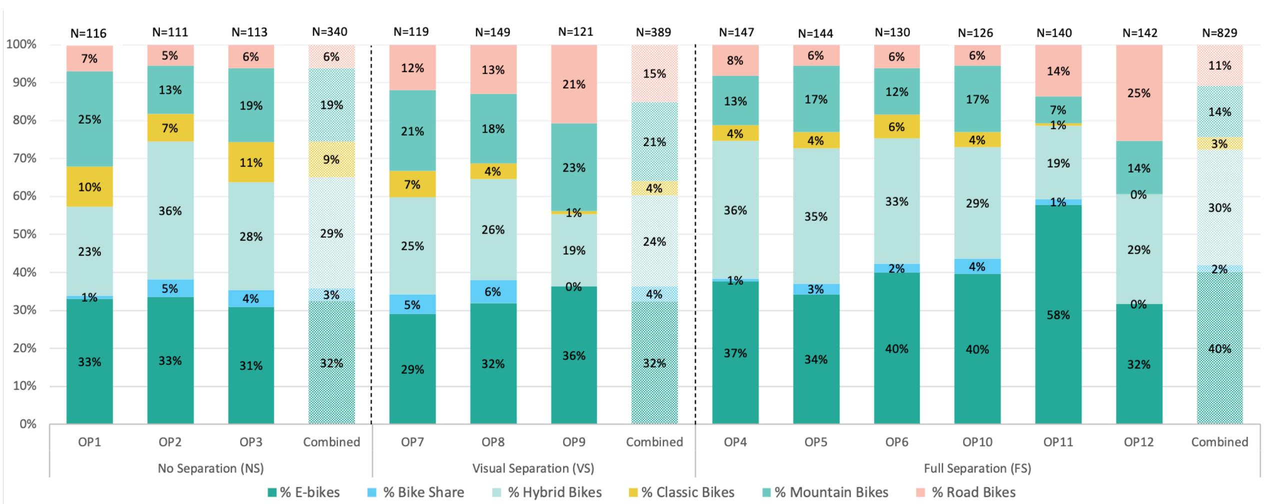


Figure 5.14 - Percentage of Bike types used by observation point and typology.

The assumption was based on theory which shows e-bikers as being less averse to risk due to greater speed of travel and subsequent increased confidence, which could lead to them more commonly traveling in mixed cyclist/bicycle traffic situations. Also, that e-bikers can be deterred by slower traffic, such as that of pedestrians or conventional cyclists, so they will often avoid infrastructure which may provide conflict with these users (such as fully separated infrastructure shared with pedestrians). In this case it could be that the fully separated infrastructure, does not have great enough levels of conventional cyclists or pedestrian traffic or that it provides enough separation between uses (ie. Pedestrian and cyclist) and width, to not deter e-bike users. In addition, fully separated infrastructure may also provide other benefits, such as greater environmental quality. As the fully separated typology observation points more often go through the most park like areas with high green quality. Although, the increase in e-bike use along the fully separated infrastructure is not that much greater than the other typologies in general, except for at observation point 11. This observation point had more than half of observed cyclists (58%) using e-bikes, a (+18%) percent increase from the next highest observation point. Observation point 11 is located in the middle of Sørmarka forest, which is quite large and this point is quite isolated and central within the forest. In addition, to reach this observation point the cyclist is required to cycle up a significant elevation gain, no matter the direction of travel, given its hilltop location. A possible explanation of this high proportion of e-bikes users is the reduced levels of efforts required by e-bikes, means they are less deterred by the great elevation gains and therefore are able to utilize infrastructure which provides a very high-quality green environment.

Another assumption with the use of e-bikes was that they could be supportive for women or older adults, particularly along infrastructure or within environments which they are underrepresented. In general, lower proportions of women were found at higher trafficked and less centrality located observation points and therefore presents a good opportunity to analyze this possible relationship. This was done by separating the proportion of women cyclists into the categories of conventional bike users (all other bike types aside from e-bikes), as well as e-bike users, which was then plotted against the measures of traffic intensity (Figure 5.15) and centrality (Figure 5.16).

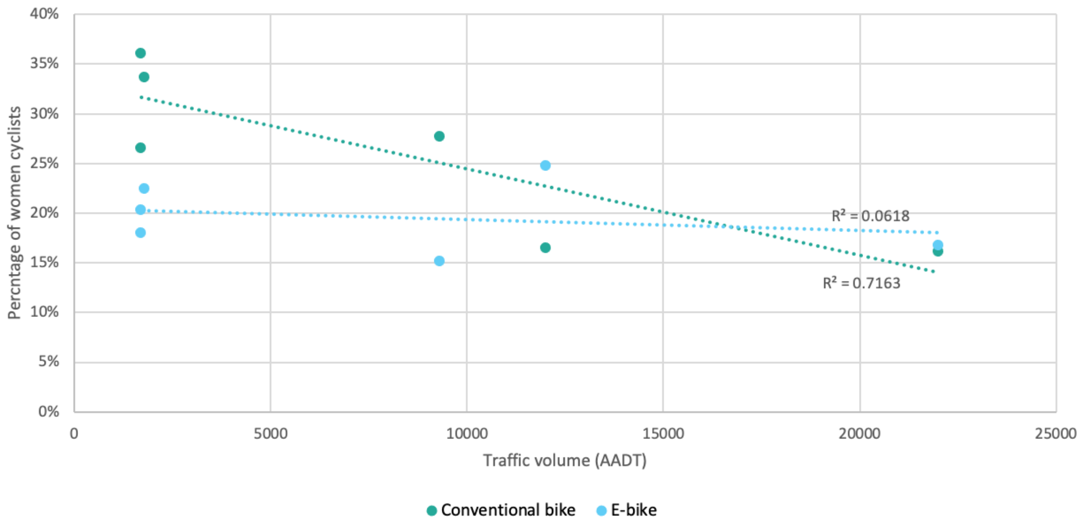


Figure 5.15 - Percentage of women cyclists on conventional bikes and e-bikes compared to traffic volume of observation points (only visually separated and fully separated typologies)

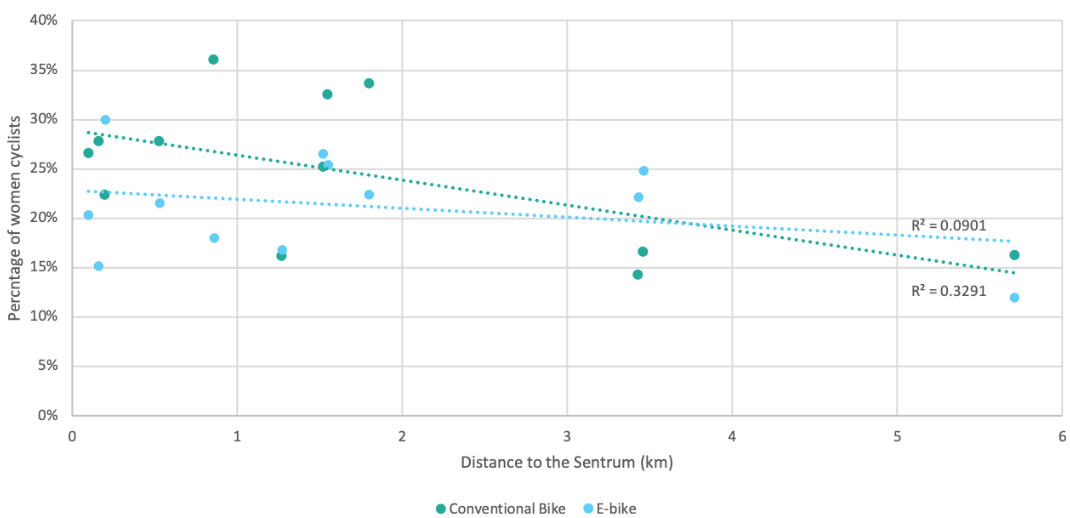


Figure 5.16 - Percentage of women cyclists on conventional bikes and e-bikes compared to distance to Sentrum of observation points.

When the proportion of women cyclists using e-bikes is separated from conventional bikes and compared to the observation points traffic volume, it is seen that the relationship with traffic volume only exists with women cyclists using conventional bikes. Therefore, it could be said that the relationship between women and traffic volume, where higher levels of traffic volume led to lower proportions of women is somewhat mitigated or lessened when women use e-bikes. This could be linked to the increased confidence levels, as well as decreased levels of exertion and greater speeds that e-bikes provide. Although another possibility is that e-bikes attract women who are less risk averse, given their added speed. Meaning that they would also be less likely influenced by the perceived risks of driving near high volumes of vehicle traffic. A similar trend is noted when comparing the use of conventional bike and e-bike use of women to the measure of centrality, where the relationship between e-bike use of women and centrality is less strong than with conventional bikes.

