ANALYSIS OF TRAVEL BEHAVIOR OF MILLENNIALS AND OLDER ADULTS

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By

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Abstract

The main goal of this thesis is to explore the differences and similarities in travel behavior between millennials/ young adults and older adults. Understanding these differences can help policymakers and transportation providers to better serve the needs of these two generations and to develop strategies to promote greater mobility for all members of a community.

To fulfill the study objective, a scoping review of recent publications in developed countries was first conducted to understand the state of research regarding millennials/ young adults and older adults' travel behavior. Travel behaviors are explored in terms of mode choice, trip distance, trip frequency, use of alternative transport, ridesharing, and mobility tool (i.e., car, bike, transit pass) ownership. Associated factors were categorized into five themes: personal attributes, geography and built environment, living arrangements and family life, technology adoption, and perceptions and attitudes toward travel options and environment. The results of the scoping review indicated that differences exist between generations in terms of travel behavior and that the factors that influence each generation's travel characteristics are either different or differ in their nature of influence.

Next, using cross-sectional data from Hamilton, Ontario, the automobility behavior of millennials/ young adults and older adults were explored. Exploratory analysis of the comparison between young and older adults' attitudes and preferences towards different travel modes and

residential characteristics suggested that the difference between these two groups is marginal in terms of their attitudes toward driving. In general, young and older auto users both showed similar attitudes towards different transportation modes. A similar trend has been seen for non-auto users of young and older adults.

Multiple regression analyses were used to explore the automobility behavior of these two generational cohorts. Results suggested that depending on whether a millennial or older adult lives alone, with a partner or in an apartment, their automobility behavior differs. The study also found that positive attitudes and preferences towards sustainable travel behavior make both generations less auto-oriented, especially millennials. Compared to older adults, living arrangements, attitudes and preferences influence millennials' attributes of automobility behavior to a greater extent. Further, the results suggested that living arrangements, attitudes and preferences can differ among millennials and older adults; therefore, the impact on each of the attributes of automobility behavior will differ.

Finally, the study developed a daily travelers' typology based on attitudes and preferences toward different transportation options. First, the relative probabilities of attitudes and perceptions toward transportation modes are used to define different travel types/groups. Second, the effects of socio-demographics and trip attributes on the likelihood of belonging to these traveler groups are analyzed. Results suggested that heterogeneity exists within travel-related attitudes among different traveler types. Further, heterogeneous traveler types existed

among individuals belonging to the same generation, with the same living arrangements, and possession of a driver's license.

Together, the results of the thesis provide an understanding of the diverse transportation needs of millennials and older adults in Hamilton and can lead policymakers and stakeholders toward more effective, equitable and sustainable transportation solutions for both generations.

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Preface

This thesis is composed of six chapters that are based on four research papers, along with introduction and conclusion chapters. All four research papers have been published in peer-reviewed journals. The thesis mainly discusses the differences and similarities in the travel behavior of millennials and older adults. Hamilton, Ontario has been used as a case study in chapters three to five. There are some overlaps in terms of introduction, study area and data descriptions as the focus of those chapters are millennials and older adults residing in Hamilton, Ontario. Research activities including literature review, data cleaning, exploratory analysis, modeling, interpretation of the results, and writing of the papers were done by Shaila Jamal. Dr. Bruce Newbold, the thesis supervisor, is a co-author of all four papers. He provided continuous guidance in developing research methodologies, critical appraisal, and editorial reviews. Dr. Darren Scott co-authored the papers provided in chapters three to five with similar contributions as Dr. Bruce Newbold. The dataset used in chapters three to five was provided by Drs. Bruce Newbold and Darren Scott and was collected under the project "Automobility in Canada: An Intergenerational Perspective" funded by Social Sciences and Humanities Research Council (SSHRC, # 435-2017-1141).

The research papers under the thesis are as follows.

Chapter 2: Jamal, S., & Newbold, K. B. (2020). Factors associated with travel behavior of millennials and older adults: A scoping review. *Sustainability*, *12*(19), 8236.

Chapter 3: Jamal, S., Newbold, K. B., & Scott, D. M. (2022). A comparison of young and older adults' attitudes and preferences towards different travel modes and residential characteristics: A study in Hamilton, Ontario. *The Canadian Geographer/Le Géographe canadien*, *66*(1), 76-93.

Chapter 4: Jamal, S., Newbold, K. B., & Scott, D. M. (2023). Analysis of millennials and older adults' automobility behavior in Hamilton, Ontario. *Urban, Planning and Transport Research, 11*(1), 2197979.

