Perspectives of Older Adult Cyclists on E-bikes As a Way to Prolong Mobility

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public

Abstract

In Canada, population aging will become an increasingly challenging issue as the proportion of the senior population is rapidly growing where it is expected to increase from 15.6% to 23% of Country's total population by 2030 (Government of Canada, 2019). This growth Indicates a greater need to ensure that Canadian cities provide opportunities for older adults to age-in-place as these cities lack the density and connectivity needed to encourage active trips (Barnett et al. 2017; Cerin et al. 2017).

This study investigates how e-bikes and e-trikes can prolong older adult mobility to support aging-in-place using the following research objectives: i) understand how older adults' perceptions and experiences that influence their future adoption; ii) To investigate which technological aspects of e-bikes and/or e-trikes are supportive for older rider; and, iii) To examine the built environment determinants of e-bikes and/or e-trike use among older adult riders. The qualitative approach used a modified go-along interview method to explore the thoughts and experiences of e-bikes and e-trikes from older adult cyclists using targeted sampling techniques (Palinkas et al., 2015). The study reached saturation after a total of 12 older adult cyclists were interviewed using the modified go-along process.

The findings of this study found that e-bikes and e-trikes can prolong older adult mobility, allowing them to age-in-place in Canadian communities. It was due to their ability to reduce the barriers associated with cycling, allowing older adults to maintain their social relationships and overall health. Although the technology itself can prolong mobility, the place has an equally important role in facilitating their use through clear policies and supportive cycling infrastructure. This study provides recommendations for older adult e-bike adoption.

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List of Definitions:

Active-Aging: The process of optimizing opportunities for health, participation and security to enhance the quality of life as people age. Active-aging is dependent on several influences which include economic determinants, health and social services, behavioural determinants, personal determinants, physical environment, and social determinants (WHO, 2007).

Aging-in-Place: Having the health, services and social supports needed to live safely and independently in a community for as long as one desires (WHO, 2007).

Age-Friendly City: A city that optimizes opportunities for health, participant and security to enhance the quality of life as people age (WHO, 2007)

Mobility: The ability to independently and safely move from one place to another, and is understood to be influenced by the built environment and their age (Wong et al., 2018)

Older adult: Refers to a stage in life, rather than a definitive age which occurs one defines themselves as a senior citizen (City of Hamilton, 2014).

Chapter 1: Introduction

1.1 Background

Population aging has been an increasing trend globally, where the proportion of individuals over the age of 60 will surpass 22% by the year 2050 (WHO, 2007, p.3). Older adults are living longer, which puts them at higher risk of developing a chronic disease (Barnett et al. 2017; WHO, 2007; Wong, Szeto, Yang, Li, & Wong, 2018, p.73;). To address issues associated with the growing older adult population, the necessity of aging-in-place is significant to support the overall health and independence of older adults to allow them to continue living in their community (WHO, 2007). Aging-in-place is influenced by several factors that include: Housing, Social Participation, Respect and Social Inclusion, Civic participation and employment, communication and information, community support and health services, Outdoor spaces and building, and Transportation (Kerr et al., 2012; WHO, 2007). Due to auto-centric planning practices that have promoted urban sprawl and suburban development, automobile infrastructure has been favoured at the expense of infrastructure that supports walking and cycling (Kerr et al., 2012; Leger, Dean & Casello, 2019). Auto-centric practices are evident at the neighbourhood level as disconnected street patterns, single-use zoning and sprawling low-density residential development have deterred physical activity (Kerr et al., 2012). A reality that is magnified for older adults who have declining mobility and shrinking activity space (Kerr et al., 2012).

The built environment plays a significant role in older adult mobility due to barriers such as the long distances to services and lack of supportive walking and cycling infrastructure (Barnett et al., 2017; Cerin et al., 2017; Kerr et al., 2012; Miller, 2017; WHO, 2007). It is evident by comparing the cycling infrastructure in Europe and Canada. There is a greater dependence on personal vehicles within the North American context where cities have been designed to favour

car travel where four out of five Canadians used a private car to travel to work in 2016 (Statistics Canada, 2017a). Contrast to Europe, where compact development and traffic calming policies have promoted active modes of travel such as cycling (Cairns, Behrendt, Raffo, Beaumont, & Kiefer, 2017; Van Cauwenberg et al., 2018). Although efforts towards adopting land-use planning policies that support densification, mixed-land use and active transportation infrastructure have been made, there remains to be a gap between policy adoption and implementation due to the cost and time that is needed to achieve these changes. Considering 66 percent of the Canadian population lives in the suburbs (Statistics Canada, 2017b), there continues to be a need to provide older adults with new options that would allow them to maintain or even enhance their current levels of mobility while aging-in-place (Leger et al., 2019).

Mobility plays a crucial role in the overall health of older adults as it refers to their ability to maintain social relationships and their physical health as they get older, in turn, enabling them to age-in-place (Kerr et al., 2012; Webber et al., 2010). Physical activity has shown to be a modifiable risk factor, as activities such as walking, cycling, and going to social events have been associated with higher levels of physical and social health (Barnett et al. 2017; Crist et al., 2017; Hirsch et al., 2017; Hirsch, Winters, Ashe, Clarke, & McKay, 2016; Gojanovic et al., 2011; Leger et al., 2019; Kerr, Rosenberg, & Frank, 2012; Martens, 2018; Winters et al., 2015;). Conversely, aging has been linked to a decline in both physical and cognitive ability which is exacerbated by the built environment as poor surface conditions and long distances to destinations deter older adults from being active (Kerr et al., 2012; Rosso et al., 2010; WHO, 2007). Several studies have found that older adults can prolong their levels of physical activity resulting in a higher quality of life (See Appendix A) (Ryan et al., 2016; Rosso et al., 2010; van

den Berg et al., 2016; WHO, 2007). As a result, there is a greater need to encourage older adults to maintain and/or increase their mobility as they get older and for communities to create supportive environments for them to do so.

1.2 New Mobility

Technology has played an essential role in how people interact with their environment, including how they move across space. New emerging transportation technology in North America can significantly improve older adult mobility and positively impact the physical environment and human health. Among these new technologies is the electric bicycle. Transport Canada defines e-bikes as "power-assisted bicycle" which are a vehicle with an electric motor that is capable of being propelled by muscular power and designed not to travel with more than three wheels in contact with the ground (Transport Canada, 2019). Compared to conventional bicycles, e-bikes allow users to go faster and farther while using less effort due to the electric assist that the electric motor provides (Jones, Harm, & Heinen, 2016; Leger et al., 2019; MacArthur et al., 2018; Rose, 2012; WSP, 2019). This technology presents an opportunity for older adults to overcome barriers such as distances and physical exertion that may be associated with using a conventional bicycle at an older age. Due to the benefits that e-bikes present, they may be a potential intervention that would allow older adults to maintain their mobility and remain active in auto-centric communities (Kerr et al., 2012; Leger et al., 2019; WSP, 2019). However, the lack of research and policies associated with an e-bike and e-trike use in Canada have decreased their adoption. The lack of policies and knowledge has led to confusion about what they are and where they can be used. As a result, there is a need to explore the perceptions that older adults have towards e-bikes and how to incorporate them to facilitate their integration in the Canadian planning context.

1.3 Research Question and Objectives

E-bikes present a promising solution that allows active older adults to prolong their mobility as they provide an opportunity for older adults to remain physically and socially active through the aging process (Leger et al., 2019). Currently, there are only four studies that have explored barriers and facilitators associated with older adult e-bike use, meaning that there remains to be a paucity of literature that has explored whether e-bikes are a suitable mobility intervention for older adults within a car-dependent context (Johnson & Rose, 2015; Jones et al., 2016; Leger et al., 2019). Three of the papers (Johnson & Rose, 2015; Jones et al., 2016; Van Cauwenberg, De Bourdeaudhuji, Clarys, de Geus & Deforche, 2019) were written within a British, Australian and Belgium context which do not directly relate to the Canadian context due to the different built form and cultural norms which influence cycling (Leger et al., 2019).

Further, older adults are not a homogenous group as their thoughts and experiences towards e-bikes and e-trikes may differ based on their personal histories and the built environment around. Accordingly, there is a greater need to explore the relationship between older adult cyclists and e-bikes to inform planning and policy directions that may facilitate their adoption and use within a Canadian context (Kerr et al., 2012; Leger et al., 2019; Webber et al., 2010). This research explores the experiences of older adults in the Waterloo Region, to provide a greater understanding of the barriers and facilitators towards their adoption and to develop planning recommendations for Canadian cities. The broad aim of this study is to determine the viability of e-bikes and e-trikes as an alternative mode of transportation for older adults in a Canadian suburban community. The primary research question is:

How can e-bikes and e-trikes prolong older adult mobility to support aging- in- place?

To answer this question, the following objectives need to be addressed:

i) To understand how older adults' perceptions and experiences of e-bikes and/or e-trikes influence their future adoption;

ii) To investigate which technological aspects of e-bikes and/or e-trikes are supportive of older adult riders; and,

iii) To examine the built environment determinants of e-bike and/or e-trike use among older adult riders.

1.4 Thesis Organization

This thesis is organized into six chapters. The following section provides background on the issue and the need to understand the importance of mobility and aging-in-place and the research question and objectives of the study. The next chapter includes a literature review that highlights key themes present in older adult e-bike mobility, which include: i) Aging, mobility and Health ii) active-transportation and iii) Electric bicycles (e-bikes). The third chapter outlines the research design methodology that was used to explore this relationship as well as the study area where it takes place. Chapter four summarizes the findings from follow-up interviews that took place one or days after the e-bike trial. The following chapter highlights the significance and limitations of the results as well as areas for future research. The final chapter provides theoretical and practical recommendations derived from the findings of the study that can be applied towards both academic research and planning practices to encourage active-transportation.

Chapter 2: Literature Review

2.1 Introduction

Mobility plays an essential role in supporting the health and well-being of individuals since it pertains to their ability to freely and easily move across space, especially within an age-friendly and healthy city framework (Webber et al., 2010; WHO, 2007). The purpose of this chapter aims to synthesize and evaluate the current literature about older adult mobility and e-bikes as a new form of mobility. Virtually no research exists which has analyzed this relationship. This chapter will focus on the literature that pertains to four themes associated with older adult e-bike use. The four themes being: i) Active Transportation ii) Active Transportation & Older Adults, iii) E-bikes and iv) Older adult E-bike use. It will not only address issues about mobility and e-bikes but further understand overlapping and contested findings, but it will also outline the gaps in the literature about older adults, mobility and e-bikes that need to be filled. By understanding what is already known and unknown about older adults and e-bikes, an informed research question can be developed.

The review will also evaluate the theoretical and methodological approaches used in similar studies to inform the methodological approach that will be used in the data collection phase of this study, as well as highlight limitations that should be considered when collecting and analyzing data. The literature review will also uncover new research questions regarding older adult mobility, as the literature may present newfound information that should be addressed in the study. As a result, the literature review will provide an evaluation of e-bikes as a tool for mobility for older adults, and provide context and understanding of how similar research related to this topic was conducted in the past.

2.2 Literature Review Methods

An exploratory qualitative approach is needed to determine whether e-bikes can prolong older adult mobility within a Canadian context to support aging-in-place (Creswell, 2014). Due to the lack of research done in this field, an exploratory method will be used to uncover information regarding this topic, which will inform future research surrounding this relationship.

In terms of the research approach, qualitative information will be gathered in two phases to collect both generalizable and specific information regarding older adults and location-specific issues/concerns (Creswell, 2014). This information will be informed by secondary research as it is necessary to understand the body of knowledge that exists towards aging and transportation. Although the main focus is on e-bikes and older adult mobility, the search was broken up into looking at broader terms that would provide a wider scope of literature to provide context for active mobility of older adults.

Keywords were used to ensure that the results across various journal databases would provide relevant information about older adult mobility. Keywords included: 'older adults', 'cycling', 'mobility', 'urban, 'electric bicycles',' e-bike',' seniors', and 'health'. These keywords were derived from the continuous reading of related literature and reappeared throughout all relevant works. However, other keywords such as 'active mobility' and 'age-friendly' were used to search for literature that focused on the built environment and its relationship concerning health. Authors were also used in searches, such as Winters et al. (2010), as she is a well-known researcher who has published many articles about e-bikes as a mode of transportation.

Several databases were used to carry out the literature review. These databases included 'Web of Science', 'Scopus', 'Google Scholar' and "Elsevier'. These databases are widely used databases for planning scholars and commonly used in published literature reviews. The majority of articles found in these databases looked at older adult mobility, electric bicycles, and how

older adults perceive the built around them. 'Transport Policy' was also used as it consisted of literature about transportation, more specifically, mobility. These articles again focused on how older adults perceived the built environment around them, including studies that focused on measures to improve older adult mobility.

In terms of success for this research, methods that worked well included ensuring that the articles that were collected primarily focused either on e-bikes or cycling and the mobility of older adults. These articles tended to have relevant information about the research question. These articles were also able to inform methodology as the researchers either surveyed or interviewed their respondents.

2.3 Key Findings in the Literature

The emergent themes from the literature on aging and transportation were interpreted through a health and planning lens with the purpose of the analysis was to synthesize and evaluate the literature regarding aging, mobility, and health of older adults, and active transportation. The review was also used to understand the methodologies and shortcomings of previous research. The end of this section will outline what is already known about older adult e-bike use, provide further research questions, as well as inform the methodology of this study. All of which will further contribute to the understanding of whether e-bikes are a viable mode of transportation for older adults that allow active older adults to prolong their mobility to age-in-place.

2.4 Determinants of Active-Transportation

The following section outlines key findings and methodologies associated with active transportation and its relationship with older adults. Active modes of transportation have been described as an essential way to maintain both physical and mental health amongst older adults (Barnett et al. 2017; Crist et al., 2017; Gojanovic et al., 2011; Hirsch et al., 2016; Hirsch et al.,

2017; Johnson & Rose, 2015; Kerr, Rosenberg, & Frank, 2012; Leger, Dean, & Casello, 2019; Martens, 2018; Winters et al., 2015). This section will synthesize findings associated with active travel to inform the results and methodology of this study.

2.4.1 Built Environment

The built environment was found to have a strong influence towards walkability and overall physical activity (Cerin et al., 2017; Chudyk et al., 2017; Chudyk, Winters, Moniruzzaman, Ash, Gould, McKay, 2015; Jones et al., 2016; Kerr, Rosenberg, & Frank, 2012; Leger et al., 2019; Winters et al., 2015). This section will synthesize the literature that focused on active transportation and the influence of the built environment. Most studies found that older adults were more physically active if they lived within proximity to parks, shops and public spaces. For example, walking was found to be the dominant mode choice for older adults that lived in highly walkable neighbourhoods in Vancouver, Canada. The reason being was that older adults were found to use more active modes such as walking and cycling if they lived close to bus stops and shops (Cerin et al., 2017; Webber, Porter, & Menec, 2010; Winters, Brauer, Setton, & Teschke, 2010; Wong et al., 2015).

As for parks, multiple studies found that older adults expressed that they were more likely to walk or bike if their routes consisted of elements that made it aesthetically pleasing (Cerin et al., 2017). More specifically, the presence of greenery such as trees and flowers and facilities such as benches and stoops along sidewalks were motivators of active travel (Cerin et al., 2017; Kerr, Rosenberg, & Frank, 2012). These areas provided spaces that facilitate social interaction and aesthetics, which were critical arguments made by Jane Jacobs in her book *The Death and Life of Great American Cities* (Jacobs, 1961). For services and public transit infrastructure, active travel was associated convenience as walking distances were relatively short to these services (Cerin et al., 2017; Webber, Porter, & Menec, 2010; Winters et al., 2015).

However, these findings varied depending on the country and methodology that was used to collect the data. For example, a study that used qualitative data through interviews found that physical activity was associated with the quality of sidewalks (Crist et al., 2017).

Conversely, a study that used quantitative methods such as surveys did not find an association between sidewalk quality and physical activity (Barnett et al. (2017). Meaning that qualitative methods provided more insight compared to surveys because the technique did not allow the respondent to express all their attitudes towards active travel (Crist et al., 2017). By using a qualitative approach, researchers were able to collect thoughts and experiences that could not be captured using quantitative surveys due to their limited ability to provide data outside the scope of the closed-ended questions.

For the geographic location, issues such as proximity to high-speed traffic and topography have influenced active travel (Cerin et al., 2017; Jones et al., 2016; Reynolds, Harris, Teschke, Cripton, & Winters, 2009). Studies have found that older adults are less likely to bike near areas with high-speed traffic due to fear of getting injured or harmed (Reynolds, Harris, Teschke, Cripton, & Winters, 2009; Winters, Brauer, Setton, & Teschke, 2010). Hills have also acted as a deterrent as older adults may not be physically capable of walking or biking up steep hills. In turn, forcing them to either stay home or use a personal vehicle (Van Cauwenberg et al., 2018; Winters, Brauer, Setton, & Teschke, 2010). Other individuals have tried to overcome these issues by taking different routes, which were farther (Van Cauwenberg et al., 2018; Winters, Brauer, Setton, & Teschke, 2010). These issues were also evident at a global scale as motivators and deterrents differed, which was seen in a study from the Netherlands by Van Cauwenberg et al. (2018), who found that cycling space between heavy traffic was expressed as a significant concern by older adults. Compared to the United States where cycling was deterred by fear of crime (von Schönfeld & Bertolini, 2017).

Density was also found to play a role, as older adults who lived in dense neighbourhoods were found to take more trips compared to those who lived who did not (Kerr et al., 2012; Barnett et al., 2017). Density was associated with the proximity to services, where shops and parks within a short distance motivated active travel (Kerr et al., 2012; Barnett et al., 2017; Cerin et al., 2017; Winters et al., 2015; Hirsch et al., 2016). The literature points to the fact that the built environment in North America favours personal vehicles, where most trips are most efficiently performed by cars, which explains the low share in active modes of travel (Winters et al. 2010).

2.4.2 Cycling

Compared to other modes of active travel, cycling has had a low mode share, especially in North America contrast to Europe where cycling has a larger modal share in countries such as Germany and the Netherlands (Van Cauwenberg et al., 2018; Winters, Davidson, Kao, & Teschke, 2011). In the Netherlands, 25% of bicycle trips are made by older adults for both commuting and recreational purposes (Van Cauwenberg et al., 2018, p. 37). Compared to Canada where only 3.5% of seniors reported to cycle or walked as their primary mode of transportation (Winters, Sims-Gould, Franke, & McKay, 2015, p. 59). This difference was primarily due to the built environment, which acted as a barrier or facilitator towards their use. It was also found that there was only a small body of research that looks at cycling as a mode of transportation, especially in Canada which reflects the lack of supportive infrastructure which facilitates higher level of cycling compared to European counties such as the Netherlands (Winters et al., 2010; Winters et al., 2011).

As for common trends in the literature, most studies found similar findings around trip length and destination of most trips. For trip length, it was found that cycling trips tended to be short (less than 5km) in most cases where destinations were associated with running errands and

social activities (Winters et al., 2010, 970). These locations included shops, restaurants, grocery stores, and the home of friends and relatives (Cairns et al., 2017; Hirsch et al., 2016; Van Cauwenberg et al., 2018; Winters et al., 2010; Winters et al., 2015).

The literature that has explored the relationship between the built environment and cycling, most studies used a mixed-methods approach to collect data. Quantitative surveys provided general information regarding ridership, which included how often older adults used bicycles as a mode of transportation and why they used them (Crist et al., 2017; Van Cauwenberg et al., 2018; Winters, Sims-Gould, Franke, & McKay, 2015; Winters et al., 2011). Qualitative interviews were able to supplement the surveys by gathering the feelings that interviewees had towards their community regarding their motivations and reservations for cycling (Crist et al., 2017; Van Cauwenberg et al., 2018; Winters, Sims-Gould, Franke, & McKay, 2015). By using both these approaches, researchers were able to gather data that both gave them a general sense regarding motivations towards cyclin and the specific reasons which have led to these decisions.

2.5 Active Transportation in Older Adults

Throughout the literature regarding older adults and e-bikes, aging, mobility and health have been reoccurring themes associated with older adult active transportation. The consensus amongst researchers is that the older population is rapidly increasing globally and that the growing number of adults (age of 50+) indicates the need to re-think the way that cities are planned and organized (WHO, 2007, p.3; Wong, Szeto, Yang, Li, & Wong, 2018, p.73). The following subsections will evaluate the current literature about aging and mobility and understand their relevance to health. It will also note the methodologies used to inform the methodology for my research.

2.5.1 Older Adult Mobility

As for the definition of mobility, the majority of literature refer to it as an individuals ability to move across space (Franke, Winters, McKay, Chaudhury, & Sims-Gould, 2017; Hirsch et al., 2017; Rosso, Auchincloss, & Michael, 2011; von Schönfeld & Bertolini, 2017; WHO, 2007; Webber, Porter, & Menec, 2010; Wong, Szeto, Yang, Li, & Wong, 2018). Other research defines mobility as ones ability to move without the use of a walking aid, or reach a certain distance via motorized or non-motorized means (von Schönfeld & Bertolini, 2017; Winters, Sims-Gould, Franke, & McKay, 2015). However, this definition differs between planning and a public health perspective as planning views mobility as ones ability to independently and safely move from one place to another, which was understood to be influenced by the built environment and their age (Kerr, Rosenberg, & Frank, 2012; Wong et al., 2018; Von Schönfeld & Bertolini, 2017). Whereas Public health views mobility as an individuals perception of their ability concerning the functional capacity to move oneself across space, which was influenced by the physical and social environmental around them (Cerin et al., 2017; Rosso, Auchincloss, & Michael, 2011; Webber, Porter, & Menec, 2010). The lack of mobility was a result of shrinking social networks, financial constraints, and physical impairments that reduce their ability to travel (Rosso, Auchincloss, & Michael, 2011; Webber, Porter, & Menec, 2010).

Multiple articles expressed that the decline in mobility and health that has been apparent in individuals as they age through various pathways (Rosso, Auchincloss, & Michael, 2011). These pathways being the social, biological, cognitive, physical and mental ability to move across space (See Figure 1). The first pathway speaks to the social aspect of aging which negatively affects social participation of older adults and further contributes to poor health and well-being (Barnett et al. 2017; Cerin et al., 2017; Crist et al., 2017; Gojanovic, Welker, Iglesias, Daucourt, & Gremion, 2011; Hirsch et al., 2017; Hirsch, Winters, Ashe, Clarke, & McKay,

2016; Kerr, Rosenberg, & Frank, 2012; Leger et al., 2019; Martens, 2018; Rosso, Auchincloss, & Michael, 2011; Webber, Porter, & Menec, 2010; Winters et al., 2015). This negative relationship was due to the decline in social networks and opportunities to engage with other members of the community at various events (Franke, Winters, McKay, Chaudhury, & Sims-Gould, 2017; Winters et al., 2015). Biologically variables were also found to play a role as several articles which refer to the lack of mobility of older adult with the decline in biological health (Cerin et al., 2017; Kerr, Rosenberg, & Frank, 2012; Rosso et al., 2010). Aging has been associated with a decline in one's physical and mental ability as well as a higher chance of developing a chronic disease (e.g. Cardiovascular disease, high cholesterol, etc.) (Barnett et al., 2017; Hirsch, Winters, Clarke, & McKay., 2017; Kerr, Rosenberg, & Frank, 2012; Rosso, Auchincloss, & Michael, 2011; Wong et al., 2018).

Figure 1: Mobility Pathways

Mobility Pathway	Explanation	References
Social	The decline in social networks and opportunities to engage with others due to shrinking social networks and activity-spaces associated with aging	Franke, Winters, McKay, Chaudhury, & Sims-Gould, 2017; Winters et al., 2015
Biological	The functional capacity of individuals declines throughout the aging process. Additionally, older adults are more likely to develop a chronic disease.	Cerin et al., 2017; Kerr, Rosenberg, & Frank, 2012; Rosso et al., 2010; WHO, 2007
Mental/Cognitive	The decline in mental ability deters older adults from making trips due to their perception of danger associated with making trips (i.e. fear of falling).	Barnett et al., 2017; Hirsch, Winters, Clarke, & McKay., 2017; Rosso, Auchincloss, & Michael, 2011; Van Cauwenberg et al., 2018; Webber, Porter, & Menec, 2010; Winters et al., 2015; Winters, Sims-Gould, Franke, & McKay, 2015; Wong et al., 2018

Physical	Mobility limitations associated with aging have been found to cause a decrease in muscle mass, bone density and increased fat mass in older adults	Barnett et al., 2017; Hirsch, Winters, Clarke, & McKay., 2017; Rosso, Auchincloss, & Michael, 2011; Van Cauwenberg et al., 2018; Webber, Porter, & Menec, 2010; Winters, Sims-Gould, Franke, & McKay, 2015; Winters et al., 2015; Wong et al., 2018

The decline in the physical and mental ability of older adults was also found to deter older adults from making trips due to their perception of danger or inability to travel far distances (Hirsch, Winters, Ashe, Clarke, & McKay, 2016; Jones et al., 2016; Kerr, Rosenberg, & Frank, 2012; Martens, 2018; Winters et al., 2015). The fear of injury also pertains to falling and was more apparent with older adults who have previously experienced a fall (Cerin et al., 2017; Hirsch, Winters, Ashe, Clarke, & McKay, 2016; Webber, Porter, & Menec, 2010). The research that analyzes the health of older adults all point to the fact that the lack of mobility was associated with declining health and lower physical and cognitive function (Cerin et al., 2017; Hirsch, Winters, Ashe, Clarke, & McKay, 2016; Kerr, Rosenberg, & Frank, 2012; Webber, Porter, & Menec, 2010).