6 Conclusion

The main hypothesis of this thesis asked if the degree of separation (from motor vehicles) of cycling infrastructure, influenced the demographic composition of the cyclists that use it, such as the proportion of women and older adults. It also analyzed the possible influence of this degree of separation on the gear and bike use of the cyclists, that is the use of helmets, high visibility gear and sport clothing (lycra and tight-fitting clothes) as well as the use of e-bikes. The comparison was across three infrastructure typologies with varying degrees of separation, with non-separated being the lowest degree (consisting of no visual or physical delineation between the cyclist and the vehicle traffic), visually separated the next (use of painted lines and lane coloring to delineate between vehicle and cyclist traffic) and fully separated as the highest degree (some type of physical barrier or large distance between cyclist and vehicle traffic. No clear relationships were found between the degree of separation and the examined variables, at least in the directions assumed. While other correlations with infrastructure and environmental characteristics were found and discussed.

The degree of separation did not directly influence the proportion of women cyclists using it. This could possibly be attributed to the even greater influence of other infrastructure and environmental characteristics, aside from the degree of separation. For example, stronger relationships were found between the observation points traffic intensity and the proportion of women cyclists using it. Therefore, it may be better to think of the degree of separation in playing a role in reducing the impact of these other stronger variables such as traffic intensity. Although when traffic intensity is low enough, the degree of separation could then become irrelevant in influencing the proportion of women cyclists (such as which may be occurring with the non-separated infrastructure). Similar relationships with the traffic intensity were not found with the proportion of older adults. This could possibly be explained by the more sporadic geographic distribution of older adults within Stavanger. Where large variations in the proportion of older adults occurs depending on geographic area and could possibly influence the proportions of older adults at nearby observation points.

The degree of separation did not seem to influence the proportion of cyclists using safety gear and sport clothing in the direction expected. The most separated typology (fully separated) had the lowest proportion of casually dressed cyclists (ie. Not wearing helmets, sport clothing or high visibility gear). Which opposes the assumption that greater levels of separation lead to greater levels of a more casual everyday (traditional) cyclist. When other possible influencing infrastructure and environmental characters variables were explored, a relationship between measures of centrality and the use of safety gear were found. Where observation points that were further from the Sentrum area of Stavanger were more likely to have cyclists using helmets, high visibility. This is possibly attributable to a difference in the type of cyclists who travel further distances, versus short trips and is described in terms of a more traditional slower moving cyclist compared to speed happy group, citing earlier findings from Fyhri et al. (2012). Where the latter is more likely to use safety gear or sport clothing. Although in this case, given the limited number of observation points and their location along possible routes to the area of Forus (large business center with high employment density), it is difficult to determine if this is a generalizable relationship (between centrality and use of safety gear and sport clothing) or if it is specific to the demographic of cyclist which commutes to Forus. As the employment demographics within Forus are skewed towards men and the employment is spread across a limited number of business sectors (75% of employees within business services, mining and oil extraction, industry and construction). The visually separated typology was also found to have higher levels of sport clothing then the others. This likely relates to the higher volumes of traffic along these observation points. Where the higher levels of sport clothing could mean a higher proportion of the speed happy training cyclists, which were found to also have lower perceptions of risk (Fyhri et al., 2012).

The degree of separation did not seem to influence the proportion of e-bike users in the direction expected. The fully separated typology (highest degree of separation) which was anticipated to have the lowest proportion of e-bike users, actually had the greatest. This could signal that the fully separated infrastructure provided an obstruction free environment, separated enough from pedestrians and wide enough to pass slower conventional cyclists, or that the amount of traffic on the infrastructure is still low enough to not be a hindrance. Additionally, the fully separated infrastructure may be more accessible to e-bikes given they may be less direct and could provide some other advantages, such as there more often greener and natural surroundings. This was likely the case at observation point 11, located in an isolated forest area but on top of a large hill, which saw a much greater proportion of e-bike users. Some findings point towards e-bikes as a possible supportive intervention for women within contexts such has higher traffic environments or in less dense areas where longer travel is required. When the relationships between traffic volume and the distance to the Sentrum was plotted separately for proportion of women cyclists using conventional bikes and using e-bikes, the relationship only existed for conventional bicycle users. Meaning that while women that used conventional bicycles were less often seen at observation points with higher traffic volumes and that were less central, the same could not be said for women which used e-bikes.

7 Discussion

7.1 Opportunities for creating infrastructure and environments conducive to greater cycling uptake

A key finding in this thesis was that higher levels of traffic volume were related to lower proportions of women cyclists. Lower proportions of women cyclists were found consistently along the visually separated infrastructure (OP7 Lågardsveien, OP8 Hillevågsveien, OP9 Mareiroveien), with a particularly low proportion found at observation point 8. These findings corresponds to an article in Stavanger Aftenblad summarizing feedback from 1200 reader responses on bicycle infrastructure in Stavanger, where this section was labeled as second most troublesome spot for cyclists (Risa, 2021). The findings in this thesis support that further measures to increase the safety of cyclists along the visually separated are required, particularly along the section of roadway adjacent to OP8 on Hillevågsveien, adjacent to Strømsbrua. Such improvements could have implications towards increased representation of women as well as attracting more inexperienced cyclists to travel to destinations which are most conveniently accessed by this roadway. A study by Fyhri et al. (2021) observed the impacts of temporary protective barriers as well as public feedback on them from semi-structured interviews. The researchers were not able to conclude with a clear recommendation as to whether they thought the barriers had an overall positive impact. Stating that many believed, particularly more experienced cyclists, that due to the lane width and limited ability to pass cyclists, that the barriers were quite restrictive. Although, it is more likely that less experienced (potential cyclists) and more risk averse cyclists would benefit from this type of measure. Which the researchers acknowledge were a more limited part of their sample (Fyhri et al., 2019). This section of bicycle infrastructure in Stavanger could therefor present an opportunity to implement temporary or more permanent barrier measures and examine shifts in cycling levels across varying demographics both prior to and following the installation.

Some findings in this thesis could potentially also suggest that women who ride e-bikes may be less discouraged to cycle in environments with less supportive infrastructure or with higher volumes of vehicle traffic. This may also extend to less experienced or people categorized as potential cyclists. If this is the case, programs which can provide opportunities for people to experience using e-bikes could be said to help encourage these people to begin cycling. Where the opportunities could provide them with some understanding of the increased confidence and ease of use when riding e-bikes. This could include businesses having e-bikes available for employees to try for work trips, events through organizations giving people opportunities for groups rides on e-bikes or extending potentially to the subsidization on costs to e-bike purchases. As this study is set in a context with a relatively equal balance of women and men cyclists and intermediate levels of cycling, the possible equalizing and incentivizing impacts of e-bike use may not be as strong. Although, in contexts with much lower cycling modal shares and lower proportion of women cyclists, increased e-bike use could have greater implications towards equality in cycling across gender.

This thesis found a high level of sport clothing and safety gear using cyclists at observation points which were less central. This is speculated to represent an increased proportion of a speed happy and training oriented group of cyclist at these locations, a category which was defined and exhibited in the Norwegian population by Fyhri et al. (2012). Proportions are particularly high at the observation point on the newly constructed bicycle trunk road leading to Forus. Given the bicycle roads intent of incentivizing more people to shift from use of personal vehicles to bicycle transport, implying the conversion of non-cyclist to cyclist. As well as research showing that less experienced cyclists as well as women are more impacted by sporty and dangerous images of cycling. This higher level of sport and safety gear could possibly disseminate an image of cycling risk and athleticism and potentially mitigate the positive influence of the very supportive, safe and direct infrastructure. Meaning that less women and possibly more inexperienced cyclists may begin to use it. Although, this thesis has only observed a sample of cyclists at one period of time and therefore can only highlight that the proportion of women found here is lower than at other infrastructure in Stavanger as well as lower than the estimated proportion of women working in Forus. It could be that the partial opening of the bicycle trunk road has actually increased the representation of women and the more traditional or casual type of cyclist. Given the very speculative nature of the findings in this thesis, no clear recommendations are made to help in mitigating this potential impact. Although it could be of benefit to observe if there is a future change in the proportion of women as well as sport and safety gear using cyclists after the bicycle trunk road is fully completed, with full connection between the central areas of Stavanger and Forus.

