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Near accidents and collisions between pedestrians and cyclists:
Present situation and related safety issues constraining walking and cycling in Finland

Johannes Mesimäki

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Supervisor: Jani Vuolteenaho

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Abstract

Collisions and near accidents between pedestrians and cyclists can result in serious injuries and death but have received limited academic attention. Using an online survey, this thesis aimed to increase knowledge of such events, assess the sense of safety of pedestrians and cyclists in traffic as well as identify safety-related constraints to the uptake of walking and cycling with practice theory. Practice theory considers human behaviour to be guided via participation in established social practices constituted by interconnected elements of meaning, material and competence. As such, this thesis contributes to debates concerning barriers to walking and cycling from a safety perspective.

The survey was directed to Finnish cities with over 100,000 population and asked frequent pedestrians and cyclists to report details of collisions and near accidents between pedestrians and cyclists that they had experienced in the previous three years. Additionally, the survey asked questions concerning respondents' sense of safety in traffic when walking or cycling. Survey data was analysed with chi-square tests of independence and ordinal logistic regression. Constraints to the uptake of cycling and walking and ways to overcome them were identified with a practice theory analysis. This involved examining the implications of survey results for the elements constituting the practices, their interrelations and how the practices influenced each other.

According to the results, near accidents are roughly 50 times more frequent than collisions. Only 16 respondents had experienced a collision, whereas roughly a third had experienced at least one near accident. Additionally, shared paths were associated with more collisions and near accidents compared to separated spaces, and respondents felt less safe and less willing to travel on them compared to separated paths. The most common type of collision and near accident involved both road users travelling in the same direction.

Constraints to cycling and walking were found to surface from meanings of danger associated particularly with shared infrastructure, a material element of the practices. These issues are evidenced by a high near accident frequency, low sense of safety and low willingness to travel on shared spaces. In addition, these issues were exacerbated by a lack of competences concerning space sharing, resulting in poor rapport and respect between pedestrians and cyclists. Significant effects regarding sense of safety were detected between pedestrians and cyclists and across age and genders with ordinal logistic regression, suggesting variance in how different groups experience meanings of danger. Intervening in the material element of the practices by preferring the provision of spatially separated infrastructure was considered to have potential to help overcome these constraints due to their associated safety benefits and respondents' more favourable position toward them. In addition, working to develop a shared code of conduct for travel on shared environments could further mitigate constraints. Overcoming these constraints could assist the promotion of active travel and help improve the sustainability of transport while improving traffic safety and increasing physical activity.

Keywords

Walking, cycling, traffic safety, sustainability transition, ordinal logistic regression

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Tiivistelmä

Jalankulkijoiden ja pyöräilijöiden väliset onnettomuudet ja vaaratilanteet voivat johtaa vakaviin loukkaantumisiin ja kuolemiin, mutta niitä on tutkittu vähän. Tämän maisterintutkielman tavoite on selvittää tietoa näistä tapahtumista sekä jalankulkijoiden ja pyöräilijöiden turvallisuuden tunteesta liikenteessä nettikyselyn avulla. Lisäksi tavoitteena on tunnistaa kyselyn tuloksista liikenneturvallisuuteen liittyviä jalankulun ja pyöräilyn edistämistä rajoittavia tekijöitä käytäntöteoriaa käyttäen. Teorian mukaan ihmisten käyttäytymistä ohjaa erillisinä olioina toimivat käytännöt, jotka koostuvat kolmen eri kategorian (materiaali, merkitys ja kompetenssi) elementeistä. Näin ollen tämä maisterintutkielma on kontribuutio jalankulun ja pyöräilyn esteisiin liittyviin keskusteluihin liikenneturvallisuuden näkökulmasta.

Kysely kohdistettiin Suomen yli 100 000 asukaslukuisiin kaupunkeihin, ja siinä pyydettiin säännöllisesti käveleviltä ja pyöräileviltä tietoja heille viimeisen kolmen vuoden aikana tapahtuneista jalankulkijoiden ja pyöräilijöiden välisistä onnettomuuksista ja vaaratilanteista. Lisäksi kysely kartoitti jalankulkijoiden ja pyöräilijöiden turvallisuuden tunnetta liikenteessä. Kyselyn tuloksia analysoitiin Khiin neliötesteillä sekä logistisella ordinaaliregressiolla. Jalankulun ja pyöräilyn edistämistä rajoittavia tekijöitä pääteltiin käytäntöteorialla arvioimalla kyselyn tulosten merkitystä jalankulun ja pyöräilyn käytäntöjä muodostaville elementeille, sekä niiden että itse käytäntöjen keskinäisille suhteille.

Tulosten mukaan vaaratilanteet ovat noin 50 kertaa yleisempiä kuin onnettomuudet. Vain 16 vastaajaa oli kokenut onnettomuuden, kun taas noin kolmannes oli kokenut vähintään yhden vaaratilanteen. Jalankulkijoiden ja pyöräilijöiden jakamilla väylillä tapahtui huomattavasti enemmän onnettomuuksia ja vaaratilanteita verrattuna kulkumuotoja erottaviin väyliin. Lisäksi vastaajilla oli heikompi turvallisuuden tunne ja halukkuus kulkea jaetuilla väylillä verrattuna kulkumuotoja erottaviin väyliin. Yleisimmässä tapauksessa jalankulkija ja pyöräilijä matkustivat samaan suuntaan sekä vaaratilanteissa että onnettomuuksissa.

Jalankulun ja pyöräilyn edistämistä rajoittavat tekijät aiheutuivat tilan jakamiseen liittyvistä vaaran merkityksistä sekä huonoista liikkumismuotojen välisistä suhteista. Näitä seikkoja puoltaa jaettuihin väyliin liittyvä heikko turvallisuuden tunne, heikko käyttöhalukkuus sekä vaaratilanteiden yleisyys ja tilan jakamiseen liittyvien kompetenssien puutteellisuus. Ordinaaliset regressiomallit paljastivat turvallisuuden tunteen vaihtelevan merkitsevästi iän, sukupuolen ja kulkutavan mukaan, osoittaen vaihtelua vaaran merkityksissä eri ryhmien kohdalla. Kulkutapojen erottamisen hyödyt liikenneturvallisuuteen, turvallisuuden tunteeseen ja halukkuuteen kulkea kävellen tai pyörällä ovat ilmeisiä. Kulkutapoja erottavien tieympäristöjen suosiminen, eli käytäntöjen materiaalisiin elementteihin puuttuminen, sekä yhteisten tilanjakamismenettelytapojen kehittäminen, eli kompetensseihin puuttuminen, voisivat lieventää näitä rajoittavia tekijöitä. Näiden rajoittavien tekijöiden lieventäminen voisi edesauttaa jalankulun ja pyöräilyn edistämistavoitteita, tukea liikenteen ympäristöystävällisyyttä sekä parantaa liikenneturvallisuutta.

Avainsanat

Kävely, pyöräily, liikenneturvallisuus, liikenne, kestävyysmurros, logistinen ordinaaliregressio

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Foreword

This thesis represents an expanded edition of a commissioned study carried out as part of the Traffic Safety 2025 consortium project (Mesimäki & Luoma, 2020). The present study includes the research objectives, data and content from the original study, but features expanded data analyses, a broader theoretical scope as well as an additional aim involving interpretation of the results with a practice theory approach.

Appreciation is extended to the consortium project Traffic Safety 2025 for funding the data used in this study and the original study which this thesis is based on (Mesimäki & Luoma, 2020). Participants in the consortium project in 2019 were the Finnish Transport Infrastructure Agency, the Finnish Transport and Communications Agency, Nokian Tyres Ltd., 21 Finnish cities (KEHTO-foorumi) and VTT Technical Research Centre of Finland Ltd. Thesis supervision and assistance from Jani Vuolteenaho is also gratefully acknowledged.

Contents

1 Introduction

Transportation and mobility represent essential human needs facilitating social interactions and supporting livelihoods (Spinney et al., 2009; Vella-Brodrick & Stanley, 2013). However, motorised mobility has become one of the most carbon-intensive sectors of anthropogenic activity, and transport accounts for the greatest increase in greenhouse gas emissions since 1990 after power generation (International Energy Agency, 2016, p. 219). In addition, the predominantly motorised nature of transportation contributes to adverse health impacts emergent from the sedentary lifestyles it promotes (Mason, 2000; Tremblay et al., 2010) and its contribution to air and noise pollution (Lelieveld et al., 2019; Mason, 2000; Whitelegg, 2003). Furthermore, prioritising motorised travel as the default in cities has been criticised to detrimentally affect the nature of city streets due to its high associated spatial demands, often rendering streets single purpose "pass-through" areas representing mediators of motorised motion with little intrinsic value or reason for people to spend time in them (Sennett, 1977, p. 14). Due to these issues, calls to lower dependence on motorised travel and increase the sustainability of urban transportation systems have become warranted.

Unlike motorised modes, walking and cycling feature virtually no emissions and can improve human health through increased physical activity (Pucher & Buehler, 2010, p. 392; Rojas-Rueda et al., 2011; Schauder & Foley, 2015). The Intergovernmental Panel on Climate Change also recommends modal shifting to such low-carbon forms of travel, claiming meaningful climate change mitigation potential (Sims et al., 2014, p. 603). Additionally, urban design methods stimulating walking and cycling, such as traffic calming and providing plenty of space for pedestrians and cyclists to travel, can also help create livelier and more sociable urban environments (Pucher & Buehler, 2010, pp. 405–406; Gehl, 2010). For example, in Copenhagen where such principles have been employed, busy pedestrianised streets, increased rates of cycling and a declining trend in cycling accidents indicate the potential of what such approaches can offer (Gehl, 2010, p. 35, 107, 186).

Unfortunately, walking and cycling show evidence of decline in Europe. In France and the UK, such rates have seen a particularly sharp drop since the 1970s, while more gradual declines have been recorded in Germany and Denmark (Buehler & Pucher, 2012, p. 35). Meanwhile, rates of walking and cycling have remained very low throughout the same period in the United States (Buehler & Pucher, 2012, p. 35). In Finland, the share of all trips cycled and walked accounts for a combined total of 30%, with the highest rates seen in the largest cities. However, rates of cycling and walking have also decreased slightly in Finland, partially due to declining interest in the modes from children and middle-aged adults (Finnish Traffic Agency, 2018a, p. 66). In attempts to reverse these trends, the Finnish government has a nationwide programme to increase the role of cycling and walking to a combined total of at least 35–38% by the year 2030 (Ministry of Transport and Communications, 2018), and several cities and municipalities in the country have their own similar initiatives (e.g. City of Helsinki, 2014; Lohja, 2019; Tampere City Region, 2012).

The safety of cycling and walking should be considered as part of a responsible effort to promote their use. Not only do pedestrian and cyclist accidents result in injuries and deaths, but they can decrease sense of safety and willingness to walk and cycle (Chataway et al., 2014; Pucher & Dijkstra, 2003; Ravensbergen et al., 2020; Sanders, 2015). Collisions between motor vehicles and pedestrians or cyclists have been extensively studied, and much knowledge exists on how pedestrians and cyclists can be protected against these (Elvik et al., 2009, p. 143–152). However, collisions between pedestrians and cyclists have received less academic attention despite their potential to result in serious injuries and fatalities (Chong et al., 2010; Graw & König, 2002). Furthermore, most studies on the topic have been performed outside Europe.

In addition to collisions, near accidents between pedestrians and cyclists negatively affect sense of safety and willingness to travel (Sanders, 2015) and appear to occur more often than collisions (Aldred & Crosweller, 2015; Poulos et al., 2017). As such, they represent safety-critical interactions between the modes remaining hidden from traffic safety statistics, potentially reducing the attractiveness of walking and cycling by increasing perceived accident risk (Sanders, 2015, pp. 32–33). Furthermore, the study of near accidents provides an increased volume of data enabling a more intricate investigation into the safety of cycling and walking, compensating for relatively scant and incomplete cyclist and pedestrian accident statistics (Kautiala & Seimelä, 2012; Poulos et al., 2017, p. 152; Puchades et al., 2018, p. 168).

This thesis represents an expanded edition of a commissioned study carried out as part of the Traffic Safety 2025 consortium project (Mesimäki & Luoma, 2020). The present study includes the research objectives, data and content from the original study, but features expanded data analyses, a broader theoretical scope as well as an additional aim involving interpretation of the results with an interpretation of practice theory by Shove et al., (2012). As such, this thesis contributes to debates regarding barriers to walking and cycling from the perspective of transport safety. Data for this research was collected using an online survey directed to Finnish cities with populations over 100,000.

Practice theory considers social practices like walking and cycling to consist of a set of interconnected elements falling under three categories: material, competence and meaning (Shove et al., 2012, p. 23). Furthermore, it considers practices as entities in their own right as the objects of analysis instead of the minds of those who perform them (Shove et al., 2012, p. 139). The theory enables the investigation of how everyday practices emerge, develop and die out by examining the relations between these elements as well as between practices themselves. Therefore, the theory offers appropriate tools to examine how safety issues influence the practices of walking and cycling and constraints to their uptake on a broad scale (Sportswood et al., 2015).

The research objectives of this thesis are:

RO1. Investigate the characteristics of near accidents and collisions between pedestrians and cyclists and assess pedestrians' and cyclists' sense of safety in traffic.

RO2. Investigate how safety issues found in RO1 might constrain uptake of the practices of walking and cycling.

Chapter 2 first introduces practice theory, the theoretical background used to interpret the results of the research (2.1). This is followed by a review of previous literature concerning safety issues between pedestrians and cyclists (2.2). Chapter 3 discusses the methods employed for data collection and analysis, Chapter 4 focuses on reporting the survey results and Chapter 5 explores their significance in relation to previous literature and practice theory. Conclusions based on the research close the thesis in Chapter 6.

2 Theory

This chapter introduces and discusses the theoretical background used to frame and interpret the research presented this thesis. Chapter 2.1 contains an introduction to practice theory, used as the theoretical framework for the interpretation of survey results. Chapter 2.2 reviews existing literature on pedestrian and cyclist safety as well as these road users' sense of safety in traffic. Findings in the literature review were used to inform design of the survey used for data collection.

2.1 Theories of practice

This thesis uses an interpretation of practice theory by Shove et al. (2012) as the theoretical framework to interpret how safety issues discovered in the survey results constrain cycling and walking. This chapter introduces and justifies the use of the theory by first discussing the its roots within and position amongst other social theories, before describing in detail its key mechanisms relevant for the present study.

2.1.1 Introduction to theories of practice

Theories of practice have their roots within classic cultural theories of the 20th century, which according to Rinkinen (2015) can be roughly categorised into three waves (p. 22). The first wave consists of the theories of classical thinkers such as Bourdieu, Giddens and Foucault, who share a notion that behaviour is the manifestation of more than just personal will and choice (Rinkinen, 2015, pp. 22–23). For instance, Bourdieu (1972) and Giddens (1984) theorised that behaviour results from the interplay between human agency and prevailing social structure, positing that much of human action is uninformed by rational decision making and personal determination.

Giddens' structuration theory considers social structure and human agency to constitute an inseparable duality, in which the two are recursively related (Giddens, 1984). Action is regulated by rules, both informal and normative, and by resources contained within structures. These structures are upheld via practices supporting their continued existence, through favourable conduct encouraged by a "practical consciousness" – an unspoken but tacitly known way of proceeding through everyday life (Giddens, 1984).

Somewhat similarly, Bourdieu claims that individuals and societal structures act together to regulate flows of human behaviour (Bourdieu, 1972). Not through strict rules, but through Habitus, i.e. the embodiment of social structures, such as shared understandings within social groups, that result in tendencies and propensities to act in certain ways. Habitus involves continuously responding to probabilities within social structures which guide the flow of human action by making some courses of action more likely than others (Bourdieu, 1972). As such, social practices and habitus are related in a circular fashion, where habitus encourages the performance of practices upholding the prevalent and embodied social structures.

Despite the pervasiveness of these first-wave theories, they remain inadequate for studying practices beyond their interaction with predominantly social effects. For instance, the role of physical things are barely featured in the theories of Giddens and Bourdieu (Shove et al., 2012, p. 23). Representing an alternative and what Rinkinen (2015) classifies as part of the second wave (p. 23), Schatzki et al. (2001) outlined the emergence of practice theories borne from dissatisfaction with what prominent cultural theories of the 20th century offered, known as the "practice turn" in the social sciences (pp. 10–12). In contrast to previous theories, these generally consider practices as *entities*, constituted by a range of interconnected elements. Furthermore, they strongly emphasise the role of materiality and how "material configurations" influence behaviour alongside the influence of social structure, resembling Latour's (2005) actor-network theory (Rinkinen, 2015, p. 23). However, despite the emergence of these theories, Schatzki et al. (2001) noted a lack of a consensus regarding what exactly practice theory is due to the abundance of somewhat different interpretations (p. 11).

Addressing this gap and progressing the second wave, Reckwitz (2002) discerned an "ideal type of practice theory" (p. 244), whose distinguishing feature became the consideration of individual practices as the objects of analysis, while emphasising material elements and social structure as their co-creators. Thus, observable social action can be traceable to established social practices encouraged by social structure through meanings of what counts as 'normal' behaviour, as well as the qualities of material things, instead of as the results of purpose-oriented, independent and free decisions (Kolehmainen, 2018; Reckwitz, 2002).

Reckwitz (2002) defines a practice as "a routinized type of behaviour which consists of several elements, interconnected to one other" (p. 249). These elements include "forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge" (Reckwitz 2002, p. 249). The existence of a practice relies on both the presence of and interconnections between these elements (Reckwitz 2002, p. 250). For example, cycling consists of the bodily skills and competences required to ride a bicycle, the material requirements of bikes and suitable infrastructure as well as rules and norms like traffic codes and even meanings of well-being and vitality, which define cycling as a practice and its meanings to both those who participate in the practice and outsiders (Shove et al., 2012, p. 7).

A practice essentially represents a pattern that may be realised by a variety of single actions, reproduced through performance. Continued reproduction is what sustains a practice as a recognisable entity by both those carrying out the practice and its observers (Reckwitz, 2002, p. 250). With sufficient momentum, practices persist between moments of enactment as concepts that can be known and discussed (Shove et. al. 2007; Watson, 2012). Crucially, individuals are only considered "carriers" of practices, differing from more conventional social theories where elements of knowledge, meanings and skill are considered qualities of individuals (Reckwitz, 2002, p. 250). The life and survival of practices is ultimately determined by how carriers adopt, modify and abandon them (Shove et al., 2012, pp. 119–120).

The third wave of practice theories refers to works such as this thesis using the theory to make sense of empirical findings (Rinkinen, 2015, p. 23). The next chapter introduces a version of practice theory by Shove et al. (2012), suited particularly well for this purpose.

2.1.2 Shove, Pantzar and Watson's Practice Theory

Shove et al., (2012) comment that Reckwitz's (2002) interpretation of practice theory falls short of appropriately conceptualising how individual practices emerge, develop and vanish. In response, they suggest an alternative interpretation better suited for charting practices undergoing change, while remaining dedicated to its element-based structure and principle of consistent recurrence. They present a visual framework to illustrate the theory, which collapses the elements constituting practices as defined by Reckwitz (2002) into three distinct but interconnected categories (Figure 1). Among these categories, *competences* refer to skill, practical knowledgeability, technique and embodied knowledge that are required to perform a practice. *Meanings* refer to ideas, aspirations and symbolic meanings associated with the practices. Finally, *materials* refer to physical entities and things, essential for the performance of practices (Shove et al. 2012, p. 23).

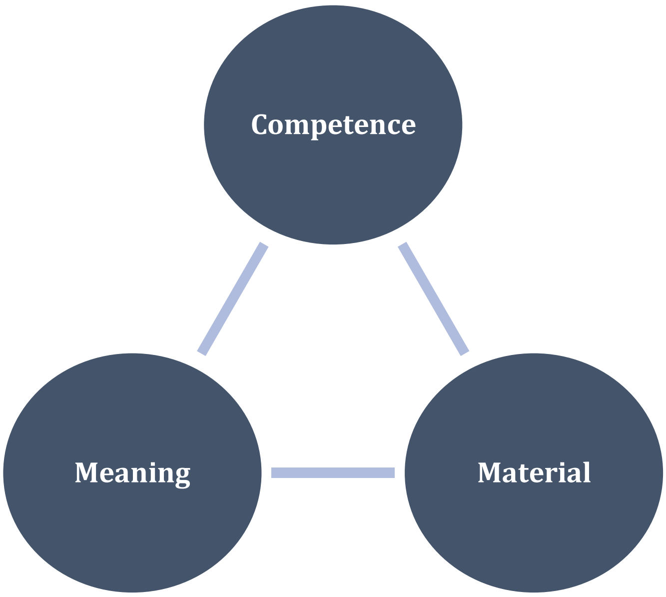

Figure 1. The three interlinked elements of practices (Adapted from Shove et al., 2012, p. 29).

These elements connect each time practices are carried out, and for practices to be sustained, such connections require constant renewal (Shove et al., 2012, p. 24). This reinforces the routinised nature of practices, as they must continuously be reproduced as needed, not because they have reached some point of stability or normalisation (Shove et al., 2012, p. 24). Practices appear, endure and disintegrate when the connections between elements are created, sustained or broken. Practices may also change as new elements are introduced or new combinations of existing elements form (Shove et al., 2012, p. 119–120).

Practice theory considers physical material entities as elements of practices with the capacity to configure their users, not merely as mediators of activities (Reckwitz, 2002, p. 252; Shove et al., 2012, p. 23). Maller (2015) argues that this allows the role of design and the built and natural environment to be recognised as elements "co-creating practice rather than being external 'factors' or 'context'" (p. 5). For example, as the role of safe and appropriate infrastructure is known to be of importance when making a choice regarding travel mode (Dill & Carter 2003), it is useful to explicitly consider how change in the material elements associated with travel practices reflect on their competences and meanings, and how they in turn may encourage or discourage practices.

Shove et al. (2012) further maintain that the interconnections between the elements of a practice are transformative, i.e. elements influence each other over time (p. 32). For instance, the competences involved in the practice of cycling may change if infrastructure, a material element, becomes modified. Consider if a bicycle lane is removed from a road. To continue riding on the road, a cyclist's competences would have to shift in order to be up to the relatively different task of cycling among motor traffic. This might include abiding by principles of "traffic cycling", in which cyclists ride on roads according to the rules of motor vehicle driving, potentially involving new competences such as lane changing (Forrester 2012). Given that many cyclists perceive road sharing with motor vehicles dangerous and stressful (Kaplan & Prato, 2016; Sportswood, et al., 2015), such a shift might also lead to a change in the meanings of cycling regarding the dangerousness and attractiveness of the practice.