2.5.2 Older Adult Active-Transportation

In light of the association between aging and declining health, the literature proposes that older adults who remain physically active, by walking or cycling tend to be healthier both physically and mentally (Barnett et al. 2017; Crist et al., 2017; Gojanovic et al., 2011; Hirsch et al., 2017; Hirsch et al., 2016; Jones et al., 2016; Kerr, Rosenberg, & Frank, 2012; Leger et al., 2019; Martens, 2018; Winters et al., 2015). Seniors who were seen to take more trips to various locations via walking or cycling were less likely to have or develop cognitive impairments, depression, coronary heart disease, and hypertension (Jones et al., 2016; Van Cauwenberg et al.,

2018; Winters et al., 2015). This relationship was seen in various studies that used walking or cycling scores to determine mobility patterns of adults over the age of 60 in a downtown setting (Winters et al., 2015; Winters et al., 2016).

These sources included data information regarding the walkability of a neighbourhood via 'walk scores' and 'Walk the Talk' (WTT) cross-sectional study that looks at the relationship between the environment and health (Hirsch, Winters, Ashe, Clarke, & McKay, 2016; Jones et al., 2016; Winters et al., 2015). The studies used this data in tandem with questionnaires and GPS devices that kept track of the trips that were made throughout the study period (Franke et al., 2017; Hirsch et al., 2016). This type of study was done with hundreds of older resident households in their respective research areas. It was also found that the built environment played a significant role towards the mobility of older adults where higher levels of mobility were associated with higher densities and amenities and services such as shops and bus routes located within proximity to their home (Hirsch et al., 2016; Winters et al., 2015).

However, according to Franke, Winters, McKay, Chaudhury, & Sims-Gould (2017), this trend existed at the individual level, as some seniors who were interviewed perceive the space around them differently. This difference was the result of their life histories, which are composed of past experiences and intrinsic factors such as culture, which influence their mobility (Webber et al., 2010). Life histories was highlighted by Jones et al. (2016), which found that individuals adapt to their environments differently based on experience which was seen by interviewing two seniors, where one of them had a larger activity space than their peers (Franke et al., 2017). The differences in their perception was the result of frequent places older adults visited or spent time socializing such as shops, banks, and the home of friends and relatives which shaped the activities of individuals as they aged (Franke et al., 2017; Hirsch et al., 2016; Winters et al., 2015). This relationship was seen again in a Hong Kong study, where the researchers found that

older adult walkability was associated with overall access to destinations/services (Wong et al. 2018). Contrast to other articles that have found that walkability was associated with the connectivity and places where they can sit (e.g. benches) in key destinations (Cerin et al., 2017; Chudyk et al., 2017; Kerr, Rosenberg, & Frank, 2012; Winters et al., 2015). The key learning from the literature suggests that proximity to services and the addition of facilities in a community has a positive association with higher levels of older adult mobility (and physical activity).

2.6 New transportation technology: Electric Bicycles

E-bikes are commonly defined as bicycles that consist of an electric motor that provide peddling assistance to the rider (Edge, Dean, Cuomo & Keshav, 2018; Gojanovic et al., 2011; Jin et al., 2015; Jones, Harm & Heinen, 2016; Leger et al., 2019). There are a variety of models that offer the user different levels of assistance (Leger et al., 2019). However, these models vary based on region. Most of the European literature refer to Pedelecs, which support peddling assistance up to 25km/h, and S-Pedelecs, which support speeds up to 45km/h (Cairns, Behrendt, Raffo, Beaumont, & Kiefer, 2017; Gojanovic, Welker, Iglesias, Daucourt, & Gremion, 2011; Jin et al., 2015; Schleinitz et al. 2017).

E-bike motors can range from 200W (watts) to 1000W and can have up to a 150km range (Fishman & Cherry, 2016, p.74). There are two types of motors, the first one being mid-drive motors, which are located between the pedals which and tend to be cheaper and hub-drive motors, which are located in the front or rear wheel (Hawkins, 2019). Hub-drive motors tend to be more efficient and give users with more torque when accelerating (Hawkins, 2019). To deliver power, e-bikes use either torque sensors which provide assistance based on how hard the user is pedalling or cadence sensors, which provide power based on how fast the cyclist is pedalling (Hawkins, 2019). The level of pedal-assist can be also be adjusted through a throttle

that users can adjust based on how much pressure they apply to the switch (Hawkins, 2019; Leger et al., 2019). Additionally, users can change the amount of pedal-assist using the speedometer located on the handlebars (Hawkins, 2019).

In North America, e-bikes are commonly referred to as bicycle-style electric bikes (BSEB) and come in two categories (MacArthur & Kobel, 2014; Rose, 2012; WSP, 2019). The first being a powered bicycle, which includes a throttle assist to propel the bike. The second category is the power-assisted bicycle, which assists the user as they pedal (MacArthur & Kobel, 2014; WSP 2019; Rose, 2012). In other cases, e-bikes can operate as a hybrid of both categories where users can pedal and a throttle to propel the bicycle. However, this was dependent on local policies that restrict the use of powered bicycles (MacArthur & Kobel, 2014; Rose, 2012; WSP, 2019). In terms of form, e-bikes are no different than a conventional bicycle aside from consisting of a battery and electric motor, which are typically located at the downtube or within the hub of the front or rear wheel (MacArthur & Kobel, 2014).

2.6.1 Trends and Usage of Electric Bicycles

Due to the assistance that e-bikes offer, they have become increasingly popular in China, and have begun emerging in North America (Jin et al., 2015; Schleinitz et al. 2017). As a result, there have been multiple studies that have tried to understand how e-bikes compare to conventional bicycles and for what purpose they are used for (i.e. commuting, recreational, etc.). When comparing e-bikes to conventional bicycles, studies have found that cyclists who use e-bikes tended to go on longer trips on average compared to their peers (Cairns et al., 2017; Fishman & Cherry, 2016; Jin et al., 2015; Johnson & Rose, 2016; Schleinitz et al., 2017). The longer trip lengths was due to the lack of physical effort that was needed to travel farther distances (Cairns et al., 2017; Fishman & Cherry, 2016; Fyhri & Fearnley, 2015; Jin et al., 2015; Johnson & Rose, 2016; Jones, Harm, & Heinen, 2016; Schleinitz et al., 2017). In terms of speed,

e-bike users had higher top and average speeds compared to users who had conventional bicycles (Fyhri & Fearnley, 2015; Schleinitz et al., 2017). This finding was common in most studies that compared both modes regardless of the country the research was conducted.

As for the trips, little information exists regarding the destination of individuals and older adults who used e-bikes. The majority of literature focused on comparing performance indicators of e-bikes such as the speed and safety to other modes of transportation (e.g. conventional bicycles) (Johnson & Rose, 2016; Langford et al., 2015; Schleinitz et al., 2017). Only a few articles looked at trip purpose, more specifically, whether individuals used e-bikes for commuting or recreation purposes. For example, Jin et al. (2015), looked at the flow of bicycle traffic in China using traffic camera information. Multiple articles were also found that looked at the effect of e-bike mode share while considering whether they were used for commuting or non-commuting purposes (Dill & Rose, 2012; Gojanovic et al., 2011; Johnson & Rose, 2016; Jones, Harm, & Heinen, 2016; Lopez et al., 2017; Schleinitz et al., 2017). These studies both used mixed-methods approaches that also included questionnaires and follow up interviews to understand the motivations behind e-bike use (Dill & Rose, 2012; Gojanovic et al., 2011; Jones, Harm, & Heinen, 2016; Schleinitz et al., 2017).

The common finding was that e-bikes were mainly used for commuting purposes, followed by recreation and exercise (Dill & Rose, 2012; Gojanovic et al., 2011; Lopez et al., 2017; Jones, Harm, & Heinen, 2016; Schleinitz et al., 2017). In terms of recruitment for these studies, citizens were contracted through email or flyers and followed up with qualitative interviews or given travel diaries to keep track of their trips over time (Schleinitz et al., 2017). The target demographic for most studies tended to be of all age groups, but the average sample group had an approximate age of 40 years old (Schleinitz et al., 2017, p.292). After analyzing E-

bike literature regarding their usage, it was found that statistics regarding the demographic information for e-bikes users for North America was minimal, and none available for Canada.

2.6.1.1 E-cargo bicycles

Electric cargo bicycles (ECBs) have also become popular among couriers such as UPS, DHL and TNT (AUAS, 2017; Bike Europe, 2018). Due to their configurability and battery assist, e-bikes have been viewed as a sustainable and efficient mode for last-mile deliveries compared to small trucks and vans (Electric Bike Report, 2018a; Electric Bike Report, 2018b; Melo & Baptista, 2017; Pembina Foundation, 2017). The battery assist allows couriers to travel through hilly topography with a payload capacity up to 408kg (Pembina Foundation, 2017; Pembina Institute, 2019). Their size also gave them the ability to utilize bicycle routes and sidewalk parking in otherwise congested city centres (AUAS, 2017; Pembina Foundation, 2017). The bicycles are also configurable, which allow couriers and businesses to customize them based on their needs. Their configurability includes the addition of storage compartments, locks, signals, and lights (Toronto Star, 2017).

The majority of these couriers operate ECBs in Europe, where UPS has been using ECBs as the last-mile delivery solution in Europe since 2012 in Germany and Switzerland (Pembina Foundation, 2017). Where DHL currently operates their Cubicycle, in over 80 cities across 13 countries in Europe (DHL, 2017; Ecommerce News, 2017; Electric Bike Report, 2018a; Electric Bike Report, 2018b). More recently, UPS launched ECB pilots in Portland, Pittsburgh, Seattle and Toronto between 2016 and 2017 (UPS, 2016; Toronto Start, 2017). However, their adoption in North America has been slow due to policies and regulations that have restricted or limited their potential as a form of urban freight (i.e. weight restrictions, dimensions, battery size, etc.) (AUAS, 2017; Toronto Star, 2017).

Local businesses have also adopted ECB and e-bikes to deliver goods as opposed to vans and small trucks (AUAS, 2017; Pembina Foundation, 2017). Their adoption was predominately seen in larger North American cities like New York and Toronto, which have the density and cycling infrastructure (e.g. bike lanes) that would make ECBs feasible (Pembina Foundation, 2017). These businesses mainly provide time-sensitive on-demand services such as food delivery (AUAS, 2017; Pembina Foundation, 2017). Examples include Domino's Pizza, Foodora and Deliveroo (AUAS, 2017; Pembina Foundation, 2017).

2.6.1.2 Electric-bicycle Share

E-bikes have also become popular amongst bicycle share programs. Their popularity was seen in European and North American cities such as Stuggart, Milan, and Copenhagen, all of which have either have a mixed or entire fleet composed of e-bikes (He, Song, Liu, & Sze, 2019). In North America, the first e-bike share emerged as a pilot at the University of Tennessee-Knoxville (UTK) in 2011 (He, Song, Liu, & Sze, 2019, p. 2). Although e-bike share is not a new form of mobility, there was very little literature that has examined their popularity and use compared to conventional bicycles. However, research by He et al. & CNN Business (2019 & 2018) found that commuters make up the largest proportion of users. The reason being was to avoid car congestion throughout commuting hours, wherein 2018 Uber saw a 15% increase in e-bike ridership via Jump Bicycles and a 10% decrease in vehicle trips in San Francisco (CNN Business, 2018). Furthermore, e-bike share was found to be utilized best when in areas with high population density and located within proximity to transit stations (He et al., 2019). Although there is little research that has explored e-bike share adoption and operations, the existing literature shows that e-bikes are becoming more popular and attainable through ride-share programs, especially as a last-mile alternative.

2.6.2 Environmental impact of E-bikes

There was a lack of research that pertained to the environmental benefits of using e-bikes. Environmental concerns were found to play a role in the purchase of e-bikes, as it was a typical response by survey respondents (Dill & Rose, 2012). However, all the articles that were reviewed found that e-bikes are more environmentally friendly compared to both motorized and electric vehicles (Dill & Rose, 2012; Edge, Dean, Cuomo, & Keshav, 2018; Fishman & Cherry, 2016; Jin et al., 2015; Leger, Dean, & Casello, 2019). Their lower environmental impact was due to their relatively lightweight design, and low energy consumption rate made them more efficient per passenger-kilometre basis (Elliot, McLaren, & Sims, 2018; Fishman & Cherry, 2016). For example, e-bikes were found to consume an average of 150kWh of electricity over their lifetime and emit twenty times less greenhouse gas emission per functional unit than cars (Elliot, McLaren, & Sims, 2018, p. 231; Fishman & Cherry, 2016, p. 82). Throughout the overall lifecycle of e-bikes, they were found to have less environmental impact compared to vehicles due to their smaller size and efficiency throughout their use.

In terms of negative environmental aspects associated with e-bikes, the production, battery and energy source was found to have a significant environmental impact (Dill & Rose, 2012; Elliot, McLaren, & Sims, 2018; Jin et al., 2015). Per functional unit, e-bikes were found to have a higher environmental impact compared to cars due to the extraction and production of their materials, which included lithium and lead for the batteries and the aluminum frame (Elliot, McLaren, & Sims, 2018). Their environmental impact was more of a concern in China due to their use of lead batteries, which may cause contamination of land after their disposal (Dill & Rose, 2012; Jin et al., 2015). The energy source used to charge the batteries also influenced the environmental impact of e-bikes. Electric power derived from non-renewable sources such as coal did not make e-bike as environmentally friendly as their owners perceived them to be due to

the emissions caused upstream (Dill & Rose, 2012; Jin et al., 2015). Although there are negative aspects associated with the power source of e-bikes, the overall use of e-bikes had a lower environmental impact compared to cars.

2.6.3 Electric Bicycle Policies and Regulations

Policies and regulations associated with e-bikes are a factor in the sale and use of e-bikes. More specifically, what defines an e-bike and where they are permitted in Canada (e.g. local roads, multi-use paths, etc.). According to Transport Canada's *Motor Vehicle Safety Regulation* in the *Motor Vehicle Safety Act,* e-bikes are categorized as a bicycle which can provide an assist up to 32km/h when muscular power is applied where each shaft of each motor provides a continuous power output of 500W or less (Transport Canada, 2019; MacArthur & Kobel, 2014). Regulations about to battery size were also found to be lower compared to the United States, where the battery size is limited to 750W (MacArthur & Kobel, 2014). Furthermore, Transport Canada states that e-bikes must include safety features such as cutting power when the e-bike reach 32km/h and when muscular power ceases (Transport Canada, 2019; MacArthur & Kobel, 2014).

Although the Federal government plays a role in defining what e-bikes are, they only act as a guide, which is interpreted by each province and territory. At the provincial scale, regulations were found to align with Transport Canada's definition generally, but there were differences in restrictions and how e-bikes were defined between provinces (MacArthur & Kobel, 2014). For example, New Brunswick, Newfoundland and Labrador, the North-West Territories and Nova Scotia did not have a proper vehicle definition for e-bikes in their planning legislation. In contrast, Alberta and British Columbia had stricter regulations as they only permit the use of pedal-assisted bicycles (MacArthur & Kobel, 2014). In Ontario, e-bikes are defined in the Highway Traffic Act's (HTA), which state that their operation must be through muscular

power and have a manufacturer label stating its compliance with the description by Transport Canada (Ontario, 2019). The HTA also says that users must be over the age of 16 to operate an e-bike (Ontario, 2019; MacArthur & Kobel, 2014). For licencing, all Provinces and Territories except for Prince Edward Island, require users to have a valid drivers license (MacArthur & Kobel, 2014). These regulations are limited to public thoroughfares/roads which have led to issues associated with their use on municipality regulated bicycle lanes and multi-use paths

Although the Province of Ontario regulates the use of e-bikes on public roads, municipalities have jurisdiction over bicycle lanes and multi-use paths (MacArthur & Kobel, 2014). As e-bikes are a relatively new form of transportation, its definition or lack thereof has acted as a barrier towards their use. Their vague definition in Canada and the United States has led to some cities categorizing them as a "motor-vehicle" as opposed to a "bicycle" (MacArthur & Kobel, 2014). For example, the City of Toronto previously banned the use of e-bikes on bike lanes and multi-use paths due to their local definition, which categorized e-bikes as a "motor vehicle". This definition changed in 2014, where the city amended its definition of a *bicycle* to include e-bikes (MacArthur & Kobel, 2014, p. 26). In New York City, e-bikes are categorized as "motorized scooters", and remain banned on public thoroughfares due to their risk of safety to pedestrians (MacArthur & Kobel, 2014). The lack of clear policies and regulations of e-bikes in North America has contributed towards barriers such as confusion and misinterpretation that has restricted their use.

Regulations and policies differ In European countries compared to North America as enforcement is through the European Union (EU). The definition of an e-bike, the EU was found to have a more specific way to categorize different vehicles where they classify e-bikes as a bicycle with pedal assistance (European Cyclists Federation, 2016). Similar to North America, the EU has placed limitations on pedal assistance and battery size where they may assist riders

up to 25km/h and have a battery size, up to 250W (European Cyclists Federation, 2016; AUAS, 2017, p.116). Unlike North America, e-bike regulations in the EU are set by a larger governmental body, providing a greater sense of clarity across a broader jurisdiction regarding what defines an e-bike and where users can ride them.

2.6.4 Electric Bicycle Sales Trends

Although e-bikes pose a potential opportunity to maintain the mobility of older adults, there is very little literature that has explored their adoption through e-bike sales. The majority of research that has looked at e-bike sales trends was in Europe and Asia, with only one study focused on e-bike sales trends in North America. However, there was greater emphasis on the United States e-bike market, making it inapplicable towards a Canadian context (Bicycle Retailer, 2017b). As for global e-bike sales, approximately 40 million e-bikes were sold in 2013, with the majority of sales being in China and European countries, indicating that there is a rise in their popularity (INSG, 2014, 2; Bike Europe, 2019). The following section will highlight these sales trends as a means to compare them to North America.

2.6.4.1 European E-bike Sales trends

European e-bike sales were found to account for approximately 4.5 percent of global sales in 2013, or 1.8 million e-bikes (INSG, 2014, p.2). Germany had the largest share of e-European e-bike sales at 25 percent, followed by the Netherlands, which had a 21 percent market share (INSG, 2014, p.3). France, Italy and Austria each had a market share of approximately 5 percent (INSG, 2014, p.3). Although the number for e-bike sales account for a small proportion of global e-bike sales, sales in Germany and the Netherlands have begun to outperform conventional bicycles (Bike Europe, 2019; Reid, 2019). In the case of the Netherlands, e-bikes accounted for 40 percent of all bicycle sales in 2018 (Bike Europe, 2019; Reid, 2019). Where a bicycle retailer survey found that the turnover for e-bikes was up by 34.4 percent in the first

quarter compared to the same period in 2017 compared to 2011 where e-bikes only account for 15 percent of sales, e-bikes sales have significantly increased (Bike Europe, 2019; Reid, 2019). Although there was no specific explanation for this occurrence, factors such as favourability for high-quality e-bikes and current conventional bicycle ownership were assumed to be the cause in the increase in e-bike sales (Bicycle retailer, 2017a; Reid, 2019).

Similar to the Netherlands, e-bike sales in Germany were found to outperform conventional bicycles as well (Bicycle Retailer, 2017a; Reid, 2019). German e-bike sales saw an increase of 30 percent as conventional bicycle sales decreased by 2.2 percent in the first half of 2017 (Bicycle Retailer, 2017a). The decrease in bicycle sales was due to current bicycle ownership since 80 percent of Germany households owned at least one bicycle (Bicycle Retailer, 2017a). Another reason for the increase in sales included the need for their aging population to replace conventional bicycles with e-bikes (Bicycle Retailer, 2017a). As a result, e-bikes sales in Germany were forecasted to exceed 680,000 units by the end of 2017, indicating their growing popularity in Europe (Bicycle Retailer, 2017a). The built environment and cycling culture differ in Canada, the rising demand and adoption by older adults due to their ability to allow them to travel farther and faster while using less energy than a conventional bicycle.

2.6.4.2 Asian E-bike Sales Trends

Asia accounted for the most significant proportion of global e-bike sales with China accounting for 85 percent of all e-bike sales in 2013, which translated to approximately 32 million units, followed by Japan with 440,000 units (INSG, 2014, p.3). Compared to Europe, China began promoting the development of e-bikes in the early 1990s, which eventually led to their e-bike sales to outnumber global electric car sales in 2013 (INSG, 2014, p.1-2). Where in 2014, the Chinese e-bike market outnumbered cars with an estimated total of 150 million units (MacArthur & Kobel, 2014, p.1). The increase in e-bike sales is similar to the increasing trend in

Europe, where the number of e-bike sales has been increasing since 2013. Although sales trends from 2013-14 have changed drastically compared to trends in 2017, the proportion of e-bikes in the bicycle market has increased regardless of increased costs and current bicycle ownership, especially in Europe. These trends contrast China's e-bike market as sales were found to be the result of lower costs associated with lead-acid batteries versus the costlier nickel-metal hydride and lithium-ion batteries used in Europe and North America (INSG, 2014).

2.6.4.3 North America E-bike Sales Trends

The literature indicated that e-bike sales in North America are not to the same extent as Europe and Asia as the United States only had 185,000 e-bikes sales in 2013 (INSG, 2014, p.2). More recently, e-bike sales doubled between 2016-2017, from USD 16.7 million to USD 31.8 million, indicating that the United States is experiencing an upward trend in e-bike sales similar to Europe and Asia (Bicycle Retailer, 2017b; Bike Europe, 2017). A shortcoming of the literature was that no research analyzed the sales trends of e-bikes in Canada. There was only one study was found which analyzed sales trends of North American e-bike retailers. This survey was conducted by Bicycle Retailer Magazine in 2017 and included retailers in the United States and Canada. However, there was a greater focus on retailers in the United States (Bicycle Retailer, 2017b). In terms of the e-bike retailer survey, 602 responses were collected (Bicycle Retailer, 2017b, p.30). They found that 62 percent of retailers sold e-bikes, where approximately 60 percent of the retailers have only been selling e-bikes for less than three years (Bicycle Retailer, 2017b, p.30). It was also noted that in an online survey they conducted din 2014, only 38 percent of retailers sold e-bikes (Bicycle Retailer, 2017b, 30). Although the second survey was not a replication of the 2014 study, it indicated that the demand for e-bikes has increased since then. As for sales, three-fourths of retailers stated that e-bikes only represented 10 percent or less of their overall bicycle sales (Bicycle Retailer, 2017b, p.30). Although the surveys did not

account for the age of customers, it indicates that there is a rise in e-bike ownership in North America, which could suggest that there is a growing number of older adults adopting this technology.

2.7 Older Adult E-bike Use

Only four papers exist which have looked at the relationship between older adults and e-bikes. They all share similarities and differences concerning ownership and their use. These similarities were through a temporal element as these papers were exploring e-bike use from different stages of adoption where three of the studies analyzed current trends associated with e-bikes within their respective countries (Johnson & Rose, 2015; Jones et al., 2016; Van Cauwenberg et al., 2019). In contrast, Leger et al. (2019) aimed to explore their potential for future adoption to support the independent mobility of older adults. As for their research objectives, Jones et al. (2016) and Leger et al. (2015) aimed to determine facilitators and barriers associated with e-bike adoption of older adult cyclists and non-cyclists over the age of 50. Their objectives included understanding how the built environment effect e-bike adoption from an individual perspective, compared to Jones et al. (2016), who explored the various types of riders that included: reluctant, resilient and re-engaged riders. Both papers aimed to provide policy advice concerning cycling infrastructure to planners and practitioners. Whereas Johnson & Rose (2015) and Van Cauwenberg et al. (2019) collected data to provide insight into the current state of e-bike ownership in Australia and Belgium, respectively. They both did this through qualitative interviews with existing older adult e-cyclists as a means to understand current ridership levels. In terms of how they differed, Jones et al. (2016) explored various types of riders, which they categorized as Reluctant, Resilient or re-engaged riders. Where reluctant referred to individuals who were less likely to cycle, resilient who enjoy cycling and adapt to changes over time and re-engaged, which apply to individuals have got back into cycling again

since they have placed importance to being active. Compared to Johnson & Rose (2016) and Van Cauwenberg et al. (2019), who looked at users more broadly. Looking at e-bike ownership and how often older adults used e-bikes to replace trips made by cars and conventional bikes. Additionally, Van Cauwenberg et al. (2019) explored crash characteristics between men and women which found no significant differences in crashes between them

Additionally, a quantitative North American e-bike survey of e-bike owners by MacArthur et al. (2018, 11) that analyzed e-bike trends found that older adults over the age of 55 reported having physical limitations, which led to their decision to purchase an e-bike. These limitations included knee pain, respiratory disease and arthritis. Similar to the e-bike survey by Johnson & Rose (2015) and Van Cauwenberg et al. (2019)), the findings provided a broad understanding of e-bike ownership trends as a whole. Additionally, it found that older adults used e-bikes for recreational purposes because it was easier to use and less strenuous compared to a conventional bicycle (MacArthur et al., 2018). Additionally, Johnson & Rose (2015) and Leger et al. (2019) found that older adult cyclists were more likely to adopt an e-bike compared to non-cyclists to remain engaged with their community.