8 Bibliography

Akar, G., Fischer, N., & Namgung, M. (2013). Bicycling Choice and Gender Case Study: The Ohio State University. *International journal of sustainable transportation, 7*(5), 347-365. https://doi.org/10.1080/15568318.2012.673694

Aldred, R., & Dales, J. (2017). Diversifying and normalising cycling in London, UK: An exploratory study on the influence of infrastructure. *Journal of transport & health, 4*, 348-362. https://doi.org/10.1016/j.jth.2016.11.002

Aldred, R., & Woodcock, J. (2015). Reframing safety: An analysis of perceptions of cycle safety clothing. *Transport policy, 42*, 103-112. https://doi.org/10.1016/j.tranpol.2015.05.001

Aldred, R., Woodcock, J., & Goodman, A. (2016). Does More Cycling Mean More Diversity in Cycling? *Transport reviews, 36*(1), 28-44. https://doi.org/10.1080/01441647.2015.1014451

Allemann, D., & Raubal, M. (2015). Usage Differences Between Bikes and E-Bikes. 201-217. https://doi.org/10.1007/978-3-319-16787-9_12 (Lecture Notes in Geoinformation and Cartography)

Berg, C. (2017). *Hva skjer i Stavanger?* https://www.sykkelbynettverket.no/_attachment/1792420/binary/1173106?download=true

Bjørnskau, T., Fyhri, A., & Wøhlik, M. (2016). *Evaluering av sykkelfelt i Oslo* (1512/2016). https://www.toi.no/publikasjoner/evaluering-av-sykkelfelt-i-oslo-article34115-8.html

Böcker, L., Anderson, E., Uteng, T. P., & Throndsen, T. (2020). Bike sharing use in conjunction to public transport: Exploring spatiotemporal, age and gender dimensions in Oslo, Norway. *Transportation research. Part A, Policy and practice, 138*, 389-401. https://doi.org/10.1016/j.tra.2020.06.009

Bourne, J. E., Cooper, A. R., Kelly, P., Kinnear, F. J., England, C., Leary, S., & Page, A. (2020). The impact of e-cycling on travel behaviour: A scoping review. *Journal of transport & health, 19*, 100910-100910. https://doi.org/10.1016/j.jth.2020.100910

Broach, J., Dill, J., & Gliebe, J. (2012). Where do cyclists ride? A route choice model developed with revealed preference GPS data. *Transportation research. Part A, Policy and practice, 46*(10), 1730-1740. https://doi.org/10.1016/j.tra.2012.07.005

Buehler, R., & Dill, J. (2016). Bikeway Networks: A Review of Effects on Cycling. *Transport reviews, 36*(1), 9-27. https://doi.org/10.1080/01441647.2015.1069908

Buehler, R., & Pucher, J. (2011). Cycling to work in 90 large American cities: new evidence on the role of bike paths and lanes. *Transportation (Dordrecht), 39*(2), 409-432. https://doi.org/10.1007/s11116-011-9355-8 (Transportation)

Buehler, R., & Pucher, J. (2012, May - June 2012). Walking and Cycling in Western Europe and the United States: Trends, Policies, and Lessons. *TR NEWS,* 34-42. https://onlinepubs.trb.org/onlinepubs/trnews/trnews280westerneurope.pdf

Bymiljøpakken. (2020). *Bymiljøpakken Handlingsprogram 2022-2025*. https://bymiljopakken.no/wp-content/uploads/2021/06/Vedlegg-5-HP-2022-2025-v12.pdf

Cerin, E., Nathan, A., Cauwenberg, J. V., & Barnett, A. (2019). Urban Environments for Healthy Ageing: A Global Perspective. In A. P. Lane (Ed.), *Routledge advances in sociology* (1 ed.). Abingdon, Oxon: Routledge. https://doi.org/10.4324/9780429243097

Chen, Z., van Lierop, D., & Ettema, D. (2020). Dockless bike-sharing systems: what are the implications? *Transport reviews, 40*(3), 333-353. https://doi.org/10.1080/01441647.2019.1710306

Clark, C., Mokhtarian, P., Circella, G., & Watkins, K. (2019). User Preferences for Bicycle Infrastructure in Communities with Emerging Cycling Cultures. *Transportation research record, 2673*(12), 89-102. https://doi.org/10.1177/0361198119854084

Daley, M., & Rissel, C. (2011). Perspectives and images of cycling as a barrier or facilitator of cycling. *Transport policy, 18*(1), 211-216. https://doi.org/10.1016/j.tranpol.2010.08.004 (Transport Policy)

Danielsen, B. Ø. (2019, July 11, 2019). Her blir det røde sykkelfelt. *Stavanger Aftenblad*. https://www.aftenbladet.no/lokalt/i/8mxnWr/her-blir-det-roede-sykkelfelt

Davidsen, R., Undheim, I., Berg, C., Dahl, T., Børresen, R., & Gøtterup, T. (2016). *Sykkelstrategi for Nord-Jæren 2017-2032*. https://www.sykkelbynettverket.no/_attachment/1873622/binary/1183637?download=true#:~:text=Sykkelstrategi%20for%20Nord%2DJ%C3%A6ren%202017%2D2032%20skal%20synliggj%C3%B8re%20regionens%20felles,av%20etatene%20p%C3%A5%20Nord%2DJ%C3%A6ren.

Debnath, A. K., Haworth, N., & Heesch, K. C. (2021). Women cycling in Queensland: Results from an observational study. *Accid Anal Prev, 151*, 105980-105980. https://doi.org/10.1016/j.aap.2021.105980

Dekra. (2020). *Verkehrssicherheitsreport 2020 - Mobilität auf zwei Rädern Schritte zur Realisierung der Vision Zero.* https://www.dekra.de/media/dekra-evs-report-2020-de.pdf

Dennis, J., Ramsay, T., Turgeon, A. F., & Zarychanski, R. (2013). Helmet legislation and admissions to hospital for cycling related head injuries in Canadian provinces and territories: interrupted time series analysis. *BMJ, 346*(may14 1), 45,46,47,27,592,131,496,177,1974,1299,1772,1212,1214,1238,1337,1316,1993,1219,1714,e1960,1976,1252,2064,e1192,1481,1262,1166,1122,1783,1145,1565,1245,1126,132

5,1128,1722,1327,1228,1509,1901,1725,1825,1605-f2674. https://doi.org/10.1136/bmj.f2674

Dickinson, J. E., Kingham, S., Copsey, S., & Hougie, D. J. P. (2003). Employer travel plans, cycling and gender: will travel plan measures improve the outlook for cycling to work in the UK? *Transportation research. Part D, Transport and environment, 8*(1), 53-67. https://doi.org/10.1016/S1361-9209(02)00018-4

Egan, S. K., & Perry, D. G. (2001). Gender Identity: A Multidimensional Analysis With Implications for Psychosocial Adjustment. *Developmental psychology, 37*(4), 451-463. https://doi.org/10.1037/0012-1649.37.4.451

Ellingsen, Ø. (2020, August 27, 2020). Åpner snart sykkelvei til 1,4 milliarder: – Bortkastede penger. *NRK*. https://www.nrk.no/rogaland/apner-snart-sykkelvei-til-1_4-milliarder_-_-bortkastede-penger-1.15137842

Emond, C. R., Tang, W., & Handy, S. L. (2009). Explaining gender difference in bicycling behavior. *Transportation research record, 2125*(2125), 16-25. https://doi.org/10.3141/2125-03

EU. (2020). *Aging Europe - Looking at the lives of older people in the EU*. https://ec.europa.eu/eurostat/documents/3217494/11478057/KS-02-20-655-EN-N.pdf/9b09606c-d4e8-4c33-63d2-3b20d5c19c91?t=1604055531000

Fyhri, A., Bjørnskau, T., & Backer-Grøndahl, A. (2012). Bicycle helmets – A case of risk compensation? *Transportation research. Part F, Traffic psychology and behaviour, 15*(5), 612-624. https://doi.org/10.1016/j.trf.2012.06.003

Fyhri, A., Heinen, E., Fearnley, N., & Sundfor, H. B. (2017). A push to cyclingexploring the e-bike's role in overcoming barriers to bicycle use with a survey and an intervention study. *International journal of sustainable transportation, 11*(9), 681-695. https://doi.org/10.1080/15568318.2017.1302526

Fyhri, A., Jong, T. D., Weber, C., & Johnsson, E. (2019). *Analyser av sykkeltiltak i Oslo, Bergen, Trondheim og Stavanger med app-data* (1697/2019). https://www.toi.no/publikasjoner/analyser-av-sykkeltiltak-i-oslo-bergen-trondheim-og-stavanger-med-app-data-article35646-8.html

Fyhri, A., Karlsen, K., & Pokorny, P. (2021). *Beskyttede sykkelfelt og midlertidig sykkelinfrastruktur* (1837/2021). https://www.toi.no/publikasjoner/beskyttede-sykkelfelt-og-midlertidig-sykkelinfrastruktur-article36890-8.html

Fylkeskommune, R. (2020, February 6, 2020). *Nye bysykler*. Rogaland Fylkeskommune.