Similar to how elements of a practice connect, practices may also connect and form co-evolutionary relations known as "bundles" or "complexes" (Shove et al., 2012, p. 81). Where bundles refer to "loose-knit patterns based on co-location and co-existence", complexes refer to more integrated configurations, characterised by "co-dependent forms of sequence and synchronisation" (Shove et al., 2012, p. 17). Co-location is considered one of the most significant drivers connecting practices, as it allows for otherwise discrete practices to support, compete with or otherwise influence each other (Shove et al., 2012, p. 87). Relations between practices can vary greatly, taking collaborative, competitive, weak or strong forms. Crucially, these relations can determine how practices and the elements they consist of develop (Shove et al., 2012, pp. 87–90).

For example, the practices of cycling and walking often co-occur on shared spaces such as pavements or shared pedestrian and bicycle paths. Evidence of these practices influencing each other include records of safety issues such as collisions and near accidents between cyclists and pedestrians (De Rome et al. 2014; Hatfield & Prabhakharan 2016; Poulos et al. 2017), which can have implications for the meanings of the practices, how they are enacted and who wishes to participate in them. Practitioners systematically gain feedback on the outcome of the practices they perform by monitoring their actions (Shove et al., 2012, p. 99). Poor feedback, such as interference from another practice in the form of a negative encounter, can decrease the attractiveness of cycling and/or walking and feed forward to whether a practitioner decides to continue walking or cycling in the future.

Shove et al. (2012) encapsulate how connected practices transform through a set of relationships called the "circuits of reproduction" (p. 114):

1. For a practice to last, the connections between its constituent elements must be recurred over time through performance.
2. The purposeful and unintended outcomes of recursions determine their practical result.
3. The feedback between performances and the mutual influence between practices determine whether a practice perseveres or changes.

Practice theory as depicted by Shove et al. (2012) provides appropriate tools for conceptualising how safety issues might affect the elements of meaning, material and competence constituting the practices of cycling and walking, as well as the relationships between those elements and the practices themselves. The next chapter reviews literature on safety issues between pedestrians and cyclists to build a better understanding of these issues, before integrating the content of both theory chapters to interpret the results of the present study.

2.2 Safety issues between pedestrians and cyclists

This chapter reviews literature on the frequency and characteristics of near accidents and collisions between pedestrians and cyclists (2.2.1), the safety of these road users in different road environments (2.2.2), the severity of pedestrian-cyclist collisions (2.2.3) and the sense of safety felt by pedestrians and cyclists in traffic (2.2.4). Findings presented here are used to contextualise results of the present study.

2.2.1 Near accidents and collisions between pedestrians and cyclists

This sub-chapter reviews research on the safety of pedestrians and cyclists as well as collisions and near accidents between the modes. Research concerning collisions and near accidents between pedestrians and cyclists is scarce, with the majority carried out in Australia. In addition, studies largely focus on specific locations such as individual cities. These issues undoubtably affect the generalisability of the findings for the context of this thesis due to differing urban and road environments. Studies tend to rely on police and hospital statistics, but observational and survey methods have also been employed, especially in studies concerning near accidents. In addition to these international results, trends concerning pedestrian and cyclist safety in Finland are discussed. A common issue noted in such studies is the poor coverage of pedestrian and cyclist accidents in traffic safety statistics (Sikic et al., 2009; Airaksinen et al., 2010; Kautiala & Seimelä, 2012; O'Hern & Oxley, 2019).

O'Hern and Oxley (2019) studied the frequency of pedestrian injuries caused by collisions between pedestrians and cyclists in Melbourne, Australia during 2006–2016 by analysing emergency department, hospital and police datasets. The eleven-year period contained 183 emergency department presentations and 273 hospital admissions. A total of 6,699 pedestrian hospital admissions occurred due to road traffic collisions during the same period, the majority of which involved a motor vehicle. Based on the emergency department data, 2.6 male pedestrians and 3.4 female pedestrians were injured in collisions between cyclists and pedestrians per 100,000 population. The respective figures are 4.4 and 4.4 for the hospital data. The police dataset contained 155 collisions between pedestrians and cyclists, representing 1% of all pedestrian accidents. Pedestrians over the age of 65 were overrepresented in the injury statistics compared to other age groups. The results show that pedestrian injuries in collisions with cyclists are less frequent than pedestrian injuries in collisions involving a motor vehicle.

De Rome et al. (2014) studied characteristics of cyclist accidents by interviewing 202 injured cyclists in 2009–2010 in the Australian Capital Territory. Of reported accidents, 6% involved pedestrians. Half of these were cyclist-pedestrian crashes and the rest were accidents in which the cyclist fell while overtaking. The study did not address pedestrian injuries.

Poulos et al., (2015) evaluated the frequency of cyclist accidents in Sydney, Australia. Study participants (n=2,038) kept a diary for several weeks documenting accidents they had experienced. Out of 198 recorded crashes, 5% (n=10) involved pedestrians and 6 of these occurred on shared pedestrian and cycle paths. The risk for cyclist crashes was 0.29 (0.26–0.32) per 1,000 cycled kilometres, and 6.1 (5.5–6.7) per 1,000 cycled hours. The crash risk for cyclists riding on footpaths was 26.4 (16.8–40.0) per 1,000 hours, which was clearly greater than in other road environments. For example, the risk was 8.8 (6.5–11.8) on shared pedestrian and cycle paths, 5.8 (3.2–9.5) on cycle lanes and 4.7 (3.8–5.8) on roads. In addition, cyclists older than 60 years of age had a lower risk of experiencing a cyclist accident compared to those aged 25–59. Crash risk per 1,000 cycled kilometres for the age group was 0.2 (0.1–0.3), while the risk for cyclists aged 25–59 was 0.3 (0.27–0.33). However, injuries resulting from cyclist accidents were generally more serious for those aged over 60. The authors considered this a possible reason why the elderly are often overrepresented in transport accident studies based on injury statistics.

In a later study, Poulos et al. (2017) studied near accidents contained in the same data as examined above. According to the results, 105.2 (100.0–110.5) near accidents occurred per 1,000 hours of travel, and 5.04 (4.8–5.3) occurred per 1,000 kilometres travelled. Of recorded near accidents, 72.0% involved a motor vehicle, 10.9% involved a pedestrian, 6.9% involved another bicycle and the remainder were associated with other factors. Inexperienced cyclists were more likely to report a near accident than experienced cyclists, and elderly cyclists (60+) were less likely to report a near accident than cyclists between the ages of 25–59. The ratio of near accidents to collisions involving motor vehicles was 49.3 to 1, and the respective ratio involving pedestrians was 35.8 to 1. Most near accidents between pedestrians and cyclists occurred on the road (30.0%), followed by shared paths (28.8%) and bicycle paths (21.3%). Factors contributing to near accidents between pedestrians and cyclists included unexpected pedestrian manoeuvres in the way of a cyclist, pedestrians distracted in conversation and pedestrians walking on cycle lanes.

Haworth et al. (2014) studied the frequency of conflicts between pedestrians and cyclists by observing cyclists in the city centre of Brisbane, Australia in 2010 and 2012. A conflict was defined as a situation in which a crash between a cyclist and pedestrian would be unavoidable without an evasive manoeuvre by one or both involved road users. Of 4,495 observed cyclists, 48 conflicts between pedestrians and cyclists were recorded, 38 (79%) of which occurred on footpaths and 10 (21%) on roads.

According to official road traffic accident statistics, approximately 106 pedestrian accidents and 169 cyclist accidents occurred in Helsinki during 2012–2016 (Yli-Seppälä, 2018, p. 26, 30). The clear majority (64%) of pedestrian accidents occurred with a car in 2007–2016. Only 5% of accidents occurred with a cyclist. During the same period, the clear majority of cyclist accidents (70%) occurred with a car, with only approximately 4% of occurring with pedestrians. Pasanen and Räsänen (1999) also estimated that 7% of police reported cyclist accidents occurred with a pedestrian in 1995.

The city of Helsinki conducted a survey in 2018 to assess the current level of safety in Helsinki and its development over time (Pyyhtiä, 2019). The sample consisted of 7,818 randomly selected residents aged 15–79, 4,155 (53%) of which responded to the survey. Of the respondents, 99 had been involved in an accident as a pedestrian, 17% of which had involved a cyclist in the preceding 12 months. A further 187 respondents reported having been involved in an accident as a cyclist, of which 6% involved a pedestrian.

Airaksinen et al. (2010) examined traffic accident data from the specialised care unit in North Kymi hospital concerning the period 1.5.2004–31.5.2006. During the period, 215 cyclist accidents were reported, the majority of which (81%) were single accidents. Only 1% of accidents involved a pedestrian or a rollerblader, and resultant injuries were mild or moderate at most.

According to official Finnish traffic accident statistics, an average of 27 cyclist deaths and approximately 750 cyclist injuries, of which 51 were serious, occurred annually during 2014–2017 (Statistics Finland, 2019a). Cyclist deaths have reduced by approximately a third and accidents by approximately a fifth in the last 10 years in Finland (Finnish Road Safety Council, 2019a). During the same period, an average of 31 pedestrian deaths and approximately 420 pedestrian injuries, of which 45 were serious, occurred annually according to official statistics (Statistics Finland, 2019a). The statistic does not include injuries caused by slipping or falling. Hospital registry data contains an additional 215 serious cyclist injuries and 37 serious pedestrian injuries during the same period (Statistics Finland, 2019b). Pedestrian deaths have halved, and injuries have reduced by a third during the last 10 years in Finland (Finnish Road Safety Council, 2019b). Monitoring pedestrian and cyclist accidents with official statistics in Finland is challenging due to the poor coverage of total real cases (Airaksinen et al., 2010; Kautiala & Seimelä, 2012; Kokkonen, 2017). Incomplete accident statistics for cyclists and pedestrians has emerged as an issue internationally (Sikic et al., 2009; O'Hern & Oxley, 2019).

Table 1 summarises the findings concerning collisions and near accidents between cyclists and pedestrians discussed above.

Study	Time and place	Data	Results
Yli-Seppälä (2018)	Helsinki, 2012–2016	Police statistics	• 5% of pedestrian accidents involved a cyclist. • 4.3% of cyclist accidents involved a pedestrian.
Pyyhtiä (2019)	Helsinki, 2018	Survey	• 17% of pedestrian accidents involved a cyclist. • 6% of cyclist accidents involved a pedestrian.
Pasanen & Räsänen (1999)	Helsinki, 1995	Police statistics	• Approx. 7% of police reported cyclist accidents involved a pedestrian.
Airaksinen et al. (2010)	North Kymi hospital catchment area, 2004–2006	Hospital data	• 3 cyclist accidents which involved either a pedestrian or a rollerblader.
O'Hern & Oxley (2019)	Melbourne, Australia, 2006–2016	Emergency department, hospital and police statistics	• 2.6 male and 3.4 female pedestrians were admitted to the emergency department due to a cyclist-pedestrian accident per 100,000 persons • The respective figures according to hospital data were 4.4 and 4.4. • Pedestrian injuries in cyclist collisions are less frequent than pedestrian injuries in motor vehicle collisions.
De Rome et al. (2014)	Australian capital territory, 2009–2010	Interviews	• Interaction with a pedestrian was a factor behind approx. 6% of cyclist injury accidents. • Half of these accidents were cyclist-pedestrian accidents and half were falls, which occurred while the cyclist's attempt to overtake a pedestrian.
Poulos et al. (2015)	Sydney, Australia, 2011–2012	Survey	• 5% of cyclist accidents involved a pedestrian.
Poulos et al. (2017)			• 10.9% of cyclist-pedestrian near misses involved a pedestrian
Haworth et al., (2014)	Brisbane, Australia, 2010 & 2012	Observations	• 48 cyclist-pedestrian near accidents observed during two weeks of observations.

Table 1. Summary of reviewed studies concerning collisions between pedestrians and cyclists.

2.2.2 Pedestrian and cyclist safety in different road environments

In addition to understanding the frequency and characteristics of collisions and near accidents between pedestrians and cyclists, it is also valuable to know where they typically occur. This sub-chapter focuses on the safety of different road environments for pedestrians and cyclists. As in the previous chapter, most research on this topic has been carried out in Australia. Several studies suggest that shared pedestrian and cycle paths are relatively dangerous road environments (Haworth & Schramm, 2011; De Rome et al., 2014; Cripton et al., 2015; Beck et al., 2016; Poulos et al., 2017). Such paths are also common in Finland (Finnish Traffic Agency, 2018b), although their similarity to shared paths examined in international studies is unclear.

In De Rome et al. (2014), the second largest share of cyclist accidents (approximately 37%, n=74) occurred on shared pedestrian and cycle paths, with 16% (n=12) involving a pedestrian. Only one pedestrian-cyclist accident occurred in another road environment. Most recorded accidents occurred while riding among motor traffic (approximately 39%, n=79). The interviews revealed that only 17% (n=35) of accidents were reported to the police, none of which were between cyclists and pedestrians. These results differ from Canadian results in Cripton et al. (2015), according to which injuries sustained from cyclist accidents on shared pedestrian and cycle paths and footpaths were more likely to require hospital transport than cyclist accidents on roads without cyclist infrastructure. However, the role of pedestrians in the study is unclear. In a study on cyclist accident characteristics, more accidents occurred on shared pedestrian and cycle paths than cycle paths (Beck et al. 2016). However, only one cyclist accident involved a pedestrian.

Hatfield and Prabhakharan (2016) investigated the behaviour of pedestrians and cyclists travelling on shared paths in Australia by observing 407 passing events between users of the modes. According to the results, the presence of a marked centreline was associated with keeping left (Australia follows left-hand traffic) and lower cyclist speeds. However, cyclists were observed to frequently pass on the left, passing dangerously close and passing without reducing their speed or giving a warning. Moreover, factors contributing to near accidents included use of mobile phones and mp3 players. Five near accidents were observed by the researchers, and a survey (n=53) conducted by the observation area further revealed 2 collisions and 13 near accidents. Hatfield and Prabhakharan (2016) conclude by positing that travel on shared pedestrian and bicycle paths suffers from issues with perceived space ownership. The results also suggest that near accidents are more frequent than collisions.

In her Ph. D. thesis, Delaney (2016) investigated interactions between pedestrians and cyclists on shared paths in Bristol, UK. A case study of a shared path in the city was carried out with on-site intercept surveys, and qualitative interviews. According to the results, over half of all respondents, especially cyclists, reported being frustrated with the actions of another road user due to lack of consideration by users of different modes (p. 140). In addition, study participants had formed negative perceptions of other road users borne from the varied expectations and interpretations of how they should travel on shared paths (p. 146). Study participants generally wished for clearer rules regarding where they should travel on the paths to reduce such tensions, and the promotion of a shared code of conduct was recommended as one of the conclusions of the thesis (p. 185). Moreover, pedestrians were particularly fond of marked space separation (p. 149), and worried about the unpredictable movements of dogs (p. 188).

According to a survey study on safety issues concerning shared paths in New South Wales, Australia, a sense of intrusion and uncomfortable proximity to pedestrians by cyclists were associated with conflicts (Transport for New South Wales, 2015). Of cyclists, 70% felt that pedestrians often get in their way on shared paths, with most pedestrians considering cyclists to travel too fast and pass to close.

Haworth and Schramm (2011) studied cyclist injuries and travel behaviour in Queensland, Australia using a survey conducted in 2009–2010. The data contained 1,179 experienced cyclist accidents, most of which were single accidents (approximately 70%) or crashes with motor vehicles (approximately 14%). Of all cyclist-pedestrian accidents, 18% (n=32) occurred on cycle lanes, 10% (n=7) on footpaths, 1% (n=9) on streets without cycle lanes and 1% (n=1) on a highway.

2.2.3 Severity of collisions between pedestrians and cyclists

This sub-chapter briefly discusses the severity of collisions between pedestrians. Accidents between cyclists and pedestrians can lead to serious injury and even death (Chong et al., 2010; Grzebieta et al., 2011). Pedestrians are generally injured more seriously than cyclists (Chong et al., 2010). Generally, the most severe injuries in cyclist-pedestrian crashes occur as the pedestrian's head strikes the ground (Graw & König, 2002; Short et al., 2007). This differs from accidents between pedestrians and motor vehicles, in which the most serious injuries occur upon impact with the vehicle (Graw & König, 2002; Short et al., 2007; O'Hern & Oxley, 2019). Graw and König (2002) determine that injuries sustained by the pedestrian from handlebar impact are most likely minor. Additionally, they found that the cyclist's fall generally consists of a throw-off and sliding phase, leading to a lower impact load on the head relative to the pedestrian (p. 241).

Chong et al. (2010) recommend a speed limit of 10 km/h for cyclists on shared pedestrian and cycle paths, to ensure pedestrian safety (p. 295). The limit is justified by the notion that the kinetic energy differential between a car travelling at 60 km/h and cyclist travelling at 10 km/h in the same direction does not differ significantly from the corresponding differential of a cyclist travelling at 30 km/h and a pedestrian travelling at 5 km/h (Chong et al., 2010, p. 295; Grzebieta et al., 2011, p. 2). However, Hatfield and Prabkahran (2016) criticise the limit as too low for commuter cycling to be worthwhile. Additionally, the elderly have a greater risk of serious injury in a cyclist-pedestrian accident (Chong et al., 2010; O'Hern & Oxley, 2019), likely due to their greater overall physical vulnerability (Oxley, 2004).

2.2.4 Sense of safety

This sub-chapter discusses literature related to pedestrians' and cyclists' sense of safety in traffic and its effect on willingness to travel. Most studies focus on specific locales outside Europe such as individual cities, and there is a lack of international comparisons on the topic. The studies summarised here suggest that both safety, sense of safety and interactions with other vehicles affect risk perception and willingness to walk and cycle. Willingness varies to some degree by age and gender and is also affected by the perceived safety of infrastructure.

Singleton and Wang (2014) analysed the effect of safety and security on travel mode choice based on household travel survey data collected from Portland, Oregon, USA with discrete choice analysis. The results indicate that concerns over traffic safety significantly influenced mode and destination choice, particularly for cycling and walking. Cycling and walking were less likely to be chosen as travel options in areas where transportation infrastructure was considered unsafe.

De Souza et al. (2014) analysed the influence of attitudes toward cycling and perceived barriers to cycling in Brazilian cities. Low perceived safety associated with lack of appropriate infrastructure was considered a strong barrier preventing cycling. Strong negative attitudes toward cycling were associated with perceptions of greater barriers, while positive attitudes were associated with perceptions of weaker barriers.

Agrawal et al. (2008) studied factors determining route choice for pedestrians walking to transit using a survey conducted in California and Oregon. Safety was the most substantial reported factor after route distance. Most safety-related responses were associated with traffic safety, with only a few respondents mentioning crime. Females were more likely to consider safety factors as important for route choice compared to men (69% vs. 43%).

Aziz et al., (2018) examined the role of cycling and walking infrastructure for modal uptake in New York City. A random parameter logit model based on 2010–2011 Regional Household Survey Data was estimated to explore the impact of traffic safety, bike network facilities and land use attributes on mode choice for work commuting trips. Factors found to increase the likelihood of active transport choice related to infrastructure design, such as "increasing sidewalk width, total length of bike lane and proportion of protected bike lane" (Aziz et al., 2018, p. 1207). The authors further note that the likelihood of cycling and walking may be increased by improving traffic safety for cyclists and pedestrians (p. 1224–1226).

In her survey results, Delaney (2016) found that road users were slightly more comfortable sharing space with other users of the same mode on shared pedestrian and bicycle paths, with the effect stronger for pedestrian respondents (p. 138). Furthermore, respondents generally agreed that pedestrians are not as considerate on shared paths compared to shared paths with separate lanes.

Christmas et al. (2010) discovered through qualitative interviews of cyclists in Britain that poor quality infrastructure frequently led to safety issues. Examples of poor infrastructure included cycle lanes which ended suddenly, lanes with frequent potholes and irregularities as well as paths that required constant stopping or were disturbed by parked cars. Issues related to poor infrastructure were considered by interview participants to worsen road sharing and increase the risk of accidents (pp. 60–61). The authors also found that for some interviewees, the risk of accidents constituted a reason not to cycle. For many, this was due to either having seen or experienced a near accident or an actual collision (p. 24). However, this anxiety was mainly due to vehicular road users and the role of pedestrians remains unclear.

Winters et al. (2012) studied differences in perceived accident risk and observed risk when cycling in different road environments in Toronto. Perceived risk was reported by a sample of 690 injured cyclists on a scale from +1 (very safe) to -1 (very unsafe). For most road types, observed and perceived accident risk matched relatively well, but differences were observed for cycle tracks, which was associated with a higher perceived risk than observed risk, as well as shared pedestrian and bicycle paths, which were considered safer than observed. Perceptions of safety were considered to affect choice of route and the decision to cycle.

Sanders (2015) studied the relationship between near accidents between cyclists and motor vehicles and perceived accident risk in the San Francisco Bay Area with a survey. Near accidents were concluded to occur much more often than collisions and increase worries of traffic risk among cyclists travelling both frequently (weekly, daily) and infrequently (yearly, monthly), although frequent cyclists were much more likely to have such concerns. Sanders (2015) concludes that experiencing both collisions and near accidents influenced perceived traffic risk considerably, affecting whether people choose to cycle (pp. 32–33). Interestingly, while many cyclists chose not to cycle due to high perceived accident risk as a result of experiencing near accidents, others, perhaps due to necessity, continued cycling frequently but felt usually or always worried about experiencing an accident.

Kiyota et al. (2000) compared risk perceptions of different age groups for cyclist-pedestrian accidents in different scenarios in Japan. Based on video material of 38 near accidents involving cyclists and pedestrians on shared paths, respondents estimated the risk of a near accident from the pedestrian's perspective on a numerical scale. Young children (ages 9–10) and the elderly (65+) perceived risks to be the greatest, while the university student age group (20–22) perceived the risks to be the lowest. Although cyclist speed was lower in scenarios involving high pedestrian density, risk perceptions remained unaffected. Additionally, the severity of the perceived risks was reduced the greater the space between pedestrians and cyclists.