The methodology that was used by each paper shared similarities to previous e-bike studies. For example, Jones et al. (2016) and Leger et al. (2019) who used go-along interviews similar to other studies which explored different modes of active transportation such as walking and cycling (Carpiano, 2009; Van Cauwenberg et al., 2018; Winters et al., 2015). Compared to Johnston and Rose (2015) and Van Cauwenberg et al. (2019), which used an online survey or interview-version of the same questionnaire to understand e-bike ownership and ridership rates. In turn, the survey yielded a higher number of responses from a larger geographic area (Creswell, 2014; Johnson & Rose, 2015).

2.8 Summary

To understand the nature of older adult e-bike use, to evaluate and to synthesize the literature was necessary to continue further research about this topic. By assessing the key findings and methodologies in the relevant literature, it presented the gaps that exist, which then can be used to inform the direction that this research will undertake. The key points taken from the evaluation were that research older adult e-bike use is virtually non-existent. The literature review examined four major themes: 'active mobility', 'active transportation & Older adults', 'E-bikes' and 'Older adult E-bike use'. As a result, it found that active modes of travel, such as cycling, were associated with positive environmental and health benefits. For the environment, e-bikes have lower rates of emissions compared to motorized vehicles. As for health, e-bikes may lower the risk of developing chronic diseases and depression (Barnett et al. 2017; Kerr, Rosenberg, & Frank, 2012; Martens, 2018; Crist et al., 2017; Winters et al., 2015). However, older adults expressed concerns towards the built environment as some communities or trips consisted of barriers that inhibited their motivation to bike which included distances to services/convenience of routes, hilly topography, and the physical exertion involved with cycling at an older age (Cairns et al., 2017; Cerin et al., 2017; Fishman & Cherry, 2016; Winters et al., 2010; Schleinitz et al., 2017). The literature indicates that e-bike technology may prove to be an intervention that allows older adults, namely active older adults, to remain mobile as they get older and lose their mobility. The electric motor will enable them to overcome the barriers that they expressed with using a conventional bicycle such as physical exertion and distance (Cairns et al., 2017; Fishman & Cherry, 2016; Jin et al., 2015; Schleinitz et al., 2017).

The majority of the research used a mixed-methods approach, which collected vast amounts of data through surveys that gave broad information about cycling. Qualitative data collected through a small number of interviews provided rich information about the experiences

of specific groups of individuals (e.g. Older adults) (Crist et al., 2017; Van Cauwenberg et al., 2018; Winters et al., 2015). These methods were used to inform the methodology for the exploratory qualitative approach that this research will undertake to fill the gap in the literature about older adult active transportation through the use of both e-bikes and e-trikes within a Canadian context.

Chapter 3: Research Methodology

3.1 Introduction

The research question of this study is to determine if e-bikes may be a potential intervention that allows older adults to prolong their mobility and support aging in place within a Canadian context. The research used a qualitative research approach to explore this relationship that incorporated a modified go-along interview. The modified go-along included a trial-ride of the e-bike and e-trike followed by sit-down interviews which included reviewing the trial-ride footage with participants one or two days after the ride to ensure their safety while on the e-bike and e-trike (Carpiano, 2009; Dean, 2016; Kusenbach, 2003). In doing so, it allowed the study to meet the research objectives:

i) To understand how older adult' perceptions and experiences of e-bikes and/or e-trikes influence their future adoption

ii) To investigate which technological aspects of e-bikes and/or e-trikes are supportive of older adult riders; and,

iii) To examine the built environmental determinants of e-bike and/or e-trike use among older adult riders

By reaching the research objectives, this study support efforts that encourage e-bike and e-trike use to allow older adults to mobility their mobility and age-in-place in North America. Given the existing literature that has shown a positive association between physical activity with physical and social health, e-bikes provide an intervention which allow older adults to maintain and/or extend their mobility.

3.2 Research Philosophy/Paradigm

A pragmatic research philosophy, understanding of planning issues from a holistic perspective using an exploratory qualitative research approach, guides this research to explore how e-bikes may be or are a viable mode choice for active older adults to prolong their mobility. The approach provided the ability for the researcher to develop solutions and policies to solve problems for real-world situations, allowing the researcher to understand the multiple factors associated with the use of the e-bike and e-trike (Creswell, 2014; Salkind, 2010). Qualitative data was gathered using a modified go-along method, which included two stages that will provide a deeper/insightful understanding concerning the barriers and facilitators associated with e-bike use and future adoption (Johnson & Onwuegbuzie, 2004). The stages included an e-bike trial-ride along a pre-determined route in the Waterloo Region and a follow-up interview one or two days after the ride-along. This data was not only be used to answer the research question but provide a foundation that researchers may use for future research in this area. The study was also practice-oriented as it not only informs policy and municipal planning practices but provides an opportunity that enables older adults to maintain and/or improve their mobility (Creswell, 2014).

3.3 Research Methods: Qualitative Approach

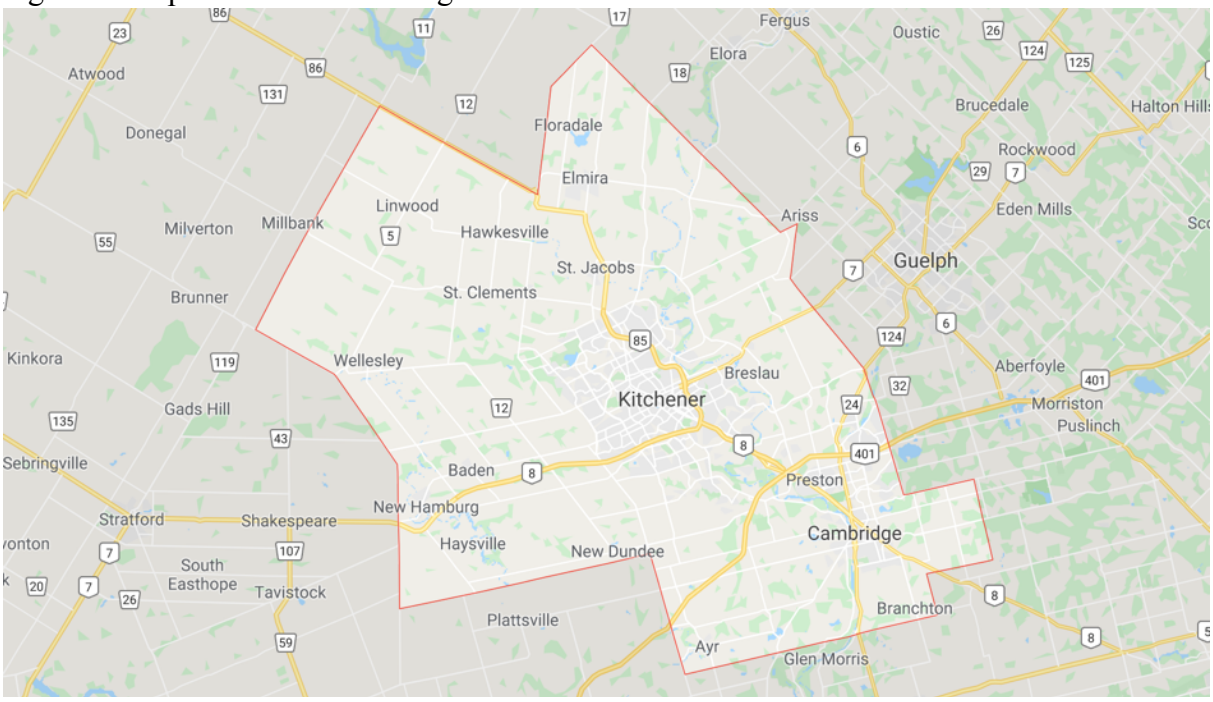
Qualitative research aims to understand broad behaviours and attitudes by collecting information from participants and organizing them into themes. This approach may be through interviews or focus groups, which allow respondents to speak freely about their thoughts about a topic or issue (Creswell, 2014; Johnson & Onwuegbuzie, 2004). Qualitative approaches are useful when attempting to understand the thoughts and experiences of a particular group of individuals that share common characteristics (Creswell, 2014). Questions can be tailored to suit the specific context that the study is conducted under, and explain phenomena within the scope of the study (Creswell, 2014). For this study, a qualitative research approach would allow the

researcher to understand whether e-bikes and e-trikes can prolong the mobility of active older adults to support aging-in-place. The approach would provide an understanding of the behaviours and attitudes that active older adults have towards e-bikes. This understanding would be through open-ended questions that would provide insight towards the individual, technological and built environment that would allow older adults to prolong their mobility and age-in-place. Qualitative methods were used to understand whether e-bikes and e-trikes can prolong the mobility of older adults by uncovering barriers and facilitators that influence their potential adoption and use.

For this study, the qualitative approach contributed in-depth, rich information from active older adults. Additionally, by using targeted sampling to target an existing population of older adult cyclists, this research sheds light on whether e-bikes can prolong mobility to support aging-in-place (Patton, 2015). In doing so, the research allows the investigator to understand the barriers and facilitators associated with adopting an e-bike and e-trike from the perspective of each participant, providing a holistic account which can be generalized towards the experiences of other older adult cyclists (Creswell, 2014). This approach provided a diverse sample of respondents that engages a variety of individual, technological and environmental factors associated with adopting an e-bike and e-trike.

3.4 Research Setting: Waterloo Region

Figure 2: Map of the Waterloo Region



(Google maps, 2019a)

To explore the older adult e-bike use, the Waterloo Region was used for the study area because of its mid-large population size and the urban-suburban mixed urban form (Region of Waterloo, 2014). Additionally, the population growth rate of seniors was 21.4 percent between 2011 and 2016; Individuals over 55 are forecasted to make up 29% of the population by 2021 (Region of Waterloo, 2014, p.1; Region of Waterloo, 2016). The growing older adult population presented the need to ensure that they will be able to maintain their mobility in the future, facilitating aging-in-place (Region of Waterloo, 2014). Additionally, the study area's proximity to the University of Waterloo reduced the time and costs associated with travelling for the researcher. The urban-suburban nature of the Waterloo Region also provides diversity concerning the type of cycling infrastructure available, allowing the individual, technological, and environmental factors that influence e-bike use for older adults to apply to other mid-large

sized municipalities. Especially municipalities which are expecting future population growth and potential development projects to improve their active transportation network. As a result, the study area of the Waterloo Region presented an opportunity to study the relationship between older adults and e-bike due to the growing number of older adults and the urban-suburban mixed nature of the Region (Region of Waterloo, 2014). The Waterloo Region encourages mobility and aging-in-place which was evident through their designations with the World Health Organization network for age-friendly cities and communities as well as their bicycle-friendliness (Share the road, 2019; WHO, 2019). This information can be shared amongst their networks and used by decision-makers that can make changes towards cycling infrastructure as well as inform policy and plans that aim to make areas more age-friendly.

3.5 Participants: Active Older Adults

To understand whether e-bikes may be a potential intervention that allows older adults to maintain their mobility as they age, active older adults served as the sample population of this study. The term older adult has been used interchangeably with senior and has typically referred to individuals 65 years of age by governmental organizations and non-governmental agencies (Statistics Canada, 2018; WHO, 2019). However, there is no definitive age when an individual is considered "old-age" due to the variety of factors which include interests, abilities, level of independence and health, retirement age, etc. (City of Hamilton, 2014). These factors indicate that "old-age" varies at an individual level as it implies that people age at different rates, meaning that individuals at the same stage of life may be different ages. For this study, the definition of older adults are individuals over the age of 50, which aligned with the City of Hamilton's definition of an older adult, which defines it as a stage of life rather than a fixed age (City of Hamilton, 2014, p. 2).

Active older adults presented an ideal sample group for this study because they have not yet lost their independent mobility due to aging. However, they may soon need the benefits of the e-bike or e-trike if they wish to continue cycling due to the health and social benefits that are associated with it. Similar studies have accomplished this through the use of go-along interviews, which have a holistic understanding of the thoughts and experiences that older adults have towards e-bike use and adoption (Jones et al., 2016). These studies have found that older adults who cycled as a social activity or were already active were more likely to adopt an e-bike to stay engaged with their community (Jones et al., 2016; Leger et al., 2019). By exploring the thoughts and experiences of active older adults in the Waterloo Region may confirm these results, as well as further explore the individual, mode and environmental factors that are associated with their decision to adopt an e-bike to prolong their mobility, in turn, allowing them to age-in-place.

3.6 Participant Recruitment

The recruitment of participants was through older adult cycling clubs in the Waterloo Region, which consisted of active individuals over the age of 50 and/or who identified themselves as an older adult. This method was used to ensure maximum variation, which refers to collecting data from a wide variety of potential e-bike users to uncover patterns that cut across the experiences of older adult cyclists at all skill levels (Palinkas et al., 2015). However, for the case of this study, younger participants and non-cyclists were excluded as the purpose of this research was to determine the experiences of older adult cyclists and whether e-bikes can prolong their mobility to support aging-in-place.

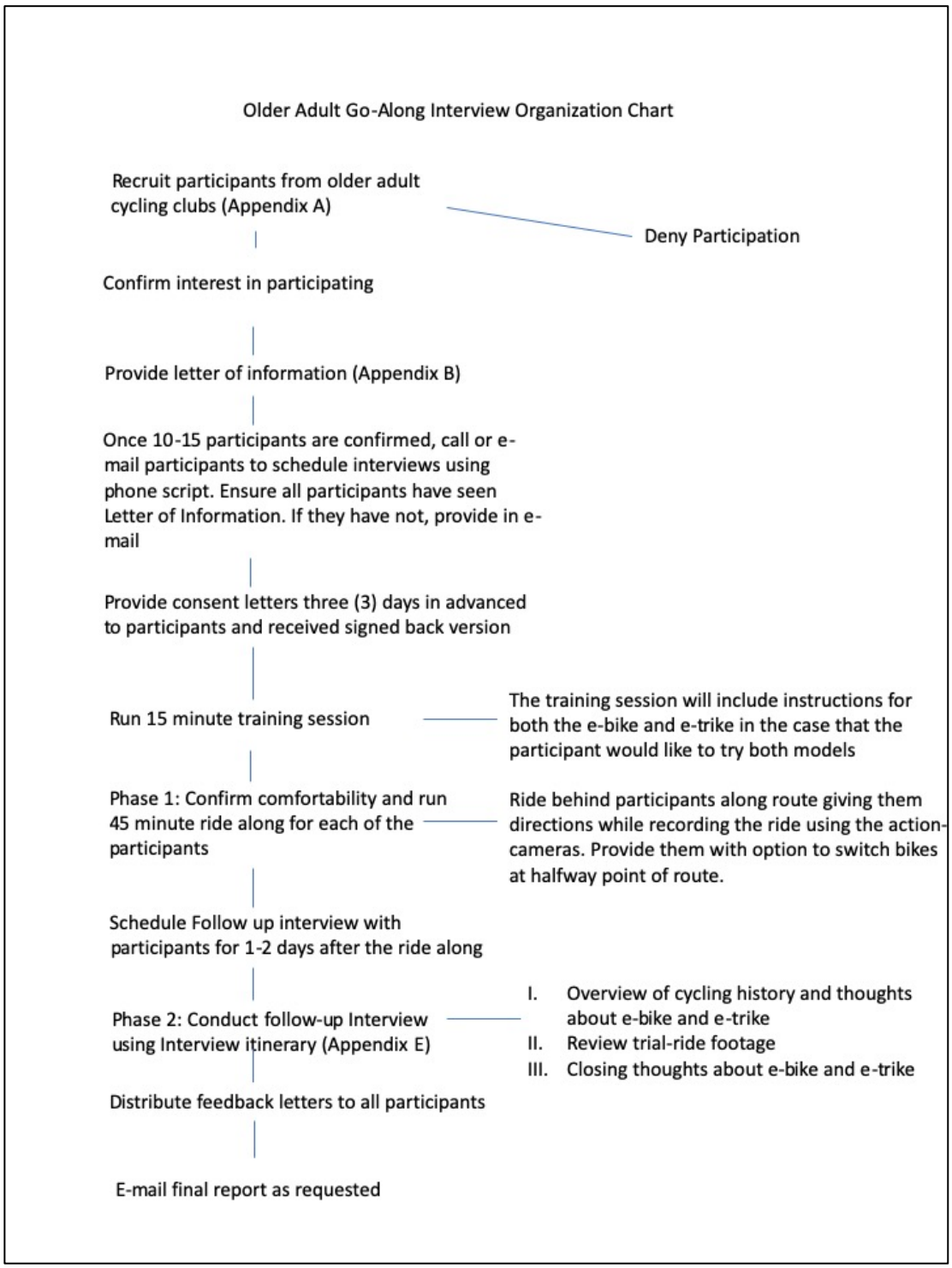
Recruitment was initiated by e-mailing two older adult cycling clubs with a short description of the study and benefits to their members. These e-mails were followed up by executive members who served as gatekeepers to the older adult cyclists for both cycling clubs.

The researcher gave both executive members with more information about the study through an e-mail or phone call from the researcher who followed a recruitment script which can be found in Appendix B. The researcher then e-mailed both cycling clubs with a recruitment summary which they sent to all members of their respective cycling clubs. The summary included a brief overview of the study and the researchers' contact information if their members were interested and wanted to take part.

Participants were recruited from older adult cycling clubs within the region by e-mailing and calling board members of each cycling club who acted as gatekeepers to the study group. The research provided gatekeepers with a brief overview of the study, which included the purpose of the research and points of contact if their members were interested in learning more and taking part in the study. When members e-mailed the primary researcher, they were given information and consent form to their review, which they signed before the ride-along. The form outlined the purpose of the study, procedures, risks and benefits, confidentiality, and highlighting the participation in the study was voluntary (See Appendix C). A total of 20 individuals expressed interest, but only 12 took part in both the ride-along and follow-up interviews. Eight of the respondents were not able to participate due to conflicting schedules and that the study reached saturation (Creswell, 2014; Baxter & Eyles, 1996). Individuals who were able to attend scheduled two one-hour sessions with the researcher for the modified go-along interview, which consisted of a one-hour trial-ride session and a follow-up interview. A two-hour timeslot was planned for the follow-up interview for participants 5 and 6 who completed their sessions together. A total of 22 sessions were conducted between June 19, 2019, to July 3, 2019. Participants met with the researcher at Environment 3 to receive training for both the e-bike and e-trike before riding them along Ring Road and the Laurel Creek Multi-use trail. For the

qualitative interview, participants met with the researcher at Environment 3 one or two days after the trial-ride. The interview took place in a private room in the building, which had a large television screen that was used to watch the action-camera footage and will be discussed further in the following section (See Figure 3).

Figure 3: Older Adult Interview Process Organization Chart



3.6 Research Methods

To determine whether e-bikes and e-trikes can prolong older adult mobility, an exploratory qualitative approach was used. The Waterloo Region was used as the study area using a modified go-along method that consists of two stages. The first phase was a trial ride on the e-bike and e-trike, followed by the second phase, which included a semi-structured interview. These methods aimed to answer the research questions while providing a generalizable context that can be transferable to other Canadian cities.

3.7.1 Go-Along

Modified go-along interviews were used throughout the qualitative portion of the study. The purpose of these interviews is to allow older adults to try an e-bike and e-trike to understand their initial thoughts regarding this technology. Although go-along interviews are a relatively new method of qualitative research, they allow researchers to obtain more depth about how the environment affects human behaviour in situ (Carpiano, 2009; Kusenbach 2003). More specifically, understand how individuals used and perceived the environment around them, which met the research objectives of this study (Carpiano, 2009; Kusenbach 2003).

Go-along interviews resemble the concept of life-spaces, which refer to the various locations which individuals interact with based on their level of mobility where this study focuses on the neighbourhood level which included areas where they cycle in the Region (Kusenbach, 2003; Webber et al., 2010). According to Hand et al. (2017) and Hand et al. (2018), the way people interact with their neighbourhoods due to the complex interconnected environmental elements which shape allow them to shape one another. Similarly, research has shown that neighbourhoods play a role in maintaining and/or expanding the life-spaces of individuals. It is based on the various opportunities they bring as a result of mixed-use land use planning and new

technologies that allow older adults to maintain their health (Golant, 2019). Due to the dynamic nature of places, qualitative methods are needed to fully understand the complexity associated with the meanings that are attached to them at the individual level (Golant, 2019; Hand et al., 2017). Go-along interviews allowed the researcher to explore the complex relationships between the participant, e-bike and their surrounding environment.

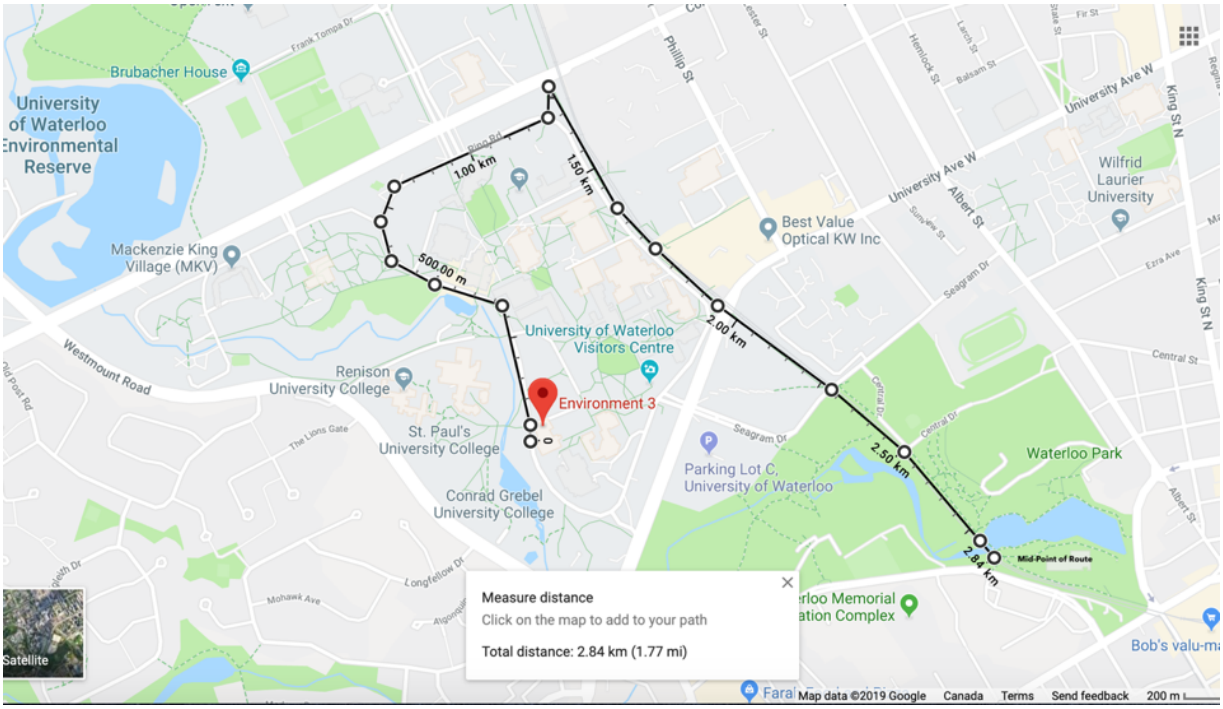
Due to the combination of interviews, participant observation, and field observations that used for this method, five thematic areas were explored throughout this process (Kusenbach, 2003). These areas being: 'Perceptions', 'Biographies', 'Spatial practices', 'Social architecture', and the 'Social realm' (Kusenbach, 2003). Where 'perceptions' referred to how the individual values affected the way they experience the social and physical environment (Kusenbach, 2003). 'Social practices' referred to the degree and forms of engagement with their environment (Kusenbach, 2003). 'Biographies' which explored the relationship between one's life history and places (Kusenbach, 2003). 'Social architecture' which looked at how people-oriented themselves concerning their social setting (Kusenbach, 2003). 'Social Realms' was the last thematic area that looked at how the place influenced the patterns of interactions (Kusenbach, 2003). These thematic areas further enhanced the ability of the researcher to explore how the environment influenced everyday decisions that were made by the respondent.

Go-along interviews allowed the researcher to see first-hand how older adults react and used the technology, but follow up and ask meaningful questions regarding their experience. For example, similar studies used go-along interviews to explore themes and motivations concerning older adult mobility (Crist et al., 2017; Van Cauwenberg et al., 2018; Winters et al., 2015). Due to the exploratory nature of this study and the older participants, the researcher conducted a modified version of the go-along interview in two phases. The first phase included a trial-ride

where the participant's test rode the e-trike and e-trike along a controlled route that was six kilometres in total. The route consisted of cycling along Ring Road around the University of Waterloo and down the multi-use trail, which ran parallel to the Light Rail Transit (LRT) line towards Uptown Waterloo (See Figure 4). The second phase included a sit-down interview where both the research and participant went over the interview itinerary and watch the camera footage from the trial-ride (See appendix F). By using qualitative methods, the twelve participants were able to reflect on their experience riding the e-bike and e-trike and how particular aspects of their own experiences, the bicycle itself and the cycling infrastructure influenced how they felt about the research question of the study. The researcher coded each interview and was guided by pragmatic research philosophy to understand the issue from a holistic perspective.