Google. (n.d.). *Google street view image*. https://www.google.com/maps/@58.9581671,5.7017997,3a,75y,62.05h,88.18t/data=!3m6!1e1!3m4!1s5AGtdHN73-BV5TOZKqUkKg!2e0!7i16384!8i8192

Grønnestad, K. S. (2020, September 5, 2020). Nå er «motorveien» for syklistene klar. Her skal det være trygt å sykle i høy fart. *Teknisk Ukeblad*. https://www.tu.no/artikler/na-er-motorveien-for-syklistene-klar-her-skal-det-vaere-trygt-a-sykle-i-hoy-fart/498810

Grudgings, N., Hughes, S., & Hagen-Zanker, A. (2021). The comparison and interaction of age and gender effects on cycling mode-share: An analysis of commuting in England and Wales. *Journal of transport & health, 20*, 101004. https://doi.org/10.1016/j.jth.2020.101004

Grue, B., Landa-Mata, I., & Flotve, B. L. (2021). *Den nasjonale reisevaneundersøkelsen 2018/19 - Nøkkelrapport* (1835/2021). T. institutt. https://www.toi.no/getfile.php?mmfileid=71405

Handy, S., van Wee, B., & Kroesen, M. (2014). Promoting Cycling for Transport: Research Needs and Challenges. *Transport reviews, 34*(1), 4-24. https://doi.org/10.1080/01441647.2013.860204

Hanson, S. (2010). Gender and mobility: new approaches for informing sustainability. *Gender, place and culture : a journal of feminist geography, 17*(1), 5-23. https://doi.org/10.1080/09663690903498225

Heesch, K. C., Sahlqvist, S., & Garrard, J. (2012). Gender differences in recreational and transport cycling: a cross-sectional mixed-methods comparison of cycling patterns, motivators, and constraints. *Int J Behav Nutr Phys Act, 9*(1), 106-106. https://doi.org/10.1186/1479-5868-9-106

Heinen, E., & Handy, S. (2012). Similarities in Attitudes and Norms and the Effect on Bicycle Commuting: Evidence from the Bicycle Cities Davis and Delft. *International journal of sustainable transportation, 6*(5), 257-281. https://doi.org/10.1080/15568318.2011.593695

Hjorthol, R., Engebretsen, Ø., & Uteng, T. P. (2014). *Den nasjonale reisevaneundersøkelsen 2013/14 - nøkkelrapport* (1383/2014). T. institutt. https://www.toi.no/getfile.php/1339511-1441362561/Publikasjoner/T%C3%98I%20rapporter/2014/1383-2014/1383-2014-elektronisk.pdf

Hoye, A. (2018). Recommend or mandate? A systematic review and meta-analysis of the effects of mandatory bicycle helmet legislation. *Accid Anal Prev, 120*, 239-249. https://doi.org/10.1016/j.aap.2018.08.001

Ikpeze, T. C., Glaun, G., McCalla, D., & Elfar, J. C. (2018). Geriatric Cyclists: Assessing Risks, Safety, and Benefits. *Geriatr Orthop Surg Rehabil, 9*, 2151458517748742-2151458517748742. https://doi.org/10.1177/2151458517748742

Jacobsen, P. L. (2003). Safety in numbers: more walkers and bicyclists, safer walking and bicycling. *Inj Prev, 9*(3), 205-209. https://doi.org/10.1136/ip.9.3.205

Janke, J., & Handy, S. (2019). How life course events trigger changes in bicycling attitudes and behavior: Insights into causality. *Travel, behaviour & society, 16*, 31-41. https://doi.org/10.1016/j.tbs.2019.03.004

Johnson, M., & Rose, G. (2015). Extending life on the bike: Electric bike use by older Australians. *Journal of transport & health, 2*(2), 276-283. https://doi.org/10.1016/j.jth.2015.03.001

Kautto, M., Fritzell, J., Hvinden, B., Kvist, J., & Uusitalo, H. (Eds.). (2001). *Nordic Welfare States in the European Context*. Routledge.

Kett, P., Rivara, F., Gomez, A., Kirk, A. P., & Yantsides, C. (2016). The Effect of an All-Ages Bicycle Helmet Law on Bicycle-Related Trauma. *J Community Health, 41*(6), 1160-1166. https://doi.org/10.1007/s10900-016-0197-3

Krizek, K. J., Johnson, P. J., & Tilahun, N. (2004, November 18-20). Gender differences in bicycling behavior and facility preferences. Research on Women's Issues in Transportation, Chicago, Illinois.

Laugaland, J. M., & Buene, J. R. (2016, June 3, 2016). Stavanger får landets første sykkelprioriterte gate. *NRK*. https://www.nrk.no/rogaland/stavanger-far-landets-forste-sykkelprioriterte-gate-1.12978133

Law, R. (1999). Beyond 'women and transport': towards new geographies of gender and daily mobility. *Progress in human geography, 23*(4), 567-588. https://doi.org/10.1191/030913299666161864

Leck, E. (2011). The Impact of Urban Form on Travel Behavior: A Meta-Analysis. *Berkeley planning journal, 19*(1). https://doi.org/10.5070/BP319111488

Leger, S. J., Dean, J. L., Edge, S., & Casello, J. M. (2019). "If I had a regular bicycle, I wouldn't be out riding anymore": Perspectives on the potential of e-bikes to support active living and independent mobility among older adults in Waterloo, Canada. *Transportation research. Part A, Policy and practice, 123*, 240-254. https://doi.org/10.1016/j.tra.2018.10.009

Lunke, E. B., Aarhaug, J., Jong, T. d., & Fyhri, A. (2018). *Cycling in Oslo, Bergen, Stavanger and Trondheim - A study of cycling and travel behaviour*. https://www.toi.no/getfile.php?mmfileid=49048

Lunke, E. B., & Grue, B. (2018). *Sykling og sykkelmål: Analyser av sykkelandeler og ulike målsetninger for Nasjonal Transportplan* (TØI-rapport 1676/2018). https://www.toi.no/getfile.php?mmfileid=49561

MacArthur, J., Cherry, C. R., Harpool, M., & Scheppke, D. (2018). *A North American survey of electric bicycle owners*.

MacArthur, J., Dill, J., & Person, M. (2014). Electric Bikes in North America: Results of an Online Survey. *Transportation research record, 2468*(2468), 123-130. https://doi.org/10.3141/2468-14

Miller, P. D., Kendrick, D., Coupland, C., & Coffey, F. (2017). Use of conspicuity aids by cyclists and risk of crashes involving other road users: Population based case-control study. *Journal of transport & health, 7*, 64-74. https://doi.org/10.1016/j.jth.2017.03.008

Monro, S. (2005). Beyond Male and Female: Poststructuralism and the Spectrum of Gender. *The international journal of transgenderism, 8*(1), 3-22. https://doi.org/10.1300/J485v08n01_02

Nævestad, T.-O., Elvebakk, B., & Bjørnskau, T. (2014). Traffic safety culture among bicyclists – Results from a Norwegian study. *Safety science, 70*, 29-40. https://doi.org/10.1016/j.ssci.2014.04.020

Nightingale, A. (2006). The Nature of Gender: Work, Gender, and Environment. *Environment and planning. D, Society & space, 24*(2), 165-185. https://doi.org/10.1068/d01k

Olivier, J., & Creighton, P. (2017). Bicycle injuries and helmet use: a systematic review and meta-analysis (vol 46, pg 278, 2016). *Int J Epidemiol, 46*(1), 372-372. https://doi.org/10.1093/ije/dyw360

Oosterhuis, H. (2016). Cycling, modernity and national culture. *Social History, 41*(3), 233-248. https://doi.org/http://dx.doi.org/10.1080/03071022.2016.1180897

Parkin, J., Ison, S., & Shaw, J. (2012). *Cycling and Sustainability* (Vol. 1). Bingley: Emerald Publishing Limited.