2.3 Summary

The reviewed literature suggests that collisions between pedestrians and cyclists account for a relatively small portion of all road traffic accidents. However, near accidents seem to be noticeably more frequent (Poulos et al. 2017; Sanders, 2015). For example, Haworth et al. (2014) observed plenty of near accidents, but not a single collision. In addition, shared pedestrian and cycle paths appear to be relatively dangerous compared to other road environments (Beck et al., 2016; Cripton et al., 2015; De Rome et al., 2014; Haworth & Schramm, 2011), suggesting that such spaces could also represent hotspots for near accidents. Collisions between pedestrians and cyclists may also lead to serious injuries and deaths (Chong et al., 2010; Grzebieta et al., 2011), and pedestrians are generally injured more seriously than cyclists (Graw & König, 2002). Furthermore, perceiving traffic as unsafe (Agrawal et al., 2008; Singleton & Wang, 2014; Aziz et al, 2018) and experiencing a collision or near accident (Christmas et al., 2010; Sanders, 2015) reduced willingness to walk and cycle. Most studies have been conducted outside Europe, especially Australia, which likely influences the generalisability of results as roads and urban environments likely differ to those in Finland. The literature introduced in Chapter 2.2 is used to contextualise the results of the present study and inspired some of the questions in the online survey.

Practice theory by Shove et al. (2012) introduced in Chapter 2.1 is used to interpret how safety issues in the survey findings constrain walking and cycling. This involved assessing the implications of survey findings for the elements constituting the practices, the relationships between elements and examining how the practices influence each other. Furthermore, the theory is used to analyse how these identified constraints might be overcome.

3 Method

In this chapter I first introduce the survey, its aim, structure and how it was distributed (3.1). Following this, I discuss the statistical analysis undertaken on the survey data (3.2.1) and briefly discuss how practice theory was used to interpret results (3.2.2).

3.1 Survey

An online survey was used to collect the data used in this thesis. Its aims were to gain an understanding of the characteristics of near accidents and collisions between pedestrians and cyclists, the frequency of near accidents, the factors contributing to these events as well as the sense of safety of pedestrians and cyclists in traffic. As the survey was designed to meet the research aims of the original study that this thesis is based on (Mesimäki & Luoma, 2020), it was not designed with a practice theory analysis in mind. However, Sportswood et al. (2015) show that it is common to rely on data not originally intended for interpretation with practice theory in practice theory analyses (p. 26). Data collection occurred in June 2019, and respondents were accessed through a survey panel provided by Taloustutkimus OY.

According to Whittaker (2009), surveys are well suited to study large populations in a standardised manner to identify “beliefs, attitudes, behaviours and other characteristics” on a large scale (p. 61). The use of a survey to collect data for this thesis was considered appropriate given the level of detail required of these events and to obtain information on near accidents.

To be eligible to participate, respondents had to engage either in walking trips of at least 300 metres once a month or more, or in bicycle trips during summer once a month or more. In addition, respondents had to be aged 15–79 to ensure that the sample would mainly represent adult cyclists. To gain a sample of urban respondents, the survey was directed to Finnish cities with populations greater than 100,000. A sample size of approximately 1,000 was requested from Taloustutkimus.

The survey asked respondents questions concerning collisions and near accidents between pedestrians and cyclists that they had experienced, with questions inspired partially by the results of literature review. In this study, a collision refers to a situation in which a pedestrian and cyclist either crashed or collided with each other. A near accident refers to a situation in which at least one participant became frightened, was forced to evade or had to brake forcefully to avoid a collision. An underlying assumption in this research was that near accidents and collisions are closely related phenomena. Although more accurately defined terms such as “conflict” exist to depict similar events (Zheng et al. 2014), the term “near accident” is used in this thesis as it allows for a somewhat broader interpretation.

The survey asked respondents to provide details for a maximum of three collisions and two near accidents occurring during the previous three years. These details included information on for example road environment, accident type, factors related to involved parties and the consequences of collisions.

The 3-year cut-off was decided based on an assumption that older memories of respondents would likely be unreliable. Additionally, respondents answered questions related to their sense of safety in traffic by stating how much they agreed or disagreed with a set of statements on five-point Likert scales, which are frequently used in survey research to measure attitudes and agreement (Jamieson, 2014, p. 1217). Finally, some demographic background data was provided by the survey panel. Sense of safety on shared pedestrian and bicycle paths was considered especially relevant due to safety issues associated with them reported in previous research (see Chapter 2.2.2), and the frequency of such paths in Finland (Finnish Traffic Agency, 2018b). The survey can be viewed in Appendix – Survey.

At the time of data collection, Finnish traffic law (Finnish Traffic Law 3.4.1981/267) obliged pedestrians and cyclists to travel on paths provided for them if they were available. Such paths usually either a) separate pedestrians and cyclists from each other with lane markings, or b) require sharing the path. If no dedicated infrastructure exists, cyclists and pedestrians must travel along the side of the road. Only children under the age of 12 may cycle on pedestrian paths. Right-hand traffic applies to all road users except pedestrians.

Several ethical issues were considered regarding data collection. Respondents were made aware of the purpose of the research by the survey panel provider as also recommended by Whittaker (2009, p. 68) and Oldendick (2012, p. 24). As further recommended by Oldendick (2012), information that could be used to reveal the identity of individual respondents was not collected (p. 24). Participation in the survey was voluntary, and respondents had the opportunity to withdraw from the survey without their data being collected by closing the survey before submitting their responses.

3.2 Analysis of survey data

This chapter describes and justifies the statistical analysis undertaken on the survey data, closing with a brief discussion on how the results were interpreted.

3.2.1 Statistical analysis

The statistical data obtained from the online survey was analysed using R 3.6.1 and RStudio 1.3.1093. R is an open source programming language facilitating a variety of statistical analyses and graphical outputs (R-Project, 2020). RStudio provides a user-friendly interface for performing statistical analyses with R (RStudio, 2020).

Most questions in the survey resulted in categorical variables, such as type of near accident and type of road environment. Continuous age data of respondents was also converted to a categorical variable consisting of three groups of roughly equal size representing ages 15–49, 50–64, and 65–79 for some analyses. Responses to questions concerning sense of safety represented ordinal variables, as these were responded to on five-point Likert scales ranging from strongly disagree to strongly agree, in which intervals between the response categories are not equal (Osborne, 2017, p. 414).

Chi-Squared Tests of Independence were used to test variables concerning near accident characteristics for independence based on age group and gender. Chi-Squared tests of independence are used to test whether an association between two categorical variables is too strong to be reasonably explained by chance (Ross, 2017, pp. 599–604). Essentially, the test aims to detect whether the proportions of observations falling into each combination of categories are roughly the same as what would be expected if no association existed. The test statistic is the sum of squared differences between the expected values and the observed values, which represents a chi-squared random variable with degrees of freedom equal to (r−1)*(s−1), where r and s represent the number of categories in each variable (Ross, 2017, pp. 599–604).

Ordinal logistic regression (OLR) models were fitted for responses to each Likert-scale question regarding sense of safety to detect associations between age (continuous variable), gender and whether the respondent was a pedestrian or cyclist (categorical variables). OLR was used instead of ordinary least squares (OLS) regression, because OLS assumes that variables included in the model are continuous and normally distributed (Osborne, 2017, p. 414; Ross, 2017, p. 534). As the Likert-scale responses are not continuous, use of an OLS regression may have produced misleading results (Gerhard, 2012, p. 241; Osborne, 2017, p. 414). A multinomial logistic regression which could have also been used but would not have captured the ordered nature of the response variables (Osborne, 2017, p. 407).

Responses from respondents who walked and cycled frequently enough to answer from both perspectives were removed from pedestrian answers to comply with the assumption of independent observations (Osborne, 2017, p. 86). Inclusion of multiple observations from the same respondent could result in responses that are too similar and produce standard errors that are too small for a model assuming independent observations, increasing the chances of falsely rejecting a null hypothesis (Osborne 2017, p. 86). As such, the "pedestrian or cyclist" variable in the model essentially compares the perspectives of pedestrians who do not cycle and cyclists. For each model, the data contained 387–397 pedestrian responses and 633–643 cyclist responses.

Responses in both extremes of the response scales ("Strongly disagree" and "Strongly agree") were merged with their "disagree" and "agree" counterparts, to ensure adequate sample sizes for all response categories. Responses were also converted from text form to numerical form ("Disagree" = 1, "Neutral" = 2, "Agree" = 3) to be compatible with the model.

There are several assumptions for ordinal logistic regression:

1. The dependent variable is ordered (Osborne, 2017, pp. 409–410).

2. There is no multi-collinearity between independent variables (Osborne, 2017, p. 87).
3. Observations are independent of each other (Osborne, 2017, p. 87).
4. The relationship between each pair of outcome groups is the same, i.e. they have proportional odds (Osborne, 2017, pp. 409–410).

OLR models are similar to binary logistic regression models, but support more than two factor levels for each independent variable and assume that each "response variable behaves in an ordinal fashion with respect to each predictor" (Harrell, 2015, p. 312). The model achieves this by calculating cumulative probabilities for the possible outcomes of the ordered dependent variable with a set of cumulative binary logistic regressions for each independent variable, holding other independent variables constant (Osborne, 2017, p. 408). For instance, in a model with 3 potential outcomes, the first binary comparison would be 1 vs 2, 3, and the second would be 1, 2 vs 3.

Essentially, the proportional odds assumption means that the effects of an independent variable on the dependent variable are equal regardless of which pairs of outcome groups are being compared. The assumption allows summarising the effects of each independent variable level on all pairs of outcome groups with one odds ratio (Osborne, 2017, p. 409). The odds ratios compare the effect of each level of an independent variable to that independent variable's reference level (Harrell, 2015, p. 313). A partial-proportional odds model can also be used to relax the assumption of proportional odds for variables which violate it. However, it is preferable to use a simpler model if this can be avoided (Williams, 2016, p. 14).

Brant tests were used to ensure that the proportional odds assumption holds. P-values for the tests for each independent variable are presented in Table 2. The test essentially approximates whether differences between the OLR model and the set of binary logistic regression models which underlie it are too large to be attributable to chance (Brant, 1990).

The proportional odds assumption held for all models except for the gender variable in model 4. Therefore, a partial proportional-odds model with the proportional odds assumption relaxed for this variable was performed instead. The partial proportional-odds model calculates separate odds ratios for different outcome groups to depict the effect of the independent variables which are assumed to not have proportional odds. As a hypothetical example, a model with 3 possible outcomes would calculate separate odds ratios for a partial-proportional variable comparing outcomes 1 vs. 2, 3 and 1, 2 vs. 3, whereas a proportional-odds model would produce one odds ratio to represent all these effects.

*Table 2. Brant test p-values for the OLR models. Non-significant result (p>0.05) indicates that the assumption of proportional odds holds. *Pedestrian respondents only, **cyclist respondents only. Significant effects marked in bold.*

Model (Statement)	Pedestrian or cyclist	Gender	Age
1. Shared paths are safe	0.27	0.75	0.17
2. I am happy to travel on shared paths	0.13	0.92	0.67
3. Shared paths with separate lanes are safe	0.18	0.22	0.30
4. I am happy to travel on shared paths with separate lanes	0.99	**0.02**	0.21
5. Pedestrians are considerate toward other pedestrians*		0.91	0.42
6. Cyclists are considerate toward pedestrians*		0.55	0.92
7. Pedestrians considerate toward cyclists**		0.41	0.27
8. Cyclists considerate toward cyclists**		0.60	0.71

A correlation matrix was used to test for multicollinearity between independent variables (Table 3). The lack of strong correlation coefficients suggests no meaningful multicollinearity and that the assumption holds (Osborne, 2017, pp 87–88).

Table 3. Correlation matrix for independent variables.

	Gender	Age	Pedestrian or cyclist
Gender	1.000		
Age	-0.059	1.000	
Pedestrian or cyclist	-0.078	-0.177	1.000

Likelihood-ratio tests were used to assess goodness-of-fit for the models by comparing them to models with intercept terms only. A statistically significant result means that inclusion of the independent variables significantly improves model fit over the intercepts only model (Hosmer et al. 2013, pp. 276–278). Therefore, a non-significant result indicates that the independent variables do not fit the data well enough for the model to be serviceable.

The models were constructed using the “polr” and “vglm” commands in the “MASS” and “VGAM” packages for R. To assist interpretation of the directionality of results and visualise effects of different combinations of independent variables on responses, plots depicting the predicted probabilities of responses calculated and used by the models to produce the odds ratios are presented. These graphical plots were produced with the “ggplot2” package.

The 95% level of significance is used for all statistical tests, which means that there is only a 5% risk of falsely determining a statistically significant effect (Statistics Finland, 2020). The sample size of detailed collision accounts was too small for statistical testing.

3.2.2 Interpretation of results

To answer RO1, results from the survey are analysed and contrasted with findings reported in previous research to highlight similarities, differences and to synthesize new findings. To answer RO2, these findings are interpreted using the interpretation of practice theory by Shove et al., (2012) to identify how safety issues discovered in RO1 constrain the uptake of walking and cycling. This involved assessing the implications of survey findings for the elements constituting the practices, the relationships between elements and examining how the practices influence each other. Furthermore, the theory is used to analyse how the identified constraints might be overcome by identifying areas for interventions.

When interpreting our results, it is important to consider the implications associated with voluntary survey panels. Social researchers extensively use survey panels to obtain data, especially when respondents from a broad geographical coverage are desired (May, 2011, p. 121). However, as these panels consist of voluntary participants, they generally result in non-probability samples that do not represent target populations accurately enough for broader inferences to be valid (Callegaro et al., 2014, pp. 266–267). As the purpose of this study was to analyse the characteristics of near accidents and collisions as well as gain an approximate estimate of near accident frequency, it was not important for the survey to represent any particular groups with great accuracy. Nevertheless, it is essential to consider both the urban context of the target population as well as the sampling method when interpreting the results of this study.

4 Survey Results

This chapter presents the results from the online survey. The characteristics of the survey respondents are discussed in Chapter 4.1. This is followed by results concerning collisions between pedestrians and cyclists (4.2), near accidents (4.3) as well as the sense of safety felt by pedestrians and cyclists in traffic (4.4).

4.1 Characteristics of respondents

The gender distribution of the sample was 51.8% male and 48.2% female, which is similar to Finland's population (49.9% male and 50.1% female (Statistics Finland, 2019c)). The average age is 55.2 (SD=14.6). Compared to Finland's age distribution (Statistics Finland, 2019c), younger age groups were somewhat underrepresented and older age groups were somewhat overrepresented (Figure 2). Such a skew was expected, as the elderly are known to be overrepresented in cyclist-pedestrian accident injury statistics (O'Hern & Oxley, 2019). This may have motivated them to participate in the survey.

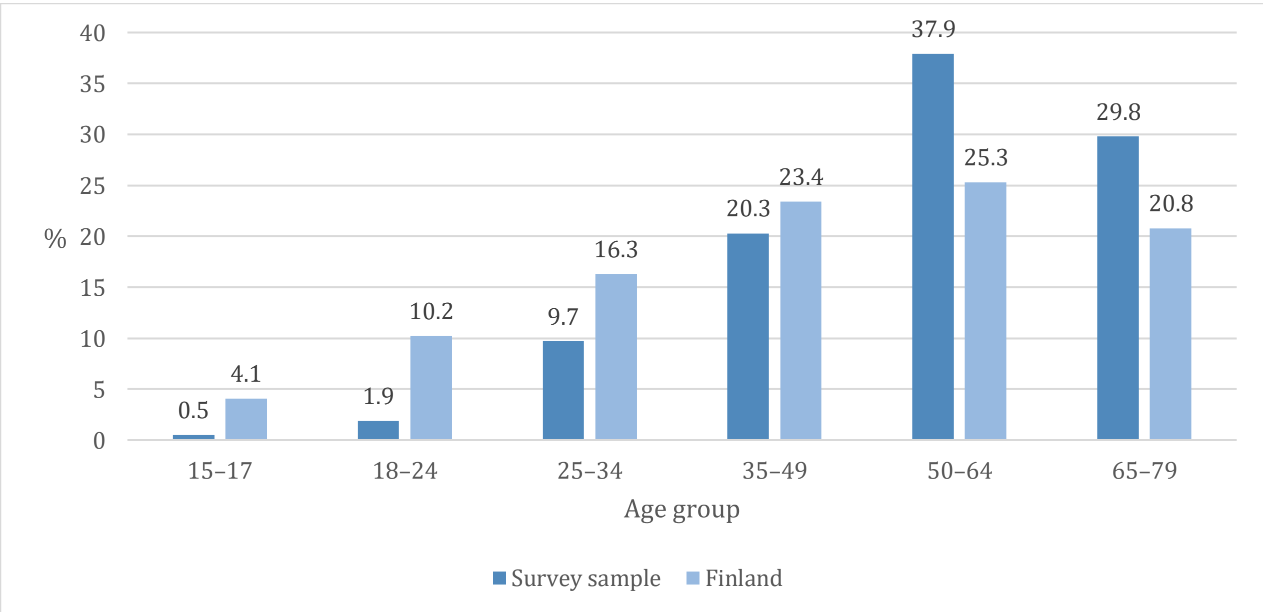

Figure 2. Survey sample age distribution compared to Finland's age distribution (Relative to ages 15–79).

The majority of respondents (34.5%) lived in the capital city region, followed by Turku (12.1%), Oulu (12.1%), Jyväskylä (12.0%), Tampere (11.2%), Kuopio (10.5%) and Lahti (7.6%). The survey sample differed slightly from these cities' age distributions (City of Tampere, 2018; City of Lahti, 2019; City of Kuopio, 2019; City of Turku, 2019; Helsingin Seudun Aluesarjat, 2019; Oulun Kaupunki, 2019). This is however expected, given that the proportion of trips cycled differs between cities. For instance, 17% of trips are cycled in Oulu (WSP Finland Oy, 2018a), while only 7% are in Tampere (WSP Finland Oy, 2018b).

Of all respondents, 87.5% reported walking trips of over 300 meters at least once a week, and 34.5% reported cycling at least several times a week during summer (Figure 3). Respondents walk slightly more often, and cycle slightly less often than Finns do in general according to the 2016 National Travel Survey (Finnish Traffic Agency, 2018a). However, methodological differences prevent a detailed comparison.

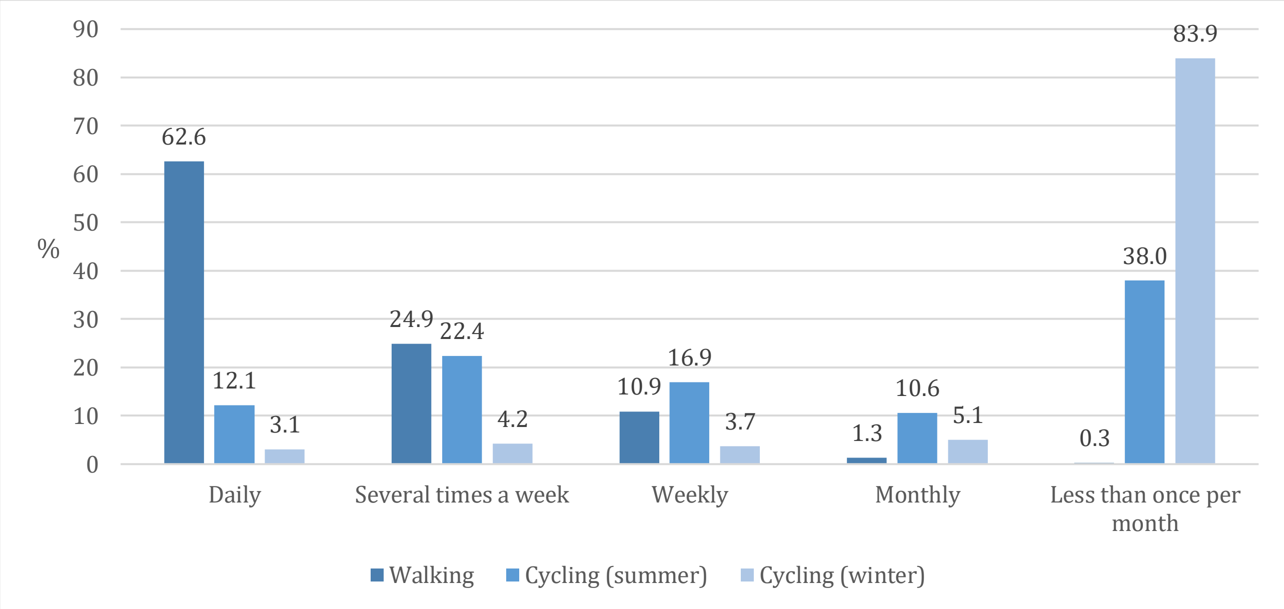

Figure 3. Travel characteristics of respondents

Typical distances for cycling and walking trips were slightly longer than in Finland's 2016 National Travel Survey (Finnish Traffic Agency, 2018a), according to which approximately 60% of pedestrians typically travel distances less than one kilometre, and approximately 70% of cyclists typically travel distances between 0–3 kilometres.

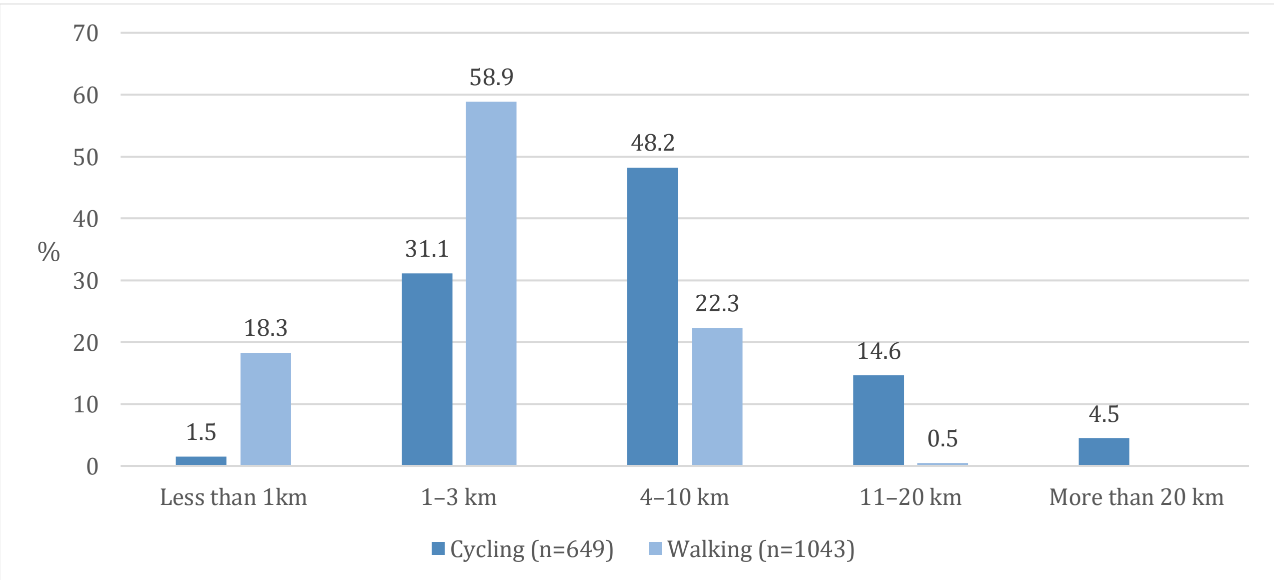

Figure 4. Respondents' typical trip distances according to mode.