The researcher used a framework analysis to identify the relevance of existing themes recognized in the literature while also generating new ones. Specific themes from the literature incorporated into the framework included barriers and facilitators to riding e-bikes and e-trikes. Responses from the modified go-along interviews would then be organized into an analytic framework that would allow the researcher to understand the rider perceptions towards riding the e-bike and e-trike, future adoption and the infrastructure that facilitates or deters their use. In doing so, it would highlight the individual, technological and built environment aspects of e-bikes and e-trikes that prolong older adult mobility and support aging-in-place.

Figure 4: Map of Trial-Ride Route



(Google Maps, 2019b)

3.7.2 Phase I: E-bike Ride-along

The first phase of the modified go-along interview consisted of a trial-ride along a fixed route, which allowed the participants to learn more about both the e-bike and e-trike and have the opportunity to ride them along a fixed route. Before the go-along portion of the interview, the researcher went over the go-along interview itinerary which included the first-aid procedures and set up two action-cameras on the e-bike and the e-trike to record the ride which will be used to re-watch the trip during the second phase of the go-along (See Figure 3). Participants were then given an overview of both the e-bike and e-trike and given time to ride them behind Environment 3 in a small parking lot, allowing them to become familiar with each bike. From there, the researcher explained the trial-route to participants and that the research would be behind them on the e-trike, giving them instructions throughout the route as they were riding the e-bike (See Appendix E). Once both the researcher and participants reached the mid-point of the route, the

researcher asked participants of their overall thoughts of the e-bike, which would be used to spark conversation during the follow-up interview, which took place one or two days after the go-along. The researcher gave participants the option to continue riding the e-bike or switch to the e-trike for the remainder of the go-along ride. The researcher also gauged their overall thoughts once the go-along portion was complete, allowing the participants could recollect their thoughts during the ride.

The researcher conducted the modified go-along interviews individually apart from one due to the availability of a married couple that took part in the study. The researcher conducted the modified go-along interview with both participants at the same time. To ensure that both participants were able to experience both the e-bike and e-trike, they switched bikes halfway through the trial-route as the researcher followed both of them on a conventional bicycle. Once both the researcher and participant returned to the starting point, Environment 3, the researcher asked the participant about their overall thoughts about the trial-ride and confirmed their availability for the follow-up interview that would take place one or two days after. Weather played a significant role when scheduling participants due to forecasted thunderstorms and rain. As a result, the researcher rescheduled four of the go-along interviews for two reasons 1) participants preferred to try the e-bike and e-trike in dry weather and 2) was to ensure the safety of participants as slippery surfaces and lighting posed a danger. Eight of the interviews were conducted during their scheduled time-slot due to last-minute changes in the forecast and dry surface conditions. Another shortcoming of conducting go-along interviews was that the trial route is not representative of the cycling infrastructure that is present throughout the region. However, throughout the ride and follow-up interview, participants were aware of this. They highlighted how their experience on the e-bike and/or e-trike might differ within their communities.

3.7.3 Phase II: Follow-up Interview

Unlike tradition go-along interviews where the research asks the participant questions while in situ, qualitative follow-up interviews were conducted one or two days after the go-along portion of the interview. The reflection period was done for all the modified go-along interviews aside from one which took place immediately after the go-along ride since the participant was going away on a trip the next day. By conducting the interview one or two days after the go-along portion, it allowed the researcher to accomplish two objectives. The first was to ensure the safety of the participant so they could focus on riding the e-bike. The second was to allow participants to reflect on their experience riding the e-bikes. The gap allowed participants to reflect on their full experience riding the e-bike and e-trike and recount other thoughts and experiences relevant to e-bike adoption. For example, participant 6 said that they had discussions with their colleagues and personal views about the e-bike between the time of the go-along and follow-up interview. For the participant that was interviewed on the same day, the researcher gave them time to reflect on their experience while they put away both e-bikes in the storage closet.

The sit-down interviews took place in a private room in the Environment 3 building and were approximately one hour in length. The interviews consisted of three parts that collected data that fulfilled the research objectives through questions that complemented the existing literature by expanding on reasons that would influence their decision to use an e-bike based on individual, technological and environmental influences. These influences either being facilitators or barriers, which were the result of their cycling history, experience riding the e-bikes and the environment around them (e.g. cycling infrastructure). Collecting this information was accomplished through an open-ended semi-structured interview process, which included watching action camera footage of the participants riding both the e-bike and e-trike, which

allowed the researcher and participant to 'go-along' the route again. The first part of the interview included asking participants to provide a brief overview of their cycling history and current cycling conditions in their community to give the researcher a general idea of the individual and environmental factors that may influence the participants' perception of the e-bike and the e-trike. It was followed by asking about their experiences using the e-bike and e-trike which included any challenges, surprises and feelings that they throughout the trial ride. It also included asking them what type of trips they would make using the e-bike, whether they would use it to replace their conventional bicycle or use it as an alternative mode of transportation as opposed to using a car.

The second part of the interview included reviewing the action camera footage from their ride. By examining the footage back to participants, it was able to trigger location-specific memories while they rode the e-bike and e-trike, similar to a traditional go-along interview. Participants would pause the footage and speak about their thoughts about the e-bike during the trial-ride. A map of the route was used in tandem with the camera footage which allowed participants to keep track of the location on the route and label areas where they had difficulties or enjoyed riding e-bike and e-trike. After the footage ended, participants were asked to rate their level of comfortability on a Likert scale from '1' to '10', where '1' was 'very uncomfortable' and '10' being 'very comfortable' for both the e-bike and e-trike. This information was used in the next section of the interview, where the researcher asked participants for their overall thoughts of e-bike and e-trike and whether they are a viable mode of transportation for older adults. The combination of reflection and reviewing the footage encouraged participants to make connections to themes from previous literature and allow new themes to emerge as they recounted experiences by reflecting on memories and while watching themselves riding both the e-bike and e-trike (Creswell, 2014).

The third part of the interview consisted of an open discussion about the overall perceptions that participants had towards the e-bike and e-trike and whether they thought they were a viable form of transportation that allow older adults to maintain their mobility as they age. The researcher asked participants why they were initially interested in taking part in the study and what their priorities were going into the study (e.g. health, environment, cost, etc.). Participants were then asked whether they felt that e-bikes and e-trikes were a viable mode of transportation for older adults. The questions contributed insight as to whether e-bikes and e-trike can allow active older adults to prolong their mobility as they get older. The third part concluded with asking participants if they had any further comments or questions about the study. Afterwards, participants were given compensation in the form of $25 gift cards to various retailers and a feedback and appreciation form (Appendix D).

To ensure that responses were interpreted correctly and comparable for future studies, all interviews were audio-recorded and used the same interview itinerary and asked to elaborate on short answers or facial cues (e.g. head nodding) (See Appendix E). For the paired interview, the researcher ensured that both participants gave their responses for each question and reflected on their own experience riding the e-bike and e-trike while watching their action camera footage. Implementing these measures were done to ensure the credibility of the study and allow the researcher to explore the experiences of the participants without research bias.

3.8 Research Ethics

This research was reviewed and received ethics clearance by the University of Waterloo Research Ethics Committee (ORE#31517). As this research targeted active older adults, the study considered multiple ethical considerations. These ethical considerations were due to the vulnerability associated with their potential lack of physical and cognitive ability (Barnett et al., 2017; Crist et al., 2017; Gojanovic et al., 2011; Hirsch et al., 2017; Hirsch et al., 2016; Kerr,

Rosenberg, & Frank, 2012; Leger et al., 2019; Martens, 2018; Winters et al., 2015). The researcher included measures to ensured that the participants are physically and cognitively capable of riding an e-bike.

The researcher provided participants who expressed interest in the study with a letter of information and informed consent form, which outlined the following: The purpose of the study, the timeline and procedures involved with the research, participation benefits and risks, confidentiality and their rights as a participant. The researcher also gave the participants with an informed consent form to sign before participants rode the e-bike and e-trike. The researcher was required to have first-aid training and ensure that the respondent was fully prepped to use the e-bike and e-trike to minimize exposure to physical harm throughout the go-along process. Regarding the data analysis and write-up stage, the researcher used an alias when describing quotes or experiences throughout the report to uphold confidentiality and protect the identity of the respondents. The respondents who took part in the study were also be rewarded with $25 gift cards to various retailers (e.g. Apple, Loblaws, Chapters Indigo, Canadian Tire & Cineplex) and will receive the results of the study after completion.

3.9 Data Analysis

A framework analysis was used for the data analysis due to the exploratory nature of the study. As the study aims to build on existing literature, a deductive approach was taken since the core outcomes of the relationship is already known (Jones et al., 2016; Leger et al., 2019; Johnson & Rose, 2015). As a result, the data was organized through a thematic framework which was deductively taken from prior themes/issues from exiting literature rather than using a grounded theory approach which was used to generate new codes and categories from the data (Creswell, 2014; Gale et al., 2013; Srivastava & Thomson, 2009). Additionally, the flexibility of the framework analysis was able to inductively create new theories based on the findings as they

relate to the research question (Srivastava & Thomson, 2009). The framework analysis was able to generate and compare themes across various cases while maintaining their context and their connection to each account, making it an ideal data analysis approach to the variation amongst the participants (Gale et al., 2013). Due to the shortage of information that exists in Canada regarding older adult e-bike use, a framework analysis was ideal as it would build and confirm existing themes from previous research as well as generate new ones that may emerge from the study. From the 11 follow-up interviews, no new themes emerged that were dissimilar from the prior themes from existing literature. All the follow-up interviews were audio-recorded and personally transcribed. Upon completion of the transcriptions, data analysis was initiated.

By using a framework analysis, the data from each interview was familiarized through several readings over the eleven transcripts which lead to the development of the thematic framework which was used to filter and classy the data using prior themes from existing literature (Gale et al., 2013; Srivastava & Thomson, 2009). Portions of textual data from the transcripts were identified based on their correspondence to particular themes through indexing. Themes/codes were organized using assigned numbers for the organization and to link them back to their respective references (Srivastava & Thomson, 2009). The portions of data were then lifted from their original textual context and inputted into charts to organized them based on the prior themes taken from the thematic framework (Srivastava & Thomson, 2009). Data from each interview was organized in a separate chart in chronological order to maintain context and identify the participant in which the text came from (See appendix F). A schematic diagram was developed, which guided the interpretation and analysis of key characteristics of each chart (Srivastava & Thomson, 2009). A framework analysis facilitated constant comparisons between each participant while retaining the connection to each experience with the e-bike and e-trike (Gale et al., 2013; Srivastava & Thomson, 2009). By using a qualitative approach, a

comprehensive review of the data can build on existing core concepts and themes related to older adult e-bike use. Additionally, it allowed the researcher to discover systematic patterns that were used to provide recommendations for policy issues towards electric mobility in Canadian cities.

3.10 Rigour in Qualitative Research

Quality and validity in qualitative research are dependent on ensuring rigour throughout the data collection and analysis phase of the study. Rigour in qualitative research is achieved by meeting the following criteria: credibility, transferability, dependability and confirmability (Baxter & Eyles, 1996). By following these criteria, it shows that the researcher went through a series of self-reflection to ensure that the research is trustworthy and valid. These criteria were met using several techniques in the research design, data collection, analysis and the final reporting of this study outlined in the following section.

3.10.1 Credibility

Credibility in qualitative research refers to the "authentic representation of experiences" (Lincoln & Guba, 1985, p.512). It evaluates how well the experiences of the participants are reflected by the theoretical concepts that the researcher uses to recreate, simplify and recreate them, ensuring that the data adequately represents the reality of participants (Baxter & Eyles, 1996). Credibility assumes there is no one reality, but multiple realities that are interpreted through their recollection of experiences during the interview, meaning that there are opportunities for these realities to be misinterpreted due to the gap between what is reported and what actually happened (Baxter & Eyles, 1996). Credibility was achieved using several methods such as targeted-sampling and the sample size of the study. Targeted sampling provided a sample that provided in-depth information about the perceptions and experiences of avid older adult cyclists. The researcher recruited older adults from older adult cycling clubs in the Waterloo Region, which presented a wide variety of cycling histories and abilities. Additionally, the

sample size of the study reached saturation, meaning that no new themes or concepts emerged once the final interview was complete (Baxter & Eyles, 1996; Creswell, 2014).

Other techniques to achieve credibility was through prolonged engagement and the use of a temporal and visual element. These techniques included building rapport with participants and by allowing them to reflect on their experience from the trial-ride. Prolonged engagement was used during the data collection phase of the modified go-along interviews. This technique was used because the researcher played a vital role in the study as their characteristics such as their outward appearance, age, gender and rapport with the participant have a significant effect towards their ability collect information throughout the interview process (Baxter & Eyles, 1996; Creswell, 2014). In terms of characteristics, factors such as outward appearances, age, ethnicity and gender affect how participants react throughout the interview process (Baxter & Eyles, 1996; Creswell, 2014). Credibility was achieved by ensuring that the researcher was dressed in business-casual attire for both the ride-along and follow-up interview and was knowledgeable of the interview process to uphold professionalism as well as being mindful of any bias (Baxter & Eyles, 1996). Participants were confident in the ability of the researcher to conduct the study, which encouraged them to give information-rich responses. The researcher also developed a rapport with participants by introducing themselves and engaging in conversation throughout each phase of the go-along interview. This reduced power relations between the interviewer and interviewee, so the participant would be comfortable with sharing their experience and other information related to the study during the interview. The researcher was also able to avoid partial accounts by conducting the interview one or two days after the ride and by reviewing the action-camera footage of the ride during the second phase of the go-along interview. In doing so, it allowed participants to provide full accounts of their experience during the trial-ride eliminating the gap between what participants reported and what occurred in reality.

3.10.2 Transferability

Transferability refers to "the degree to which findings fit within the contests outside the study" (Baxter & Eyles, 1996, p.515). Although qualitative research tends to be bounded by the context in which the research took place, by providing thick descriptions of the study, it ensured that the findings are transferable or meaningful to other groups (Baxter & Eyles, 1996; Lincoln & Guba, 1985). In doing so, it allowed elements of the research to be transferable or meaningful to other groups (e.g. Older adults) (Baxter & Eyles, 1996). By providing detailed recounts of the data collection, analysis, interpretations and theory construction in the methodology section, it allowed for the findings of the study to be transferable for future studies related to older adult e-bike use.

3.10.3 Dependability

Dependability refers to "the consistency with which the same constructs may be matched with the same phenomena over space and time (Baxter & Eyles, 1996, p.516). In qualitative research, this pertains to the consistency of interpretations from each interview transcript (Baxter & Eyles, 1996). To achieve dependability, strategies such as low-inference descriptors, manually recorded data and using peer examination to provide an alternative perspective on the findings (Baxter & Eyles, 1996). Dependability was achieved by audio and video recording both the trial-ride and sit-down interviews with participants as well as allowing the respondents to reflect for one or two days after the trial-ride. By audio recording the qualitative interview and video recording the trial ride, it met two goals. The first being that it would allow other researchers to compare the findings through co-analysis. The second being was that it allowed participants to go-along again using the video footage during the follow-up interview. Participants were able to provide commentary for the entirety of their experience using the e-bike and e-trike, ensuring

that the events, in reality, reflect the ones that were reported since they were not subject to bias or interpretation by the researcher (Baxter & Eyles, 1996).

Rigour was also achieved through the co-analysis of the data with another academic researcher. Co-analysis was used to ensure that themes from the data were consistent between each interview and with the prior themes taken from similar research. Co-analysis was done at the first stage of the framework analysis, where both the student and supervisor independently coded two interview transcripts to account for any bias or errors in applying the coding framework (Baxter & Eyles, 1996). Once the transcripts were coded and organized by themes, this process was repeated to ensure the interpretation of the findings was an accurate representation of the data (Baxter & Eyles, 1996). Rigour was also achieved by connecting the findings of this study to themes found in similar studies that were written within an Australian and European context (Jones et al., 2016; Johnson & Rose, 2015). Connecting the themes was done to ensure that interpretations from this study are consistent with previous studies, in turn, allowing them to match similar phenomena in future research.

Pilot tests of the e-bike trial and follow-up interview were conducted before the older adult participants were recruited to the study to ensure the rigour of the research. The researcher conducted three pilot tests with three graduate students who have never ridden an e-bike or e-trike in the past, similar to the older adults that the researcher interviewed. The pilot tests included going the entire ride-along process with each student, which included going over the purpose of the study, providing them with an overview of each e-bike and riding along-side the students along the trial-route while giving them directions. The follow-up interview was conducted after the trial-ride in the same room that the follow-up interviews would take place in Environment 3. By conducting pilot tests of the modified go-along interviews, they provided the researcher with areas that needed more explanation, such as the overview of how to use both the

e-bike and e-trike and whether the interview itinerary was appropriate. More specially, to determine changes that were needed to improve the flow of questions and placement of the action-camera footage were logical and transparent for participants to understand throughout the modified go-along process. The pilot tests also ensured that the technology such as the e-bikes, action-cameras and screen used to review the trial ride footage were in working order. By conducting pilot tests of the entire interview process, it ensured dependability by ensuring that the trial ride was safe for the participants and that the interviews were consistent and collected information that was relevant to the research question of the study.

3.10.4 Confirmability

Confirmability refers to the "extent of bias, motivations, interests or perspective of the inquirer influences interpretations" (Baxter & Eyles, 1996, p.512). More broadly, confirmability pertains to the accountability of the researcher to ensure that interpretations of the data were derived from the participants rather than the researcher (Shenton, 2004). Confirmability highlights the research audit of the paper trail, which includes all data and products that have resulted from the study. This included the interview transcripts, analysis products, process notes, and how decisions about the credibility, transferability, and dependability were developed (Baxter & Eyles, 1996). Confirmability was achieved by ensuring that a full paper and electronic trail of the research process were stored. Journal notes, full interview transcripts, framework analysis, as well as the audio and video recordings, were kept to account for the researchers' interests and motivations and how it affected their interpretation of the findings. Additionally, confirmability was ensured through the co-analysis of another academic researcher to reduce any bias or perspectives that the researcher may have had when interpreting the data (Palinkas et al., 2015).

3.11 Summary

Due to the exploratory nature of this study, a qualitative approach was used to explore the individual, technological, and environmental factors that influence e-bikes and e-trike adoption by older adult cyclists to prolong their mobility, allowing them to age-in-place. The research objectives were met through the use of modified go-along interviews, which consisted of a trial-ride along the Laurel Creek Multi-use trail and a follow-up interview that provided rich, in-depth data about the experience and perceptions older adults had towards to the e-bike and e-trike. Targeted sampling was used to attain maximum variation of older adult cyclists, which involved recruiting participants from older adult cycling clubs to provide a diverse sample population of individuals who are cyclists and identify as an older adult. Participants possessed a range of cycling experience and ability, which resulted in a variety of discussions about barriers and facilitators associated with the e-bike and the e-trike. The range of experiences and knowledge was collected through the combination of temporal and visual techniques where participants were able to reflect and review the ride footage during the follow-up interview. Allowing them to reflect and provide an in-depth dialogue about the individual, technologically and environmental factors that influenced their experience and perceptions about the e-bike and the e-trike. All research was reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee, and research rigour was ensured throughout the research processes using criteria for rigour.

Chapter 4: Findings

4.Introduction

This chapter outlines the results of the 11 go-along and follow-up interview sessions that the researcher conducted for the 12 participants that took part in the study. The purpose of conducting both the go-along and follow-up interviews was to explore the individual, technological and environmental factors older adults had while riding both the e-bike and e-trike. The interviews would determine whether e-bikes and e-trikes pose as a potential mobility intervention that allow active older adults to prolong their mobility and age-in-place in a Canadian context. The go-along method not only provided an in-depth understanding of their experience using the e-bike and e-trike itself but also how the environment played a factor in their experience riding the e-bike and the e-trike. The results were assessed using a framework analysis which not only allowed this research to build on existing literature that explores this relationship, but also determine new themes that emerged from this study. The following section outlines the findings of the research and how they met the research objectives which were to i) understand the perception that older adult cyclists have towards e-bikes ii) What factors would need to occur for them to adopt an e-bike and/or e-trike and; iii) the role infrastructure plays towards encouraging or deterring older adults from using an e-bike and/or e-trike.

4.1 Participant Sample

Due to the heterogeneity of the older adult population, the individual perceptions and experiences of e-bike and e-trikes varied for each participant due to the use of targeted sampling of older adult cyclists. Targeted sampling resulted in a range of thoughts and experiences which were reflective of their individual cycling histories and the built environment of their community. The following section outlines demographic information and the cycling history of

the sample group and their knowledge of e-bikes and e-trikes, which initially led them to take part in this study.

4.1.1 Maximum Variation

The sample group comprised six males and six females who live in the Waterloo Region. The average age of all 12 participants was 63. Their ages ranged from 53 to 76, a range of 23 years. The majority of participants were retired, with only four who were either still working or transitioning to full retirement. Eleven of the twelve participants were Caucasian, and one was Asian.

4.1.2 Cycling History

The recruitment process resulted in a sample comprising of active older adult cyclists as the purpose of the study aims to determine whether e-bikes and e-trikes can prolong their mobility to support aging-in-place. Four of the participants regularly began cycling after they retired and/or joined a cycling club. For example, participants 4 and 9 began cycling regularly when they were close to retirement as they did not have the time when they worked.

I've been riding with the Waterloo County Wanderers for 15, since I retired. Before that I didn't do a lot of cycling. I'd go you know get together with a few guys and go out for a little ride on a Sunday let's say in Toronto trails and that was it, then I joined the WCW the next year after I retired through friends and I've been riding with them ever since – Participant 4, Male, 70's

I've been a fairly avid cycler now since probably since I retired… I bike less before I joined the club because work and my evenings used to be pretty booked up - Participant 9, Female, 60's

The remaining eight participants stated that they began cycling regularly before retirement through the encouragement of friends and family. For example, participants 3 and 10 said that after they started to cycle later in life as it became a part of their social life. They began cycling with friends and eventually started to cycle more and became more involved with their local cycling community. Where participant 10 said:

I didn't really start cycling until I was almost 50… I had a friend that wanted me to go and bicycle with her so I was reluctant and did it and as part of my job we were doing a bicycle to work promotion, and that's sort of what got me doing the longer distances – Participant 10, Female, 60's

Experience levels varied amongst participants due to the differences in age and time they dedicate to cycling. A number of participants considered themselves as avid cyclists since they cycle regularly throughout the year. This was the case for participants 1 and 12 who both said that they travel across the Province and Europe to for various cycling events.

Most of the riding I do is out in the county and I go to bike events around the province and I've traveled to France a few times to cycle – Participant 1, Male, 60's

I sort of found that the older I got, the further I biked, I also belong to a couple of cycling groups and I go on cycling holidays – Participant 12, Female, 60's

Three of the participants considered themselves casual cyclists, typically cycling a couple times a week with cycling clubs or their partners. For instance, participants 2 and 7 did not consider themselves as avid cyclists since they join the shorter rides with their club, or are more reluctant to ride on roads or in unfavourable weather.

I'm very much a fair-weather cyclist in the sense that if it even looks like it's going to rain I'm driving – Participant 2, Male, 50's

Only one participant, Participant 5, did not cycle regularly due to a chronic health issue. She stated that they have not rode a bike in two years, but plan to begin cycling again once they regain their health.

I've only cycled for 2 years but the last 2 years I've haven't due to health issues, but I'm looking to get back into it next year – Participant 5, Female, 50's

Many stated that they felt that they were in good health many of them attributing cycling as an important activity which helps them maintain their health. This was the case for P4 and P7 who both said that maintaining their health was an important priority in their life, further adding that cycling has allowed them to stay in shape.

I've had blood pressure problems the last year or so and I know that even after I go back out for a ride and go back and check my blood pressure It's way down – Participant 4, Male, 70's

I like to bike, I like to exercise, keep fit – Participant 7, Female, 60's

Participants 3 and 6 added that their health is much better compared to what it was in the past as a result of cycling. Both participants stated that cycling has allowed them to lose weight, which has improved their health.

I think I'm in better shape than I was when graduating University and weigh less which was in 1977 – Participant 3, Male, 60's

I was about 30 pounds heavier than I am now, where up until that point my health wasn't as important and now my health is on a much higher priority level now and an even higher one going forward so having a more active lifestyle is gonna be more critical going forward – Participant 6, Male, 50's

Cycling experience and abilities varied between the participants who took part in the study which ranged from avid cyclists who are mobile and in good health to casual cyclists who ride occasionally or have an impairment which has limited their ability to regularly cycle. Health and the social connections associated with cycling has played an important factor for participants to start cycling, motivating them to cycling regularly and join a cycling club within the Waterloo Region. These experiences relate back to their life histories as their cycling abilities and health are reflective of their individual characteristics which have influenced their level of cycling.