Pedroso, D. (2021). *Still I Ride - How Women of Colour are challenging discourses in and through cycling* [Master Thesis, Malmö University]. Digitala Vetenskapliga Arkivet. https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1597811&dswid=3954

Plazier, P. A., Weitkamp, G., & van den Berg, A. E. (2017). “Cycling was never so easy!” An analysis of e-bike commuters' motives, travel behaviour and experiences using GPS-tracking and interviews. *Journal of Transport Geography, 65*, 25-34. https://doi.org/10.1016/j.jtrangeo.2017.09.017

Prati, G. (2018). Gender equality and women's participation in transport cycling. *Journal of Transport Geography, 66*, 369-375. https://doi.org/10.1016/j.jtrangeo.2017.11.003

Pritchard, R. (2018). Revealed Preference Methods for Studying Bicycle Route Choice-A Systematic Review. *Int J Environ Res Public Health, 15*(3), 470. https://doi.org/10.3390/ijerph15030470

Pucher, J., & Buehler, R. (2008). Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany. *Transport reviews, 28*(4), 495-528. https://doi.org/10.1080/01441640701806612

Pucher, J., & Buehler, R. (2017). Cycling towards a more sustainable transport future. *Transport reviews, 37*(6), 689-694. https://doi.org/10.1080/01441647.2017.1340234

Pucher, J., Dill, J., & Handy, S. (2009). Infrastructure, programs, and policies to increase bicycling: An international review. *Prev Med, 50*, S106-S125. https://doi.org/10.1016/j.ypmed.2009.07.028

Rabben, M. B., High, E. S., LEiro, R., & Eriksen, L. H. (2021, June 17, 2021). *Sykkel*. Store norske leksikon.

Ravensbergen, L., Buliung, R., & Laliberté, N. (2019). Toward feminist geographies of cycling. *Geography compass, 13*(7), n/a. https://doi.org/10.1111/gec3.12461

Risa, E. (2021). Her er Stavangers sju verste sykkelveier. *Stavanger Aftenblad*. https://www.aftenbladet.no/lokalt/i/0KE5KE/her-er-stavangers-sju-verste-sykkelveier

Rissel, C., Ashley, B., Campbell, F., & Jackson, L. (2002). Driver Road Rule Knowledge and Attitudes towards Cyclists. *Australian journal of primary health, 8*(2), 66-69. https://doi.org/10.1071/PY02029 © La Trobe University 2002
10.1071/PY02029

Robinson, D. L. (1996). Head injuries and bicycle helmet laws. *Accid Anal Prev, 28*(4), 463-475. https://doi.org/10.1016/0001-4575(96)00016-4

Rosales, R. (2019). *Governance in the Urban Growth Agreement for Nord- Jæren: how increased Multi-Level Governance could help achieve the zero-growth goal in the region* [Master’s Thesis, Universitetet i Stavanger].

Samferdselsdepartementet. (2016). *Finansiering av Bypakke Nord-Jæren i Randaberg, Sandnes, Sola og Stavanger kommunar i Rogaland* (Prop. 47 S. (2016-2017)). https://www.regjeringen.no/no/dokumenter/prop.-47-s-20162017/id2524304/?ch=2

Samferdselsdepartment. (2017). *Nasjonal transportplan 2018–2029* (Meld. St. 33. (2016 – 2017)). https://www.regjeringen.no/contentassets/7c52fd2938ca42209e4286fe86bb28bd/no/pdfs/stm201620170033000dddpdfs.pdf

Spirduso, W. W., MacRae, P. G., & Francis, K. L. (2005). *Physical dimensions of aging* (2nd ed. ed.). Human Kinetics.

Statensvegvesen. *Røde løpere for syklister*. Retrieved October 7, 2021 from https://www.vegvesen.no/fag/fokusomrader/miljovennlig-transport/sykkeltrafikk/enkle-tiltak/rodt-dekke/

Statensvegvesen. (2017). *National Plan of Action for Road Safety 2018–2021*. Statensvegvesen. https://www.vegvesen.no/globalassets/fag/fokusomrader/trafikksikkerhet/nasjonal-tiltaksplan-for-trafikksikkerhet-pa-veg-2018-2021.pdf

Statensvegvesen. (n.d.). *Vegkart*. https://vegkart.atlas.vegvesen.no/#kartlag:geodata/@600000,7225000,3

Statistics-Norway. (2020). *07984: Sysselsatte per 4. kvartal, etter næring (SN2007), kjønn, statistikkvariabel, region og år*. https://www.ssb.no/statbank/table/07984/

Statistics-Norway. (2021a). *04362: Population, by sex and age (BU) 2001 - 2021*. https://www.ssb.no/en/statbank/table/04362/

Statistics-Norway. (2021b). *10826: Population, by sex and age (UD) 2001 - 2021*. https://www.ssb.no/en/statbank/table/10826/

Stavanger-Kommune. (2010). *Sykkelstrategi for Stavanger med handlingsplan 2011 – 2015*. https://docplayer.me/5498464-Sykkelstrategi-for-stavanger-med-handlingsplan-2011-2015-vedtatt-12-03-2012-stavanger-kommune-kultur-og-byutvikling-transportplanavdelingen.html

Stavanger-Kommune. (2018). *Climate and Environmental Plan 2018-2030*. https://www.stavanger.kommune.no/siteassets/renovasjon-klima-og-miljo/miljo-og-klima/climate-and-environmental-plan-stavanger-2018-2030---final-version.pdf

Stavanger-Kommune. (2019). *Den store sykkelundersøkelsen* https://www.stavanger.kommune.no/siteassets/vei-og-trafikk/stavanger-pa-sykkel/sykkelundersokelser/rapport-stavanger-kommune-sykkelundersokelse-2019.pdf

Stavanger-Kommune. (2021a, June 18, 2021). *Gatenorm for Stavanger*. Stavanger Kommune. https://www.stavanger.kommune.no/vei-og-trafikk/veinorm-for-stavanger/#15419

Stavanger-Kommune. (2021b, November 1, 2021). *Tjodolvs gate blir sykkelprioritert*. Stavange Kommune. https://www.stavanger.kommune.no/vei-og-trafikk/her-graver-kommunen/tjodolvs-gate-blir-sykkelprioritert/

Stavanger-Kommune. (n.d.). *Kommunedeler i Stavanger*. Retrieved August 30, 2021 from https://www.stavanger.kommune.no/om-stavanger-kommune/bydeler-i-stavanger/

Stavanger-Statistikken. (2019, June 11, 2021). *Bedrifter og ansatte i Stavanger - Brønnøysundregisteret*. https://public.tableau.com/app/profile/stavanger.statistikken/viz/Brnnyssund_bedrifter/Dashboard1

Stavanger-Statistikken. (2020, January 1, 2020). *Befolkning pr. grunnkrets i Stavanger*. https://public.tableau.com/app/profile/stavanger.statistikken/viz/Brnnyssund_bedrifter/Dashboard1

Stokka, M. (2020, September 2, 2020). Slår tilbake mot kostnadskritikk: – Dyrt å bygga motorveg for syklistar. *NRK*. https://www.nrk.no/rogaland/slar-tilbake-mot-sykkelveg-kritikk-1.15143101

Teschke, K., Koehoorn, M., Shen, H., & Dennis, J. (2015). Bicycling injury hospitalisation rates in Canadian jurisdictions: analyses examining associations with helmet legislation and mode share. *BMJ Open, 5*(11), e008052-e008052. https://doi.org/10.1136/bmjopen-2015-008052

Vågane, L., Brechan, I., & Hjorthol, R. (2011). *Den nasjonale reisevaneundersøkelsen 2009 - nøkkelrapport* (1130/2011). T. institutt. https://www.toi.no/getfile.php?mmfileid=16282

Van Cauwenberg, J., Clarys, P., De Bourdeaudhuij, I., Ghekiere, A., de Geus, B., Owen, N., & Deforche, B. (2018). Environmental influences on older adults' transportation cycling experiences: A study using bike-along interviews. *Landscape and urban planning, 169*, 37-46. https://doi.org/10.1016/j.landurbplan.2017.08.003

Van Cauwenberg, J., De Bourdeaudhuij, I., Clarys, P., De Geus, B., & Deforche, B. (2019). Older adults' environmental preferences for transportation cycling. *Journal of transport & health, 13*, 185-199. https://doi.org/10.1016/j.jth.2019.03.014

Waengnerud, L., Solevid, M., & Djerf-Pierre, M. (2019). Moving beyond Categorical Gender in Studies of Risk Aversion and Anxiety. *Politics & gender, 15*(4), 826-850. https://doi.org/10.1017/S1743923X18000648

Walker, B. (2005). Heads Up. *Cycle*.