Chapter 5: Jamal, S., Newbold, K. B., & Scott, D. M. (2023). Developing a Typology of Daily Travelers based on Transportation Attitudes: Application of Latent Class Analysis using a Survey of Millennials and Older Adults in Hamilton, Ontario. *Growth and Change*. Doi: https://doi.org/10.1111/grow.12678

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Chapter 1

Introduction

1.1 Background

In recent years, investigations of intergenerational differences in travel behavior have gained considerable attention. The Canadian population is comprised of different generations, with each generation representative of individuals who are about the same age and have experienced similar historical, economic, and political events and possess similar views of the world (Statistic Canada 2012). To date, transportation and demography-related studies have characterized different generations with distinct features. For instance, the baby boomer generation (individuals born between 1945 and 1964) are highly reliant on the personal automobile, have a preference for suburban living, retire at or near 65, and have higher rates of holding a drivers' license compared to other generations (Fordham et al. 2017, Chudyk et al. 2017). By 2031, nearly 1 in 4 Canadians will be aged 65 or over (Statistics Canada 2017), indicating the need for policy considerations in different sectors such as transportation, housing, social services, and healthcare. While the demographic shift is profound, other processes are at work, with an increasing number and proportion of older adults remaining engaged in the labor force (Statistics Canada 2017) beyond the typical retirement age of 65, along with spatial variations in population ageing (Statistics Canada 2017).

Millennials (born approximately 1980-2000) are labeled as the tech-savvy generation as they are the first generation to be grown up in the digital era and surrounded by internet connectivity (Wang and Wang, 2021). They are prominent users of different technology-based solutions such as performing online tasks (e.g., telecommuting, e-shopping) and using ride-sharing services such as Uber and Lyft. However, millennials and baby boomer generations are not identical. In the case of millennials, studies have established some common assumptions related to their lifestyles and mobility patterns such as a lower likelihood of automobile ownership and use, preference for using transit and active transportation, licensure delay, living with parents, preference for urban living, and delay in starting families (Thakuriah et al. 2010, Lavieri et al. 2017, Zhong and Lee 2017, Thigpen and Handy 2018). Although millennials are already in the workforce, minimal information is available related to their day-to-day travel and how their travel characteristics will evolve as they age.

It is also evident that each generation's travel behavior are somewhat different than the other generations (McDonald 2015). Moreover, not all individuals within the same generation act homogeneously (Lavieri et al. 2017). For example, a portion of millennials have been observed to act differently from the common assumptions regarding their generation. They are more likely to get married early, live in suburban single-family houses, and drive alone for their commute (Circella et al. 2017). Also, in the US, only 30% of the millennials were found to be living with a spouse and child in 2019, compared with 40% of gen Xers (those who are born approximately between 1965-1979), 46% of the baby boomers (those who are born approximately between

1946-1964) and 70% of the greatest generations (those who are born before 1946) when they were the age millennials are now (Barroso et al. 2020). Heterogeneity in individuals' travel behavior could exist because of socio-demographic status, economic condition, place of residence, lifestyle choice, and attitudes towards transportation services and quality of life.

In terms of statistical profile, the 2021Canadian Census counted 7.9 million millennials in Canada accounting for approximately 1 in 5 Canadians (21%) who also represent one-third (33%) of the working-age (15-64 years) population – currently, the largest working group in Canada (The Vanier Institute of the Family, 2022). On the other hand, in 2021, 19% of Canadians (1 in 5 persons) were aged 65 and older (7 million), and approximately 25% were baby boomers (9.2 million) (The Vanier Institute of the Family, 2022). Twenty-two percent (more than 1 in 5 Canadians) in the working-age population were aged 55 to 64 - close to the retirement age of 65 (The Vanier Institute of the Family, 2022). In terms of residential location, millennials accounted for 35% of the downtown population of larger urban centers of Canada, whereas boomers accounted for 21% of the urban core population in Canada's larger cities (The Vanier Institute of the Family, 2022).

1.2 Thesis Rationale

It is important to understand the transportation choices of millennials and older adults for several reasons. For instance, different generations may have different preferences or choices in terms of transportation modes. Existing literature widely assumes that millennials are more likely

to use active transportation (walking and cycling) and public transit than the preceding generations. On the other hand, older adults such as baby boomers and the greatest generations are more likely to be automobile-oriented (Lee et al., 2014; Newbold and Scott, 2016; Zhang and Li, 2022). Studies indicated a linear decrease in active transportation and public transit use from generation Z to the greatest generations (Olsson et al., 2020; Grimsrud and El-Geneidy, 2014). However, studies also indicated that public transit use among the older generations is changing – many urban older adults use public transit more than the younger cohorts and their suburban counterparts (Lee et al. 2014; Fordham et al., 2017). In terms of millennials' automobility behavior, studies indicate that millennials are just delaying their car ownership and driving due to economic constraints and delayed life events such as entering the job market, marriage, having children, etc. (e.g., Janke et al. 2021; Hong and McArthur, 2019; Delbosc and Nakashi, 2017). Studies (e.g., Ralph 2017; Busch-Geertsema and Lanzendorf 2017; Newbold and Scott 2018; Wang 2019; Lee et al. 2020) also suggested that millennials' sustainable travel behavior will change to a greater extent and will follow (in some cases, already following) the same travel patterns of previous generations as they go through different transitions in life, such as family formation and job change – which indicates that millennials may follow the same automobility pattern like their preceding generations as they age.