4.2 Past Knowledge and Experience of e-bikes/e-trikes

All the participants that took part in the study had prior knowledge or have experience riding an e-bike in the past. Knowledge about e-bikes varied as some participants said that they have been looking at e-bikes prior to the interview because they were planning to purchase one for themselves or their spouse. Participants 3 and 6 were planning on purchasing an e-bike for their spouse allowing them to keep up with them on bike rides.

I would be looking for an e-bike for my wife so she could go on more rides with me and keep up – Participant 3, Male, 60's

Participant 6 stating that it would give them confidence that their spouse, participant 5, would not be left behind on group rides when they are not present.

When I'm riding with them, I will slow down to what they're doing, but if I'm riding with a different group and they're riding with a different group, while the group will stop and wait for you, its hard to watch the pack your cycling with ride away and knowing you can't keep up, or and you know, and struggling, so the e-bike makes it so I know that without a doubt that I can comfortably let them ride with the group and not worry about them – Participant 6, Male, 50's

Participants who were not planning on purchasing an e-bike said that they knew someone who own an e-bike which was why they were interested in riding one. For example, participants 1 and 9 said that they have friends who own an e-bike and have heard positive comments about them which initially raised their interested towards e-bikes.

I have friends whose wives have them for example and this study was an opportunity to try one out and actually ride one rather than just be sort of aware that they are there – Participant 1, Male, 60's

I do know a couple of people who have e-bikes and I've had really positive feedback from them – Participant 9, Female, 60's

Similarly, Participant 8 was initially interested in e-bikes after their colleague began to use one to commute to work, saying that they said they enjoy using it for their 15km commute to the University.

My colleague actually commutes in from Conestogo each day on an e-bike so that's partly why I started thinking about it. He's had the same for a couple of years now and just loves it, because he can just hop in and out and not be sweaty – Participant 8, Male, 60's

Only three participants stated that they have ridden in e-bike in the past, but their experienced ranged due to the duration of their ride. For example, Participant 7 was able to fully experience an e-bike while on a bike tour.

We rented them for three hours so we had a good amount of time to try them out – and then, we tried a variety of different things, well I tried anyway a variety of different speeds on the bike itself and then also on the assist, different levels of assist and then on the particular one we rented also had the throttle – Participant 7, Female, 60's

While Participant 11 said that they only tried an e-bike for a short period of time, where they felt they didn't get to fully experience the e-bikes capabilities.

I had tried it before but I never really tried it – like I went on a really short ride and I thought that would be really fun to try it in town – Participant 11, Female, 60's

None of the participants said that they have seen or heard of an e-trike prior to the interview and only two of them said they have dealt with tricycles in the past for work. This was the case for participants 2 and 7 who said that their only experience with a trike was when they worked with individuals who required the one due to physical impairments.

I would associate it with an adult tricycle which is in my experience working with developmentally disabled adults and kids for years – Participant 2, Male, 50's

I've trained dogs for children with autism and a lot of the children parents buy tricycles for their children with autism because it's easier – Participant 7, Female, 60's

All the participants were found to have some prior knowledge and experience of the e-bike. Conversely, Participants were not as familiar with the e-trike since none of them had heard of them before the interview. The reason being was that all the participants were active cyclists and never thought of trikes as an option since there was an association between physical limitations and trike use and all the participants were fully mobile and had no issues with balance.

4.3 Riders perceptions of e-bike ride-along

The follow section outlines the perceptions that the participants had towards both the e-bike and e-trike. This includes their individual perception from their experience using the both e-

bikes and how the technology itself and the environment may be able to prolong their mobility in the future.

4.3.1 Ride comfort of the e-bike and e-trike

The majority of participants found the e-bike comfortable to ride since it was similar to riding a conventional bicycle. Only four participants did not find it comfortable to ride for three reasons. These being the size of the e-bike, previous experience riding other e-bikes and one participant had limited mobility which has not allowed them to ride a bike in two years. For the case of the participant with limited mobility, they were included in the study as they provided the perspective of an active older adult who has limited mobility but viewed the e-bike as an opportunity that would allow them to remain active and connected with their social groups.

Participants 1, 2 and 6 found the e-bike uncomfortable because the frame was too small for their body type but they both of them said that if the bicycle was their size that they would have found it to be more comfortable since the electric motor was not the cause of the discomfort.

I'd have to ignore that because of the sizing of the bike… but going forward when that you know when its just about being out and being mobile, you know, you care about less about those competitive things and it just makes the whole ride more comfortable – Participant 1, Male, 60's

The second for discomfort was due to previous expectations of how e-bikes performed which was case for Participant 3 who test rode a newer e-bike model in the past that was more comfortable to ride than the model that was used for the study. Saying that the newer battery and engine technology made the newer model much quieter and smoother at accelerating.

I tried the [brand] e-bike twice, once this year and once last year and it was [brand] technology for the battery and driver, and it was a lot smoother and nicer than the e-bike that I drove on Friday – Participant 3, Male, 60's

The remaining eight participants had very few issues getting used to the e-bikes and found them to be comfortable to ride. For example, participants 9 and 12 said they were comfortable riding the e-bike.

And getting used to the bike, I was quite comfortable after a short time – Participant 9, Female, 60's

I was gonna say, I mean, I was quite comfortable [riding the e-bike] – Participant 12, Female, 60's

To quantify how comfortable participants found the e-bikes, they were asked to rate their level of comfortability on the e-bike during the follow-up interview. Their level of comfortability was ranked on a scale from 1 to 10, with ten being very comfortable and one being not comfortable. The average rating was 8 out of 10, indicating that the e-bikes were found to be comfortable by the participants that took part in the study. The score was attributed to the fact that the e-bike was no different than riding a conventional bicycle. Participants commented during the go-along ride that they were not used to the more upright position of the e-bikes since they were used to their more forward-leaning road bikes, but overall, they found the e-bikes to be comfortable.

Participants were not as comfortable riding the e-trike compared to the e-bike, with many saying that it was due to the fact that they were not used to the balance and stability associated with the e-trikes configuration. This was attributed to the learning curve of the e-bike since Participant 1 said it was something that they could get used to over time if they were to use it more frequently.

It would take a little bit of getting used to, but I think as you get older, that comfortability would move up – Participant 1, Male, 60's

Due to the learning curve of the e-trike participants said that they found the e-trike to be more comfortable on the multi-use path compared to the road since the pavement was smoother

and there were fewer turns. This was the case for participants 9 and 10 who said they preferred using the e-trike along the straight sections of the path since they were not used to the way it shifted their body weight when they made turns.

The e-trike, well, when we did it around the parking lot out here I wasn't really comfortable at all on it but I think it was you know trying to do those turns but once we got out onto the trail and did it, then I, you know, I was okay once I got going – Participant 9, Female, 60's

The e-trike, ya once I did the first distance into the park I felt pretty comfortable with it – Participant 10, Female, 60's

This discomfort was also caused by the e-trikes three-points of contact which was pointed out by participants 3 and 6 who said that the e-trike uncomfortable going over potholes and poorly paved pavement since one wheel was not following the other.

Instead of umm having one track where the rear wheel is following the front wheel, umm, you have three tracks which makes it even more difficult to avoid potholes because you could be hitting three potholes at the same time – Participant 3, Male, 60's

You have three points of contact with the road it just means that the extra point of roughness, whereas on a bicycle you have just your two points on contact and on that bike you had suspension – Participant 6, Male, 50's

The only participant who found the e-trike to be very comfortable was Participant 5 because they found the upright seating position and balance on the e-trike to be more comfortable than the e-bike. Saying that it provided a good transition into cycling since she was still not used to cycling after their hiatus.

It was a more comfortable sitting position, a little more back, more upright so it didn't kick it quite as quickly, but sitting wise it was more comfortable – Participant 5, Female, 50's

Overall, the participants that rode the e-trike along the trial route gave it an average score of 6.7/10. Where the combined score of all participants, which included the participants who only rode it in the small parking lot by the start of the route, gave it an average rating of 4.6/10.

This result was expected since all the participants were used to a bicycle configuration. Participants stated that if they had more time to use the e-trike, their willingness to use one later in life would be higher. The reason being is that they would find it more comfortable since their discomfort was attributed to the learning curve and getting used to the way the e-trike operated.

4.3.2 Ease of use of the e-bike & e-trike

The majority of participants found the e-bike easy to use and that it was an easy transition switching from conventional bicycles. For example, participants 8 and 10 said:

So pretty much transferring from a regular bike to that bike was simple, no less than a minute right, you know and your riding and you're fine, just push a button – Participant 8, Male, 60's

Once I got the hang of what it was doing, it gave me the power I expected and still stopped quite readily. I wasn't jerking all over the place and so on so I thought the transition was fairly seamless – Participant 10, Female 60's

A few participants did mention that there was a learning curve, but it did not take long to get accustomed to the e-bike since it was no different than adjusting to a new bike. This was the case for participants 9 and 12 who equated the learning curve associated with the e-assist levels with shifting gears on a conventional bike.

Probably just the same as having a new bike and getting used to the kind of, equate it, used to the new gears. So it's kind of that same thing for the e-assist, so you have those different levels, but I thought it was very easy to, to get on to it – Participant 9, Female, 60's

I didn't find other particular challenges with it, just changing gears and there's a few different things like changing the power mode but it wasn't terribly difficult – Participant 12, Female, 60's

Participants also said that the weight of the e-bike played a factor towards moving the e-bike. However, other participants said that the e-assist allowed them to overcome the weight of the bike when accelerating. This was the case for participants 2 and 6 who said that e-assist compensated for the weight once they began to pedal.

So it seemed to me like the majority of the boost was to compensate for the ridiculous weight of the bike itself – Participant 2, Male, 50's

You know that first quarter-turn of the pedal you felt the weight of the bike, but that was quickly mitigated so no real obvious concern with the e-bike – Participant 6, Male, 50's

The learning curve associated with adjusting the e-assist levels was also a concern for one of the participants because they found the assist levels confusing at first which may have been attributed to the age of the e-bike itself. This was the case for Participant 2 who said that were not receiving the level of assist they expected going up a hill.

I was a little confused about the level of assist because at one point I think it was 2, I stopped pedaling and I felt like it was like where an electric car would have a re-gen mode, where it starts grinding down, but I was expecting it to kind of coast and it was not coasting. I was pretty surprised by that. I don't know whether that's a flaw in the bike because its age or whether it's designed that way – Participant 2, Male, 50's

Overall, the e-bike was well received by the majority of participants. Discounting the size and age of the model that was used for the study, participants found the e-bike easy to ride since it was similar to what they were used to riding. They were also informed that other e-bike models exist (i.e. road bike style e-bikes) which have overcome the concerns such as the lag and assist level issues that were brought up by participants.

For the e-trike, the majority of participants commented that they had some difficulties while riding the e-trike which was the case for participants 7, 8 and 10 who had difficulties getting used to the steering because of the different seating position.

The[e-]trike is a totally different configuration and it was what I had difficulty with was the turning – Participant 7, Female, 60's

It just felt really weird and because the leaning one way or the other and I actually found the steering really light – I guess it's because you sit really far back on it – Participant 8, Male, 60's

This was also associated with how the e-trike shifted their body while making turns. For example, participants 9 said that they found turning difficult because they were not used to shifting their body weight in the opposite direction that they were turning.

Another thing was the shifting your weight into the turn and going opposite direction – Participant 9, Female, 60's

However, some participants said that these difficulties were associated with the learning curve since many of them were used to riding bicycles which behave differently than trikes. For example, participants 3 and 7 said that they could get used to the e-trike if they were given more time to ride it.

I think It's partly a learning curve because I'm not really used to the feel of a e-trike – Participant 3, Male, 60's

I think I could adjust to it if I rode it more, frequent- more but it was more difficult to get going, to get that assist going and it was heavier and umm, so it was more awkward for me adjusting to riding a trike was a big part of it – Participant 7, Female, 60's

The amount of effort needed to move the e-trike was also brought up by participants 6 and 7 who said that the e-trike took more effort to get moving compared to the e-bike. Saying that they were working harder to get the bike up to speed while using the top gear and pushing the throttle.

It took more manpower to manage, because its heavier too and took me more manpower – Participant 7, Female, 60's

However, Participant 6 said that they understood that the e-trike was not meant to go fast as it was built for utility and not speed, but still said that they had to work harder riding the e-trike.

I found the e-trike to be much more work than the e-bike partly, due to design, just due to the fact that It's not meant to go the speed of the bike so I found it be more work – Participant 6, Male, 50's

Conversely, Participant 5 said that the e-assist was helpful when accelerating and going up an incline and that it was able to help them balance and ride up an incline without feeling out of breath

There's definitely relief because when I was going up the hill in the trike, I could keep on pedalling. I could get on top the hill and keep on going, I didn't have to stop and take a breather – Participant 5, Female, 50's

Given that they were not as mobile compared to the other participants due to health issue this spoke to how the e- trikes three-wheeled configuration gave an opportunity for older adults with lower mobility to continue cycling.

Overall, the ease of use of the e-trike was influenced by two factors. The first being that participants were not used to the three-wheeled configuration of the tricycle due to the learning curve associated with riding it. The second was that they were all fully mobile aside from one participant. Since the e-trike is designed for individuals with balance and/or mobility issues, the participants were not able to get the full benefit of using the e-trike. This was shown as participant 5 received the e-trike much more positively than the other participants.

4.3.3 Bike Design

Other than the size of the e-bike model that was used for the study the main design element that was brought up for both the e-bike and e-trike was their weight since the majority of participants commented on how heavy both models were. For example, participants 9 and 11 said that they didn't expect both models to weight over 50 pounds.

The one thing maybe that surprised me that I didn't really realize was the weight of the bikes – Participant 9, Female, 60's

Well I did note that they were heavy and it is heavy to lift compared to a regular, an ordinary bicycle – I have a carbon frame which is really light and then it's quite noticeable when you go to lift it and you think oh my gosh, this is really heavy – Participant 11, Female, 60's

Their weight was also a surprise for participants 3 and 7 who have ridden e-bikes prior to the interview saying the ones they tried were much lighter than the e-bike and e-trike that was used for the study.

The [brand] e-bike that I rode was less than 50 pounds – Participant 3, Male, 60's

The one we rented was light but it was heavier than I anticipated, umm but so the weight of them really caught me by surprise – Participant 7, Female, 60's

The weight of the e-bike was attributed to the age of the research e-bikes since newer models are now much lighter while still providing the same range (See Figure 5). Although that there are many different types of e-bike models, e-bike manufacturers have developed models that weigh less than 27 pounds with a range of up to 128km, which is 32km more than the e-bike use for the study (See Figure 6) (Phillips, M., 2019). The weight and range highlight that there have been advancements towards improving the shortcomings associated with an older e-bike and e-trike models.

Figure 5: Whistler E-prodigy

(Eprodigy, 2019)

Figure 6: Specialized Turbo Creo SL

(Phillips, M., 2019)

Other design elements that were highlighted was when the e-bike provided the e-assist. With one participant saying that they would prefer if the assist only turned on when they needed it. This was the case for Participant 2 who said that they would prefer if the e-assist only turned on when they were going up hills since they are capable of riding comfortably on level roads.

It should be off by default and when I push the throttle button, like give me a little assist here, that to me would be the benefit and just have an assist there for when someone wants it as opposed to coming on automatically – Participant 2, Male, 50's

Other participants felt that the assist kicked in later than they expected which was the case for participants 3 and 7 who said that the assist was much more instant and smoother on the bikes they rode in the past compared to the ones used for the study.

The [brand] e-bike I was really impressed, it was very smooth and quiet and quieter than the one I drove on Friday – Participant 3, Male, 60's

The one I was riding it picked it up really quickly, one or two pedals and you were like flying – participant 7, Female, 60's

Safety on the e-bike was another design element that was brought up about the e-bike, as participants agreed that the e-bike included many features that ensured their safety while riding it. For example, participants 7 said they liked having the safety features so they would not accelerate unexpectedly and 8 said that they could not think of any other safety features that manufacturers could add to the e-bike to make it safer.

I do, because otherwise if you accidentally push something and you start going – Participant 7, Female, 60's

I think they've built in a lot of the safety features… what else would you add? I can't think of anything – Participant 8, Male, 60's

Regarding the design of the e-trike, the upright seating position was a limitation for some participants because they felt like they did not have as much control and leverage on the e-trike

compared to the e-trike. For example, Participant 6 said they did not feel comfortable sitting farther back on the e-trike and that they felt that they did not have as much control when turning.

That was the limitation of the design of the bike and the limitation of the seating position. I just couldn't get the leverage I was used to on the bike, where you're more on top. I couldn't find the leverage point that I felt you know, where I felt that I could maximize the motor I have – Participant 6, Male, 50's

However, Participant 2 acknowledged the upright position stating that seniors who use the e-trike would prefer the upright position compared to a classic road bike position because it would be more comfortable for them due to their lack of mobility.

That's fine, again seniors are and that's what I'm picturing, seniors getting on there and not wanting to get into a classic road bike position if they're, you know have trouble for mobility just inside the home – Participant 2, Male, 50's

As the purpose of the e-trike aims to prolong the mobility of older adults who have limited mobility, the riding position links back to the individual factors that influence their willingness to adopt the e-trike in the future. Due to the lack of mobility and flexibility that is associated with aging, the upright position of the e-trike is well suited to prolong the mobility of older adults when they no longer have the ability to operate a bicycle.

Other design elements of the e-trike that were brought up by participants included the configuration itself, which caused their bodyweight to shift in the opposite direction when they turned. For example, participants 2 and 6 said that they would have liked if there was a way to design the trike so their body weight would not go in the opposite direction when they were turning.

I'm not sure how to get it to improve unless you re-architect it to allow you to lean – Participant 2, Male, 50's

Somehow build a gyroscope into it so you're not feeling like your tipping over. How you do that without misaligning your legs, I'm not sure – Participant 6, Male, 50's

Other comments about the design of the e-trike included how wide the rear was since participants said that they had to be more cautious when they were riding on the multi-use path with other users since they were not used to the width of the e-trike. For instance, gates were set up in the middle of the multi-use path when Participant 3 rode the e-trike for the opening ceremony of the Light Rail Transit (LRT) in the Waterloo Region (See Figure 7). As a result, participant 3 said there was added caution on their ride since they had to be more aware of the width of the e-trike.

When you're trying to pass somebody with the e-trike that's more difficult too, you gotta be more careful, you know so you don't hit them because the trike was wider and there were a couple of times where I hit the bottom of the gate – Participant 3, Male, 60's

Figure 7: Participant 3 passing pedestrians on the e-trike

(Donato, 2019)

The width was also brought up by Participant 9 who said that there was a learning curve associated with riding the e-trike and it would take time to become familiar with it. As a result, they felt more comfortable riding the e-trike along the multi-use path rather than the road. Saying

that they did not feel comfortable sharing the road with vehicles while on the e-trike for the first time.

Ya the biggest thing I think about the e-trike was having the wheels out wider than your two wheeled bike and that for sure takes some getting used to – Participant 9, Female, 60's

A key design element that was viewed positively on the e-trike was the integrated cargo space at the rear as participants said it gave another option other than a car for shopping or commuting trips (See Figure 8). For example, participant 9 said they would find the e-trike useful for trips which involve carrying their belonging when driving would no longer an option.

The way that one's set up to have that extra little space in the back, you know if you were using it if you didn't have a car – Participant 9, Female, 60's

Another advantage to that for commuting is that you have a nice cargo space when you go grocery shopping or whatever – Participant 10, Female, 60's

Figure 8: Pedego E-trike

(Pedego Electric Bicycles, 2019)

Overall, the design of the e-trike was viewed positively for the carrying capacity and function that it would have as participants get older. However, for the e-trike to be more favourable, elements such as the weight, seating position, turning and the width of the e-trike would have to change. Of note, this was a limitation of the study, as many e-trike models in the market have varying seating positions and wheelbases that reflect the design elements that were brought up by participants.

4.4 Rider Perceptions of Future Adoptions

The following section outlines whether participants are willing to adopt an e-bike and/or e-trike in the future. As mentioned previously, each participant was at a different life stage, meaning that they do not know when they would adopt one. The following section aims to highlight the parameters that would need to occur for the participant to decide to adopt or not adopt one in the future.

4.4.1 When and If they would adopt

Overall, participants were open to adopting e-bikes and e-trikes for the e-assist. All 12 participants could see themselves adopting an e-bike either now or in the future. Their willingness to adopt was due to the multiple benefits associated with the electric motor since it would allow them to overcome barriers such as hills and distance. When they would adopt one, participants stated it was dependent on both their health and mobility, which is reflective of the fact that each individual is in a different stage of their life. For example, participants 5 and 11 said they would be open to adopting one now. However, their motivation for adoption differed since participant 5 would adopt it due to their health since she was not capable of keeping up with her peers on group rides using a conventional bicycle. Whereas participant 11 said, they would adopt one because they think it would be fun to use for commuting and leisurely rides around the city.

"To continue like, I wanna get back to doing our biking together because I, he goes out to go biking last night but I stay home" – Participant 5, Female, 50's

Whereas Participant 11 thought it would be a fun and fast way to commute around the city instead of sitting in a car or using their conventional bicycle.

"Well actually you know, if I really thought about it, I'd like one now just for fun" – Participant 11, Female, 60's

The remaining group of participants stated that they do not see themselves needing an e-bike now, but can see themselves adopting one in the future based on their physical health. For example, participants 3 and 10 who are currently in good health said that they would be open to purchasing one the future if their health was to become an issue.

I could see myself eventually depending on my health and how long I live, eventually can see myself buying one" – Participant 3, Male, 60's

I may see because due to health issues I'd be doing that so I can continue to bike perhaps. Right now, as far as I have my health, my ability to allow me to do it – Participant 10, Female, 60's

This was the same for the e-trike, as participants mentioned that they would adopt the e-trike if they were to begin to lose their sense of balance or if they could no longer ride a bicycle due to their health. For example, Participant 6 said that the e-trike would be useful when their health begins to decline in the future.

If at some point where walking the distance becomes issue and carrying stuff becomes an issue, having the e-trike would be nice - Participant 6, Male, 50's

Although the majority of participants were in good health and mobile, they all could see themselves adopting an e-bike in the future since they suspect that their mobility may decrease as they get older. Participants could not give a specific timeline as to when that would occur for several reasons. The first one was that they were unsure when they will begin losing their mobility since they were all at different stages of their life and that there was an uncertainty of

any health issues that may arise in the future. Their uncertainty spoke to the individual factors that are associated with adopting an e-bike or e-trike, as they based it on their health and ability to continue to use a conventional bicycle.

4.4.2 Willingness/Why Adopt

The participants stated that they would be willing to adopt an e-bike/e-trike in the future since it would allow them to continue cycling for leisure or commuting when they get older. For commuting, three participants stated that they would prefer to use the e-bike for commuting or for getting around the city as opposed to recreational use. This was the case for participant 8 and 11 who felt that e-bikes would be great for getting around the city when they get older since when they are no longer able to make medium to long length trips using a conventional bicycle.

And if you have to get somewhere, because it seems like the e-bikes are perfect… you get on there, get to where you want" – Participant 8, Male, 60's

I would find it really handy if you wanted to go downtown for example you can just jump on that and you'd be down there in no time" – Participant 11, Female, 60's

The remaining participants said that they would be willing to adopt e-bikes since it would reduce the barriers such as the physical exertion needed to keep up with friends and riding up hills that would otherwise lead them to quit cycling. For example, participants 1 and 7 said that having the e-assist would make them more inclined to continue cycling when they get older.

You know some of these other things like wind and hills are basically eliminated, so umm there's a great benefit to you know when you really get older – Participant 1, Male, 60's

What would deter me from biking would be more so the hills and stuff so to know that I had that assist, then I can continue to ride my bike and use the assist when I needed it…You know umm so with that assist on those difficult moments, rather than getting off the bike and walking it up the hill… I would be more inclined to continue to ride my bike" – Participant 7, Female, 60's

Participants also said that they would be willing to adopt e-bikes for cycling tours, especially for places where they were not sure how many hills there were or how steep they

would be. For example, participants 7 and 12 said that they would be fine for the flat sections of the ride, but would find e-bikes great for the hills.

Well interesting enough, we have recently thought about going overseas to do some bike tours…you know in that case I think I would want to rent an e-bike… I've never been over there so I don't know how many hills there are and hills are not my friend – Participant 7, Female, 60's

I'd do it in the future I would think if it's a [cycling] vacation that has lots of hills – Participant 12, Female, 60's

Another motivation for e-bike adoption was to maintain their mobility and well-being as it's becoming an increasingly important priority of older adults as they age. This was the case for participants 4 and 6 who cycle as a means to maintain their health. Where Participant 4 said that e-bikes are a great way for themselves and other older adults to stay active and maintain their health and mobility.

I think a lot of people are more thinking about fitness than they have in the past – there's a certain group, I wouldn't say what the percentage is but I, in our friends because we have a lot of friends in the YMCA…people are concerned, getting the idea of move it or lose it – Participant 4, Male, 70's

Having a more active lifestyle is gonna be more critical going forward – Participant 6, Male, 50's

Other participants stated that e-bikes are a great way to remain active since they do not take away from the fact that the rider is getting exercise. As an older adult, maintaining mobility and quality of life was of importance, e-bikes were discussed as being something to prolong this state in the future. For example, participants 6 and 9 said that e-bikes provided a medium for older adults to remain active as they begin to lose their mobility.