Walker, I., Garrard, I., & Jowitt, F. (2014). The influence of a bicycle commuter's appearance on drivers' overtaking proximities: An on-road test of bicyclist stereotypes, high-visibility clothing and safety aids in the United Kingdom. *Accid Anal Prev, 64*, 69-77. https://doi.org/10.1016/j.aap.2013.11.007

Walter, S. R., Olivier, J., Churches, T., & Grzebieta, R. (2011). The impact of compulsory cycle helmet legislation on cyclist head injuries in New South Wales, Australia. *Accid Anal Prev, 43*(6), 2064-2071. https://doi.org/10.1016/j.aap.2011.05.029

Wild, K., Woodward, A., & Shaw, C. (2021). Gender and the E-bike: Exploring the Role of Electric Bikes in Increasing Women's Access to Cycling and Physical Activity. *Active Travel Studies, 1*(1). https://doi.org/10.16997/ats.991

Willard, F. E. *A Wheel Within a Wheel How I Learned to Ride the Bicycle, With Some Reflections by the Way*. Project Gutenberg.

Willard, F. E. (1895). *A Wheel Within a Wheel How I Learned to Ride the Bicycle, With Some Reflections by the Way*. Project Gutenberg.

Winters, M., Zanotto, M., & Butler, G. (2020). The Canadian Bikeway Comfort and Safety (Can-BICS) Classification System: A common naming convention for cycling infrastructure. *Health promotion and chronic disease prevention in Canada, 40*(9), 288-293. https://doi.org/10.24095/hpcdp.40.9.04

Wuerzer, T., & Mason, S. G. (2015). Cycling willingness: Investigating distance as a dependent variable in cycling behavior among college students. *Applied geography (Sevenoaks), 60*, 95-106. https://doi.org/10.1016/j.apgeog.2015.03.009

9 Figure List

10 Table List

11 Appendix

11.1 Detailed descriptions of observation points

OBSERVATION POINT 1 | NON-SEPARATED TYPOLOGY | EAST-WEST AXIS

Infrastructure and surroundings at observation point 1, left & center self-produced, far right from google street view (Google, n.d.).

Observation point 1 is located along the road Eiganesveien, which has mixed vehicle and cyclist traffic, it is categorized as non-separated typology. The width is approximately 5 m and there is a sidewalk with raised curb for pedestrian traffic which is 1.5 m in width along the north side of the road (total right of way width 6.5 m). The road has vehicle calming in the form of speed bumps, has a generally flat gradient and is not accessed by public transport. The usage of the surrounding area is largely characterized by detached single family housing, although some multi-family residential housing exists as well. The roadway lacks any greenery itself and is completely paved, although many trees and shrubs exist within the yards and open spaces of its residential surroundings, of diverse types and sizes. The atmosphere could be described as relatively calm and sheltered, given its seclusion from higher levels of vehicle traffic and the narrower street with some adjacent greenery.

- Mixed traffic
- Traffic calming
- Narrow width roadway (6.5 m)
- Moderate greenery
- Residential

OBSERVATION POINT 2 | NON-SEPARATED TYPOLOGY | EAST-WEST AXIS

Infrastructure and surroundings at observation point 2, left & center self-produced, far right from google (Google, n.d.).

Observation point 2 is located approximately 1 km from point 1 and is along the same mixed cyclist and vehicle traffic road (Eiganesveien) within the non-separated typology. At this point the roadway has widened to approximately 7.5 m and has a pedestrian sidewalk on both sides approximately 2 m wide each (total right of way width 11.5 m). The traffic calming in the form of speed bumps continues and the gradient is again flat. The increased width allows for the presence of public transit busses and there are bus stops on either side of the road adjacent to the observation point. The location is approximately 70 m east of an intersection with a street that has a similar level of vehicle traffic volume. The land use of the area is residential with only detached housing in the immediate area. The larger lot sizes in the adjacent area, combined with the greater road width gives the location a more spacious and less dense feeling. The immediate area around the observation point is low in greenery with a few widely spaced trees within the residential lots and hedges delineating property boundaries. Although further ahead, mature trees line the sidewalk creating a green canopy which envelopes and shades the roadway.

• Mixed traffic • Traffic calming • Intermediate width roadway (11.5 m)	• Public transit • Spacious detached residential housing • Sporadic greenery

OBSERVATION POINT 3 | NON-SEPARATED TYPOLOGY | EAST-WEST AXIS

Infrastructure and surroundings at observation point 3.

Observation point 3 is approximately 800 m from observation point 2 and is the last point along the mixed vehicle and cyclist traffic road (Eiganesveien) within the non-separated typology. The roadway is fairly wide at 7.5 m and again has 2 m pedestrian sidewalks on either side (total right of way width 11.5 m). The traffic calming has stopped at this point and the gradient is quite steep with cyclists going uphill when traveling westward. Bus stops for public transit are located in the near proximity of the observation point and on either side of the road. The location is at the edge of the urban core or centrum area of Stavanger, so therefore the land use is more mixed, with mainly residential detached and multifamily housing but also some commercial, retail and public buildings in the immediate surroundings. Its more central location is reflected in a busier environment with more bus and pedestrian activity and less green surroundings.

• Non-Separated/Mixed traffic • Intermediate width roadway (11.5 m) • Public transit	• Central • Denser mixed-use development • limited greenery

OBSERVATION POINT 4 | FULLY SEPERATED | EAST-WEST AXIS

Infrastructure and surroundings at observation point 4.

Observation point 4 is located on a bicycle pathway that crosses through a park which is adjacent to the lake Mosvatnet in Stavanger. It is categorized under the fully separated infrastructure typology the pathway has a lane for each direction of traffic and each lane is approximately 1.25 m wide (total width 2.5 m). The surroundings are quite green with many mature trees. Further to the north a more highly trafficked roadway exists but the bicycle path is separated from this with physical barriers as well as some greenery, running parallel and to the south, is a gravel pathway which is used often by pedestrians and follows the outline of the lake. Given the paths location within a park adjacent to a lake, there is not much surrounding development and the area is characterized mostly by natural features.

• Fully separated pathway • Directional lanes for cyclists (2.5 m width total)	• Rich with green features • Park surroundings

OBSERVATION POINT 5 | FULLY SEPERATED | EAST-WEST AXIS

Infrastructure and surroundings at observation point 5.

Observation point 5 is located on a bicycle pathway that leads to a cycling and pedestrian underpass which crosses below a highly trafficked road way. It is again categorized under the fully separated infrastructure typology. In this case the pathway is shared with pedestrian traffic (multipurpose). Althoug,h pedestrians have their own curb separated lane (approximately 2 m wide). The bike lanes are approximately 1.5 m each and have separation between the two directions of travel, while there is a moderate gradient due to the underpass (total cyclists infrastructure width of 3 m). The surrounding area is a mix of detached housing as well as some green areas and parks, although the area immediately surrounding the observation point is characterized more with pavement and some smaller planting beds.

• Fully separated pathway • Directional lanes for cyclists (3 m width total) • Pedestrian traffic separated with curb	• Residential area • Low in green surroundings

OBSERVATION POINT 6 | FULLY SEPERATED | EAST-WEST AXIS

Infrastructure and surroundings at observation point 6.

Observation point 6 is located on another bicycle pathway leading to a cycling and a pedestrian underpass. The road it crosses under is heavily trafficked by vehicles and leads to the Sentrum in Stavanger. The infrastructure is categorized under the fully separated typology. There is no separation between pedestrians and cyclists and they are expected to share the same space, although there is separation (Lane lines) between the directions of travel and they are approximately 1.5 m each (total cyclist infrastructure width of 3 m). There is a fairly steep gradient at the observation point. Given the proximity to the Sentrum area, the surroundings could be characterized as more urban with some mixed uses, such as residential, commercial and public buildings. The amount of greenery is low due to the more urban these more urban surroundings. Additionally, while the observation point is fully separated, cycling infrastructure adjacent to it are mostly mixed traffic/non-separated.

- Fully separated pathway
- Multipurpose with directional lanes (3 m)
- Pedestrian traffic mixed with bicycle traffic

- Mixed use area with commercial, public and residential buildings (2 to 3 stories)
- Low in green surroundings

OBSERVATION POINT 7 | VISUALLY SEPERATED | NORTH SOUTH AXIS

Infrastructure and surroundings at observation point 7, self-produced.