Statistically significant differences between age groups were detected for typical walking trip distance (X^2=27.13, df=6, p<0.001). Although this distance was most frequently 1–3 kilometres in all age groups, the youngest age group accounted for the greatest proportion of distances of under one kilometre, and the oldest age group accounted for most distances between 4-10 kilometres.

In all age groups, typical cycling trip distance was most frequently 4–10 kilometres, but statistically significant differences were also detected (X^2=27.98, df=8, p<0.001). For example, the youngest age group contained the greatest proportion of 1–3-kilometre trips, whereas the oldest age group contained the most trips over 20 kilometres. The largest proportion among all respondents (43.6%) cycled 201–1000 kilometres a year, but our sample also included respondents who cycle more than 2000 kilometres annually (Figure 5).

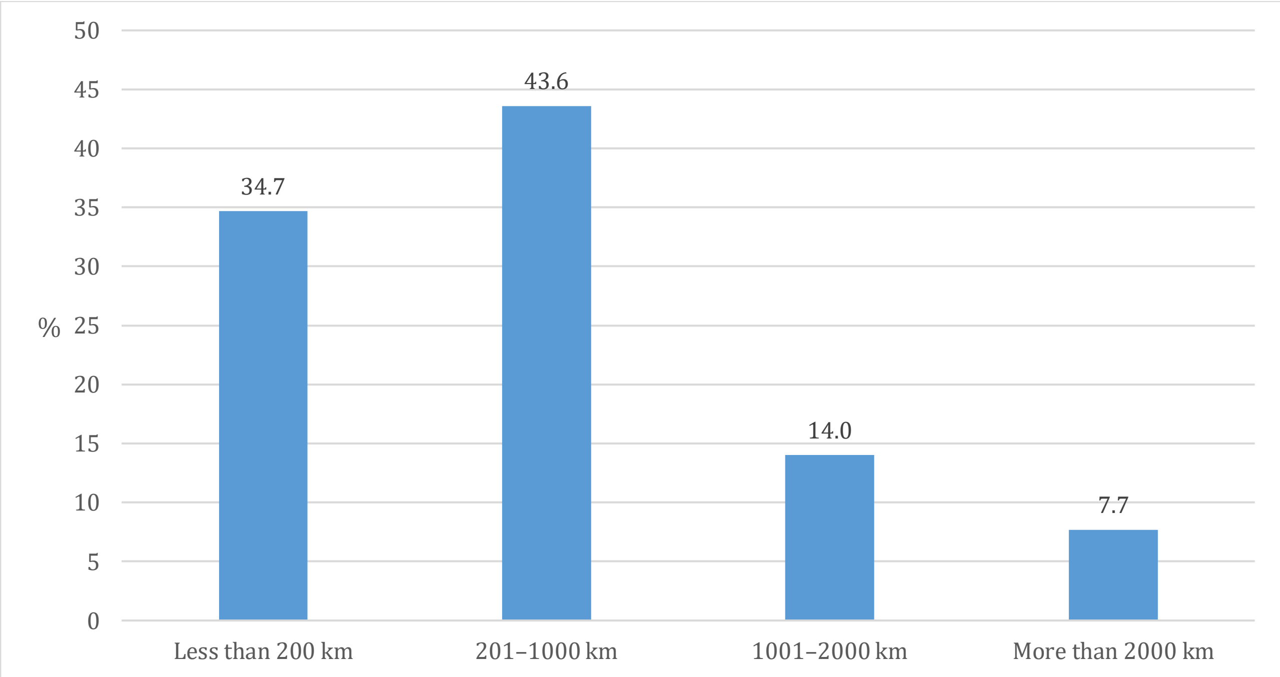

Figure 5. Cyclist respondents' annual cycled kilometres (n=649).

Annual cycled kilometres differed significantly between age groups (X^2=18.55, df=6, p=0.005), and the proportion of those cycling large numbers of annual kilometres reduced noticeably with age (Figure 6). In addition, men cycled more than women (X^2=10.90, df=3, p=0.012; Figure 7).

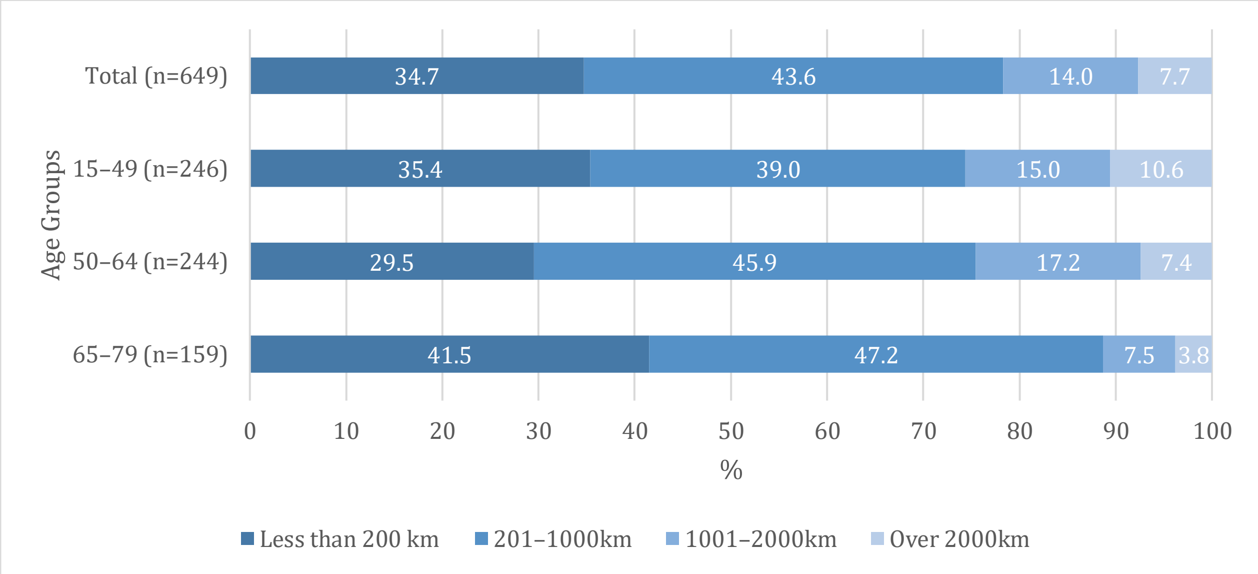

Figure 6. Annual cycled kilometres by age group.

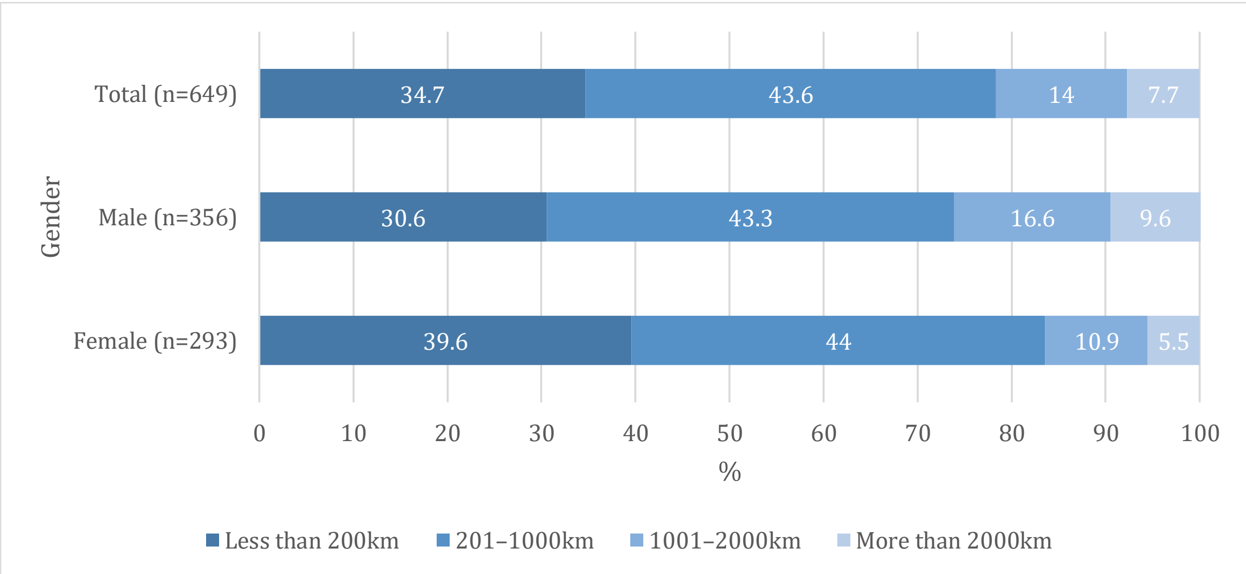

Figure 7. Annual cycled kilometres by gender.

4.2 Collisions between pedestrians and cyclists

The data contained detailed accounts of 21 collisions between pedestrians and cyclists that had occurred in the past three years. In total, 16 respondents (1.5% of all respondents) had experienced a collision. Of them, three had experienced two collisions and one had experienced three or more. Pedestrians reported 18 collisions and cyclists reported three. Of reported collisions, 10 occurred in the capital city region, two in Turku and one in all other cities (except for Lahti, which contained none). Most accidents had occurred on pedestrian paths (7) and shared pedestrian and cycle paths (6), followed by pedestrian crossings (4), shared pedestrian cycle path with separate lanes (3) and at a junction between a pedestrian and cycle path (1).

Figure 8 presents the best fitting event descriptions for collisions. Most descriptions fit within three crash types: the parties were travelling in the same, perpendicular or opposite directions.

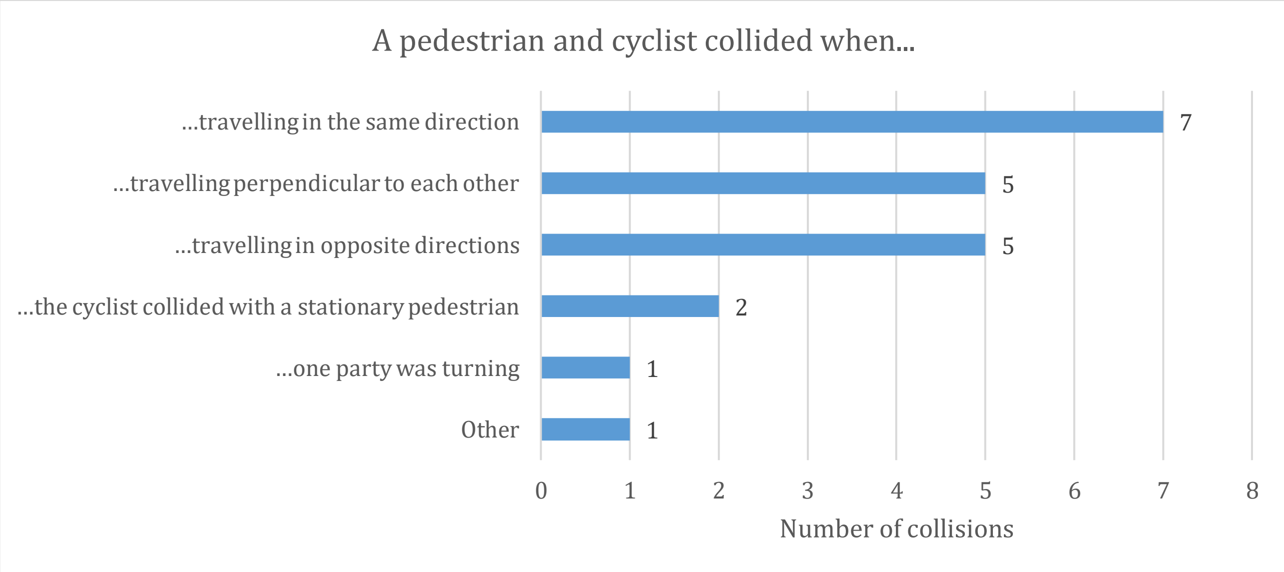

Figure 8. Event descriptions for collisions between pedestrians and cyclists. The "other" answer refers to a situation in which a cyclist fell while attempting to pass a dog off leash.

4.2.1 Factors contributing to accidents

Table 4 presents factors related to the behaviour of involved parties which respondents felt contributed to collisions. Respondents were allowed to choose several factors per collision. Cyclists were most reported to make observation errors, cycle too fast or break traffic rules. Pedestrians were also commonly reported to make observation errors. In almost all cases, pedestrians related the contributing factor to the cyclist's behaviour. Cyclists more often related factors to their own behaviour and that of pedestrians'.

Table 4. Factors related to pedestrian and cyclist behaviour contributing to accidents.

Contributing factor	Related to pedestrian behaviour			Related to cyclist behaviour		
	Self-reported	Cyclist-reported	Total	Self-reported	Cyclist-reported	Total
Observation error	3	2	5	1	10	11
Excessive speed				1	16	17
Unexpected manoeuvre	1	1	2		2	2
Mobile phone use				1	1	2
Headphone use	1		1		1	1
Rule violation					11	11
Intentional action					2	2
Total	**5**	**3**	**8**	**3**	**43**	**46**

Respondents were also asked whether environmental elements contributed to collisions. Only four responses were received:

- Poor visibility
- Tunnel or underpass feature obstructing visibility
- Visual obstruction caused by another vehicle
- Some other visual obstruction

Most respondents (52%, n=11) considered the collision they had experienced a coincidence with no clear cause. Three respondents mentioned a dog being walked and its owner, and one respondent mentioned a pedestrian with a small child having contributed to the accident. The data contained five "other" answers and three "don't know" answers.

In all, 15 respondents had injured themselves in an accident, three damaged their possessions, two visited a healthcare centre as a result of a collision and one respondent's injuries required a hospital stay. Injuries requiring medical attention accounted for 20% of the injuries reported in the data. Six respondents reported no consequences due to the accident.

4.3 Near accidents between pedestrians and cyclists

4.3.1 Frequency of near accidents

A total of 354 respondents, or 33.8% of respondents, had experienced at least one near accident between a pedestrian and cyclist in the past three years. Respondents has experienced near accidents in the following way:

- 20.1% one near accident
- 23.2% two near accidents
- 11.0% three near accidents
- 45.8% more than three near accidents

Relative to the number of respondents from each city, the greatest proportion of respondents having experienced a near accident were from the capital city region (41.9%). The second largest proportion was in Tampere 37.9%, followed by Turku (32.3%), Oulu (30.4%), Jyväskylä (28.0%), Kuopio (27.8%) and Lahti (19.0%).

Assuming that the final category contains no more than four near accidents, respondents reported 1,001 near accidents in total [354*(1*20.1% + 2*23.2% + 3*11.0% + 4*42.8%)]. As respondents reported 21 collisions, the number of near accidents is 47.7 times larger. As the final category almost certainly contained more than four near accidents for some respondents, this ratio is bound to be larger. We can therefore estimate that the data contains approximately 50 times more near accidents than collisions.

Respondents were asked to provide information on a maximum of two near accidents, resulting in 637 detailed near accident accounts. In most cases, the respondent was a pedestrian (64.6 %), with the proportion of cyclists at 36.3%. The oldest age group contained the largest proportion of respondents who had experienced a near accident as a pedestrian (79.6%) (X^2=19.5, df=2, p<0.001) (Figure 9).

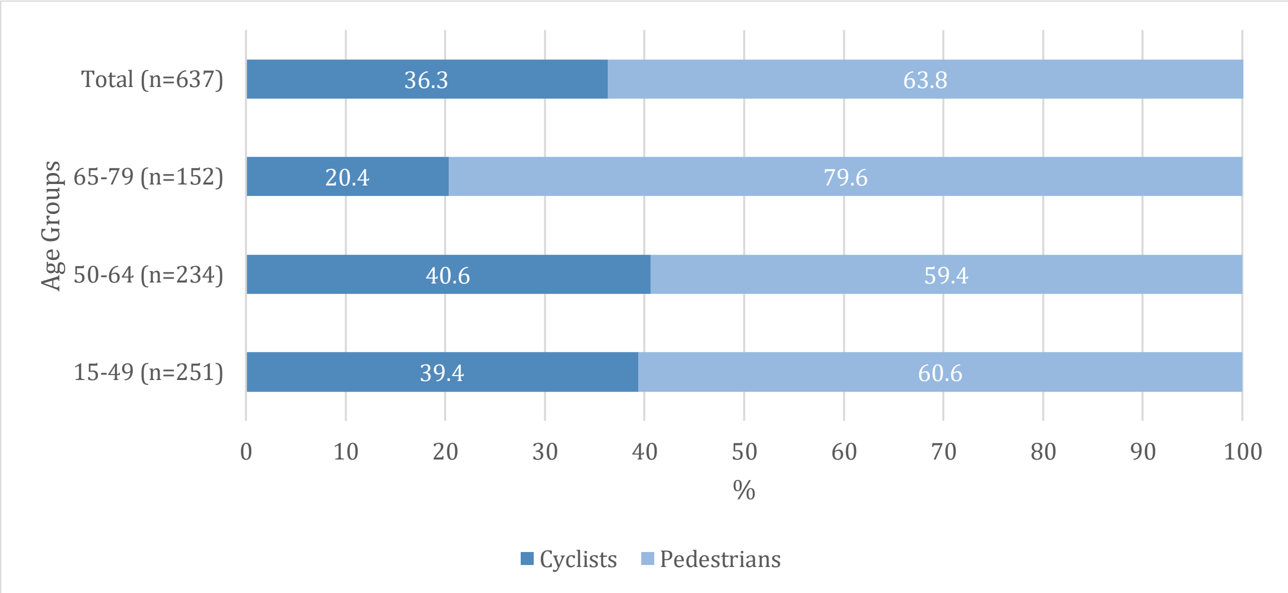

Figure 9. Respondents' travel mode in near accidents by age group.

Most near accidents described in detail occurred on shared pedestrian and bicycle paths and pedestrian paths (Figure 10). The distribution is similar to collision environments, although shared pedestrian and cycle paths were more common than pedestrian paths for near accidents.

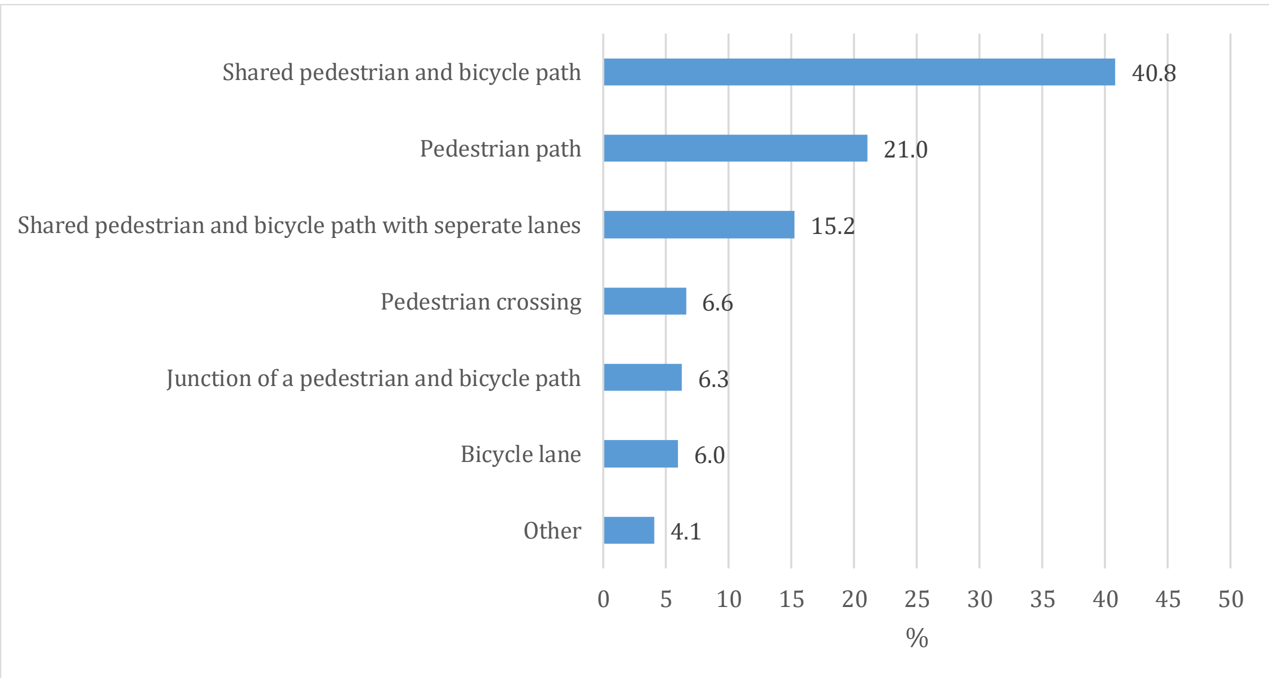

Figure 10. Near accident road environments (n=637).

Figure 11 presents the closest possible event descriptions for detailed near accident accounts. In the most frequent event type, the cyclist and pedestrian were travelling in the same direction, similar to the collision data.

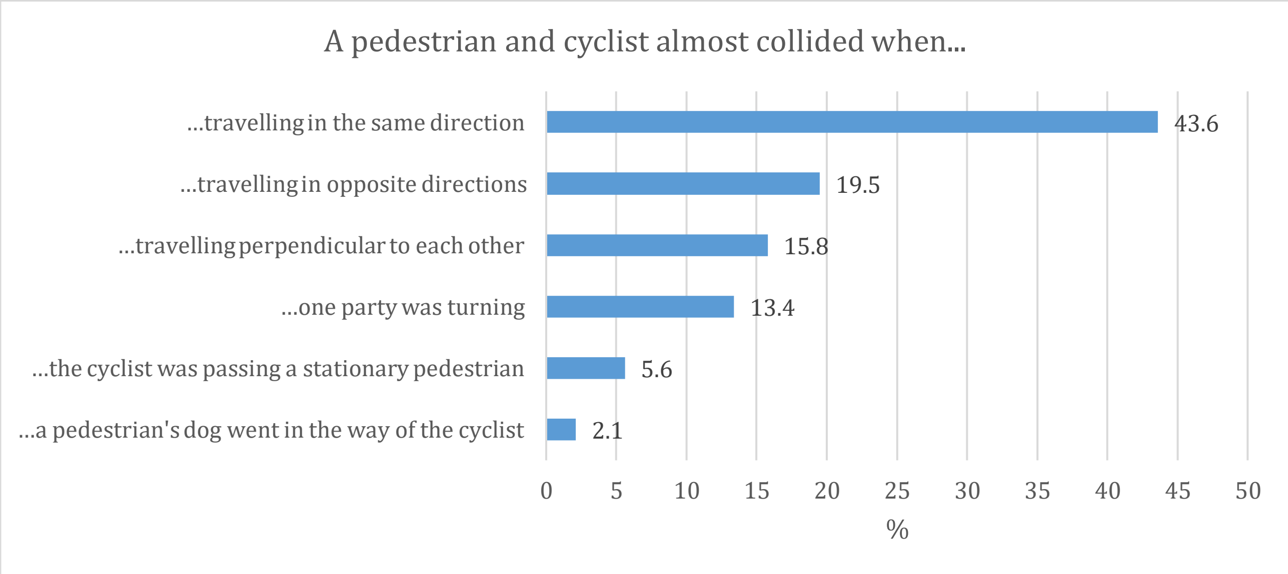

Figure 11. Near accident event descriptions (n=626. 11 irrelevant "other" answers were excluded).