The e-bike doesn't take away from the fact that your still using muscles, your just not using them as hard – Participant 6, Male, 50's

As our mobility maybe decreases it gives us you know that confidence to be able, to still be able to get out and be active – Participant 9, Female, 60's

In turn, contributing to the physical aspect associated with cycling since e-bikes still allow individuals to exercise regardless of the e-assist. This was further emphasized by participants 1 and 9 who said that it did take some effort to pedal up hills based on how much assist they added indicating that e-bikes provided a means for older adults to prolong their mobility as they get older due to the assist that the e-bike gave them in areas where they are not capable of relying on their own physical ability (e.g. hills).

Your still getting exercise but not struggling – Participant 1, Male, 60's

I was trying to use it the same as I would use my gears… you know that I would go into a lower gear as the, more of an incline…I was pretty sure I was pedalling the whole time – Participant 9, Female, 60's

E-bike and e-trikes provided an opportunity for older adults to maintain both their physical health and social life since they eliminate or even lower the barriers that may deter some adults from getting out of their homes. These barriers being physical exertion and lack of balance. Both e-bikes compensate for these barriers which give older adults the ability to maintain their ability to cycle, prolonging their mobility as they age. As a result, they would be able to remain part of their social groups and get exercise as the e-bike does not take away from the priorities that they associated with cycling (e.g. exercise, social life, etc.). For example, participants 2 and 6 stated the importance of being active and that e-bikes and e-trikes contributed an accessible way to do so.

When you have weather life today which is just glorious, you really should be out and if you had that assist on a bike then they can go out and do, I don't care if it's around the block- you know, a couple of kilometers, or whatever, so they can get that kind of exercise because their legs are moving – Participant 2, Male, 50's

If we're looking at an aging population, trying to keep them active, phenomenal, both of them actually, both of them phenomenal from the point of view of were trying to keep an aging population active – Participant 6, Male, 50's

With participant 6 also stating that cycling has a social aspect attached to it, which allows older adults to maintain their social life in their community.

That social part of getting together and talking about anything. There's a social life to your activity, so cycling has a social life – Participant 6, Male, 50's

For the e-trike, participants 2, 5, 6 and 10 mentioned that could see how the e-trike would be beneficial to others with mobility issues. For example, participants 2 and 3 said that individuals with disabilities would find utility from the it since it would allow them to keep their balance and be active within their community.

Well I do see advantages um to various people with various physical difficulties… [it]doesn't have to be a diagnosis disability, but as someone getting older, getting heavier, losing their balance, you know eyesight, is another thing to go [the e-trike] would benefit people and encourage them to get out in the limited summers that you know that we do have – Participant 2, Male, 50's

But I can could see for someone that has mobility problems that umm, needs to use it to pick stuff up from like the market or where that would be much better than an e-bike – Participant 3, Male, 60's

All the participants were willing to adopt e-bikes because of the social and physical benefits that are associated with them. This was also the case to a lesser extent for the e-trike as only a few participants were willing to adopt it in the future, that will be outlined in the next section. Many of them expressed that cycling is not only great for their physical health but as a way to remain part of their community for social purposes or using the e-bikes to go downtown to run errands. Their motivation for e-bike and e-trike adoption stems from its opportunity, which would allow them to remain active and social within their community when their health may inhibit their mobility.

4.4.3 Why not adopt

The majority of participants stated that they preferred the e-bike over the e-trike due to their level of comfortability and familiarity while riding it. As a result, five of the twelve participants said that they do not see themselves adopting the e-trike in the near which points to the design of the e-trike and negative stigma associated with it. For example, participants 1 and 3 were not comfortable using the e-trike at first due to the learning curve and configuration of it with Participant 3 adding that they wouldn't consider adopting it at their current stage in life.

Around the parking lot and I thought that I just didn't fit, so I just thought I'd stick with the bike. I've tried it and now I know generally what it feels like but like I really didn't wanna get into it – Participant 1, Male, 60's

Ya, you gotta get used to it and the steering is different and I mean, personally I would never at this stage in my life would consider that kind of vehicle – Participant 3, Male, 60's

Similar to previous comments made by participants 2 and 7, other participants had preconceived notions towards the trike linking it with old age. This stigma was reinforced by their association between the trike and immobility. This was the case for participants 9 and 11 who said that they viewed the e-trike as something meant for people much older than they are.

Those kids probably thinking what's that old lady doing on that tricycle – Participant 9, Female, 60's

But to me, it kind of looks like [it's for a] really old person – Participant 11, Female, 60's

Some participants did say that they would prefer not to adopt the e-trike because they were use a bicycle configuration since it is what they are used to. This was the case for participants 8 and 12 who stated that they prefer using a bicycle configuration and would rather configure the bicycle to suit their needs in the future.

If I was gonna use the trike I'd have to have a good reason for needing all the extra carrying capacity essentially because I can put anything on my bike now anyway so I doubt if I'll go on the trike later – Participant 8, Male, 60's

I didn't like the idea of [the e-trike] … maybe it's because I'm too much into the two wheeled bike – Participant 12, Female, 60's

Even though some participants were not eager to adopt the e-trike, with some stating that they would not adopt one, the majority of participants saw how it could be beneficial for individuals with a disability or have difficulties balancing. For similar reasons, this association reinforced the stigma which had participants more reluctant to adopting it compared to the e-bike which was further emphasized by the fact that many of them have never ridden a trike and were not used to how it operated. Overall, participants were more favourable towards the e-bike compared to the e-trike for future adoption.

4.5 Rider Perceptions of Infrastructure

As mentioned in the literature, the built environment plays a significant role in cycling, and this case, e-bike adoption. The following section outlines the environmental factors associated with e-bike adoption, especially, barriers and facilitators that affect their decision to prolong their mobility in the future using the e-bike or e-trike.

4.5.1 Adequacy of Instructure (What exists)

The existing cycling infrastructure in the Region of Waterloo was positively viewed by participants with the addition of new cycling infrastructure. However, the lack of connectivity of the cycling infrastructure throughout the Region was a significant concern regarding their decision to prolong their mobility which speaks to the environmental factors that influence e-bike and e-trike adoption. The reason being that the built environment had a significant influence on the willingness of participants to use an e-bike. This issue was brought up by many interviewees who said that there are gaps in the cycling infrastructure, which makes connectivity a considerable problem for cyclists. For example, Participant 8 said that the discontinuity of the

cycling lane in Uptown Waterloo acts as a barrier for cyclists, especially for those who are not comfortable with cycling in mixed traffic.

I think Kitchener-Waterloo has tried hard to put in appropriate bicycle paths but the discontinuity between the paths right now is a big problem. If you ride down King street you ride along a bike path then suddenly you get to an intersection and the bike paths stops. It just – well it makes it non-viable for people who don't a lot of cycling– Participant 8, Male, 60's

These issues were the same for county roads where cycling lanes ended which removed the barrier between cyclists and vehicles making it dangerous for cyclists. For example, Participant 3 stated that the lack of cycling lanes along roads made rides feel uncomfortable since there was no barrier between them and oncoming traffic.

Sometimes there's a really nice paved cycling lane on the roadway, other times almost nothing and so when our route uses highway 86 to Conestoga to St. Jacobs, it's kind of scary especially with big trucks – Participant 3, Male, 60's

Participants also spoke positively about the cycling paths in the region such as the Iron Horse and Laurel Creek Trails since as it was a safe connection to main hubs within the city. For example, participants 6 and 11 staid that they enjoyed using the Laurel Creek Trail since it provided a safe connection to Uptown Waterloo.

I really like the idea that trail because it gets you right downtown because if we continued we would cross the bridge and we'd be right in Uptown. The trail is a really nice way for people to get around that are not comfortable road riding – Participant 6, Male, 50's

I've never actually seen a split in the trail where you got cyclists like that going both ways and then on the right you got pedestrians because usually their all-together – Participant 11, Female, 60's

Although the multi-use trail was viewed positively by all participants, they were limited with their reach since they lacked an East-West connection forcing cyclists to go on the road. For example, participants 8 and 10 stated this issue, saying that it makes cycling difficult for other riders who are not used to sharing space with cars.

If your starting from North West Waterloo and you need to get into Fairview, how are you gonna do it? If I'm doing it, and I'd probably go down Courtland or I'd go down the main

street, I'm comfortable with doing that but I don't think everyone would be and I wouldn't have my kid do it – Participant 8, Male, 60's

Its just a real challenge - getting across the city from the West side to the East side is not easy, its actually easier going North to South, there's more roads that will accommodate that – Participant 10, Female, 60's

Participants also noted that there was a lack of cycling infrastructure around the University due to the lack of cycling infrastructure along Ring Road. For example, participants 3 and 6 said that they found it surprising given the volume of cycling traffic on the campus.

The fact that Ring road didn't have any bike lanes and never has, you know and that has an impact on [comfort] too – Participant 3, Male, 60's

The infrastructure around the University to points, the infrastructure around the University for cycling is a lot less than [I thought] given the volume of cyclists. I'm somewhat surprised that the University doesn't have more infrastructure for cyclists – Participant 6, Male, 50's

Figure 9: Participant 6 riding along Ring Road

(Donato, 2019)

Other issues included the size of signs indicating rights-of-way on the multi-use path because they were not visible to some participants. This was the case for participants 2 and 11 who said that they did not notice the signs indicating the split in the trail since they were not noticeable when they were riding by them.

Coming back, I didn't catch the signs the fact that there were signs for this is cycle this is for walking – Participant 2, Male, 50's

When your moving faster like that, I think it would be adventitious if there bigger because that's a very unusual split in the trail. Especially if you're not used to it and don't know it's coming – Participant 11, Female, 60's

Figure 10: Participant 2 riding past signs on multi-use path

(Donato, 2019)

The lack of secure and visible bicycle parking was another cycling infrastructure issue that was brought up by a participant which is problematic if more people use e-bikes to commute to their higher costs compared to a conventional bicycle. This issue was brought up by Participant 10, who said that they have had problems finding bike parking in Uptown and other commercial buildings in the Region.

I was in Uptown in Waterloo biking on those new lanes and I wanted to go to the bank and there was not a bike parking post in sight so, I ended up locking to a post which is not ideal. So I think they need more bicycle racks within sight of wherever you're going – Participant 10, Female, 60's

Overall, the presence of trails and cycling lanes were viewed positively by participants. The biggest concern that the majority of them shared was discontinuity associated with the cycling network. Which many of them saw as a barrier towards e-bike adoption for individuals who are not as experienced with riding on roads as they are.

4.5.2 Quality of infrastructure (How good it is)

All of the participants spoke positively about the quality of the cycling trail that was used for the e-bike trial. For example, participants 5 and 12 said that it was more pleasant to ride on compared to the road since the surface conditions were better than the roads.

I will admit, being on the trail was a lot nicer because it was a lot smoother – Participant 5, Female, 50's

The trail was very smooth, very comfortable to ride on. Not having to dodge potholes or cracks or anything like that – Participant 12, Female, 60's

Figure 11: Participant 12 riding along the Multi-Use Trail

(Donato, 2019)

Participants found surface conditions on main roads throughout the Waterloo Region and around the University of Waterloo to be poor due to potholes and sewer grates which participants had to actively avoid along with vehicle traffic. For example, participants 2 and 11 said that they avoided these obstacles to prevent damage to their e-bike or hurting themselves if they were not paying attention.

Up and down the main streets like King, Weber and Albert, it's still dangerous because you know, your weaving around the damn potholes which are just horrible– Participant 2, Male, 50's

When you're on the road, because if you look back there, there was a grate. When I'm riding I really watch the road itself, because sometimes even something you're not really thinking about can throw you off – Participant 11, Female, 60's

Figure 12: Participant 11 avoiding a sewer grate on the road

(Donato, 2019)

In terms of new cycling infrastructure, three of the participants spoke positively towards new cycling infrastructure projects such as the dedicated bike lanes along major corridors and additions to the Iron Horse trail. For example, participants 6 and 8 said that they were happy to see that the City of Waterloo was adding segregated cycling lanes along streets which typically have heavy car traffic and trying to address the lack of connectivity in the cycling network through these projects.

Seeing what they've done with the section beyond Keatsway up to Erb where they put in bike lanes and things like that - seeing when they're adding infrastructure for cycling is a good thing – Participant 6, Male, 50's

You know I spoke to one of the people involved and you know they are really making plans to try to address this discontinuity business and they are apparently gonna run a year or two-year trial program of segregated bike lanes in Uptown Waterloo – Participant 8, Male, 60's

The built environment was found to be a significant factor towards the willingness of the participants and less experienced cyclists to adopt an e-bike or e-trike to prolong their mobility. This issue was due to the quality of cycling infrastructure such as the surface conditions and

presence of infrastructure which facilitated cycling (i.e. cycling lanes, paths, etc.) which influenced whether they would be willing to continue cycling in general in the future. Participants spoke positively of the trail network and new infrastructure projects which was a safe and efficient way for them and other cyclists to get around the city. However, participants also mentioned that work still needs to be done to improve road conditions and the continuity of the cycling network.

4.5.3 Sharing the Space (Who is on it)

Participants shared space with pedestrians, cyclists and e-scooters while trialling the e-bike and e-trike. None of the participants commented about other cyclists being an issue as they were used to cycling with other people close to them. Participants shared the same thoughts for pedestrians, aside from some instances where there were clusters of participants walking on the path. This was the case for participants 1 and 12, who said they were more cautious when passing groups of pedestrians along the ride.

So here, you know, we got them on both sides here, we slowed right down, I didn't wanna go ripping between those two – Participant 1, Male, 60's

I just had to watch when I'd slowed down and start speeding up when the surge hit in case there were still people around – Participant 12, Female, 60's

Figure 13: Participant 1 slowing down for pedestrians

(Donato, 2019)

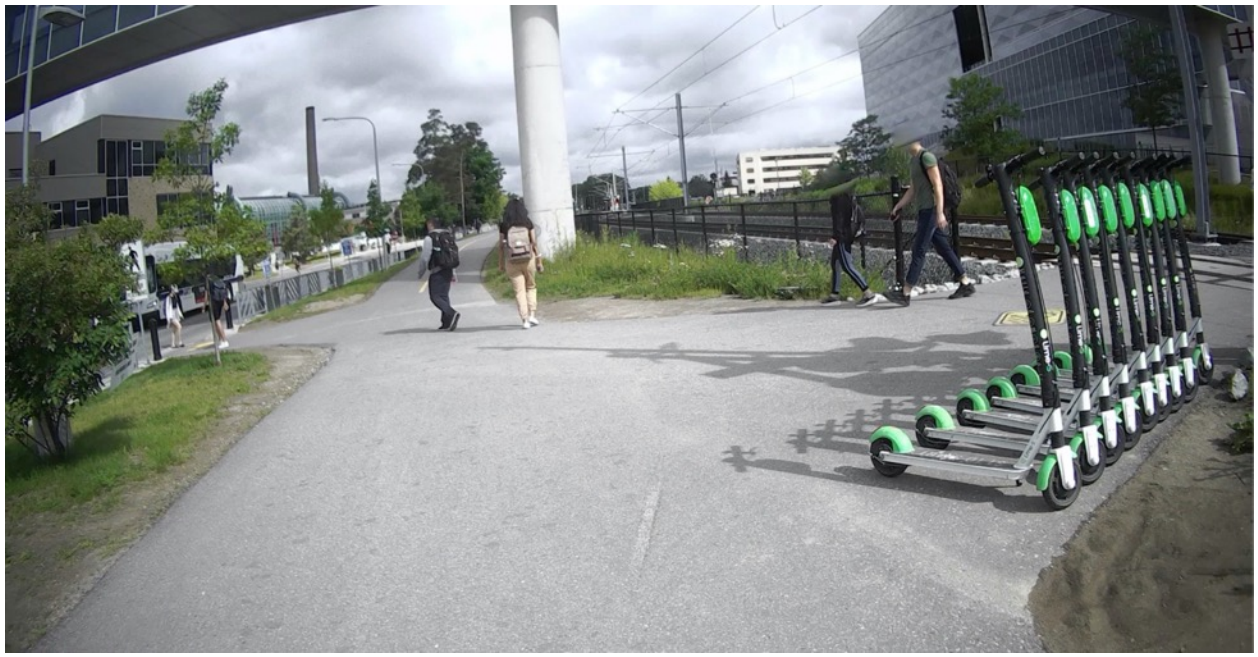
Participants also said that many pedestrians along the path were not aware of their surroundings because they had headphones on or were on their phone. Although this was not an issue for participants since they gave pedestrians the right of way they found it concerning since they were not paying attention. For example, participants 5 and 8 said that pedestrians with headphones on were not aware that they were coming, which caused them to slow down to avoid causing any incidents.

It was a little weird because some of them [pedestrians] didn't listen to you and just walked right in front of you – Participant 5, Female, 50's

Obviously, a little bit of a slowdown which I tend to do around pedestrians anyways because you never know what their gonna do because they'll be looking at their cell phone and texting – Participant 8, Male, 60's

This spoke to the safety associated with using both the e-bike and e-trike, where there was more concern regarding the safety of other users on the trial rather than their own while riding a bicycle with an electric motor.

Figure 14: Distracted pedestrians walking across path



(Donato, 2019)

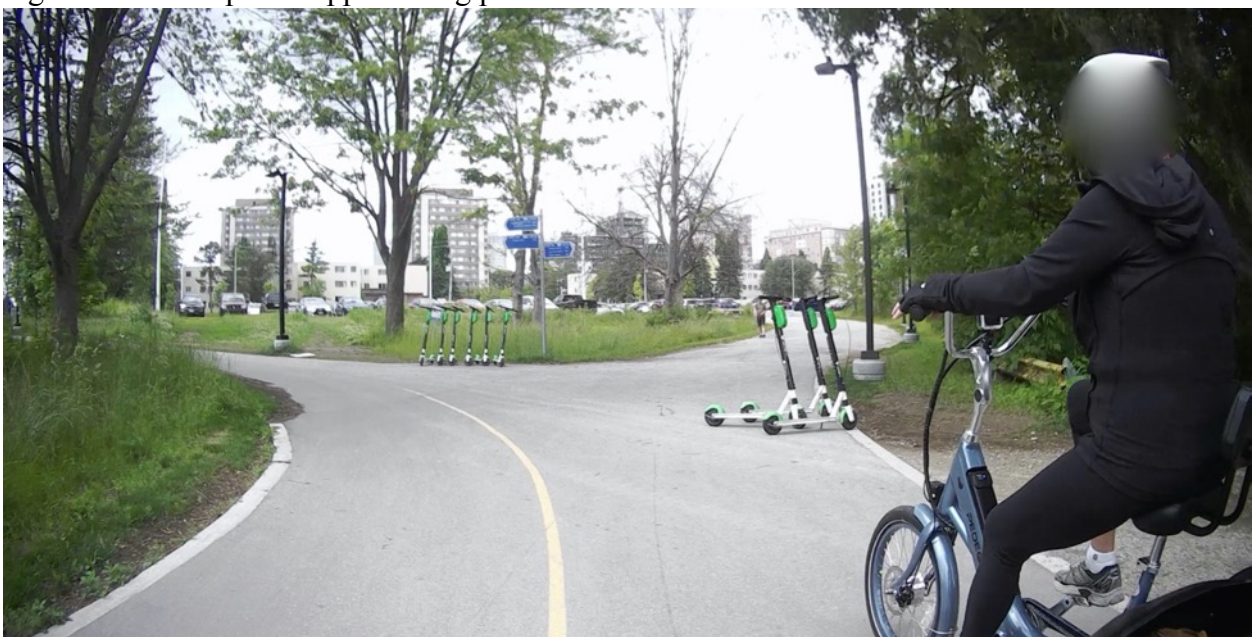
Concerning sharing the space with e-scooters, none of participants had issues with sharing the space with them. The only comments that participants made about them pertained to safety for other issues on the trail. This was the case for Participant 9 who said the e-scooters intimidated them, especially if they were parked in the middle of the path.

These scooters kind of intimidate me. Somebody just parked those scooters too – Participant 9, Female, 60's

Similarly, the e-scooters were compared to motor bikes with respect to the potential danger they had towards other users on the trails. As Participant 12 said, they have seen signs which have restricted them in some areas, similar to how they restrict motor-bikes off trails.

Like the thing is they're trying to keep like those scooters and motor bikes off the trails because their thinking its more dangerous if there's pedestrians or something – Participant 12, Female, 60's

Figure 15: Participant 9 approaching parked e-scooters



(Donato, 2019)

Right of way with respect to sharing space on the path was also brought up by participants with many of them agreeing that pedestrians should be given priority, followed by cyclists and vehicles which should be given the least priority. For example, participants 6 and 10 stated that faster moving vehicles should adjust their speed when approaching pedestrians and cyclists.

Well there's an adage in skiing and snowboarding, the fastest, even racing, the faster vehicle – the faster is the one that needs to adjust so you know, the same with driving, the faster, the one who's going faster need to adjust with the slow drivers – the same goes for pedestrians and the bicycle– Participant 6, Male, 50's

Pedestrians, bikes then vehicles! – Participant 10, Female, 60's

As for sharing space on the road, almost all the participants said that felt more comfortable riding on roads versus the multi-use path since they were used to sharing space with vehicles, not pedestrians. For example, participants 1 and 6 said that they prefer to ride on the

road because they find that vehicle traffic is less sporadic compared to pedestrians and other users on trails.

Even though riding on the road is probably more dangerous for me, because of the of vehicle traffic, you gotta be [vigilant] on trails… you have pedestrians, you have bikes you got pedestrians on the other side, you got multiple crossings you have to be aware of so I think you're probably on higher alert – Participant 1, Male, 60's

I prefer to avoid trails because I prefer to avoid the confrontation with the dogs and people – Participant 6, Male, 50's

However, participants who are comfortable with riding on roads also stated that cycling lanes can be dangerous due to the lack of education and enforcement towards drivers. For example, participants 2 and 8 said that they see drivers disobeying the rules of the road since they are either unaware of where they are on the road.

Most drivers aren't aware that they need to leave at least one meter, or they sort of aim for the meter or at least half a meter so they don't kill someone and that's that their satisfied with but you know with potholes and so on, a meter is just not enough – Participant 2, Male, 50's

I see drivers all the time stray into the bike lanes you know, I'm gonna say half the drivers out there have no clue where their car is on the road – Participant 8, Male, 60's

Overall, the majority of participants had no issues sharing space while on the multi-use path and road during the ride. The most significant concern was inattentive pedestrians, which was not much of a problem for participants while riding the e-bike since they expected that there would be a high amount of pedestrian traffic along the trial-route. Since the majority of participants cycle on the road, the majority of their concerns were towards sharing space on roads as drivers are not considerate when it comes to sharing space.

4.5.4 Ideal Infrastructure (Future idea/Desires)

Several participants brought up potential infrastructure improvements which could be implemented to promote cycling and e-bike adoption. Their suggestions included improving the connectivity of the cycling network in the region, adopting best practices from other Canadian

cities and improving the flow of cyclists at intersections. Concerning connectivity, participants suggested that there should be more cycling lanes and trails throughout the Region and the University of Waterloo which echoes the comments made by participants 3, 6, 8 and 10 in previous sections. This was also an issue along the West side of Ring Road as participant 6 said that the University should have cycling lanes considering the number of cyclists on campus.

Ring road of all roads should probably have some cycling infrastructure dedicated to cyclists – Participant 6, Male, 50's

Their responses spoke to both the environmental and individual factors associated with e-bike and e-trike adoption. Although the built environment facilitates cycling to some extent, individuals may be reluctant to use them as they may not find them to be safe, in turn, deterring their willingness to cycle and/or adopt an e-bike or e-trike in the future. For example, some individuals may be fine using cycling lanes. Still, some may prefer to cycle on separated cycling trails, away from car traffic even though the participants that took part in this study were comfortable cycling on roads. They expressed that it may not be the same for other older adults who may be fearful of sharing space with cars. Due to the individual perceptions of safety, more infrastructure that facilitates cycling would be needed to encourage older adults to prolong their mobility through e-bikes and e-trikes.

Participants suggested that adopting best practices of cycling infrastructure was an approach that could positively influence the individual and environmental factors associated e-bike adoption of older adults. In doing so, it would not only improve the safety of cyclists but make it more appealing to individuals who were reluctant to cycle before. For example, participants 6 and 8 suggested that the should city adopt similar practices used in Toronto and Vancouver, which separate cyclists from drivers.

Whether it's a separate pathway like the other side or road separation like on King street or like on Bloor street in Toronto which has a barrier. I think that if you're going to encourage

cycling you've got to encourage infrastructure that will make more people comfortable – Participant 6, Male, 50's

Places like Vancouver where they set up separate streets – it's not just segregated – well they have that as well but they have the concrete you know block, where it says cyclists on this side, cars on that side. Even if drivers are inattentive, they'll run into the concrete block – Participant 8, Male, 60's

Other suggestions included improving the right of ways for bikes and pedestrians. This was brought up by Participant 2 who suggested the city could implement algorithms which provide optimal signal crossing times which improve the flow of movement for cyclists and do not impede on the flow of car traffic.