Observation point 7 is the first point which is on the visually separated infrastructure typology and is closest to the Sentrum of Stavanger. It consists of an approximately (1.7 m) wide bicycle lane, which has been painted red and follows along the road Lagårdsveien. The entire roadway including pedestrian sidewalks is quite wide (total right of way width of approximately 21 m) containing two lanes for vehicle traffic in either direction with a small barrier between the directions of travel. While the vehicle traffic volumes are the lowest of the visually separated typology observation points (9,300 AADT). The outermost vehicle lanes, which are adjacent to the bicycle lanes, are reserved for use by busses and taxis. The area is mixed used but the surroundings are mostly characterized by many large commercial and public buildings (3 to 5 stories). There are trees which have been spaced along the sidewalks on either side of the roadway, although given their size they do not provide a high degree of greenery.

- Visually separated lane (red paint and lane lines, 1.7 m)
- Wide roadway (21 m)
- Higher traffic volumes

- Heavy vehicles/busses
- Commercial and public buildings (3 to 5 stories)

OBSERVATION POINT 8 | VISUALLY SEPERATED | NORTH-SOUTH AXIS

Infrastructure and surroundings at observation point 8, center and right images from google street view (Google, n.d.).

Observation point 8 is located along the same road as point 7 but the road is called Hillevågsveien at this location. The same red painted bicycle lane continues at this point although its width is now only (1.3 m). The roadway continues with a similar width although slightly narrower (approximately 20 m), including the sidewalks on either side. There is again, four vehicle lanes with two in each direction and the outermost lanes reserved for bus and taxi use. The largest change between observation point 8 and 7, is the larger volumes of traffic, likely due to the nearby and highly trafficked roadways which connect to Hillevågsveien (22,000 AADT). Additionally, the area has a more residential function and the commercial properties are not as large (2- 3 stories), the buildings are also setback further from the roadway. The location lacks greenery, with no trees planted along the sidewalks.

• Visually separated (red paint and lane lines) • Wide roadway (20 m) • High traffic volumes (22,000 AADT) • Heavy vehicles/busses	• Residential and commercial buildings (2 to 3 stories) • Moderate setbacks between buildings and roadway • Low in green surroundings

OBSERVATION POINT 9 | VISUALLY SEPERATED | NORTH-SOUTH AXIS

Infrastructure and surroundings at observation point 9, center and right images from google street view (Google, n.d.).

Observation point 9 continues to be along the same road way (now named Mareiroveien) but is the furthest from the Sentrum of Stavanger. The same red painted bike lane continues which is approximately 1.5 m wide. The format of the roadway has shifted and the total width of the right of way is larger (approximately 25 m). At this point there is a dedicated two-lane busway in the center of the road. The busway is separated on each side with a green boulevard including newly planted trees. At the outermost edges there is a single lane in each direction for vehicle traffic. In general, the vehicle traffic volumes are lower with more separation from cyclists from the bus traffic (12,000 AADT). The area is mostly dominated by large but sprawling commercial buildings (1-3 stories) with large allotments of surface parking and big setbacks from the roadway. The area feels very wide open with a small amount of greenery (due to the numerous but small and young trees).

- Visually separated (red paint and lane lines, 1.5 m)
- Wide roadway (25 m)
- Higher traffic volumes (12,000 AADT)

- Large commercial buildings (1 to 3 stories)
- large setbacks from roadway (sprawling/surface parking)
- Low green surroundings (young/small trees)

OBSERVATION POINT 10 | FULLY SEPERATED | NORTH-SOUTH AXIS

Infrastructure and surroundings at observation point 10.

Observation point 10 is located on a bicycle pathway crossing around the edge of a park which is again adjacent to the lake Mosvanet, although this time is located on the south side. The point is categorized under the fully separated infrastructure category and the pathway has a lane for each direction of bike travel which are approximately 1.5 m wide each (total width of infrastructure 3 m) as well as a separate gravel pathway for pedestrians. There is a small gradient along the pathway but it goes through an area rich with mature trees and greenery. The area surrounding is characterized by natural park features, lacking any buildings in the immediate area. Although, nearby are some recreational facilities such as a camping ground and swimming hall.

- Fully separated
- Bike path with directional lanes (3 m)

- Rich with green features
- Park surroundings

OBSERVATION POINT 11 | FULLY SEPERATED | NORTH-SOUTH AXIS

Infrastructure and surroundings at observation point 11.

Observation point 11 is located on a multipurpose path which goes through the middle of Sørmarka forest. The infrastructure is categorized as fully separated, is approximately (4 m) wide and is shared with pedestrians. There is no separation between pedestrians or directions of travel for cyclists. While the path is generally flat at the observation point, it requires a large elevation gain to reach no matter which direction you travel from. This is due to its hilltop location within an isolated forest area with many mature trees. It could be described as quiet and still as there is much separation between any nearby highly trafficked roadways, due to its central location within the large forested area. Additionally, there are no buildings in the immediate area surrounding the observation point.

• Fully separated pathway • Multipurpose path (4 m)	• Rich with green features • Park surroundings

OBSERVATION POINT 12 | FULLY SEPERATED | NORTH-SOUTH AXIS

Infrastructure and surroundings at observation point 12.

Observation point 12 is located on the bicycle trunk highway and is near the business center of Forus. The infrastructure is categorized under the fully separated typology. The bicycle trunk highway is dedicated to cyclists and has a lane for each direction of travel (each approximately). The gradient is very flat and the road follows parallel to the very highly trafficked E39 motorway, meaning it is very direct and straight. There is some physical separation between the motor way and the bike path as well as berms and fencing with vine planting as a means to dampen the visual and sound impacts of the heavy traffic. Although the area does not have any mature trees it has some planted greenery and adjacent farm land.

• Fully separated • Dedicated bike path with directional lanes	• Flat and direct route • Parallel to but separated from E39

11.2 Table of infrastructure and environmental characteristics for each observation point

Route & Observation Point	Kommunedel	Area (km2)	Population Size	Distance To Sentrum (km)	Population Density (Population/km2)	Classification of seperation from vehicles	Traffic Speed Limit	Traffic Volume
Madla/Stokka - Sentrum (East/West Axis)						NS- No Seperation VS - Visual Seperation FS - Full seperation	Km/Hr N/A	AADT - Average Annual Daily Traffic
1	Eiganes - Våland	7.01	24639	1.8	3515	NS	30	1800
2	Eiganes - Våland	7.01	24639	0.86	3515	NS	30	1700
3	Eiganes - Våland	7.01	24639	0.1	3515	NS	40	1700
4	Eiganes - Våland	7.01	24639	1.52	3515	FS	N/A	N/A
5	Eiganes - Våland	7.01	24639	0.53	3515	FS	N/A	N/A
6	Eiganes - Våland	7.01	24639	0.2	3515	FS	N/A	N/A
Sentrum - Forus (North/South Axis)								
7	Eiganes - Våland	7.01	24639	0.16	3515	VS	50	9,300
8	Hillevåg	8.08	19921	1.27	2465	VS	50	22,000
9	Hinna	15	22992	3.46	1533	VS	40	12,000
10	Hillevåg	8.08	19921	1.55	2465	FS	N/A	N/A
11	Hillevåg	8.08	19921	3.43	2465	FS	N/A	N/A
12	Hinna	15	22992	5.71	1533	FS	N/A	N/A

Table of infrastructure and environmental characteristics has been created using a variety of sources. Data about the kommunedel, including location and area was retrieved from Stavanger Kommune (Stavanger-Kommune, n.d.). Data on the population sizes of the kommunedeler was retrieved from statistics Norway (Statistics-Norway, 2021a). Information on traffic volume was retrieved from statensvegvesen vegkart (Statensvegvesen, n.d.). The remaining categories were calculated from that information or found from google map measurements (Google, n.d.).