Figure 12 presents the four most frequent near accident event types according to the four most frequent road environments. Significant differences were observed between the distributions (X^2=67.8, df=9, p<0.001). Events in which the involved parties were travelling in the same direction were most frequent on both types of shared paths and pedestrian paths. Events in which involved parties approached from perpendicular directions were most frequent on pedestrian crossings.

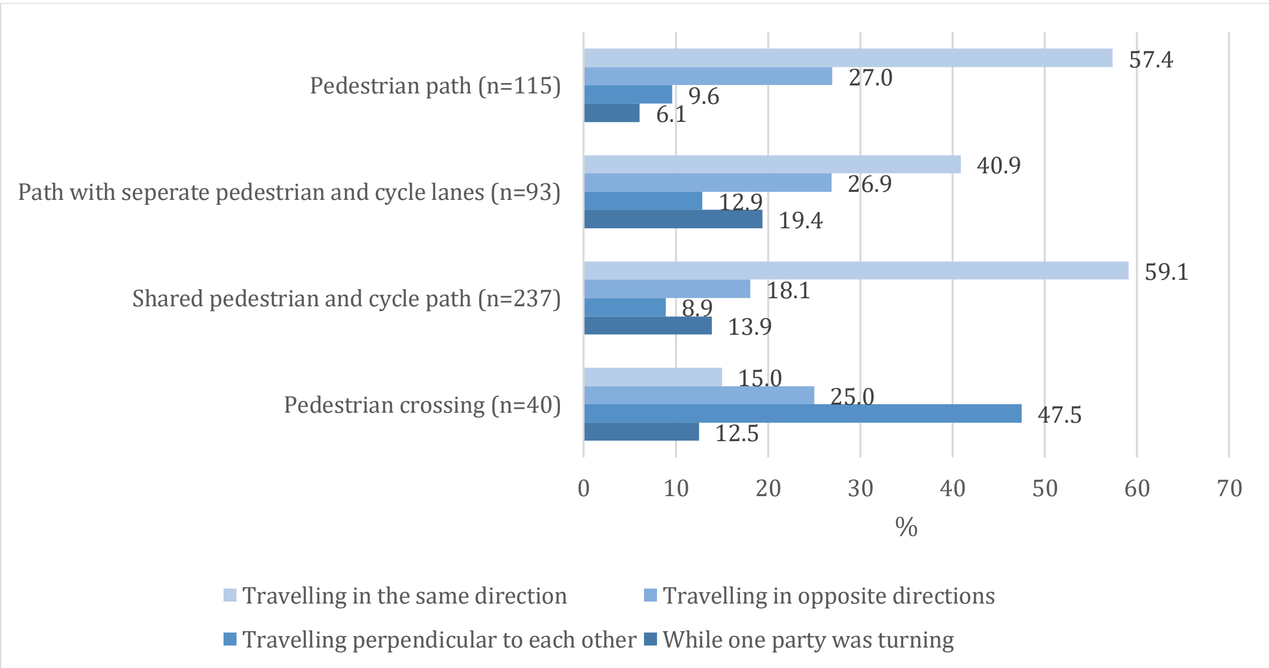

Figure 12. Proportions of the four most common near accident types according to the four most common road environments.

4.3.2 Factors contributing to near accidents

Table 5 presents factors related to the behaviour of involved parties that respondents felt contributed to near accidents. Respondents were allowed to choose more than one factor for each near accident they had experienced. Like the collision data, considerably more factors were directed at cyclists than pedestrians. This is likely somewhat due to large pedestrian reporting of near accidents.

Pedestrians' unexpected manoeuvres, observation errors and mobile phone use emerged the most frequently reported contributing factors related to pedestrians and were frequently reported by both pedestrians and cyclists. The most frequently reported factors concerning cyclists were excessive speed, observation errors and rule violations. Both pedestrians and cyclists frequently reported these factors, although cyclists self-reported rule violations less. All "don't know", "unsure" and "other" answers were removed. In total, 145 of them were directed at pedestrians and 324 at cyclists.

Table 5. Factors contributing to near accidents, which relate to involved parties. Respondents were allowed to select more than one factor per near accident (n=1,550).

Contributing factor	Related to pedestrian behaviour				Related to cyclist behaviour			
	Self-reported	Cyclist-reported	Total		Self-reported	Pedestrian-reported	Total	
Observation error	82	72	154	27.4%	57	128	185	18.7%
Excessive speed	2	3	5	0.9%	47	332	379	38.4%
Unexpected manoeuvre	35	153	188	33.5%	24	86	110	11.1%
Mobile phone use	18	71	89	15.8%	11	47	58	5.9%
Headphone use	9	36	45	8.0%	8	37	45	4.6%
Rule violation	4	37	41	7.3%	9	138	147	14.9%
Intentional action	1	10	11	2.0%	4	44	48	4.9%
Intoxication	2	13	15	2.7%	0	6	6	0.6%
Lack or reflector or light	4	10	14	2.5%	3	7	10	1.0%
Total	157	405	**562**		163	825	**988**	

Figure 13 presents environmental factors that respondents felt contributed to near accidents relative to the total number of reported near accidents (637). Respondents were able to choose more than one option. "Unintuitive or complex infrastructure" was the most frequently reported factor, but "a nearby object reducing visibility" (9.7%) and "physical barriers" (8.8%) were also frequently reported. Respondents appeared to encounter some difficulty identifying environmental factors, as 291 respondents did not report a factor, and 111 "other" answers were deemed irrelevant.

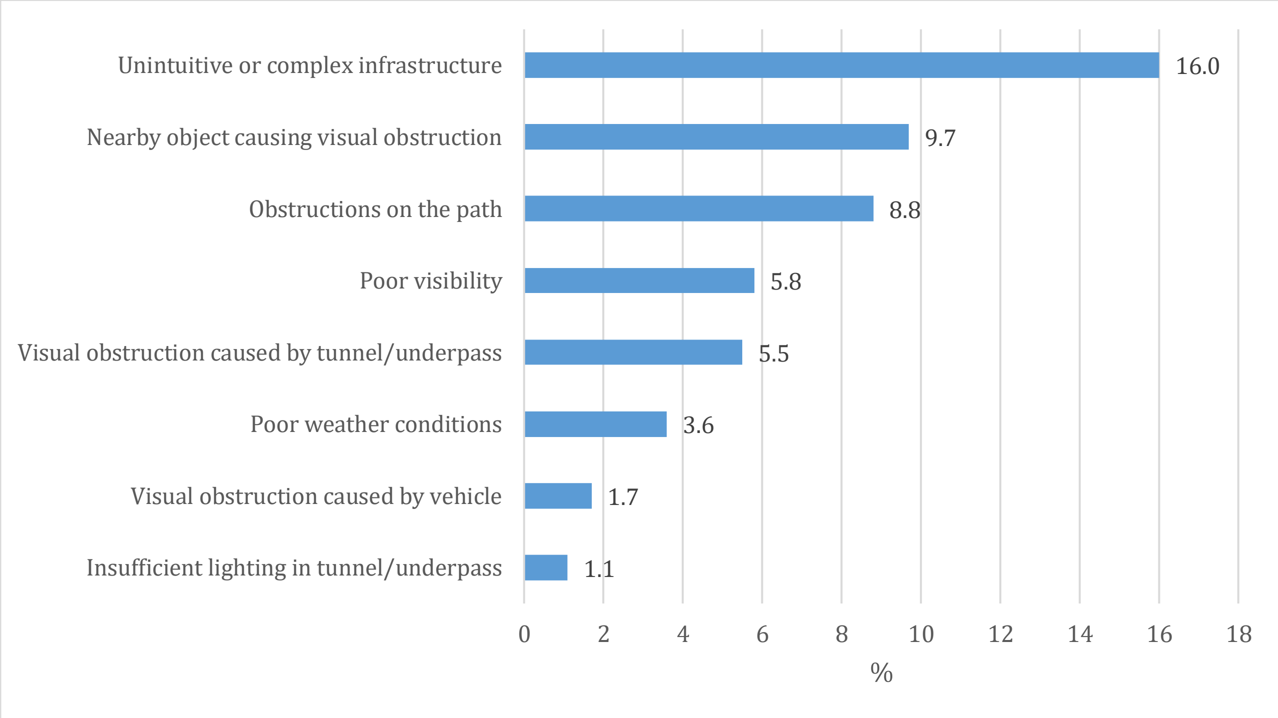

Figure 13. Environmental factors contributing to near accidents relative to all near accidents (n=637 per factor).

Finally, respondents were given an opportunity to mention any further details related to near accidents they had experienced in an open-ended question. Most of these responses related to the behaviour of pedestrians or cyclists. The main cyclist-related issues related to adults cycling on pedestrian paths and not giving way to pedestrians at pedestrian crossings. In addition, respondents expressed concern over cycling between buses and bus stops while passengers embarked or disembarked.

The main pedestrian related issues concerned unexpected manoeuvres on shared paths, walking on the left side of the path (although this is not required by law), walking abreast in groups as well as the unexpected manoeuvres of dogs. Both types of shared paths were criticised for road users not always travelling on the right side of the path, or the correct lane. Finally, several elderly respondents mentioned difficulty avoiding cyclists on shared paths and feeling unsafe on them as a result.

4.4 Sense of safety in traffic

This chapter presents results concerning pedestrians' and cyclists' sense of safety in traffic. Respondents were asked to state how much they agreed or disagreed with a set of statements, and answered from a pedestrian perspective if they reported walking trips of at least 300 meters once a month or more and answered from a cyclist's perspective if they reported cycling trips at least once a month during summer.

Differences in responses were analysed with ordinal logistic regression models. To comply with the assumption of independent observations in logistic regression (see Chapter 3.2.1), cyclist respondents were removed from the pedestrian sample. Therefore, the data used for the OLR models contained 387–397 pedestrian responses and 633–643 cyclist responses for each statement.

As the pedestrian sample discussed in this chapter and used to fit the models is different to the full pedestrian sample due to the removal of observations, it is necessary to check whether the representativeness of the subset and full sample differ meaningfully. Typical walking distance differed significantly compared to the full survey sample, with a slightly greater representation of shorter trips (X^2=13.365, df=3, p=0.004). However, the differences remain relatively small and unlikely to sway conclusions. Typical walking frequency did not differ (X^2=1.39, df=3, p=0.708). Age distributions differed significantly, with a slightly larger proportion of older respondents in the sample used to fit the models (X^2=15.05, df=5, p=0.010). However, as age is controlled for in the models, the difference in distributions is of little consequence. Finally, the gender split (X^2=2.64, df=1, p=0.104) and distribution cities of residence among respondents did not significantly differ (X^2=8.41, df=4, p=0.071). Based on the above, the representativeness of the pedestrian sample used to fit the OLR models only slightly differs from the full sample with little effect on conclusions drawn. Distributions of respondent characteristics which differed significantly are presented in Table 6.

Table 6. Typical walking frequency and age distributions between the pedestrian sample used in OLR models and the full survey sample, which differed significantly (p<0.05).

Pedestrian sample	Typical walking distance (%)				Age (%)					
	< 1 km	1–3km	4–10km	11–20km	15–17	18–24	25–34	35–49	50–64	65–79
OLR models (n=397)	23.7	61.5	14.6	0.3	0.3	1.5	7.3	14.1	38.3	38.5
Full sample (n=1,043)	18.3	58.9	22.3	0.5	0.5	1.9	9.7	20.3	37.9	29.8

Table 7 shows that the majority of both pedestrians and cyclists were happy to walk on shared paths with separate lanes and considered them safe, with cyclists responding slightly more positively to these statements. In contrast, shared paths without separate lanes were considered more dangerous and willingness to use them was lower, although cyclists regarded them somewhat more positively. Most pedestrian respondents felt that cyclists were not considerate toward them in traffic, whereas other pedestrians were. Similarly, cyclist respondents felt that pedestrians are not considerate toward them in traffic, but other cyclists were.

*Table 7. Response distributions to questions regarding sense of safety in traffic. *Only pedestrian respondents, **Only cyclist respondents.*

Statement	Response	Pedestrian respondents (%)	Cyclist respondents (%)
1. A shared pedestrian and bicycle path with separate lanes is safe.	Disagree Neutral Agree	15.7 22.6 61.7	14.2 16.5 69.3
2. I am happy to travel on a shared pedestrian and bicycle path with separate lanes.	Disagree Neutral Agree	12.9 22.6 64.5	8.5 17.2 74.2
3. A shared pedestrian and bicycle path is safe.	Disagree Neutral Agree	47.2 26.4 26.4	32.2 31.6 36.2
4. I am happy to travel on a shared pedestrian and bicycle path.	Disagree Neutral Agree	38.2 32.0 29.7	19.9 34.1 46.0
5. & 6. Pedestrians are generally considerate towards [other pedestrians* / cyclists**].	Disagree Neutral Agree	11.7* 25.7* 62.6*	37.5** 33.0** 29.5**
7. & 8. Cyclists are generally considerate towards [pedestrians* / other cyclists**].	Disagree Neutral Agree	64.1* 20.0* 15.9*	30.0** 34.5** 35.6**

Differences in responses according to gender, age and whether the respondent was a cyclist or pedestrian were explored by fitting an ordinal logistic regression model for each statement. The effect of “pedestrian or cyclist” was not tested for statements 5–8, as responses to these were based on this criterion already. Model assumptions held for all statements except statement 4, which failed the proportional odds assumption for gender. Therefore, a partial-proportional odds model was fitted for this variable. Odds ratios and their conference intervals for factor levels are presented in Table 8 and Table 9. A statistically significant result is indicated by an odds ratio that is not exactly 1.0 and a 95% confidence interval which does not contain 1.0.

The table also presents results of likelihood-ratio goodness-of-fit tests for the models. A statistically significant result ($p<0.05$) indicates that including the independent variables in the model significantly improves model fit and that the model is serviceable (Hosmer, et al. 2013, pp. 276–278). Including age and gender as independent variables did not produce well-fitting models for statements 5, 6 and 7. Moreover, Chi-Square Tests of Independence based on age group and gender were computed for responses to statements 5, 6 and 7, but no statistically significant associations were detected on the 95% confidence level.

For age, the odds ratios can be interpreted so that for 1 unit increase in age, the odds of answering more favourably ("agree" or "neutral" vs "disagree") is multiplied by the odds ratio. For example, the odds of answering "agree" or "neutral" over "disagree" is multiplied by 0.98 for every 1 unit increase in the age variable in statement 1, indicating that older respondents are less likely to agree, holding other variables constant.

For the other variables, the odds ratios can be interpreted as cyclists compared to pedestrians and females compared to males. To exemplify, the odds that a cyclist answered "agree" or "neutral" over "disagree" to statement 1 is 1.53 times that of a pedestrian, holding other variables constant. Likewise, the odds of a female respondent answering "agree" or "neutral" over "disagree" is 0.7 times that of males, (or [(1 - 0.70) * 100 = 30%] lower than males).

The interpretation of results concerning statement 4 is somewhat different due to the proportional-odds assumption being relaxed for gender. Here, the odds of a female respondent answering "agree" over "neutral" or "disagree" is 0.92 (non-significant result) times that of males, and the odds of answering "agree" or "neutral" over "disagree" is 0.58 times that of males. However, only the latter effect is statistically significant.

Interpreting the models may be easier by looking at Figure 14 and Figure 15, which show predicted probabilities for all response options for all combinations of gender, age and pedestrian or cyclist computed by the models. Predicted probability plots were not made for statements 5, 6 and 7 due to poor model fits.

For statements 1–4, we can conclude from the model results that:

- Cyclists were more likely to answer favourably compared to pedestrians, although the result is not significant for statement 3.
- Females were less likely to answer favourably compared to males.
  - Females also had lower odds for answering favourably relative to men for statement 4. However, only the odds ratio for females answering "agree" or "neutral" over "disagree" compared to males is statistically significant.
- Respondents were less likely to answer favourably as age increased.

For statement 8, the odds ratios suggest that:

- Younger cyclist respondents were likely to agree that cyclists are considerate toward other cyclists in traffic, but older cyclists were more likely to disagree.
- The effect of gender is not statistically significant.

*Table 8. Odds ratios and their 95% confidence intervals for factor levels. Significant (p<0.05) effects are marked in bold. *Only pedestrian respondents, **only cyclist respondents.*

Model	Odds Ratio [95% Confidence Interval]			Likelihood ratio test
	Cyclist (ref: pedestrian)	Female (ref: male)	Age	
1. Shared paths are safe	**1.53 [1.21–1.96]**	**0.69 [0.55–0.86]**	**0.98 [0.97–0.99]**	**LR X^2=55.76 Df=3 p<0.001**
2. I am happy to travel on shared paths	**2.00 [1.57–2.54]**	**0.67 [0.53– 0.84]**	**0.98 [0.97–0.99]**	**LR X^2=73.48 Df=3 p<0.001**
3. Shared paths with separate lanes are safe	1.20 [0.92–1.57]	**0.74 [0.58–0.96]**	**0.98 [0.97–0.99]**	**LR X^2=21.53 Df=3 p<0.001**
5. Pedestrians are considerate toward other pedestrians*		**0.65 [0.43–0.97]**	0.99 [0.98–1.01]	LR X^2=5.11 Df=2 p=0.078
6. Pedestrians are considerate toward cyclists**		0.76 [0.58–1.03]	0.99 [0.98–1.00]	LR X^2=4.22 Df=2 p=0.121
7. Cyclists are considerate toward pedestrians*		0.89 [0.59–1.33]	**0.99 [0.97–0.99]**	LR X^2=4.68 Df=2 p=0.096
8. Cyclists are considerate toward other cyclists**		0.94 [0.71–1.26]	**0.99 [0.98–0.99]**	**LR X^2=6.51 Df=2 p=0.039**

Table 9. Odds ratios and 95% confidence intervals from partial-proportional odds model for "Happy on shared path with separate lanes" with the proportional odds assumption relaxed for factors "Age" and "Gender". Significant (p<0.05) effects marked in bold.

Model	Factor	OR [95% CI]	Likelihood ratio test
4. I am happy to travel on shared paths with separate lanes	Age	**0.98 [0.97–0.99]**	**X^2=30.85 Df=4 p<0.001**
	Gender: 3 vs. 2 or 1	0.92 [0.70–1.21]	
	Gender: 3 or 2 vs. 1	**0.58 [0.38–0.89]**	
	Cyclist (ref: pedestrian)	**1.43 [1.08–1.88]**	

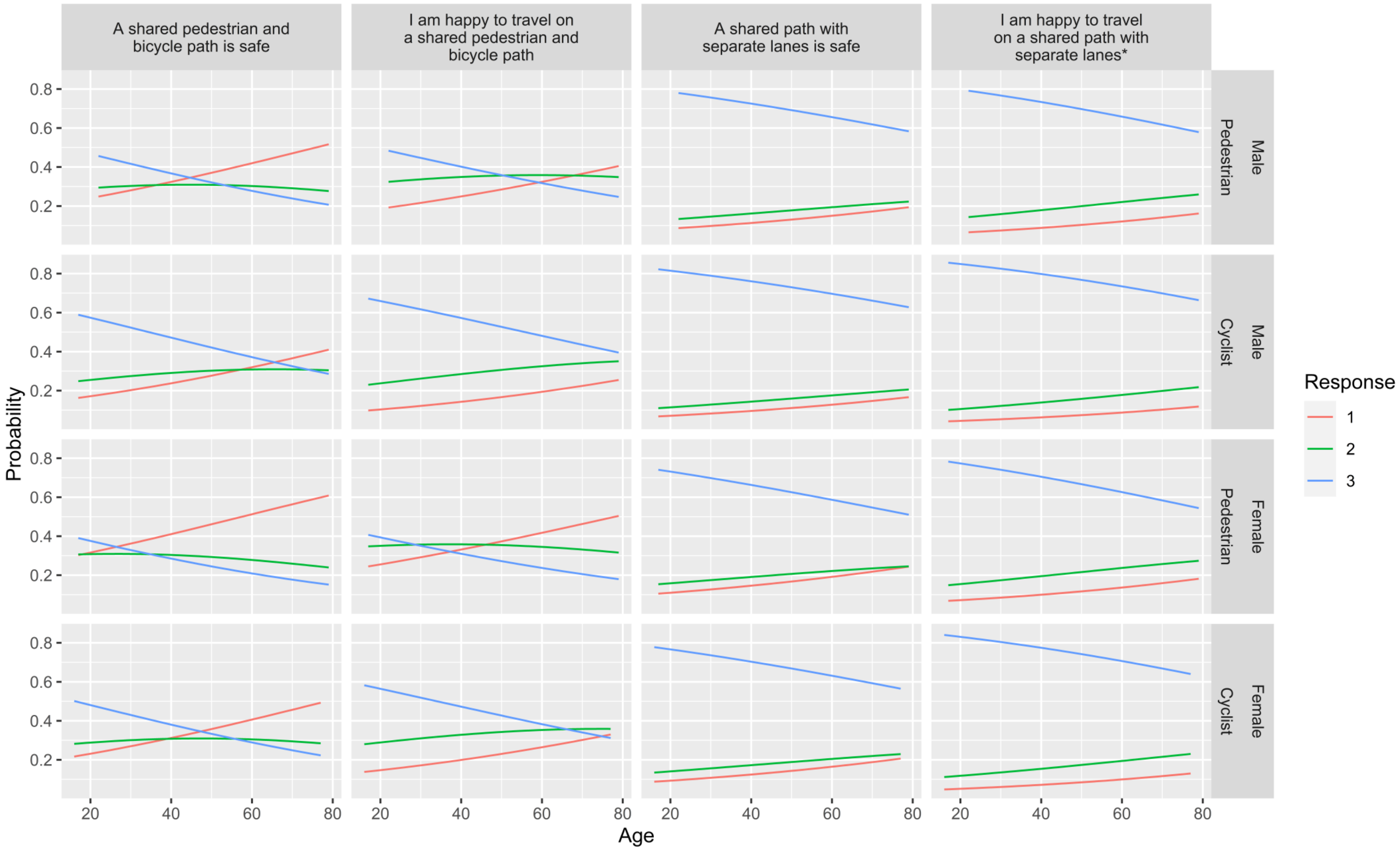

*Figure 14. Predicted probabilities for responses to statements based on gender, age and mode combinations. Probabilities range from 0–1. 1 = Disagree, 2 = Neutral, 3 = Agree. *Partial-proportional odds model.*