Whether you do it by the number of pushes on the button to cross, of course, someone would stand there. But if there was some way for the system to count how many people there are and for that time of day would be great – Participant 2, Male, 50's

Participant 10 also suggested that the city should add more bike crossings at intersections so they do not need to dismount and walk their bike across every intersection. This was the case for the crossing at University Avenue along the trial route as it would mean that cyclists would not have to dismount and walk their bike to the other side of the multi-use trail.

The city could put bicycle crossings at University Avenue to so it is legal to ride across and so you're not disobeying the law by riding on the pedestrian crossway – Participant 10, Female, 60's

This suggestion would have two benefits, the first being that it would improve the flow of cyclists. The second is that it would make it easier for older adults how have difficulties getting on and off their bikes at intersections which do not allow them to ride across.

Overall, many of the suggestions point to the need for a safer and more seamless cycling network, especially for older adults and individuals who are new to cycling. This was the case as most participants suggested implementing best practices from other Canadian cities which have separated cycling lanes which could eliminate conflicts with vehicles. Other suggestions

included intersections which facilitate the movement of bicycles. In doing so, they believe that it would promote cycling and e-bike adoption in the Region.

4.6 Conclusion

This chapter presented the findings from the 11 go-along and follow-up interviews of the 12 older adults who are members of an older adult cycling club in the Waterloo Region. Participants were asked to describe their perceptions and experiences riding both the e-bike and e-trike to determine whether it would allow them to maintain their independent mobility when they are no longer capable of using a conventional bicycle.

The findings found that e-bikes would allow older adults to maintain their mobility if their physical ability declines or if they were to develop a disability. This decision was due to the e-bike and e-trikes ability to provide them with an electrical assist which would decrease the physical exertion needed to complete trips. However, when participants would adopt one varied due to the differences in life-stages, cycling experience and the amount of supportive cycling infrastructure in their community. For individual perceptions towards e-bikes, participants viewed the e-bike adoption positively. Still, the majority were unsure when they would adopt one since many of them were in good health, but emphasized that the social and fitness aspect of cycling would have a significant influence on their adoption. The reason being was that many of them stated that maintaining or improving their health motivated them to cycle and that e-bikes would allow them to be socially engaged since many of them viewed cycling as a social activity. The technological aspect of e-bike adoption pertained to the e-bike design itself, where the weight of the e-bike and e-trike was a concern for all participants. Participants stated that they would be more willing to adopt an e-bike if they were lighter than the ones that they rode for the ride-along portion of the study. The built environment was found to be an important factor towards the participants decision to adopt and e-bike or e-trike since the lack of supportive

infrastructure acted as a barrier towards their adoption. Due to the auto-centric nature of Canadian communities, the lack of cycling infrastructure was a concern for some participants due to the lack of space allocated for cyclists and that it deterred older adults who are not cyclists who may also benefit from them. The findings suggest that the e-bike as transportation mode would allow older adults to maintain their mobility. Still, the built environment may pose as a barrier for adoption due to the individual perceptions that individuals have with cycling in an auto-centric landscape which will be discussed in the following discussion chapter.

Chapter 5: Discussion

This study aimed to determine whether e-bikes and e-trikes present an intervention that allow active older adults to prolong their mobility to support aging-in-place. The following chapter summaries the key findings and discusses their relevance to planning communities that support older adult mobility

5.1 Summary of key findings

The findings of this study found that e-bikes have the potential to support aging-in-place by maintaining mobility among older adults. Participants in this study stated that they would use e-bikes in the future as an alternative to both cars and conventional bicycles due to the efficiency and lack of effort required for short to medium trips. The literature supported these findings as older adults in Australia were motivated to replace car trips with e-bikes as they allow them to get exercise without overexerting themselves cycling up hills.

From an individual perspective, participants said that e-bikes presented an opportunity to maintain social relationships that they have associated with cycling by prolonging the time they can spend cycling and remaining engaged with their cycling group. The health status of participants also influenced their willingness to adopt an e-bike or e-trike by allowing them to remain physically active as they get older. The ability to stay physically active supported the findings of the four papers which have explored this relationship as they all found that older adults were motivated to adopt an e-bike to maintain their health when using a conventional bike was no longer feasible (Johnson & Rose, 2015; Jones et al., 2016; Leger et al., 2019; Van Cauwenberg et al., 2019).

The results of the go-along interviews indicated that both the e-bikes present an opportunity that allows older adults to remain active when they are no longer capable of using a

conventional bicycle. This opportunity was due to the familiarity of the e-bike since they are nearly identical in form with conventional bicycles and the e-assist, which reduce the barriers that were associated with their decision to quit or continue cycling. These barriers included the lack of physical ability or balance that is needed to operate a conventional bicycle. These barriers were similar for the e-trike, but to a lesser extent due to the stigma that a few participants attached to it. However, the interviewees still viewed the e-trike as an intervention to prolong their mobility in the event of developing a disability. The reason being was due to the e-trikes ability to allow users to remain mobile if they were to have issues maintaining their balance, which was evident by the comments from Participant 5.

The findings also found that older adults were motivated to prolong their mobility due to the importance they placed towards maintaining their social networks and physical health. When participants would adopt one varied amongst them due to their perceptions and experiences towards them, some participants stated that they would adopt one now. In contrast, others were unsure when they would need one to continue cycling as participants indicated that they were in good health during the time of the interview. The different life histories of participants caused this variation, as their perception towards the e-bike and e-trike was different because each participant had different needs and expectations of what it could provide them. This finding aligned with the research conducted by Leger et al. (2019), which found that older adults were more willing to adopt an e-bike to maintain their social networks or use them as a mobility aid if they were to develop a health issue.

When participants would adopt an e-bike or e-trike also varied depending on how they categorized their cycling ability. These findings touched on results from Jones et al., (2016), as some participants did not see themselves adopting an e-bike soon since they enjoyed cycling up hills and going long distances. In contrast, other participants viewed them as barriers, which are

why they would be willing to adopt one soon as the technological aspect of e-bikes allow them to overcome them. Overall, the interviewees said that both e-bikes and e-trikes were excellent tools that enable them to prolong their mobility now or in the future. E-bikes as a technology provided the opportunity to remain mobile as it reduced barriers, such as physical exertion and balance that would otherwise deter them from continuing to ride a conventional bicycle.

Participants said the technological aspect of both e-bike models poses as an alternative to car trips around the Region due to their ease of use, efficiency and the element of fun that they present. As a result, participants said that the e-bike and e-trike serve as an alternative to conventional bicycles for short to medium commutes throughout the Region where destinations are far in length due to sprawl, which is common in Canadian cities. The reason being was due to the decreased physical exertion needed to pedal while carrying their belongings on both the e-trike and the e-bike and - In turn, allowing them to maintain their overall health and social relationships when they are no longer capable of using a conventional bicycle. Maintaining overall health was similar to the results of Johnson & Rose and Van Cauwenberg et al. (2015 & 2019), which found that older adults made more active trips using the e-bike. In turn, supplementing medium-length car trips and other active modes such as walking due to their ease of use and lack of physical exertion that is needed to use them.

The built environment was stated to influence the ability of the e-bike and the e-trike to serve as an alternative mode of transportation and prolong the mobility of older adults. Although the majority of participants were comfortable cycling on the road, they still stated that the presence of cycling infrastructure played a significant role in their sense of safety when cycling as the lack of separation between vehicles was found to induce fear. Participants said that the addition of cycling paths and lanes throughout the Region would have a positive effect on whether they would adopt an e-bike, especially for the e-trike due to the width. Participants also

speculated that the presence of more cycling supportive infrastructure would encourage other older adults to adopt an e-bike or e-trike due to the increase in safety, which they acted as a deterrent for others. Similar to Leger et al. (2019) and Jones et al. (2016), older adults also viewed the lack of supportive cycling infrastructure as a barrier towards their adoption due to the lack of safety. The lack of safety also included separation from pedestrians, which the case for reported crash circumstances in Belgium (Van Cauwenberg et al., 2019). As a result, the findings of this study support the influence that the built environment has on older adult e-bike adoption.

What this study adds to the existing literature about older adult e-bike use was the experiences and perceptions of active older adult cyclists have towards adopting one in the future. These perceptions and experiences included the intended use for older adults, as several participants saw them as a mobility aid for the future when they are no longer capable of using a conventional bicycle. In contrast, other participants viewed them as a way to ease mobility in the present. Additionally, this was also the only study that explored the thoughts and perceptions towards the e-trike, as other studies have only explored the use of the e-bike. Although participants were not as familiar with the e-trike, it was viewed to be an alternative mode of transportation if they were to develop a disability or lose their balance but still want to remain active within their community.

Additionally, this research also found that a lack of opportunities exists for older adults to learn about e-bikes, which were one of the motivations the participants took part in this study, which will be discussed further in the next section. Overall, this study built on existing themes in the literature and discovered new data about the perceptions and experiences active older adults have towards e-bikes and e-trikes as an alternative mode of transportation in Canadian communities.

5.2 Viability of E-bikes to support aging-in-place

The findings of this study indicate that e-bikes and e-trikes provide a tool that allows older adults to prolong their mobility, supporting aging-in-place since e-bikes were found to allow older adults to maintain their overall health and continue to stay engaged with their community. However, the findings suggested that cycling culture in Canada has a strong influence towards the uptake of e-bikes and e-trikes as the lack of policy and planning for cycling infrastructure has acted as a deterrent for inexperienced and non-cyclists to make cycling trips, similar what was found by Leger et al. (2019). Cycling culture also spoke to the lack of education and clear policies associated with them which led some of their peers to stigmatize them and cause uncertainty of where they can be used, similar to what was found in other studies (Dill & Rose, 2012; Edge et al., 2018; Leger et al., 2019). The lack of education was evident through the experience and perceptions of participants as the majority of them stated that they were interested in taking part in this research because they wanted to learn about e-bikes and there were very few opportunities for them to do so. After learning more about both the e-bike and the e-trike, participants stated that they would be willing to adopt an e-bike or e-trike in the future. The reason being was that e-bikes allow them to age-in-place due their similarity with conventional bicycles and their ability to allow them to stay engaged with their community as they get older.

The lack of cycling culture in Canada has also resulted in cities that favour cars. It stigmatizes cyclists, in turn, creating a sense of fear associated with cycling in mixed-traffic which has deterred individuals from cycling in particular areas in this study as well as in others (Jones et al., 2016; Leger et al., 2019; Winters et al., 2010). Although e-bikes and e-trikes as a mode of transportation are viewed as a viable mode of transportation for older adults to age-in-place, the place itself plays an equally important role in facilitating their use, which speaks to the

individual and environmental factors associated with their use. Similar to other studies that have analyzed the role of the built environment on active transportation, the lack of clear policy and infrastructure that facilitates cycling acts as a barrier towards their use (Leger et al., 2019; Kerr et al., 2012). As mentioned previously, individuals perceived the built environment differently due to the various factors which influence their willingness to cycle (City of Waterloo 2017; Kerr et al., 2012; Leger et al., 2019).

Participants stated that there is a greater need for more cycling infrastructure to encourage more cycling trips, as they expressed that many of their peers are reluctant to cycle because of dangerous cycling conditions. These conditions being the lack of separation between vehicles and connectivity across the region (City of Waterloo, 2017; Jones et al., 2016, Kerr et al., 2012; Leger et al., 2019; Winters et al., 2010). These findings align with Winters et al. (2010), which found that factors such as the physical environment, land use, road network and bicycle facilities influence an individual's willingness to cycle. Although e-bikes reduce barriers such as distance, they are still susceptible to the same dangers as cycling with a conventional bicycle. The lack of infrastructure that facilitates the use of e-bikes and e-trikes proves that the built environment is a determinant towards their ability to allow older adults to age-in-place. The reason being is that the lack of supportive infrastructure discourages cycling due to the perceived danger associated with sharing space with vehicles. This was coupled with individual perceptions and experiences with cycling as some older adults are less likely to cycle when there is a lack of cycling lanes or paths that gave them a sense of safety.

5.3 Differences Between E-bikes and Conventional Bicycles

Throughout the study, participants stated the similarities and differences between e-bikes and their conventional counterparts. By trialling both e-bikes, participants said that there were many similarities in terms of their form and operation. These similarities were attributed to

similar design elements that they shared with conventional bicycles apart from the addition of the battery and buttons that allowed them to adjust the amount of assistance they required. Participants also noted that transitioning to the e-bike was no different than the learning to use a new bicycle, which also included the use of the pedal-assist, which took participants little time to get used to. Several participants who were unsure how riding an e-bike would differ compared to riding a conventional noted that there were few differences in their operation aside from the pedal-assist, which they could adjust.

Similarly, when participants cycled along the trial-route, they found that concerns towards the built environment with the e-bike were no different than issues associated with riding a conventional bicycle. These issues included sharing space with other users, such as cyclists and pedestrians. In terms of getting on and off the e-bike, a few participants stated that the weight of the e-bike might cause balancing issues when trying to lift their leg over the top-tube with their limited flexibility. However, concerns over balance may be resolved through the use of step-through frames, which enable users to get on and off the e-bike using less effort. As for stopping, to account for the weight of the e-bike, the use of hydraulic disc brakes would allow users to apply more braking force while using less effort, which would be beneficial for older adults with less dexterity in their hands. Regarding the e-trike, participants were unable to compare their experience using the pedal assist with a conventional tricycle due because they were unable to compare them. However, participants stated that they would prefer wider paths with less activity to account for the wider rear of the e-trike.

Differences between the e-bikes and conventional bicycles stated by participants included their heavier weight and faster acceleration. Although these factors were not a concern to participants while they rode them, they may pose a risk towards the safety towards other e-cyclists and pedestrians. This risk includes the potential harm that may be caused by collisions,

as the heavier weight and relatively faster acceleration of the e-bike and e-trike would have a more significant impact compared to a conventional bicycle. In turn, the potential risk may indicate the need for separate infrastructure that accommodates the use of faster and heavier active modes which may pose a danger to other users such as pedestrians and other cyclists (MacArthur et al., 2018; Van Cauwenberg et al., 2019)

For trip generation, e-bikes provide the opportunity for older adults to make trips that they otherwise may not have taken using a conventional bicycle. This opportunity touches on path choice, where cyclists were found to sacrifice directness with safety and physical exertion, as riders would take longer routes to avoid high conflict areas and gradients (Casello & Usyukov, 2014). The pedal-assist of the e-bike allows older adults to overcome these challenges as they reduce the physical exertion needed to cycle up hills, take longer routes to avoid car traffic. Conversely, e-bikes also gave riders a sense of confidence to take more direct routes as they have been found to allow e-cyclists to prevent conflicts with vehicles due to the faster acceleration (MacArthur et al., 2018). Due to the minimal differences associated with riding a conventional bicycle and e-bikes, e-bikes provide older adults with the ability to maintain, and even increase their mobility, in turn, supporting their ability to age-in-place.

5.4 limitations of the study

Limitations of this study were associated with the study area of the Waterloo Region. Although the Region provided a representative landscape of a typical mid-sized region in Canada, the culture and infrastructure for cycling posed a limitation for this study. The limitation was due to their rankings on the Bicycle Friendly Communities Network, where Waterloo, Kitchener and Cambridge are ranked Gold, Silver and Bronze, respectively (Share the Road, 2019). The ranking criteria consider five categories that include: the presence of cycling infrastructure, education, incentives, equitable laws and planning practices. These criteria

encourage cycling in each community, indicating that there is a broader cycling community throughout the Region, especially in the City of Waterloo, where the modified go-along interviews took place (Share the Road, 2019). Ideally, information regarding e-bike use in all cities within Canada would provide breadth regarding the number of respondents that would have taken part in the study and determine whether the perceptions and experiences about their adoption differ spatially. However, due to time and cost constraints, this study was limited to the Waterloo Region.

In terms of the sample group, the participants that took part in this study were recruited from older adult cycling clubs throughout the Waterloo Region. By using a targeted sample to recruit active older adults, the sample consisted of participants with a variety of cycling levels, which were used to determine whether e-bikes and e-trikes pose as an intervention that allows them to prolong their mobility (Palinkas et al., 2015). Although the purpose of this study was to determine the viability of e-bikes as a mobility intervention for active older adults, non-active older adults were excluded from the study. This exclusion criterion was a limitation of ethics approval from the Research Ethics Committee at the University of Waterloo due to the potential danger that e-bikes and e-trikes may pose to older adults who are not familiar with operating a conventional bicycle. Although this study did not include the experiences of non-cyclists, participants contributed relevant data on prolonging mobility for an active group who hope to remain active later in life. Further, the recommendation to support cyclists will have co-benefits for non-cyclists as well.

The study also lacked ethnic diversity as all of the participants as the recruitment processes and interview questions did not ask participants for their cultural background or migration status. As a result, the views towards e-bikes of this study predominantly represent older adults of that are Caucasian. Ethnic minorities may have offered different experiences and

barriers associated with e-bikes and e-trike adoption as a result of various life histories about cycling and culture. The reason being is that migrating from a different cycling culture may influence whether an e-bike and/or e-trike allow them to prolong their mobility and age-in-place. The lack of ethnic diversity highlights the need for future research to explore whether e-bikes and e-trikes enable older adults to age-in-place in Canadian communities.

The trial route of the go-along interview also presented itself as a limitation for the study because it did not represent real-world conditions and the topography that allows the participants to receive the same experience riding both bikes after they switched at the mid-point of the go-along. For the route, some participants stated that it was not representative of what it was like to cycle in a downtown setting or along county roads, which were where they typically cycled. Participants said that the route was safer due to the lack of vehicles along the road portion of the ride and that the students are not as sporadic compared to typical pedestrians when cycling in mixed traffic. Since participants were aware of this, many of them were able to speak about how their experience may differ using e-bike or e-trike along routes where they typically ride.

The other limitation of the route was the topography as the first half of the route included a steeper incline meaning that participants who started on the e-bike and switched to the e-trike half way on the ride were not able to directly compare their capabilities. Although the route did not replicate real-world conditions, it provided an ideal alternative that allowed the older adults to try an e-bike and e-trike for the first time safely as required by ethics.

The size of both the e-bike and e-trike model and their age were limitations of the study. This limitation was a result of the size of both bikes that hindered the comfortability of taller participants. Participants were also limited by the e-bike model they could ride. The models available were not only unrepresentative of the various models available in the market but that many of the participants were not used to using a mountain-style bike since they were more

familiar with riding road bikes. This issue was the same for the e-trike as different variants overcome issues associated with steering and balance on the e-trike model used in this study. The last limitation related to the e-bike and e-trike models as the models were much older compared to ones that participants have tried in the past, meaning they were heavier and did not accelerate as smoothly as newer models. As a result, the limited options and the age of both the e-bike and e-trike influenced the experience of participants as the models presented did not reflect the options participants may have when purchasing an e-bike or e-trike for themselves.

5.5 Considerations for Future Research

Due to the lack of research that has explored the relationship between older adults and e-bikes, there are still areas that should be explored to build a more holistic understanding of how e-bikes pose as a mobility intervention for older adults in Canadian communities. The limitations of this study suggest several considerations should be made when exploring this relationship in the future. Although life histories play an important role in the experiences of participants, it may not be the case for individuals with different life histories. The reason being is due to the diverse lived experiences and living situations that may influence their willingness and/or ability to maintain it in the future (Barnett et al., 2017; Webber et al., 2010). Such factors may include whether participants lived alone or with family, their cycling history, or how involved they are with their community. As a result, future research must employ methods that target older adultsof different ethnicities and abilities.

Participants spoke about the benefits that e-bikes and e-trikes present to older adults who have a disability or ARE inactive since they provide them with an opportunity for them to be physically active and re-engage with society. This benefit was especially the case for the e-trike, which provided added balance, which beneficial for Participant 5, who has not ridden a bicycle in two years due to their health. Although this may be the case for one participant, the lack of

participants that were not active or had a disability presents an opportunity for further exploration whether they may also allow this demographic to age-in-place by enhancing their mobility. Future research should utilize the use of go-along interviews on routes that participants frequent to understand what barriers and facilitators older adults face at an individual level compared to using a fixed route similar to this study that provided a general understanding of older adult cyclists (Carpiano, 2006; Jones et al., 2016). Due to the increasing proportion of older adults in Canada, there will be a higher number of older adults who will develop disabilities associated with aging. As a result, there will be a greater need to explore whether e-bikes provide them with an intervention overcome barriers related to their lack of mobility and age-in-place (Barnett et al., 2017; Leger et al., 2019; Rosso et al., 2010; WHO, 2010;).

Canadian municipalities have made efforts to improve cycling infrastructure to promote higher levels of active transportation and safety for cyclists. Although the Waterloo Region contains a diverse urban form, there is still a need to conduct similar research in other Canadian communities due to the diversity in urban form and cycling culture across the country. Urban form was apparent as participants said that cycling culture and topography differ in other Canadian cities, which either facilitate or deter cycling due to the hilliness and quality of cycling infrastructure that encourage e-bike adoption. Future research should consider the tail ends of the cycling culture spectrum in Canada to account for the outliers that were not accounted for through the use of the Waterloo Region study area. Future methods may be by conducting similar research in cities with different weather or existing bike-share programs, which may, in turn, have an influence on the perceptions and experience older adults have towards e-bikes and e-trikes. Other opportunities also include exploring the use of e-bikes and e-trikes at senior communities, which are comprised of a diverse group of older adults who live in a closed area, which may benefit from the e-bike or e-trike. By exploring an even wider variety of older adult

cyclists, it would build on the findings of this study. It may also provide insight into the interplay between the individual and environmental factors associated with e-bike use and how e-bikes as a technology fit as a potential mobility intervention for older adults in other communities.

Older adult e-bike use remains to be an understudied topic, especially in Canada, which presents opportunities to explore this relationship further and other aspects that were not touched due to the limitations of this study. Both academic researchers and planners play an essential role in facilitating the use of e-bikes by understanding their use at both a theoretical and practice level. This research can be used to implement planning practices and policies which emphasize the potential that e-bikes have to maintain and even enhance the mobility of older adults in Canadian Communities. However, this can only be accomplished through the continued research and evaluation of e-bike adoption and their use in practice.

5.6 Summary

With a growing proportion of older adults and the existing sprawled nature of cities, there is a greater need to explore further the potential that e-bikes have towards allowing older adults to age-in-place. Electric mobility devices such as e-bikes not only lowers the barriers associated with remaining physically and socially active through the aging process, but they present opportunities that support age-friendly planning practices that are environmentally friendly. These age-friendly practices may be through services and infrastructure that are accessible to older adults, allowing them to remain active and decrease their reliance on automobiles as a whole, in turn, supporting planning practices that encourage density and active transportation. However, due to the lack of existing literature and limitations of this study, opportunities for researchers, planners and policymakers to further explore this relationship are presented.

Chapter 6: Thesis Conclusions and Recommendations

6.1 Recommendations

The findings of this study not only build on the academic literature that explored the relationship between older adults and e-bikes, but it also provides planners and policymakers with an opportunity to encourage mobility for older adults so they can age-in-place. The following recommendations are based on the findings of this study collected from the go-along and follow-up interviews with older adult cyclists and the literature that accompanied this research.

Although aging has been associated with a loss in mobility, older adults that remain physically active are more likely to be healthier, both cognitively and physically (Barnett et al., 2017; WHO, 2007). However, the auto-centric nature of Canadian communities has acted as a barrier for older adults to remain active due to the lack of supportive infrastructure that facilitates aging-in-place and active-aging (WHO, 2007). E-bikes present an intervention that allows older adults to prolong their mobility because they lower the barrier associated with their decision to continue cycling. The reason being is due to their ability to let users to go farther and faster while using less effort than a conventional bicycle (Leger et al., 2019). As a result, e-bikes enable older adults to maintain their mobility by providing them with an opportunity to remain physically active and engaged with their community, which are necessary for them to age-in-place.

Understanding the individual, technological and environmental factors associated with older adult e-bike use provides practical applications that can be applied in both research and planning practices in Canadian communities. This study proved that e-bikes offer an intervention that allows older adults to maintain their mobility as they age within a Canadian context as e-bike itself is a viable mode of transportation. However, the relationship between the individual and the built environment was found to have a significant influence towards their adoption due to

fear associated with sharing space with vehicles and the lack of clear policies and education surrounding them as well as the quality and quality of cycling infrastructure between origins and destinations (e.g. cycling lanes, secure bike parking, etc.). Due to the lack of clear policies and a lack of supportive infrastructure that is needed to facilitate e-bikes, the following outlines recommendations that must be considered for future research and planning practices that encourage their use.

6.1.1 Theoretical Recommendations

Determining a solution to allow older adults to prolong their mobility poses an issue to researchers due to the complexity that is associated with a heterogeneous population that consists of varying life histories influenced by factors such as culture, social life and the built environment (Webber et al., 2010). Although the participants of this study were all at different stages of their life and presented a diverse range of experiences, they do not represent all older adults in Canada. These life histories influence the way older adults interact with their surroundings as communities have a significant impact on human activity due to the complex interplay between people and the built environment, which affects them both individually and environmentally (Hand et al., 2017; Hand et al., 2018). In turn, these transactional interactions should be taken into consideration for future research due to their impact on the health and well-being of older adults. More specifically, how these interactions play a role in an older adults willingness to use e-bikes as an intervention to maintain their independent mobility.