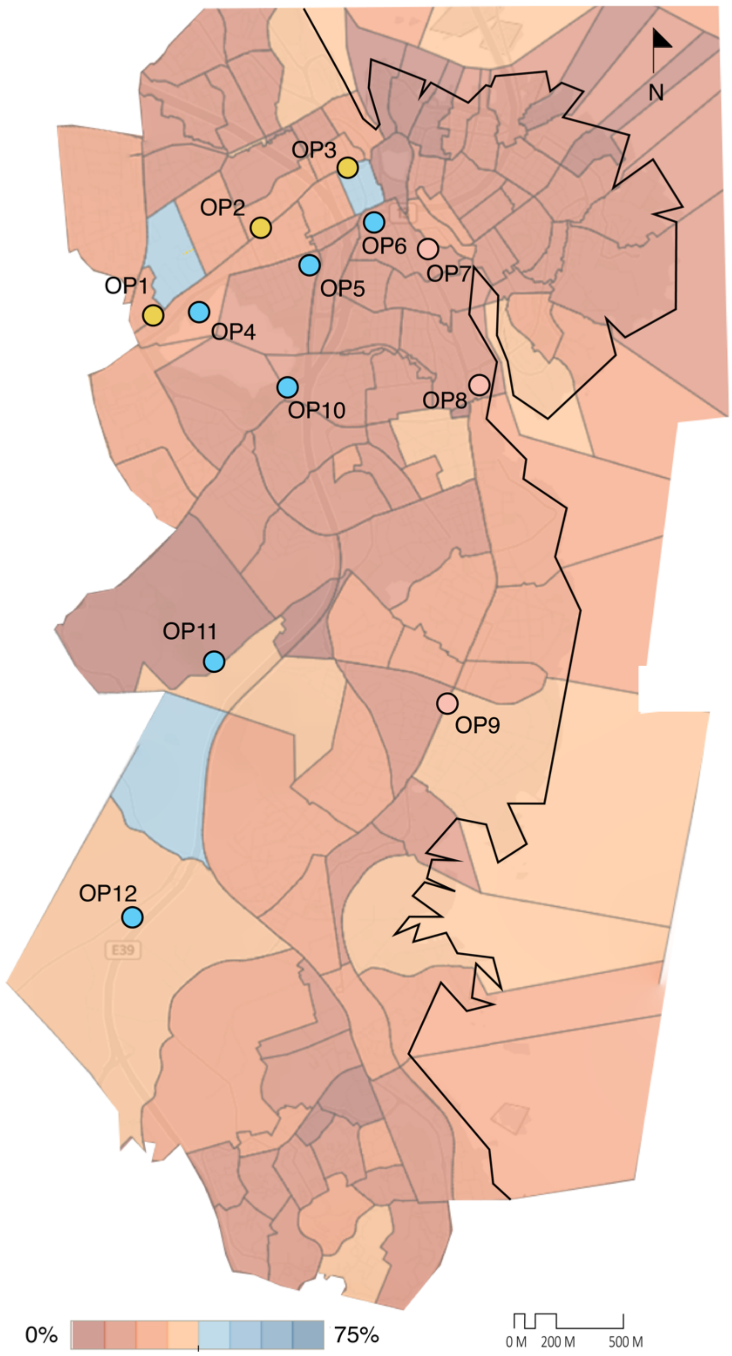
11.3 Form used to record cyclist observations

Route:					Time & Date:					
Obs. Location:					Session ID:					
Direct.	Obs. ID	**Age of Rider:** ***C*** *(U 18)* ***YA*** *(18 - 34)* ***A*** *(35 - 54)* ***O*** *(55 +)*	**Gender:** *Man or Woman (M or W)*	**Type of Bike:** *E-Bike* ***(EB)*** *Bike Share* ***(BS)*** *Hybrid (* ***HB)*** *Classic* ***(CB)*** *Mountain* ***(MB)*** *Road* ***(RB)***	**Bike Access:** *Bike Trailer or Child Carrier* ***(Y or N)***	**Hi-Vis:** ***(Y or N)***	**Helmet: (Y or N)**	**Using Infrastructure:** ***(Y or N***)	**Dist. : Speed: (secs)**	**Athletic Wear: (Y or N)**

11.4 Record of all observation periods

Session ID	Observation ID	Degree of Separation	Sample	Morning Peak (6:30 - 9:30)	Afternoon Peak (14:30 - 17:30)	Time	Round	Date	Conditions	Temperature (C)	Wind (M/S)
1	1	NS	7	X		7:00 -7:30	1	Round 1 - Thursday - June 24	Mostly Sunny	12	1
2	4	FS	51	X		7:40 - 8:10	1	Round 1 - Thursday - June 24	Mostly Sunny	12	1
3	2	NS	28	X		8:20 - 8:50	1	Round 1 - Thursday - June 24	Mostly Sunny	14	2
4	5	FS	25		X	14:45 - 15:15	1	Round 1 - Thursday - June 24	Mostly Sunny	19	2
5	3	NS	34		X	15:30 - 16:00	1	Round 1 - Thursday - June 24	Mostly Sunny	19	2
6	6	FS	36		X	16:15 - 16:45	1	Round 1 - Thursday - June 24	Mostly Sunny	19	2
7	7	VS	31	X		7:00 -7:30	1	Round 1 - Friday - June 25	Cloudy	12	2
8	11	FS	47	X		7:50 - 8:20	1	Round 1 - Friday - June 25	Cloudy	12	2
9	9	VS	11	X		8:40 - 9:10	1	Round 1 - Friday - June 25	Cloudy	14	2
10	12	FS	35		X	15:00 - 15:30	1	Round 1 - Friday - June 25	Sunny	21	2
11	8	VS	46		X	15:50 - 16:20	1	Round 1 - Friday - June 25	Sunny	21	2
12	10	FS	20		X	16:30 - 17:00	1	Round 1 - Friday - June 25	Sunny	21	2
13	3	NS	12	X		7:00 -7:30	2	Round 2 - Tuesday - August 17	Mostly Cloudy	15	4
14	5	FS	65	X		7:40 - 8:10	2	Round 2 - Tuesday - August 17	Mostly Cloudy	15	4
15	6	FS	39	X		8:15 - 8:45	2	Round 2 - Tuesday - August 17	Mostly Cloudy	15	4
16	4	FS	49		X	15:00 - 15:30	2	Round 2 - Tuesday - August 17	Cloudy	18	7
17	1	NS	34		X	15:35-16:05	2	Round 2 - Tuesday - August 17	Cloudy	18	7
18	2	NS	37		X	16:30 - 17:00	2	Round 2 - Tuesday - August 17	Cloudy	18	7
19	8	VS	52	X		14:55 - 15:25	2	Round 2 - Thursday - August 19	Partly Sunny	17	7
20	10	FS	54	X		15:35 - 16:25	2	Round 2 - Thursday - August 19	Partly Sunny	17	7
21	7	VS	41	X		16:15 - 16:45	2	Round 2 - Thursday - August 19	Partly Sunny	17	7
22	11	FS	50		X	14:45 - 15:15	2	Round 2 - Thursday - August 26	Sunny	21	5
23	9	VS	56		X	15:25 - 15:55	2	Round 2 - Thursday - August 26	Sunny	21	5
24	12	FS	47		X	16:10 - 17:15	2	Round 2 - Thursday - August 26	Sunny	21	5
25	4	FS	48	X		7:00 - 7:30	3	Round 3 - Thursday - September 2	Sunny	13	5
26	1	NS	37	X		7:35 - 8:05	3	Round 3 - Thursday - September 2	Sunny	13	5
27	5	FS	54	X		8:15 - 8:45	3	Round 3 - Thursday - September 2	Sunny	13	5
28	6	FS	56		X	15:00 - 15:30	3	Round 3 - Thursday - September 2	Sunny	17	6
29	3	NS	38		X	15:35 - 16:05	3	Round 3 - Thursday - September 2	Sunny	17	6
30	2	NS	46		X	16:10 - 16:40	3	Round 3 - Thursday - September 2	Sunny	17	6
31	7	VS	48		X	15:00 - 15:30	3	Round 3 - Friday - September 3	Sunny	17	7
32	10	FS	52		X	15:40 - 16:10	3	Round 3 - Friday - September 3	Sunny	17	7
33	8	VS	51		X	14:57 - 15:27	3	Round 3 - Monday - September 6	Cloudy	17	3
34	9	VS	54		X	15:40 - 16:10	3	Round 3 - Monday - September 6	Cloudy	17	3
35	1	NS	38		X	15:20 - 15:50	4	Round 4 - Tuesday - September 7	Cloudy (Mist in AM)	18	4
36	3	NS	29		X	15:58 - 16:28	4	Round 4 - Tuesday - September 7	Cloudy/Mist	18	4
37	12	FS	60	X		7:35 - 8:05	3	Round 3 - Friday - September 8	Fog	16	3
38	11	FS	43	X		8:18 - 8:48	3	Round 3 - Friday - September 8	Fog	16	2

11.5 Geographic distribution of population over the age of 60



Geographic distribution of population over 60 years of age, based on map data from Stavanger statistikken public tableu (Stavanger-Statistikken, 2020)