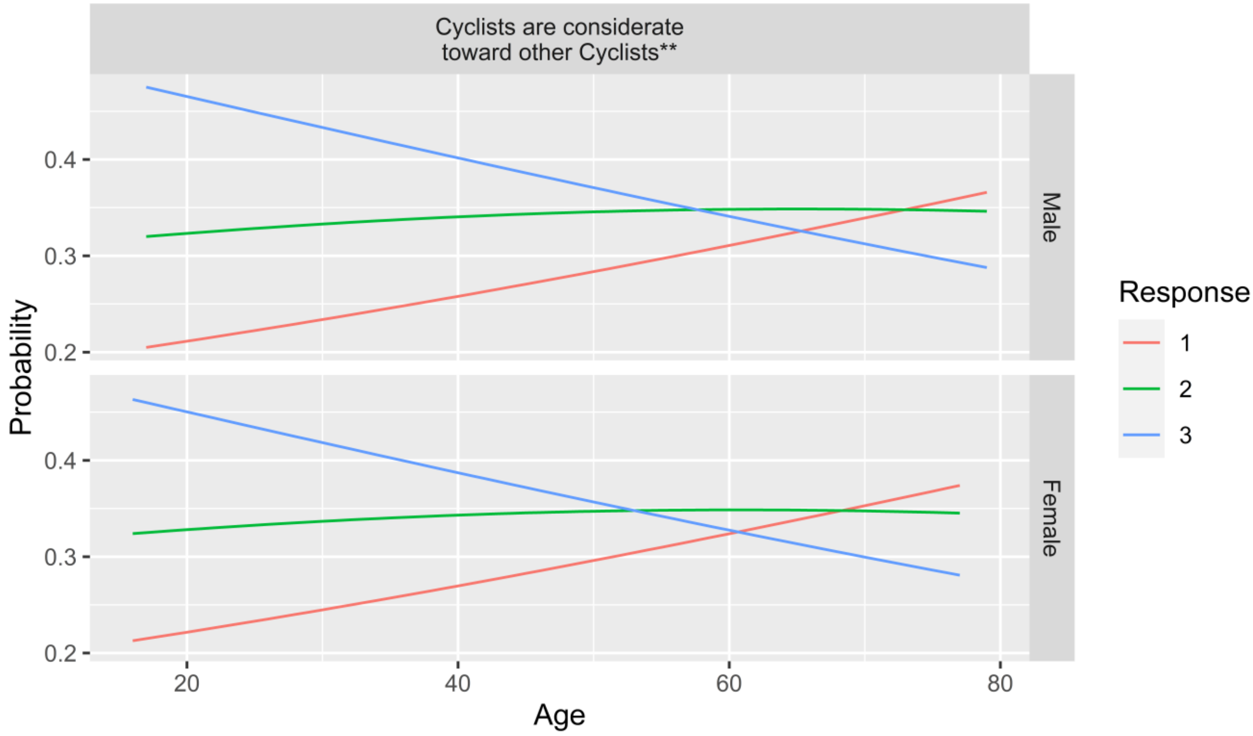

*Figure 15. Predicted probabilities for responses to statement 8. **Only cyclist respondents. 1 = Disagree, 2 = Neutral, 3 = Agree.*

4.4.1 Prevention of accidents and near accidents

Finally, respondents provided suggestions for how accidents and near accidents between pedestrians and cyclists could be prevented. A total of 615 responses were obtained and categorised. The ten most frequently mentioned suggestions are presented in Figure 16. The most frequent suggestions were lower cyclist speed (19.3%), clearly marked separate lanes for pedestrians and cyclists (17%) and greater overall attentiveness in traffic (16.9%).

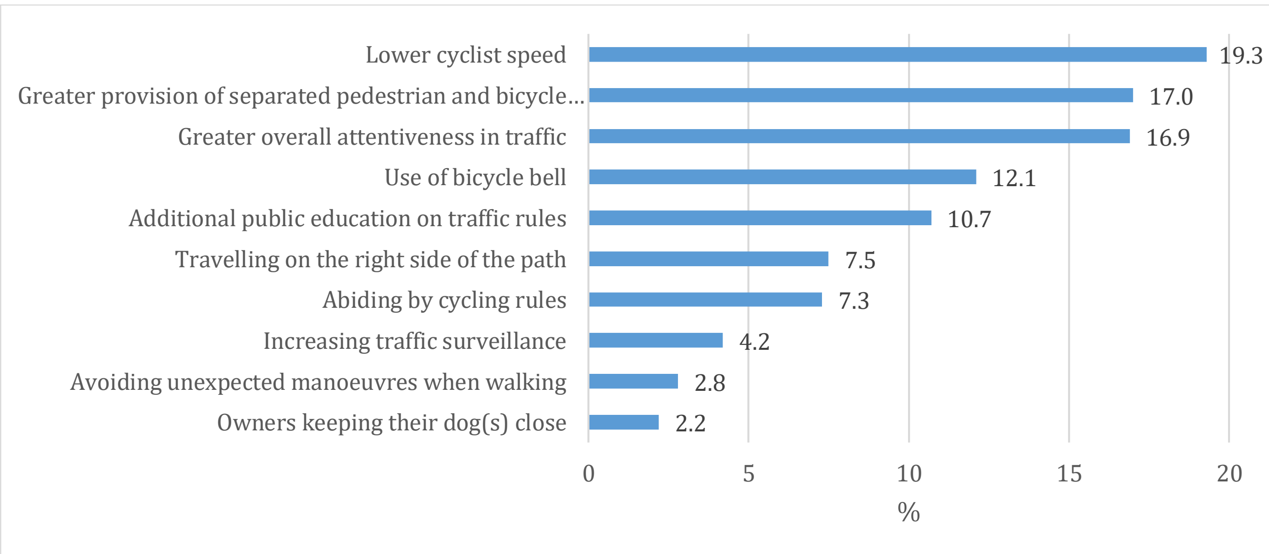

Figure 16. The ten most frequent answers to the question "What would you suggest to prevent collisions and near accidents between pedestrians and cyclists?" (n=615).

5 Discussion

The research objectives of this thesis are:

> **RO1.** Investigate the characteristics of near accidents and collisions between pedestrians and cyclists and assess pedestrians' and cyclists' sense of safety in traffic.
> **RO2.** Investigate how safety issues found in RO1 might constrain uptake of the practices of walking and cycling.

To answer these questions, the experiences of 1,046 survey respondents from Finnish cities with populations over 100,000 were examined. The characteristics of collisions and near accidents are discussed first (5.1), followed by an analysis of the rapport between pedestrians and cyclists (5.2). The chapter then addresses how constraints to cycling and walking might be overcome (5.3), before closing the chapter by briefly mentioning the limitations of the research (5.4). Each sub-chapter first contributes to the answer to RO1, followed by RO2.

The background data of respondents indicate that on average, they walk slightly more frequently, cycle slightly less frequently and travel greater distances than results in the 2016 National Travel Survey (Finnish Traffic Agency, 2018a). However, the results of the National Travel Survey consider the entire country and contains a large proportion of walking trips less than 1 kilometre in length. Furthermore, it is possible that individuals who travel longer distances were more motivated to participate in the survey.

5.1 Characteristics of collisions and near accidents

Only a small proportion (1.7%) of respondents had experienced at least one collision between a pedestrian and cyclist during the last three years. Details from a total of 21 collisions were gathered, 18 of which were pedestrian-reported and 3 were cyclist-reported. As collisions between pedestrians and cyclists are relatively rare (Airaksinen et al. 2010; Pyyhtiä 2019; O'Hern and Oxley 2019), the small sample of collisions returned by the survey was expected.

These findings concerning collisions are similar to those in the City of Helsinki's safety survey (Pyyhtiä, 2019). If the results of both surveys are examined from one year only, and if each survey had the same sample size, the results of this survey would contain 7 collisions, of which pedestrians reported 6 and cyclists 1. The corresponding figures for Pyyhtiä (2019) would be 6 collisions, of which pedestrians reported 4 [17*(1046/4155) ≈ 4] and cyclists 2 [6*(1046/4155) ≈ 2]. When accounting for random variation, the differences between the results can be considered relatively small.

A total of 15 reported collisions resulted in the respondent's injury, but only two respondents sought medical attention as a result. Additionally, only three respondents reported the collision they had experienced to the police. As such, these collisions have been hardly captured by official traffic safety statistics or hospital datasets. This finding supports Kautiala and Seimelä (2012) and Airaksinen et al. (2010), who indicate that Finnish cyclist and pedestrian traffic accident statistics suffer from poor coverage.

The survey results contain a much greater set of near accidents than collisions. A total of 33.8% of respondents had experienced a near accident in the past three years, and detailed accounts of 637 near accidents were obtained. Almost half of all respondents who reported a near accident had experienced more than three. These findings complement observational studies by Haworth et al. (2014) and Hatfield and Prabhakharan (2016), in which near accidents were also much more frequent than collisions. Furthermore, respondents with the greatest number of annual cycled kilometres had mainly experienced three or more near accidents, complementing Aldred and Crosweller (2015), who found that near accidents occur almost daily for those who cycle a large number of kilometres annually in the UK, as well as Sanders (2015), who found a strong positive correlation between cycling frequency and having experienced a near accident.

According to these results, near accidents occur often, but collisions are rare, with approximately 50 near accidents occurring for every collision. It is however highly probable that this ratio is even greater, as respondents were not able to report over 4 near accidents. Poulos et al. (2017) calculated a corresponding ratio of 35.8 to 1. However, participants in Poulos et al. (2017) were only asked to report the three most serious near accidents per day, potentially creating a bias towards near accidents involving motor vehicles. Considering such differences in measurement, random variance and environmental differences between the study sites, the ratio of 50 near accidents per collision can be considered relatively similar and in support of the same conclusion. Sanders' (2015) survey study also concluded that near accidents were much more frequent than collisions, but only considered events between cyclists and motor vehicles.

Most collisions and near accidents occurred on footpaths and shared pedestrian and cycle paths. This result is also in line with previous studies, in which shared spaces for pedestrians and cyclists have been found to be relatively dangerous (De Rome et al., 2014; Cripton et al., 2015; Beck et al., 2016; Poulos, et al. 2017). Haworth et al., (2014) also found that cycling on footpaths increased the risk of near accidents between cyclists and pedestrians. Furthermore, Cripton et al., (2015) found that cyclist accidents on footpaths and shared pedestrian and cycle paths are more likely to result in hospital transport than cyclist accidents on roads without cycle lanes.

However, on shared paths with separate lanes, the number of collisions halved and the number of near accidents more than halved. This complements findings by Hatfield and Prabhakharan (2016), who found shared spaces to be associated with issues of space ownership and noted cyclists to engage in safer behaviour on shared paths with separate lanes. Unlike Haworth and Schramm (2011), the survey results contained no collisions and a relatively small amount of near accidents on cycle lanes, but this is likely explained by the low provision of dedicated cycle lanes in Finland.

The lowest number of near accidents were recorded on pedestrian crossings. Most pedestrian crossing near accidents involved road users approaching perpendicular to each other. This result is unsurprising, given that pedestrian crossings connect to road types where an encounter with a forward travelling pedestrian or cyclist is possible. Connection points between pedestrian crossings and other paths are potentially dangerous sites for crossing collisions and near accidents.

Both pedestrians and cyclists considered shared bicycle paths less safe and were less willing to use them compared to shared paths with separate lanes, differing somewhat from results in Winters et al. (2012) where shared paths were considered the safest path type despite their relatively high actual risk. Effects concerning sense of safety and willingness to travel on different paths varied significantly by gender, age and between pedestrians and cyclists. In general, older respondents felt less safe on both types of shared paths and were less willing to use them compared to younger respondents. Female respondents also felt somewhat less safe on these paths compared to males, but the effect of gender was not as strong as age. Cyclists generally felt safer and more willing to use the paths than pedestrians, potentially due to their less vulnerable role (Graw & König, 2001; Grzebieta et al., 2011). All effects were weaker for shared paths with separate lanes, suggesting a strong consensus regarding meanings of greater safety of the road type among respondents.

In practice theory terms, the results suggest that near accidents appear to be frequent enough to attach meanings of danger to cycling and walking. This is evidenced by respondents' low sense of safety and low willingness to travel on shared pedestrian and bicycle paths, which featured the highest near accident frequencies. Such paths thus arguably represent material elements of cycling and walking associated with strong meanings of danger, established through negative experiences of space sharing. Conversely, space separation was associated with meanings of greater safety, as respondents were more favourable toward travel on shared paths with separate lanes and considered them safer. Moreover, respondents frequently suggested the spatial separation of cyclists and pedestrians to prevent near accidents, similarly to survey findings in Delaney (2016, p. 151). This relation between the practices' elements of material and meaning represents a constraint to the uptake of cycling and walking, and is supported by Singleton and Wang, (2014), De Souza et al. (2014) and Aziz et al. (2018) who found that infrastructure perceived as dangerous discourages cycling and walking.

At any given time, practices encompass a diverse set of practitioners differing in terms of skill, commitment, experience and personal qualities (Shove et al., 2012, p. 71). In the survey results, this effect is clear from the varying sense of safety across ages and genders. These differences are likely explained by personal qualities and imply differences in the respective thresholds of different groups to become practitioners. For example, elderly female pedestrians felt especially unsafe. Therefore, constraints to walking due to meanings of danger are likely experienced strongest by this group. This effect is understandable based on the particular vulnerability of the elderly in pedestrian-cyclist collisions (Chong et al., 2010; O'Hern and Oxley, 2019; Poulos et al., 2015), their greater perception of accident risks relative to other age groups (Kiyota et al., 2000), their reduced motor functions and greater physical fragility (Oxley et al., 2004). Additionally, in a study by Agrawal et al. (2008), females were more concerned of their safety in traffic than males. Furthermore, the elderly was meaningfully represented in near accidents reported in the survey.

In contrast, young male cyclists had the highest sense of safety, likely explained by lower concern of traffic accident risks associated with young males (Cordellieri et al., 2016) and the lower overall physical vulnerability of younger age groups (Oxley et al., 2004). This indicates that the least influential meanings of danger and associated constraints to cycling are likely associated with this group. These findings highlight how practices may feature inequalities of access determining who can meaningfully participate, resulting in differences in their social distributions (Shove et al. 2012, 47).

5.2 Rapport between pedestrians and cyclists

Most pedestrians and cyclists agreed that road users using the same travel mode as them treated them considerately in traffic, but users of the other mode did not. The finding is similar to survey results in Delaney (2016), although respondents in their survey did not share the sentiment as strongly. A lack of courtesy toward other path users was also noted to contribute to pedestrian-cyclist conflicts in Ker (2006). This finding is indicative of poor rapport and low respect between the practices, further supported by the large number of near accidents occurring on shared pedestrian and bicycle paths. The finding is unsurprising, as pedestrians are arguably the most vulnerable road users when pedestrians and cyclists share the same space (Graw & König, 2001; Grzebieta et al., 2011).

Age and gender had little effect on responses to how cyclists and pedestrians considered each other in traffic. Of the only well-fitting model, significant associations were detected concerning age for the statement "Cyclists are generally considerate toward other cyclists", which was only asked of cyclist respondents. Older cyclists had significantly lower odds of agreeing that cyclists considered other cyclists well compared to younger cyclists, which is likely explained by the status of the elderly as especially vulnerable road users compared to younger age groups (Poulos et al., 2015; O'Hern & Oxley, 2019). The finding highlights the possibility that cyclist-cyclist safety issues also affect sense of safety, but these are beyond the scope of the present study.

Respondents were asked to report factors they estimated to contribute to the collisions and near accidents they had experienced. The most reported factors directed at cyclist behaviour were "excessive speed", "observation error" and "rule violation". The respective factors directed at pedestrian behaviour were "unexpected manoeuvre", "observation error" and "mobile phone use". Issues of unexpected pedestrian manoeuvres and excessive cyclist speeds have also been noted by Hatfield and Prabhakharan (2016), Delaney (2016) and Poulos et al. (2017).

Respondents did not report factors relating to their own behaviour nearly as often as toward the behaviour of other road users. The low number of self-oriented factors may indicate that respondents did not feel they contributed to the event occurring, were unable to estimate the effect of their own behaviour or did not want to disclose it. It is important to note that respondents were only able to estimate contributing factors based on their own experience, implying that the information concerning events is inherently limited.

The high frequency of respondents reporting observation errors, unexpected manoeuvres, rule violations and excessive speeds are practical indications of the poor rapport and low respect between practices. In practice theory terms, the prevalence of these issues suggests a shortcoming in the elements of competence associated with the practices regarding travel in shared environments, such as collective understandings of how space ought to be shared. The frequent calls for lower cyclist speeds, greater overall attentiveness in traffic and additional education on traffic rules further supports the existence of insufficient space sharing competences and suggests the lack of a collectively understood code of conduct. Support is also provided by Transport for New South Wales (2015) and Delaney (2016), who discovered a lack of norms and differing expectations regarding the use of shared paths. Hatfield and Prabhakharan (2016) similarly noted differing perceptions of space ownership contributing to near accidents on shared paths.

Due to these likely differing expectations for shared spaces, pedestrians and cyclists likely employ different competences and behaviours when travelling on them. Conflicting expectations and competences may then facilitate negative interactions and attitudes between modes. For example, over half of respondents in Delaney (2016) reported being frustrated with another road user upon encountering them travelling in a way contrary to their expectations, despite no actual rules being violated. The result of these encounters were negative perceptions of other road users, impacting their attitudes to sharing space.

These issues of low respect, conflicting expectations and competences may also explain why a low sense of safety was strongly associated with travel on shared paths despite only a rough third of respondents having experienced either a collision or near accident. They also help explain the poor safety record of shared paths, fuelling meanings of danger associated with them and the practices themselves, constraining uptake of the modes. Finally, these attitudes and differing expectations may also shed light on why the most frequent collision and near accident type involved both parties travelling in the same direction. In most cases, this situation likely involved the cyclist approaching the pedestrian. It is not difficult to infer how unexpected pedestrian manoeuvres, excessive cyclist speeds and observation errors committed by both road users could easily lead to such events in environments where space is shared.

Bundles of practices performed in shared physical environments can "condition each other in different ways and with varied consequences", potentially leading to competitive relationships (Shove et al. 2012, p. 86). As such, infrastructure shared by both pedestrians and cyclists represent "zones of overlap" and "points of connection" between the practices, which enable these interactions to occur (Shove et al., 2012, p. 113). Based on the safety issues uncovered in the survey results, walking and cycling appear to have somewhat competitive relations, evidenced by frequent near accidents largely facilitated by the material element of shared infrastructure and shortcomings concerning competences of space sharing. The survey results provide insight into how the practices of walking and cycling have shaped each other, resulting in a low sense of safety and meanings of danger associated with both practices, constraining their uptake. The next chapter discusses how these issues may be overcome.

5.3 Overcoming constraints

If the constraints to walking and cycling identified above are not overcome, other possibly less sustainable and healthy forms of travel may gradually become more attractive, potentially dislodging rates of walking and cycling if they remain sufficiently associated with discouraging meanings. To ensure that cycling and walking are sustained or even grow as practices, connections between their constituent elements must be consistently integrated in a configuration which feeds forward to their likely reproduction (Shove et al., p. 2012). As Shove et al. (2012) explain: "If practices are to survive, they need to capture and retain practitioners willing and able to do this integrating and therefore willing and able to keep them alive" (p. 120).

Shove and Walker (2010) suggest intervening in the elements of practice as means to promote more sustainable behaviours (p. 472). A clear recommendation for overcoming the identified constraints to cycling and walking involves intervening in the material elements of the practices, i.e. the primary zone of overlap between them: the spatial separation of pedestrians and cyclists. Separated pedestrian and cycle lanes were associated with both meanings of greater safety and greater willingness to travel, while shared pedestrian and cycle paths were associated with meanings of greater perceived danger and lower willingness to travel. This measure was also frequently mentioned by respondents as a way to reduce near accidents as well as by study participants in Delaney (2016) and Transport for New South Wales (2015). Hatfield and Prabhakharan (2016) also noted lower cyclist speeds and safer riding behaviour on shared paths with marked centrelines separating modes.

Based on the circuits of reproduction in practice theory, travel on separate paths arguably enables walking and cycling to more likely result in their intended outcomes, i.e. a successful and safe walking or cycling trip, as they feature fewer collisions and near accidents, lowering the chances of a practitioner becoming discouraged to walk and cycle (Shove et al., 2012, p. 114). Moreover, issues concerning poor reciprocity reported by respondents as well as conflicting views on space ownership become less relevant when opportunities for cyclist-pedestrian interactions decrease through changes to the material elements of the practices. By reducing negative interactions by limiting space sharing, hostility between the practices and opportunities for them to be associated with meanings of danger could decline. As sense of safety varied across demographic variables, space separation may be particularly effective to assist groups most concerned by space sharing, such as the elderly, to overcome issues of perceived danger. Dill and Carr (2003) further note that spatially separated cyclist and pedestrian paths can increase sense of safety and lead to increased rates of bicycle commuting.

Constraints to walking and cycling could also be overcome by building the competences necessary for non-disruptive space sharing and overcoming the issue of poor rapport. When asked how near accidents could be reduced, respondents frequently mentioned that better compliance with traffic rules, greater overall attentiveness in traffic, reducing cyclist speeds and the unexpected manoeuvres of pedestrians could reduce near accidents. There is therefore arguably a need for a collectively understood and respected code of conduct for travel on shared paths. Similar calls were also expressed in Delaney (2016) and Transport for New South Wales (2015). Furthermore, the survey results suggest safety benefits from improving the quality and reducing the complexity of transport infrastructure, similarly noted by Christmas et al. (2010), and limiting the disruptive behaviour of dogs being walked, also noted by Ker (2006) and Delaney (2016). Identifying avenues for modifying these elements of competence and material is beyond the scope of this thesis but represent worthwhile opportunities for future research.