As the sample that was used for this research which was predominantly made up of Caucasian older adults they cycled for recreational purposes, future research should explore the experiences of older adults of different ethnicities and abilities in a variety of Canadian communities which may have a different culture towards cycling to determine similarities and differences associated with their ability to allow them to maintain their mobility (Cerin et al.,

2017; Webber et al., 2010). Due to the cultural and environmental influences that are attached to mobility, exploring the experiences of older adult e-bike adoption in different communities will provide a more in-depth understanding of barriers and facilitators that were not touched on in this study. Future methods may be through recruitment strategies that target older adults through a variety of mediums, which may include disseminating recruitment material at cultural centres, older adult-specific events and retirement communities (Jones et al., 2016; Leger et al., 2019). Additionally, to reduce stigma or concerns over safety that may deter older adults from participating, recruitment strategies should emphasize the similarities between e-bikes and conventional bicycles that were found in this study. In doing so, older adults who may not have cycling experience or who have physical limitations or disabilities would be more inclined to take part in future studies. The reason being is due to the benefit that e-bikes present compared to conventional bicycles based on the e-bike's ability to enhance their mobility, which was seen in this study. As a result, researchers may be able to determine what changes need to be made for them to be able to prolong their mobility and support aging-in-place for a much more diverse older adult population.

6.1.2 Practical Recommendations

This research was conducted through a planning lens to ensure that the findings provide practical recommendations that can be applied in practice by planners and decision-makers responsible for the health and well-being of older adults. The following section offers planners, policymakers and e-bike manufacturers with recommendations should be implemented to facilitate older adult e-bike and e-trike adoption and use in Canadian communities. These recommendations take from the interdisciplinary nature of planning as they contribute solutions that target the individual, technological and environmental factors associated with their adoption. Recommendations include e-bike education programs for older adults, implementing age-

friendly design elements for e-bikes and planning interventions and policy recommendations that can be implemented to facilitate older adult use of e-bikes in Canada further.

6.1.2a Education programs

The findings of this study suggest stigma associated with e-bikes and e-trikes are due to the lack of familiarity towards them, which has led to confusion. The lack of familiarity was attributed to participants mentioning that some of their peers viewed them as a form of cheating due to their electric motor (Edge et al., 2018; WSP, 2019). As e-bikes and conventional bicycles are virtually identical in function, the stigma associated with them was eliminated as participants became more familiar with them during the ride-along. For example, Participant 8 was able to dismiss their reservations associated with riding alongside e-bikes during the ride-along since they found it to be no different than riding alongside a conventional bicycle. The lack of knowledge about e-bikes was consistent for all participants, which was one of the reasons why all of them took part in the study. Participants stated that they wanted to learn more about e-bikes and that the study presented them with an opportunity to learn more about them and ride one without the commitment associated with going to an e-bike retailer. As a result, municipalities can partner with bicycle education programs to provide information sessions about e-bikes to older adults to reduce the stigma associated with e-bikes and e-trikes. Municipalities can achieve this by providing education programs that cater to older adults. These sessions should be hosted at locations where older adults frequent such as older adult centres, community centres, retirement communities as well as local bicycle retailers. To ensure the consistency of the information that is being provided and reduce the number of resources allocated to these programs, municipalities are encouraged to collaborate with Cycling Canada through their CAN-BIKE program, which currently offers courses by trained instructors who are knowledgeable in cycling education and promotion (CAN-BIKE, 2014). These courses can give older adults with

information about the different types of e-bikes, but also allow them to try one. These e-bike education programs would reduce the stigma associated with them and make them more approachable for older adults when they are no longer able to use a conventional bicycle.

6.1.2b Ideal e-bike & e-trike design

Due to the interdisciplinary approach of planning, the design of e-bikes and e-trikes has implications on their overall adoption by older adults and for how planners and policymakers can facilitate their use. Concerning design elements that would facilitate their adoption, participants stated that it would be ideal for both bikes to be lighter in-case the battery died and for storage, which also reflects the ideal design elements that were found by Leger et al. (2019). Flexibility and dexterity of older adults should also be considered for e-bike design as participant 10 said that mounting and dismounting the e-bike has become more demanding as they have gotten older. A solution may be to offer more step-through frame options for older adults to decrease the strain associated with mounting and dismounting the e-bike and include hydraulic disc brakes which not only reduce the effort needed to break but also increase the e-bikes ability to slow down or stop from travelling at a higher speed (Leger et al., 2019). Other design elements that are recommended are displays are easy to read and operate, and that brakes do not require a high amount of tension to stop the e-bike and e-trike. This may be through the use of brighter displays and more responsive buttons to control the e-assist. From a technological perspective, manufacturers must aim to make e-bikes and e-trikes lighter as well as provide age-friendly design elements to facilitate older adult mobility better.

6.1.2c Policy interventions

Within the Canadian planning context, the lack of transparency towards policies and regulations surrounding them. As for their definition, they are set at the Federal level through Transport Canada, then interpreted by each Province and Territory to regulate their use

(MacArthur & Kobel, 2014; WSP, 2019). The findings of this study recommend that Provincial and Territorial governments should be more transparent of safe driving practices when sharing space with cyclists on the road. The lack of transparency was apparent as participants stated the dangers associated with the lack of space drivers would leave them when passing, causing them to use alternative routes due to their fear of safety. Transparency may by providing drivers with information such as safe passing distances, and indicating which areas where they should be more cautious when sharing the road. This information may be disseminated be through driver's education courses, informational flyers as well as signs on the road. Transparency should also be aims towards cyclists, as governing bodies should be more transparent with where individuals can use e-bikes and e-trikes as well as provide educational tools to promote safer cycling practices. These tools may include the use of signs on the road, bicycle educational programs offered at community centres, and informational flyers disseminated throughout Canadian cities. Through greater transparency of safer driving and cycling practices, it will not only encourage the adoption of e-bikes and e-trikes but also reduce confusion, reducing any fear associated with their use.

How information is delivered at the municipal level also plays a vital role in the way individuals perceive e-bikes. Apart from hosting education programs, municipalities integrate e-bikes within their planning documents and by setting objectives that aim to facilitate their adoption to enable aging-in-place for an aging population. Municipalities and Regional governments are encouraged to define e-bikes in their Official plans, Transportation Master Plan or the Active Transportation Plans to ensure that they are incorporated in planning practices to facilitate their use better. Approaches may include increasing the width of cycling lanes, placing protected bicycle lanes along major transportation corridors, ensuring the cycling network allows users to make complete trips and that major trip destinations include secure bicycle parking. By

incorporating planning practices which facilitate the use of e-bikes, it will not only promote their use for older adults but reduce the stigma and uncertainty associated with their use.

6.1.2d E-bikes as a catalyst for Age-friendly planning practices

Age-friendly cities provide safe and accessible services for an aging population, where facilities are located within a walkable or cyclable distance for older adults to promote active-aging and aging-in-place (WHO, 2007). However, as Canadian communities lack some of these features, e-bike and e-trikes present an intervention that will lower the barrier associated with distance and physical exertion associated with the auto-centric landscape. From a planning perspective, e-bikes offer a catalyst which can be used to build momentum towards implementing more age-friendly planning elements in Canadian cities such as mixed land-uses that promote density and active transportation (WHO, 2007). Due to the limited ability and time associated with shifting cities away from automobile dependence, planners and policy should implement pilot projects that aim to not only provide more information about e-bikes, further promote active transportation and mobility for an aging population. Pilot projects may be through e-bike share programs with companies such as Lime Bike or Jump Bike. These pilot programs would not only act as an educational tool to increase familiarity with the transportation mode but also remove the cost barrier associated with their initial adoption by individuals (CNN Business, 2018; He, Song, Liu, & Sze, 2019, p.2; Jump Bicycles, 2019). Other projects may include piloting protected bike lanes along major corridors, similar to the Bloor Street Bike lane pilot project in the City of Toronto, which was done to improve the safety of cyclists in auto-centric environments (City of Toronto, 2019).

Additionally, municipalities can work with bicycle retailers that sell e-bikes to have trial days. Trial days not only provide an opportunity for older adults to ride an e-bike but also offer education regarding the various types of e-bikes and policies that pertain to them to reduce

stigma or misconceptions about them. As for promoting these events, bicycle retailers can contact older adults by reaching out to older adult cycling clubs, older adult communities as well as community centres. By implementing pilot projects that aim to reduce the barriers associated with using an e-bike or e-trike, it would not only reduce the stigma associated with them but encourage more age-friendly planning practices that aim to promote active-aging.

6.1.2e Monitoring and Evaluation

The progress and success of e-bike adoption of older adults in a Canadian context can be measured using several tools to monitor and evaluate their effectiveness towards lower the barriers towards their adoption and use. Measure may include conducting active transportation reports and collecting e-bike ridership statistics through household transportation surveys such as the Census and the Transportation Tomorrow Survey (TTS). By using these resources, researchers would be able to collect demographic and ridership data specific to e-bikes. This data will provide information about their overall use by older adults and the extensiveness of a municipalities' cycling network, which can be used to measure their bicycle friendliness. City and transportation planners may be able to use this information to implement interventions and planning practices that better facilitate their use through secondary and transportation master plans. From a technological perspective, age-friendly design elements of e-bikes can be monitored through checklists that include key age-friendly design elements that should be integrated into e-bikes for them to encourage their adoption by older adults. This checklist may consist of the addition of step-through frames for each e-bike model as well as visible and intuitive controls. Due to the scope and quantity of information that would be gathered on older adult e-bike use, the success of these measures should be evaluated by an active transportation research hub. This hub would consist of active transportation researchers who would synthesize the literature and data about older adult e-bike use and assess their effectiveness towards

maintaining older adults in Canada. Due to the heterogeneity of the older adult population and advancements in e-bike technology, this active transportation research hub is necessary for the on-going evaluation of the effectiveness that e-bikes possess to enable older adults to maintain their mobility and age-in-place.

6.2 Thesis Conclusions

The auto-centric nature of Canadian communities poses a threat to the growing older adult population due to barriers that inhibit their ability to maintain their independent mobility as they age. The long distances and lack of supportive, active transportation infrastructure discourage older adults from walking or cycling to destinations, which exacerbates their lack of physical ability. E-bikes present an intervention that enables older adults to maintain their mobility and overall health as it lowers the barriers associated with making trips and being physically active. E-bikes also present an opportunity to begin the transition away from auto-centric planning practices towards promoting age-friendly communities that encourage active-aging.

This research contributes to the gap in the literature, which explores the relationship between older adults and e-bikes. In doing so, it gives planners and policymakers with the knowledge that can be used when they collaborate with city councillors, transportation engineers, e-bike manufacturers and older adult stakeholders when developing community plans that support aging-in-place. The in-depth data collected through qualitative methods and analyzed using existing themes, barriers and facilitators, which can be applied to other Canadian communities. This thesis proved that e-bikes allow older adults to maintain their independent mobility as they get older since they lower the barriers associated with maintaining their independent mobility in Canadian communities. The built environment and the lack of clear e-bike policies continue to play an important role in facilitating e-bike mobility. Indicating that

changes must be made to reduce the barriers that deter older adults at the individual level regardless of the benefits that e-bikes present. As a higher proportion of the Canadian population continues to become older, there will be a greater need to support independent mobility. E-bikes present an opportunity that allows older adults to remain active as well as catalyze the shift towards planning cities that are more age-friendly to support aging-in-place.

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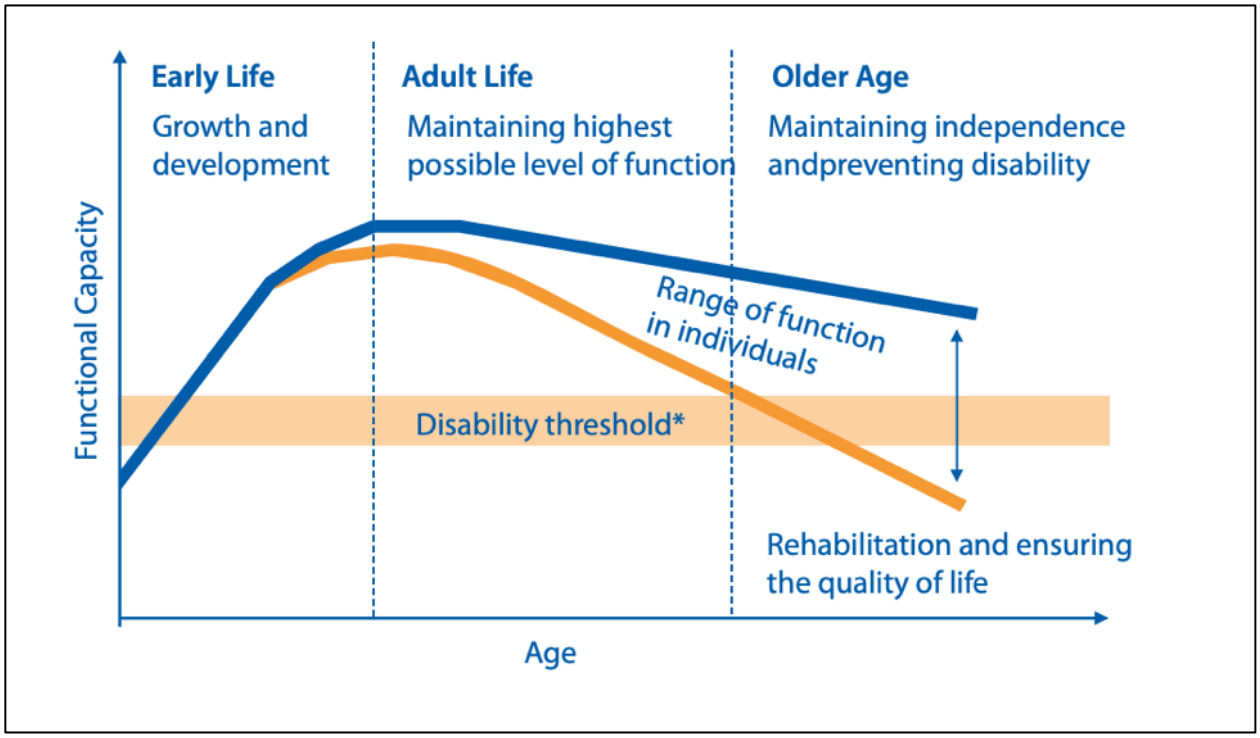
List of Appendices

Appendix A: Functional Capacity over the Life Course



(WHO, 2007, 6)

Appendix B: Recruitment Script

Hi [*potential participant's name*], my name is ***Edward Donato*** and I am a graduate student working under the supervision of **Jennifer Dean** from the ***School of Planning at the University of Waterloo***. I am contacting you because you expressed interest in participating in our e-bike trial. I was wondering if you would still be interested in participating?

[IF NO] Thank you for your time. Good-bye.

[IF YES] Continue

We would like you to partake in an e-bike trial consisting of two parts. In the first part, you will have the choice of riding an electric bicycle or electric tricycle on a predetermined route for approximately 45 minutes. Prior to riding you will receive training on how to use the e-bike, and discuss the sensors attached to the bike to measure the surrounding environment (Go-pro camera) (approximately 15 minutes). We will ride along the Laurel trail alongside the University of waterloo and through Waterloo Park on the cycling lanes. I will be riding a second e-bike beside/behind you.

Participation in this study is voluntary. This study provides a direct benefit to participants by offering them the opportunity to try a new transportation technology at no cost. Risks associated with participation in this study are common to all forms of cycling, including but not limited to, physical strain or bodily injury. These risks will be mitigated through training of participants, wearing an approved helmet, and remaining on cycling trails. With the participant's permission, audio/video recordings, and bike stability data will be analyzed as part of the study. The participant's name/face will not appear in any report resulting from this study, however, with your permission anonymous quotations may be used. Data collected during this study will be retained for 7 years in a locked office. Only researchers associated with this project will have access.

As mentioned, participation in this study involves a 45-minute ride-along followed by a 1-hour follow-up interview. Currently the ride-along trial is scheduled for (INSERT DATE) at (INSERT TIME), with the follow-up interview occurring 1-2 days after the trial. However, if you have alternate scheduling requirements we would be happy to accommodate. I would like to assure you that this study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. However, the final decision about participation is yours.

Would you be available at this time?"

[If NO] Would there be a convenient day to reschedule the trial?

(Agree on mutually convenient day OR deny participation)

[IF YES] Thank you; we appreciate your interest in our research!

[IF NO] Thank you, have a good day!

Let me give you some important information about the study. Have you got a pen and piece of paper?

The name of the study is 'Promoting active transportation to support aging-in-place: An exploratory study of electric bicycle use among older adults', and my name is Edward Donato. On the day of the study,

please meet me at [location on Laurel Trail of convenience to participant]. Also, if you wear glasses or contact lenses to correct your vision, or if you use a hearing aid, please bring them with you to the session."

If you have to withdraw participation from the interview please contact Jennifer Dean at (519) 888-4567 Ext.39107.

I look forward to meeting you on [day and time of appointment]. Thank you very much for helping us with our research!

Appendix C: Letter of Information & Consent Form

UNIVERSITY OF WATERLOO

Exploring E-bike use among older-adults to support aging-in-place

Informed Consent

Student Investigator: Edward Donato
Graduate Student, School of Planning,
University of Waterloo, 200 University Avenue West,
Waterloo, ON, Canada, N2L 3G1
Email: eldonato@uwaterloo.ca

Faculty Supervisor: Dr. Jennifer Dean
Assistant Professor, School of Planning,
Faculty of Environment, University of Waterloo
Tel. 519 888 4567 X 39107
Email: jennifer.dean@uwaterloo.ca

Purpose of the Study: To assess the older adults' perceptions and experiences of electric bicycles and electric tricycles as a form of independent mobility to support aging in place which is defined as being able to remain in your home and community as you age

Procedures involved in the Research: We would like you to partake in an e-bike trial consisting of two parts. In the first part, you will have the choice of riding an electric bicycle or electric tricycle on a predetermined route for approximately 45 minutes. Prior to riding you will receive training on how to use the e-bike, and discuss the sensors attached to the bike to measure the surrounding environment (Go-pro camera)(approximately 15 minutes). We will ride on the Laurel Trail alongside the University of waterloo and through Waterloo Park on the cycling lanes. I will be riding a second e-bike beside/behind you.

The second part of the study involves a follow-up interview lasting approximately 45-60 minutes. This will take place at the University of Waterloo during which time you will be asked questions about the riding experience and to comment on the route you rode after watching the video. With your permission, this interview will be audio recorded. Participants will receive a $25 gift card in appreciation of their time. The amount received is taxable. It is your responsibility to report this amount for income tax purposes. This study has been funded by NSERC and UW research grants.

These trials and interviews will contribute to a better understanding of the relationship between older adults' lifestyle and emerging technology in transportation. The data obtained from each of the phases of interviews will lay the foundation for potential integrations of new transportation technology

into older adult lifestyles as a means to promote aging-in-place, which is a World Health Organization recognized priority. Once all the data are collected and analyzed for this project we will share our analysis with interested communities through seminars, conferences, presentations, and journal articles.

Participation Benefits and Risks: Participation in this study is voluntary. This study provides a direct benefit to participants by offering them the opportunity to try a new transportation technology at no cost. Risks associated with participation in this study are common to all forms of cycling including but not limited to:

- physical strain
- bodily injury.

These risks will be mitigated through training of participants, wearing an approved helmet, and remaining on local roads and trails. With the participant's permission, audio/video recordings, locational data, and bike stability data will be analyzed as part of the study

Confidentially: The participant's name/face will not appear in any report resulting from this study, however, with your permission anonymous quotations may be used. Data collected during this study will be retained for at least 7 years in a locked office. Only researchers associated with this project will have access. After the study has been completed the emergency contact information will be shredded.

Participation: Participation in this study is voluntary. You may withdraw at any time or even after you have signed this consent form without any consequence to you. You may also choose to skip any question you are not comfortable with and remain in the study. If you choose to withdraw part way through the study, you may request that your earlier data be omitted from the study. Participants will receive $25.00 gift card in appreciation of their time. Please note that *the amount received is taxable. It is your responsibility to report this amount for income tax purposes.*

Information about Study Results: Interested participants will be sent a copy of future publications once the study is complete.

Information about Participating as a Study Subject: If you have questions or require more information about the study, please contact the research supervisor Dr. Jennifer Dean.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#31517). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

Appendix D: Feedback & Appreciation Form

University of Waterloo

Date

Dear (Insert Name of Participant),

We would like to thank you for your participation in the exploratory study of electric bicycle use among older adults. As a reminder, the purpose of this study is to assess the role of active transportation, specifically electric bicycles and electric tricycles, in assisting older adult's ability to comfortably age in place.

These trials and interviews will contribute to a better understanding of the relationship between older adults' lifestyle and emerging technology in transportation. The data obtained from each of the phases of interviews will lay the foundation for potential integrations of new transportation technology into older adult lifestyles as a means to promote aging-in-place, which is a World Health Organization recognized priority.

Please remember that when findings are shared, any data pertaining to you as an individual participant will be kept confidential. Once all the data are collected and analyzed for this project we will share our analysis with interested communities through seminars, conferences, presentations, and journal articles.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#31517). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

If you are interested in receiving more information regarding the results of this study, or if you have any questions about the study, please do not hesitate to contact myself Edward Donato at eldonato@uwaterloo.ca or Prof. Jennifer Dean at jennifer.dean@uwaterloo.ca, 519-888-4567 ext. 39107.

Thank you,

Edward Donato
School of Planning
Waterloo, Ontario
eldonato@uwaterloo.ca

Jennifer Dean
School of Planning
Waterloo, Ontario
jdean@uwaterloo.ca

Appendix E: Interview Itinerary

1) Introductions
2) Discussion of e-bike
    a. Can you tell me about your age and cycling history?
    b. Can you tell what it is like to ride a bike in your community?
    c. What was your first reaction when using the motor-assist?
    d. What was the biggest challenge in riding an e-bike?
    e. Were there any surprises in terms of what it is like to ride an e-bike?
    f. What trips could you see yourself using the e-bike for?
    g. Overall what feeling best describes your experience
3) View go-pro footage from ride along
4) Reflection on the video: participants comment on specific moments of the video where they felt particularly "comfortable" or "uncomfortable"
    a. When/where is it easy? Most difficult?
5) [Researcher brings print out maps of the community and surrounding road network] Participant can identify these areas on the map with their comments
6) [Same photos of e-bike models are used from focus group] participants are asked to re-rate their comfort level with each model
7) Open discussion about changed perceptions?
    a. Why were you initially interested in taking part in a study using e-bikes?
        i. What were your priorities? (health, environment, cost, time)
        ii. Now that you have experience, what is the biggest priority for you?
    b. What do you think is the biggest benefit of e-bikes?
8) Do you think this is a viable form of transportation for older adults?
    a. Why or why not?
    b. Based on your experience riding the e-bike or e-trike, how would you perceive the comparison of the e-bike and e-trike in terms of appeal to older adults?
    c. Why is that?
9) Do you have any further comments/questions?
10) Conclusions and thank you

Appendix F: Thematic Framework

Research Question 1: Understand what is necessary/what factors would need to occur for the transition to e-bike adoption?

Factor	Loss of mobility[1]	Health issues[1,5,6]	Physical exertion[1]	Social interaction[1,2,3]	Infrastructure [1,2,3,4]	Other

Research Question 2: What would they use the e-bike for?

Used	Commuting[1,5]	Leisure/Recreation[1,5]	Commuting & Leisure[1,5]	Other

Research Question 3: Why are they interested in e-bikes/e-trikes? (pre-ride thoughts)

Factor	Interest[1,2,3]	Loss of mobility[1,3,4]	Socializing with others[1,3]	Health[1,2,3,4,5,6]	Environment[1,2,4,6]	Alternative mode of transportation[1,2,3,4,5,6]	Other

Research Question 4i: Experience riding the **e-bike** (During)

Thoughts	Enjoyment[1,2,3,4,6]	Fear[1,3,6]	Balance[1,2,3,4]	Comfortable[1,3,4,5]	Ease of use[3,6]	Sharing space[3,4]	Other

Research Question 4ii: Experience riding the **e-trike** (During)

Thoughts	Enjoyment[1,2,3,4,6]	Fear[1,3,6]	Balance[1,2,3,4]	Comfortable[1,3,4,5]	Ease of use[3,6]	Sharing space[3,4]	Other

Research Question 5i: Thoughts towards the **e-bike** (after the fact)

Thoughts	Enjoyment[1,2,3,4,6]	Fear[1,3,6]	Balance[1,2,3,4]	Comfortable[1,3,4,5,]	Stigma[1]	Ease of use[3,6]	Sharing space[3,4]	Other

Research Question 5ii: Thoughts towards the **e-trike** (after the fact)

Thoughts	Enjoyment[1,2,3,4,6]	Fear[1,3,6]	Balance[1,2,3,4]	Comfortable[1,3,4,5,]	Stigma[1]	Ease of use[3,6]	Sharing space[3,4]	Other

Research Question 6: If Infrastructure Plays a role towards their potential adoption and use of e-bikes

Used	Shared space[1,3]	Surface conditions[3]	Supportive infrastructure for cycling[1,4]	Policy[2,4]	Intersections[1,4]	Other

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