5.4 Limitations of the study

The results presented in this thesis are subject to several limitations. First, the survey data is largely based on the memories and experiences of respondents, which implies inherent limitations for its validity. Disclosed information is likely to be incomplete, and the subjective opinions and views of individuals is emphasised. Respondents do not necessarily remember all near accidents which may have occurred to them in the previous three years, or all details of the events they did remember. Additionally, substantially more factors contributing to collisions and near accidents were attributed to the other involved parties, and the survey reached more elderly respondents than young respondents. Respondents also appeared to encounter difficulty identifying contributing factors related to the environment.

6 Conclusion

This thesis investigated the characteristics of near accidents and collisions between pedestrians and cyclists in Finnish cities and assessed these road users' sense of safety of safety in traffic. Inspired by calls to promote cycling and walking as sustainable travel modes, it also investigated how identified safety issues constrain the uptake of walking and cycling by using the three-element interpretation of practice theory by Shove et al., (2012). As such, this thesis represents a contribution to debates concerning barriers to cycling and walking from the perspective of transport safety. Data from an online survey (n=1,046) directed to Finnish cities with over 100,000 population was used to meet the research aims of this thesis.

Near accidents were found to be much more frequent than collisions, with approximately 50 near accidents occurring for each collision. However, as respondents could not report more than 4 near accidents, the ratio is likely greater. In addition, most collisions occurred on pedestrian paths, most near accidents occurred on shared pedestrian and bicycle paths, and most collisions and near accidents involved both road users travelling in the same direction. Shared paths with separate lanes featured half the number of collisions and less than half the number of near accidents compared to shared paths, suggesting safety benefits associated with space separation. Previous research has also highlighted the relative danger of shared paths (Haworth & Schramm, 2011; De Rome et al., 2014; Cripton et al., 2015; Beck et al., 2016; Poulos et al., 2017) and the relative rarity of pedestrian-cyclist collisions (O'Hern & Oxley, 2019; Poulos et al., 2017).

Walking and cycling represent a bundle of practices with somewhat competitive relations, with meanings of danger found to constrain their uptake. These meanings were deemed to be largely facilitated by issues associated with space sharing, such as the high frequency of near accidents, low sense of safety and low willingness to travel on shared infrastructure. Significant effects for sense of safety were detected across genders, age and between pedestrians and cyclists. Elderly pedestrians, especially female, were particularly unhappy to use shared paths and feel safe on them, while younger male cyclists regarded them more positively. Additionally, the poor state of rapport and respect between pedestrians and cyclists, likely induced through frequent negative cyclist-pedestrian interactions, suggest shortcomings of competence associated with shared infrastructure, further constraining cycling and walking. Specifically, this issue hints toward the lack of a collectively understood code of conduct on shared paths, also noted by Delaney (2016).

The benefits of spatially separating pedestrians and cyclists are evident. Shared paths with separate lanes featured fewer collisions and near accidents, with both pedestrians and cyclists feeling safer and more willing to travel on them. The sentiment was also shared across different ages and genders. Such paths are likely to reduce events ascribing meanings of danger to walking and cycling and may mitigate declining rapport and respect between the two by limiting those zones of overlap that facilitate negative interactions.

Based on these findings, intervening in the material element of the practices by preferring the provision of spatially separated infrastructure for pedestrians and cyclists could help overcome the identified constraints to the uptake of cycling and walking. As such, it represents a simple yet potentially effective tool to help to reverse the trend of declining cycling and walking rates, especially for the elderly who were particularly concerned of space sharing. Collectively building competences regarding space sharing represents another promising potential way to overcome constraints, but is an issue not adequately answered by the results in this thesis and represents an avenue for worthwhile future research.

Overcoming these constraints and contributing to efforts aiming to increasing rates of walking and cycling could contribute to meeting the national targets for active travel set by the Ministry of Transport and Communications as well as assist in the broader transition to a sustainable transport system. Doing so could also result in beneficial human health benefits through increased physical activity and reducing the sedentary nature of travel (Mason, 2000; Tremblay et al., 2010; Rojas-Rueda et al., 2011). Additionally, the move to promote cycling and walking represents a step away from prioritising motorised mobility in cities, associated with broader benefits in addition to reduced emissions, such as less space dedicated solely to facilitating mobility and more inviting and diverse city streets and public spaces (Gehl, 2010).

7 References

Airaksinen, N., Lüthje, P. & Nurmi-Lüthje I. (2010). Cyclist Injuries Treated in Emergency Department (ED): Consequences and Costs in South-eastern Finland in an Area of 100 000 Inhabitants. *Annals of Advances in Automotive Medicine*. 54. 267–274.

Aldred, R. & Crosweller, S. (2015). Investigating the rates and impacts of near misses and related incidents among UK cyclists. *Journal of Transport & Health*. 2(3). 379–393.

Agrawal, A.W., Schlossberg, M. & Irvin, K. (2008). How Far, by Which Route and Why? A Spatial Analysis of Pedestrian Preference. *Journal of Urban Design*. 13(1). 81–98.

Aziz, H.M.A., Nagle, N.N., Morton, A.M., Hilliard, M.R., White, D.A. & Stewart, R.N. (2018). Exploring the impact of walk–bike infrastructure, safety perception, and built-environment on active transportation mode choice: a random parameter model using New York City commuter data. *Transportation*. 45. 1207–1229

Beck, B., Stevenson, M., Newstead, S., Cameron, P., Judson R., Edwards, E.R., Bucknill, A., Johnson, M. & Gabbe, B. (2016). Bicycling crash characteristics: An in-depth crash investigation study. *Accident Analysis & Prevention.* 96. 219–227.

Bourdieu, P. (1972). *Outline of a Theory of Practice*. Trans. Richard Nice. Cambridge: Cambridge University Press.

Brant, R. (1990). Assessing proportionality in the proportional odds model for ordinal logistic regression. *Biometrics*. 46(4). 1171–1178.

Buehler, R. & Pucher, J. (2012). Walking and Cycling in Western Europe and the United States: Trends, Policies, and Lessons. *TR News* 280. May-June 2012. 34–42.

Callegaro, M., Baker, R., Bethlehem, J., Göritz, A.S., Krosnick, J.A. & Lavrakas, P.J. (2014). Online panel research. In: Mario, C., Baker, R.P., Jelke, B., Göritz, A.S., Krosnick, J.A. & Lavrakas, P.J. ed. *Online panel Research: A Data Quality Perspective*. John Wiley & Sons, Incorporated.

Chataway, E.S., Kaplan, S., Nielsen, T.A.S. & Prato, C.G. (2014). Safety perceptions and reported behaviour related to cycling in mixed traffic: A comparison between Brisbane and Copenhagen. *Transportation Research Part F*. 23. 32–43.

Chong, S., Poulos, R., Olivier, J., Watson, W.L., Grzebieta, R. (2010). Relative injury severity among vulnerable non-motorised road users: Comparative analysis of injury arising from bicycle-motor vehicle and bicycle-pedestrian collisions. *Accident Analysis and Prevention*. 42(1). 290–296.

City of Lahti. (2019). Lahden ikärakenne sukupuolittain alueittain 2015-. TILDA-tilastotietokanta. Retrieved 7.10.2019 http://www4.lahti.fi/verkkotilastointi/

City of Helsinki. (2014). Pyöräilyn edistämisohjelma. Helsingin kaupunkisuunnitteluviraston liikennesuunnitteluosaston selvityksiä 2014:4. (Online). Retrieved: 20.4.2020. Available from: https://www.hel.fi/hel2/ksv/julkaisut/los_2014-4.pdf

City of Kuopio. (2019). Tilastotietoa. Retrieved: 7.10.2019 https://www.kuopio.fi/tilastotietoa

City of Tampere. (2018). Väestö ja väestön muutokset. Retrieved: 7.10.2019 https://public.tableau.com/profile/tampereen.kaupunki#!/vizhome/Vestjavestnmuutokset_0/Etusivu

City of Turku. (2019). Tilastotietoja Turusta 2019. Retrieved: 7.10.2019 https://www.turku.fi/turku-tieto/tilastot/tilastotietoja-turusta#V%C3%A4est%C3%B6,%20asuminen%20ja%20koulutus

Cordellieri, P., Baralla, F., Ferlazzo, F., Sgalla, R., Piccardi, L. & Giannini, A.M. (2016). Gender Effects in Young Road Users on Road Safety Attitudes, Behaviours and Risk Perception. *Frontiers in Psychology*. 7. 1412.

Cripton, P.A., Shen, H., Brubacher, J.R., Chipman, M., Friedman, S.M., Harris, M.A., Winters, M., Reynolds, C.C.O., Cusimano, M.D., Babul, S. & Teschke, K. (2015). Severity of urban cycling injuries and the relationship with personal, trip, route and crash characteristics: analyses using four severity metrics. BMJ Open. 5.

Christmas, S., Helman, S., Buttress, S., Newman, C. & Hutchins, R. (2010). *Road Safety Web Publication No. 17. Cycling, Safety and Sharing the Road: Qualitative Research with Cyclists and Other Road Users.* Department for Transport: London. Retrieved: 3.12.2020. http://www.cyclist.ie/wp-content/uploads/2010/11/Dept-of-Trans-London-RS-Cycling-ORU-Report-1110-2.pdf

Delaney, H. (2016). *Walking and Cycling Interactions on Shared-Use Paths*. Ph. D. Thesis. University of the West of England.

De Rome, L., Boufous, S., Georgeson, T., Senserrick T., Richardson, D. & Ivers R. (2014). Bicycle crashes in different riding environments in the Australian Capital Territory. *Traffic Injury Prevention*. 15(1). 81–88.

De Souza, A.A., Sanches, S.P. & Ferreira, M.A.G. (2014). Influence of attitudes with respect to cycling on the perception of existing barriers for using this mode of transport for commuting. *Procedia – Social and Behavioural Sciences*. 162. P. 111–120.

Dill, J. & Carr, T. (2003). Bicycle Commuting and Facilities in Major U.S. Cities: If you build them, commuters will use them. *Transportation Research Record*. 1828(1). 116–123.

Elvik, R., Høye A., Vaa, T. & Sørensen, M. (2009). *The Handbook of Road Safety Measures*. 2^{nd} edition. Bingley: Emerald Group Publishing Limited.

Forrester, J. (2012). *Effective Cycling*. 7th Edition. Cambridge, Massachusetts: The MIT Press

Forsyth, A. (2015). What is a walkable place? The walkability debate in urban design. *Urban Design International*. 20. 274–292.

Finnish Road Safety Council. (2019a). Tilastokatsaus pyöräilijöiden onnettomuuksista. 19.2.2019. Retrieved: 12.6.2019 https://www.liikenneturva.fi/sites/default/files/materiaalit/Tutkittua/Tilastot/tilastokatsaukset/tilastokatsaus_pyorailijat.pdf

Finnish Road Safety Council. (2019b). Tilastokatsaus jalankulkijoiden onnettomuuksista. 2.1.2019. Retrieved: 12.6.2019 https://www.liikenneturva.fi/sites/default/files/materiaalit/Tutkittua/Tilastot/tilastokatsaukset/tilastokatsaus_jalankulkijat.pdf

Finnish Traffic Agency. (2018a). Henkilöliikennetutkimus Suomalaisten liikkuminen. *Liikenneviraston julkaisuja* 1/2018. Helsinki.

Finnish Traffic Agency. (2018b). Tietilasto 2017. Liikenneviraston tilastoja 5/2018. Helsinki, 2018.

Finnish Traffic Law (Tieliikennelaki) 3.4.1981/267. Finlex. Retrieved: 11.11.2020 https://www.finlex.fi/fi/laki/ajantasa/1981/19810267

Gehl, J. (2010). *Cities for People*. Washington DC: Island Press.

Gerhard, T. (2012). *Regression for Categorical Data*. USA: Cambridge University Press.

Giddens, A. (1984). *The Constitution of Society.* Cambridge: Polity Press.

Graw, M. & König, H.G. (2002). Fatal pedestrian-bicycle collisions. *Forensic Science International*. 126(3). 241–247.

Grzebieta, R.H., McIntosh A.M. & Chong, S. (2011). Pedestrian-Cyclist Collisions: Issues and Risk. *Proceedings of the Australasian College of Road Safety Conference-Safe System: Making it Happen*.

Gächter, S. (2013). Rationality, Social Preferences, and Strategic Decision-making from a Behavioural Economics Perspective. In: Wittek, R., Snijders, T. A. B. & Nee, V. eds. *The Handbook of Rational Choice Social Research*. California: Stanford University Press.

Harrell, F.E. (2015). *Regression Modelling Strategies*. 2nd Edition. Springer.

Hatfield, J. & Prabhakharan, P. (2016). An investigation of behaviour and attitudes relevant to the user safety of pedestrian/cyclist shared paths. *Transportation Research Part F*. 40. 35–47.

Haworth, N. L. & Schramm, A. J. (2011). Adults cycling on the footpath: what do the data show? Australasian Road Safety Research, Policing and Education Conference, 6–9 November 2011, Perth Convention and Exhibition Centre, Perth, WA.

Haworth, N. L., Schramm, A. J. & Debnath, A.K. (2014). An observational study of conflicts between cyclists and pedestrians in the city centre. *Journal of the Australasian College of Road Safety*. 25.

Helsingin seudun aluesarjat. (2019). Helsingin seudun väestörakenne. Retrieved 7.10.2019 http://www.aluesarjat.fi/

Hosmer, D.W., Lemeshow, S. & R.X., Sturdivant. (2013). *Applied Logistic Regression*. New Jersey: John Wiley & Sons.

International Energy Agency. (2016). Energy Technology Perspectives 2016: Towards Sustainable Urban Energy Systems. Paris: IEA.

Jamieson, S. 2004. Likert Scales: How to (ab)use them. *Medical Education*. 38. 1217–1218.

Kaplan, S. & Prato, C. G. (2016). ”Them or Us”: Perceptions, cognitions, emotions and over behavior associated with cyclists and motorists sharing the road. *International Journal of Sustainable Transportation.* Vol. 10(3). 193–200.

Kautiala, C. & Seimelä, K. (2012). Tieliikenteen onnettomuusrekistereiden peittävyystutkimus. LINTU-tutkimusohjelma. LINTU-julkaisuja 7/2012. 100 p.

Ker, I., Huband, A., Vieth, G. & Taylor, J. (2006). Pedestrian-cyclist conflict minimisation on shared paths and footpath. Report Number: AP-R287/06. Sydney, Australia: Austroads.

Kiyota, M., Vandebona, U., Katafuchi, N. & Inoue, S. (2000). Bicycle and Pedestrian Traffic Conflicts on Shared Pavements. In Velomondidal 2000. Amsterdam, 2000.

Kolehmainen, J.P. (2018). *Onko kotitalouksissa avaimet ilmastokriisin ratkaisuun? Suomalaiskodeissa toteutettujen energiansäästökokeiluiden arviointi käytäntöteorian näkökulmasta*. Master's thesis, University of Helsinki.

Kokkonen, M. (2017). Vakavia loukkaantumisia jää virallisen Tieliikenneonnettomuustilaston ulkopuolelle. *Tilastokeskuksen asiantuntija-artikkelit ja ajankohtaisblogit*. 25.1.2017. Retrieved: 22.10.2019. https://www.tilastokeskus.fi/tietotrendit/artikkelit/2017/vakavia-loukkaantumisia-jaa-virallisen-tieliikenneonnettomuustilaston-ulkopuolelle/

Latour, B. (2005). *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.

Lelieveld, J., Klingmüller, K., Pozzer, A., Pöschl, U., Fnais, M., Daiber, A. & Münzel, T. (2019). Cardiovascular disease burden from ambient air pollution in Europe reassessed using novel hazard ratio functions. *European Society of Cardiology*. 40(20). 1590–1596.

Lohja. (2019). Lohjasta suomen paras pyöräilykaupunki. (Online). Retrieved: 20.4.2020. Available from: https://www.lohjanliikuntakeskus.fi/lohjan-liikuntakeskus-oy/hankkeet/paras-pyorailykaupunki-2021/

Maller, C. (2015). Using social practice theory to understand everyday life: Outcomes for health and wellbeing. Sociology of Health & Illness. 37(1). 52–66.

Mason, C. (2000). Transport and health: en route to a healthier Australia? *Medical Journal of Australia*. 172(5). 230–232.

May, T. (2011). *Social Research*. McGraw-Hill Education.

Mesimäki, J. & Luoma, J. (2020). Jalankulkijoiden ja pyöräilijöiden väliset onnettomuudet ja vaaratilanteet. *Traficomin tutkimuksia ja selvityksiä 3/2020.*

Ministry of Transport and Communications. (2018). Kävelyn ja pyöräilyn edistämisohjelma. (Online). Retrieved: 20.4.2020. Available from: https://www.lvm.fi/documents/20181/959445/K%C3%A4velyn%20ja%20py%C3%B6r%C3%A4ilyn%20edist%C3%A4misohjelma%20LVM%202018.pdf/2ad61cbf-960c-4f27-9f3f-575bfeacfa52

O'Hern, S. & Oxley, J. (2019). Pedestrian injuries due to collisions with cyclists Melbourne, Australia. *Accident Analysis & Prevention*. 122. 295–300.

Oldendick, R.W. (2012). Survey Research Ethics. In: Gideon, L. *Handbook of Survey Methodology for the Social Sciences*. New York: Springer.

Osborne, J. (2017). *Best Practices in Logistic Regression*. Los Angeles, USA: SAGE.

Oulun kaupunki. (2019). Väestö ja väestönmuutokset. Retrieved 7.10.2019 https://www.ouka.fi/oulu/oulu-tietoa/vaesto-ja-vaestonmuutokset

Oxley, J., Corben, B., Fildes, B., Rothengatter, T., O'Hare, M. (2004). Older Vulnerable Road Users – Measures to Reduce Crash and Injury Risk. Victoria: Monash University Accident Research Centre.

Pasanen, E. & Räsänen, M. (1999). Pyöräilyn riskit Helsingissä. Helsingin kaupunkisuunnitteluviraston liikennesuunnitteluosaston selvityksiä. 10.6.1999.

Poulos, R.G., Hatfield, J., Rissel, C., Flack, L.K., Murphy, S., Grzebieta, R. & Mcintosh, A.S. (2015). An exposure-based study of crash and injury rates in a cohort of transport and recreational cyclists in New South Wales, Australia. *Accident Analysis and Prevention*. 78. 29–38.

Poulos, R.G., Hatfield, J., Rissel, C., Flack, L.K., Shaw, L., Grzebieta, R. & McIntosh, A.S. (2017). Near miss experiences of transport and recreational cyclists in New South Wales, Australia. Findings from a prospective cohort study. *Accident Analysis & Prevention*. 101. 143–153.

Puchades, V.M., Fassina, F., Fraboni, F., Angelis, M.D., Prati, G., de Waard, D. & Pietrantoni, L. (2018). The role of perceived risk perception in cycling near misses. *Safety Science*. 105. 167–177.

Pucher, J. & Buehler, R. (2010). Walking and Cycling for Healthy Cities. *Built Environment*. 36(4). 391–414

Pucher, J. & Dijkstra, L. (2003). Promoting Safe Walking and Cycling to Improve Public Health: Lessons from the Netherlands and Germany. *American Journal of Public Health*. 93(9). 1509–1516.

Pyyhtiä, E. (2019). Turvallisuustutkimus: Yleisimpiä tapaturmia ovat talvikeleillä liukastumiset. Kvartti Kaupunkitiedon verkkolehti. 20.6.2019. Retrieved: 24.6.2019 https://www.kvartti.fi/fi/artikkelit/turvallisuustutkimus-yleisimpia-tapaturmia-ovat-talvikeleilla-liukastumiset

Ravensbergen, L., Buliung, R. & Laliberte, N. (2020). Fear of cycling: Social, spatial, and temporal dimensions. *Journal of Transport Geography*. 87. 102813

Reckwitz, A. (2002). Toward a Theory of Social Practices A Development in Culturalist Theorizing. *European Journal of Social Theory*. 5(2). 243–263.

Rinkinen, J. (2015). *Demanding energy in everyday life: Insights from wood heating into theories of social practice*. Ph.D. thesis, Aalto University.

Rojas-Rueda, D., de Nazelle, A., Andersejn Z.J., Braun-Fahrländer, C., Bruha, J., Bruhova-Foltynova, H., Desqueyroux, H., Praznoczy, C., Ragettli, M.S., Tainio, M. & Nieuwenhuijsen, J. (2016). Health Impacts of Active Transportation in Europe. *PLoS ONE.* 11(3). 14 p.

Rojas-Rueda, D., de Nazelle, A., Tainio, M. & Nieuwenhuijsen, M.J. (2011). The health risks and benefits of cycling in urban environments compared with car use: health impact assessment study. *BMJ* 2011;343:d4521

Ross, S. (2017). *Introductory Statistics*. 4th Ed. London: Academic Press.

R-Project. (2020). *What is R?* (Online). Retrieved: 11.11.2020. https://www.r-project.org/about.html

RStudio. (2020). *About RStudio.* (Online). Retrieved: 11.11.2020. https://rstudio.com/about/

Sanders, R.L. (2015). Perceived traffic risk for cyclists: The impact of near miss and collision experiences. *Accident Analysis & Prevention*. 75. 26–34.

Schauder, S.A. & Foley, M.C. (2015). The relationship between active transportation and health. *Journal of Transport & Health*. 2(3). 343–349.

Schatzki, T. R., Cetina, K.K. & von Savigny, E. eds. (2001). *The Practice Turn in Contemporary Theory.* London: Routledge.

Sennett, R. (1977). *The Fall of Public Man*. London: Penguin Books.

Short, A., Grzebieta, R. & Arndt, N. (2007). Estimating bicyclist into pedestrian collision speed. *International Journal of Crashworthiness*. 12(2). 127–135.

Shove, E., Pantzar, M. & Watson, M. (2012). *The Dynamics of Social Practice Everyday Life and How it Changes*. SAGE Publications Ltd.

Shove E. & Walker, G. (2010). Governing transitions in the sustainability of everyday life. *Research Policy*. 39(4). 471–476.

Spinney, J.E.L., Scott, D.M. & Newbold K.B. (2009). Transport mobility benefits and quality of life: A time-use perspective of elderly Canadians. *Transport Policy*. 16(1). 1–11.

Sims R., R. Schaeffer, F. Creutzig, X. Cruz-Núñez, M. D'Agosto, D. Dimitriu, M. J. Figueroa Meza, L. Fulton, S. Kobayashi, O. Lah, A. McKinnon, P. Newman, M. Ouyang, J. J. Schauer, D. Sperling, and G. Tiwari. (2014): Transport. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovern-mental Panel on Climate Change*. Eds. Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Singleton, P.A. & Wang, L. (2014). Safety and Security in Discretionary Travel Decision Making: Focus on Active Travel Mode and Destination Choice. *Transportation Research Record: Journal of the Transportation Research Board*. 2430(1). 47–58.

Sportswood, F., Chatterton, T., Tapp, A. & Williams, D. (2015). Analysing cycling as a social practice: An empirical grounding for behaviour change. *Transportation Research Part F*. 29. 22–33.

Statistics Finland. (2019a). Tieliikenneonnettomuudet, PXWeb-tietokanta, tienkäyttäjät, Tieliikenneonnettomuuksissa kuolleet ja loukkaantuneet tienkäyttäjäryhmien mukaan. Retrieved: 12.6.2019 http://tieliikenneonnettomuudet.stat.fi/PXWeb/pxweb/fi/Tieliikenneonnettomuudet

Statistics Finland. (2019b). Tieliikenneonnettomuudet, PXWeb-tietokanta, tienkäyttäjät, virallisen tilaston ja hoitoilmoitusrekisterin perusteella vakavasti loukkaantuneet. Retrieved: 12.6.2019 http://tieliikenneonnettomuudet.stat.fi/PXWeb/pxweb/fi/Tieliikenneonnettomuudet

Statistics Finland. (2019c). Väestön ikärakenne. Findikaattori. 29.3.2019. Retrieved: 28.6.2019 https://findikaattori.fi/fi/14#_ga=2.144466738.628536325.1561699731-1511610249.1561699731

Statistics Finland, (2020). *Tilastollinen merkitsevyys*. (Online). Retrieved: 19.11.2020. https://www.stat.fi/meta/kas/til_merkitsevyy.html

Tampere City Region. (2012). Tampereen kaupunkiseudun kävelyn ja pyöräilyn kehittämisohjelma 2030. (Online). Retrieved: 20.4.2020. Available from: https://www.tampere.fi/liitteet/t/69w21D6Xk/Tampereenkaupunkiseudunkavelynjapyorailyn_kehittamisohjelma.pdf

Transport for New South Wales. (2015). *Shared Paths: Discussion of research findings and key safety issues*. (Online). Retrieved: 13.11.2020. https://roadsafety.transport.nsw.gov.au/downloads/shared-paths.pdf

Tremblay, M.S., Colley, R.C., Saunders, T.J., Healy, G.N. & Owen, N. (2010). Physiological and health implications of a sedentary lifestyle. *Applied Physiology, Nutrition and Metabolism*. Vol. 35(6). 725–740.

Tuckel, P., Milczarski, W. & Maisel, R. (2014). Pedestrian injuries due to collisions with bicycles in New York and California. *Journal of Safety Research*. 51. 7-13.

Vella-Brodrick, D.A. & Stanley, J. (2013). The significance of transport mobility in predicting well-being. *Transport Policy*. Vol. 29. P. 236–242.

Yli-Seppälä, S. (2018). Liikenneonnettomuudet Helsingissä 2014–2016. *Helsingin kaupungin kaupunkiympäristön julkaisuja* 2018:20. ISSN: 2489–4230.

Watson, M. (2012). How theories of practice can inform transition to a decarbonised transport system. *Journal of Transport Geography*. 24. 488–496.

Whittaker, A. (2009). *Research Skills for Social Work.* Glasgow: Learning Matters Ltd.

Whitelegg, J. (2003). Transport in the European Union: Time to Decide. In: Low, N. & Gleeson, B. eds. Making Urban Transport Sustainable. Hampshire, UK: Palgrave Macmillan.

Williams, R. (2016). Understanding and interpreting generalising ordered logit models. *The Journal of Mathematical Sociology*. 40(1). 7–20.

Winters, M., Babul,, S., Becker H.J.E.H., Brubacher, J.R., Chipman, M., Cripton, P., Cusimano, M.D., Friedman, S.M., Harris, M.A., Hunte, G., Monro, M., Reynolds, C.C.O, Shen, H. & Teschke, K. (2012). Safe Cycling: How do Risk Perceptions Compare with Observed Risk? *Canadian Journal of Public Health*. 103. 42–47.

WSP Finland Oy. (2018a). HLT16 Oulun seutu | seutujulkaisu. Retrieved: 17.6.2019 https://www.traficom.fi/sites/default/files/media/file/Seutujulkaisu-HLT2016-Oulun-seutu.pdf

WSP Finland Oy, (2018b). HLT16 Tampereen seutu | seutujulkaisu. Retrieved 22.10.2019 https://www.traficom.fi/sites/default/files/media/file/Seutujulkaisu-HLT2016-Tampereen-seutu.pdf

Zheng, L., Ismail, K. & Meng, X. (2014). Traffic conflict techniques for road safety analysis: open questions and some insights. *Canadian Journal of Civil Engineering*. 41(7). 633–641.

Appendix – Survey

This appendix presents the survey used to gather data for this thesis. The language of the survey is in Finnish, as it was directed to Finnish residents.

Johdanto

Tämä kyselyn tavoitteena on kerätä tietoa **jalankulkijoiden ja pyöräilijöiden välisistä** onnettomuuksista ja vaaratilanteista.

Onnettomuudella tarkoitetaan tilannetta, jossa tapahtuu osapuolten, eli jalankulkijan ja pyöräilijän välinen yhteentörmäys, osuminen toisiinsa tai vähintään toisen osapuolen kaatuminen tai muu loukkaantuminen.

Vaaratilanteella tarkoitetaan lievempää tilannetta, jossa ainakin toinen osapuoli säikähtää tai esimerkiksi joutuu väistämään tai jarruttamaan äkillisesti törmäyksen välttämiseksi.

Karsintakysymykset

(jos molempiin kysymyksiin 1 & 2 vastaus ”harvemmin” lopetetaan kysely - ei otokseen).

1. Kuinka usein liikut kävellen ulkona vähintään 300 m matkan kerralla (valitse sopivin vaihtoehto)?
    - Päivittäin
    - Useasti viikossa
    - Viikoittain
    - Kuukausittain
    - Harvemmin

2. Kuinka usein liikut polkupyörällä **kesäisin** (valitse sopivin vaihtoehto)?
    - Päivittäin
    - Useasti viikossa
    - Viikoittain
    - Kuukausittain
    - Harvemmin (ei kysytä kysymystä 3)

Lisätieto pyöräilystä (ei karsinta)

3. Kuinka usein liikut polkupyörällä **talviaikaan** (valitse sopivin vaihtoehto)**?**
    - Päivittäin
    - Useasti viikossa
    - Viikoittain
    - Kuukausittain
    - Harvemmin

Onnettomuudet

4. Oletko ollut **viimeisen kolmen vuoden** aikana sellaisessa onnettomuudessa, jonka osallisina olivat **jalankulkija ja pyöräilijä**?
    - Kyllä
    - En -> *hypätään suoraan "vaaratilanteet" -osioon*
    - En muista -> *hypätään suoraan "vaaratilanteet" -osioon*

5. Kuinka monta **jalankulkijan ja pyöräilijän välistä** onnettomuutta sinulle on sattunut viimeisen **kolmen** vuoden aikana?
    - 1 -> *kysytään kysymykset 6–14 kerran*
    - 2 -> *kysytään kysymykset 6–14 kaksi kertaa*
    - 3 -> *kysytään kysymykset 6–14 kolme kertaa*
    - Enemmän kuin 3 -> *kysytään kysymykset 6–14 kolme kertaa*

*Toistetaan tämän osion kysymykset 6–14 **korkeintaan kolmesta** onnettomuudesta niin, että ensin kaikki kysymykset yhdestä tilanteesta ja sen jälkeen kaikki kysymykset toisesta tilanteesta.*

*Huomattavaa on, että onnettomuuksia ei **oleteta tapahtuneen kuin pienelle vastaajajoukolle ja niistäkin suurimmalle osalle vain yksi**.*

6. Olitko kyseisessä onnettomuudessa pyöräilijänä vai jalankulkijana?
    - Pyöräilijänä
    - Jalankulkijana, kävellen
    - Muuna jalankulkijana, esim. rullaluistimilla, potkulaudalla tai muulla vastaavalla tavalla.

7. Millaisessa ympäristössä onnettomuus tapahtui? Valitse ympäristö, joka parhaiten kuvaa onnettomuuden tapahtumaympäristöä *(valitaan vain yksi)*.
    - Jalkakäytävällä
    - Pyörätiellä
    - Jaetulla väylällä, jossa jalkakäytävä ja pyörätie ovat rinnakkain viivalla tai kiveyksellä erotettuina
    - Yhdistetyllä kävely- ja pyörätiellä
    - Pyöräily- ja kävelytien risteämiskohdassa
    - Taajamassa ajoradalla (ei suojatiellä)
    - Suojatiellä
    - Maantiellä
    - Ulkoilureitillä / maastossa
    - Muualla, missä? ___________________

8. Mikä seuraavista onnettomuustyypeistä kuvaa onnettomuustilannetta parhaiten? Valitse sopivin vaihtoehto. *(valitaan vain yksi)*
   - polkupyöräilijä ja jalankulkija törmäsivät toisiinsa liikkuessaan samaan suuntaan
   - polkupyöräilijä ja jalankulkija törmäsivät toisiinsa vastakkaisista suunnista tullessaan/kohdatessaan
   - polkupyöräilijä ja jalankulkija törmäsivät toisiinsa risteävistä suunnista tullessaan
   - polkupyöräilijä ja jalankulkija törmäsivät, kun toinen osapuoli oli kääntymässä

   - Ei mikään yllä olevista onnettomuustyypeistä. Kuvaile onnettomuustyyppi lyhyesti.

   ____

9. Mitkä **osapuoliin liittyvät** tekijät myötävaikuttivat onnettomuuteen? Valitse kaikki myötävaikuttaneet tekijät merkitsemällä osapuolet (”pyöräilijän” ja ”jalankulkijan”). *(voi valita useamman)*

	Pyöräilijän	Jalankulkijan
Havainto- tai arviointivirhe		
Liian kova vauhti		
Yllättävä toiminta		
Kännykän käyttö		
Kuulokkeiden käyttö		
Sääntörikkomus		
Tahallinen teko		
Päihtymys		
Heijastiminen/valojen puute		

   - Jokin muu, mikä? ___________________________________
   - En osaa sanoa

10. Mitkä **ympäristöön liittyvät** tekijät myötävaikuttivat onnettomuuteen? Valitse kaikki myötävaikuttaneet tekijät. *(voi valita useamman)*
   - Huono keli (liukkaus, lumi, irtohiekka tiellä tms.)
   - Huono näkyväisyys (auringon häikäisy, sumu, sade, pimeys)
   - Epäselvät tai monimutkaiset liikennejärjestelyt
   - Tunnelin/alikulun aiheuttama näköeste
   - Auton tai työkoneen aiheuttama näköeste
   - Väylän läheisyydessä oleva kohde, joka haittasi näkyvyyttä (esim. rakennuksen kulma, mainostaulu, istutus/puu)
   - Riittämätön valaistus tunnelissa/alikulussa
   - Esteet kulkuväylällä (esim. tietyöt, päällystevauriot, väylälle pysäköidyt autot)
   - Jokin muu, mikä? _______________________________________
   - En osaa sanoa

11. Entä oliko muita onnettomuuteen myötävaikuttaneita tekijöitä? Valitse kaikki myötävaikuttaneet tekijät. *(voi valita useamman)*
    - Polkupyörän tekninen vika tai rikkoontuminen (esim. vika jarruissa)
    - Bussista poistunut matkustaja
    - Jalankulkija pienten lasten kanssa
    - Koiran ulkoiluttaja koirineen (esim. ”remmi yli tien”, arvaamattomat liikkeet)
    - Muiden liikkujien toiminta
    - Ei mikään erityisesti, kyseessä oli sattuma ja/tai huonoa onnea
    - Jokin muu, mikä? ______________________________
    - En osaa sanoa

12. Mitä seuraamuksia onnettomuudesta tuli? (valitse kaikki tapahtumaan liittyneet seuraukset) *(voi valita useamman)*
    - Loukkasin itseni
    - Kävin lääkärissä tai terveydenhoitajalla
    - Loukkaantuminen vaati sairaalahoitoa
    - Polkupyöräni rikkoontui
    - Muu omaisuuteni rikkoontui
    - Ei mitään

13. Teitkö onnettomuudesta ilmoituksen poliisille?
    - Kyllä
    - En
    - En muista

14. Tuleeko mieleesi muuta onnettomuustilanteeseen liittyvää?

____

Vaaratilanteet

15. Oletko kokenut **viimeisen kolmen vuoden** aikana sellaisen vaaratilanteen, jonka osallisina olivat **jalankulkija ja pyöräilijä**?
    - Kyllä
    - En -> *hypätään suoraan "taustakysymykset" -osioon*
    - En muista -> *hypätään suoraan "taustakysymykset" -osioon*

16. Kuinka monta **jalankulkijan ja pyöräilijän välistä** vaaratilannetta sinulle on sattunut viimeisen **kolmen** vuoden aikana?
    - 1 -> *kysytään vaaratilannekysymykset 17–23 vain kerran*
    - 2 -> *kysytään vaaratilannekysymykset 17–23 kahteen kertaan*
    - 3 -> *kysytään vaaratilannekysymykset 17–23 kahteen kertaan*
    - Enemmän kuin 3 -> *kysytään vaaratilannekysymykset 17–23 kahteen kertaan*

Toistetaan tämän osion kysymykset 17–23 ***korkeintaan kahdesta*** *vaaratilanteesta niin, että ensin kaikki kysymykset yhdestä tilanteesta ja sen jälkeen kaikki kysymykset toisesta tilanteesta.*

Mieti nyt yhtä kokemistasi vaaratilanteista *(tässä tärkeää, että vastaisi miettien yhtä tilannetta kerrallaan)*

17. Olitko kyseisessä vaaratilanteessa pyöräilijänä vai jalankulkijana?
    - Pyöräilijänä
    - Jalankulkijana, kävellen
    - Muuna jalankulkijana, esim. rullaluistimilla, potkulaudalla tai muulla vastaavalla tavalla.

18. Millaisessa ympäristössä vaaratilanne tapahtui? Valitse ympäristö, joka parhaiten kuvaa onnettomuuden tapahtumaympäristöä. *(valitaan vain yksi)*
    - Jalkakäytävällä
    - Pyörätiellä
    - Jaetulla väylällä, jossa jalkakäytävä ja pyörätie ovat rinnakkain viivalla tai kiveyksellä erotettuina
    - Yhdistetyllä kävely- ja pyörätiellä
    - Pyöräily- ja kävelytien risteämiskohdassa
    - Taajamassa ajoradalla (ei suojatiellä)
    - Suojatiellä
    - Maantiellä
    - Ulkoilureitillä / maastossa
    - Muualla, missä? ___________________

19. Mikä seuraavista kuvaa vaaratilannetta parhaiten? Valitse sopivin vaihtoehto. *(valitaan vain yksi)*
    - polkupyöräilijä ja jalankulkija olivat lähellä törmätä toisiinsa liikkuessaan samaan suuntaan
    - polkupyöräilijä ja jalankulkija olivat lähellä törmätä toisiinsa vastakkaisista suunnista tullessaan/kohdatessaan
    - polkupyöräilijä ja jalankulkija olivat lähellä törmätä toisiinsa risteävistä suunnista tullessaan
    - polkupyöräilijä ja jalankulkija olivat lähellä törmätä, kun toinen osapuoli oli kääntymässä
    - Ei mikään yllä olevista. Kuvaile vaaratilanne lyhyesti.

    ____

20. Mitkä **osapuoliin liittyvät** tekijät myötävaikuttivat vaaratilanteeseen? Valitse kaikki myötävaikuttaneet tekijät merkitsemällä osapuolet (”pyöräilijän” ja ”jalankulkijan”). *(voi valita useamman)*

	Pyöräilijän	Jalankulkijan
Havainto- tai arviointivirhe		
Liian kova vauhti		
Yllättävä toiminta		
Kännykän käyttö		
Kuulokkeiden käyttö		
Sääntörikkomus		
Tahallinen teko		
Päihtymys		
Heijastiminen/valojen puute		

- Jokin muu, mikä? ___________________________________
- En osaa sanoa

21. Mitkä **ympäristöön liittyvät** tekijät myötävaikuttivat vaaratilanteeseen? Valitse kaikki myötävaikuttaneet tekijät. *(voi valita useamman)*
    - Huono keli (liukkaus, lumi, irtohiekka tiellä tms.)
    - Huono näkyväisyys (auringon häikäisy, sumu, sade, pimeys)
    - Epäselvät tai monimutkaiset liikennejärjestelyt
    - Tunnelin/alikulun aiheuttama näköeste
    - Auton tai työkoneen aiheuttama näköeste
    - Väylän läheisyydessä oleva kohde, joka haittasi näkyvyyttä (esim. rakennuksen kulma, mainostaulu, istutus/puu)
    - Riittämätön valaistus tunnelissa/alikulussa
    - Esteet kulkuväyläyllä (esim. tietyöt, päällystevauriot, väylälle pysäköidyt autot)
    - Jokin muu, mikä? _______________________________________
    - En osaa sanoa

22. Entä oliko muita vaaratilanteeseen myötävaikuttaneita tekijöitä? Valitse kaikki myötävaikuttaneet tekijät. *(voi valita useamman)*
    - Polkupyörän tekninen vika tai rikkoontuminen (esim. vika jarruissa)
    - Bussista poistunut matkustaja

- Jalankulkija pienten lasten kanssa
- Koiran ulkoiluttaja koirineen (esim. ”remmi yli tien”, arvaamattomat liikkeet)
- Muiden liikkujien toiminta
- Ei mikään erityisesti, kyseessä oli sattuma ja/tai huonoa onnea
- Jokin muu, mikä? ______________________________
- En osaa sanoa

23. Tuleeko mieleesi muuta vaaratilanteeseen liittyvää?

____

Taustakysymykset

Pyöräily

(Kysytään ”Pyöräily” -kysymykset vain jos kysymys 2 - vastattu muuta kuin ”harvemmin”)

24. Minkälaisia matkoja yleensä **pyöräilet**? Valitse kaikki matkatyypit, joita kuljet polkupyörällä.
    - Työ- ja/tai opiskelumatkat
    - Vapaa-ajan matkat (esim. vierailut ja matkat harrastuksiin)
    - Asiointimatkat (esim. ruokaostokset)
    - Huvin tai kuntoilun vuoksi ilman määränpäätä (esim. kuntoiluna)
    - Osana pidempää matkaketjua (esim. matka julkisen liikenteen pysäkille tai asemalle)

25. Kuinka pitkiä matkoja yleensä pyöräilet kerrallaan?
    - Alle 1 km
    - 1–3 km
    - 4–10 km
    - 11–20 km
    - Yli 20 km

26. Kuinka monta kilometriä arvioit ajavasi vuodessa polkupyörällä?
    - Alle 200 km
    - 201–1000 km
    - 1001–2000 km
    - Yli 2000 km

27. Käytätkö pyöräilykypärää
    - Aina kun pyöräilen
    - Useimmiten
    - En koskaan

28. Mitä mieltä olet seuraavista väittämistä liikkuessasi **pyörällä**?
    Käytä asteikkoa 1 = Täysin eri mieltä, …, 5 = Täysin samaa mieltä.

	(1) Täysin eri mieltä	(2)	(3) Neutraali	(4)	(5) Täysin samaa mieltä	En osaa sanoa
Yhdistetty kevyen liikenteen väylä on minusta turvallinen						
Jaettu väylä, jossa pyörätie ja jalkakäytävä ovat rinnakkain erotettuna toisistaan viivalla tai kiveyksellä, on minusta turvallinen						
Pyöräilen mielelläni yhdistetyllä kevyen liikenteen väylällä						
Pyöräilen mielelläni jaetulla väylällä jossa pyörätie ja jalkakäytävä ovat rinnakkain erotettuna toisistaan viivalla tai kiveyksellä						
Jalankulkijat ovat yleensä huomaavaisia pyöräilijöitä kohtaan						
Pyöräilijät ovat yleensä huomaavaisia toisia pyöräilijöitä kohtaan						

Kävely

(Kysytään "Kävely" -kysymykset vain jos kysymys 1 - vastattu muuta kuin "harvemmin")

29. Minkälaisia matkoja yleensä **kävelet**? Valitse kaikki matkatyypit, joita kuljet jalan.
    - Työ- ja/tai opiskelumatkat
    - Lyhyet työmatkat
    - Vapaa-ajan matkat (esim. vierailut ja matkat harrastuksiin)
    - Asiointimatkat (esim. ruokaostokset)
    - Huvin vuoksi ilman kummempaa määränpäätä (esim. kuntoiluna)
    - Osana pidempää matkaketjua (esim. matka julkisen liikenteen pysäkille tai asemalle)

30. Kuinka pitkiä matkoja yleensä kävelet kerrallaan?
    - Alle 1 km
    - 1–3 km
    - 4–10 km
    - Yli 10 km

31. Mitä mieltä olet seuraavista väittämistä liikkuessasi **kävellen**? *(kysytään vain jos kysymys 1 > harvemmin)*
    Käytä asteikkoa 1 = Täysin eri mieltä, ..., 5 = Täysin samaa mieltä.

	(1) Täysin eri mieltä	(2)	(3) Neutraali	(4)	(5) Täysin samaa mieltä	En osaa sanoa
Yhdistetty kevyen liikenteen väylä on minusta turvallinen						
Jaettu väylä, jossa pyörätie ja jalkakäytävä ovat rinnakkain erotettuna toisistaan viivalla tai kiveyksellä, on minusta turvallinen						
Kävelen mielelläni yhdistetyllä väylällä						
Kävelen mielelläni jaetulla väylällä jossa pyörätie ja jalkakäytävä ovat rinnakkain erotettuna toisistaan viivalla tai kiveyksellä						
Jalankulkijat ovat yleensä huomaavaisia toisia jalankulkijoita kohtaan						
Pyöräilijät ovat yleensä huomaavaisia jalankulkijoita kohtaan						

32. Jos haluat, voit vielä kertoa mikä mielestäsi vähentäisi pyöräilijöiden ja jalankulkijoiden välisiä onnettomuuksia ja vaaratilanteita?

Lisäksi paneelista perustiedot vastaajista: ikä, sukupuoli, asuinpaikka