Also, different generations may have different transportation needs and preferences, such as older adults who may have mobility challenges or millennials who may be more likely to use technology and alternative transportation options. Transportation choices made by individuals

have a significant impact on the livability of communities, affecting the accessibility of destinations, the quality of life for residents, and the overall health and well-being of a community (Mouratidis, 2021). Understanding these differences between millennials and older adults can help transportation providers to design and implement services that better meet the needs of all generations.

Moreover, as the population ages, there will be an increasing number of Canadian older adults who will need accessible public transportation and alternative mobility solutions with many facing driving cessation (Council of Canadian Academies, 2018). Also, travel patterns and transportation can have a significant impact on the economy, both in terms of the types of jobs and businesses that are created within and beyond the city for each generation and the transportation solutions provided to access them (Cervero et al., 2017). Knowledge of these phenomena including the accessibility, costs, and benefits of different transportation options to reach those destinations will also be helpful in identifying and prioritizing potential transportation investments (Cervero et al. 2017).

1.3 Research Objectives

The overall goal of this thesis is to explore the differences in travel behavior of different generations, more specifically millennials and older adults. The specific objectives are:

- To explore different aspects of travel behavior of millennials and older adults and examine the differences and similarities in their travel behavior.

- To compare young and older adults' attitudes and preferences towards different travel modes and residential characteristics.
- To assess how automobility behavior of millennials and older adults is shaped by their socio-demographic characteristics, living arrangements, attitudes, and preferences toward transportation modes and characteristics of residential location.
- To develop a set of typologies of daily travel behavior based on attitudes and preferences toward transportation modes and explore millennials' and older adults' travel behavior based on those typologies.

1.4 Thesis Contents

The remainder of the thesis is organized as follows.

Chapter 2 contains a scoping review of travel patterns of millennials/ young adults and older adults in the developed world contexts. The review of 78 papers published between 2010 to 2018 offered a good foundation for the remaining chapters by summarizing the findings of the recent literature and identifying the research gaps regarding the travel behavior of millennials and older adults. This chapter has been published in a peer-reviewed journal, '*Sustainability*.'

Chapter 3 provides an exploratory analysis of young and older adults' attitudes and preferences toward different transportation modes and residential locations using Hamilton, Ontario a case study. These two generational cohorts were further disaggregated by auto users

and non-auto users. Through exploratory analysis, the chapter provides insights into the differences and similarities of attitudes and preferences of young and older adults based on their auto and nonauto use behavior. This chapter has been published in a peer-reviewed journal, '*The Canadian Geographer.*'

Chapter 4 offers an exploration of millennials and older adults' automobility behavior and its relationship with different factors such as sociodemographic characteristics, travel characteristics, living arrangements and attitudinal factors. Automobility has been defined as using an automobile as a common form of transport, possession of a valid driver's license, using an automobile as a driver or passenger, and number of automobiles in the household. Using multiple regression analysis, the chapter explores whether the automobility behavior of millennials and older adults differs depending on whether they live alone, with a partner or in an apartment, attitudes toward sustainable transportation modes, and residential location preferences. The chapter also explores whether these differences are similar for both generations or whether certain factors impact each generation to a different extent. This chapter is published in a peer-reviewed journal, '*Urban, Planning and Transport Research.*'

Chapter 5 develops a daily travelers' typology based on individuals' attitudes toward transportation and investigates which generation is more likely to fall under which traveler type. The study employed latent class analysis (LCA) to develop the travelers' typology and explore the likelihood of millennials and older adults belonging to each traveler type along with other sociodemographic characteristics, travel attributes, and living arrangements. Results suggest that

heterogeneous traveler types exist between millennials and older adults. Also, heterogeneous traveler types exist among individuals belonging to the same generation. This chapter is published in a peer-reviewed journal, '*Growth and Change*.'

Chapter 6 concludes this thesis with a short overview of its contents along with the specific contribution of the thesis. It also discusses the limitations and prospects of future research in terms of exploring the travel behavior of millennials and older adults.

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Chapter 2

Factors Associated with Travel Behavior of Millennials and Older Adults: A Scoping Review

2.1 Background

In recent years, a growing body of transportation studies have focused on exploring the travel behaviors of different generations, including baby boomers (born approximately between 1945 and 1964), generation X (born between 1965 and 1979), and millennials (born between 1980 and 2000). Each generation's travel behavior can be distinguished by certain features. Studies indicate, for example, that millennials or young adults are less likely to drive, are likely to travel shorter distances, delay obtaining their driver's licenses, and use more public transit and non-motorized modes of transportation (Thakuriah et al., 2010; McDonald 2015; Lavieri et al., 2017). The travel behavior of baby boomers or older adults, on the other hand, is characterized by greater automobile use and much more limited use of transit (Buehler and Nobis, 2010; Buys et al., 2012). Different reasons exist for these generational differences in travel behavior, such as the difference in trip purposes (i.e., commute, social trip), and perceptions of the physical and natural environment (i.e., safety, sustainability) among generations (Circella et al., 2016). Another possible reason is the historical-, cultural-, socio-economic-, and technology-related experiences of a particular generation that has shaped their mobility patterns (Circella et al., 2016).

The overall objective of this study is to provide an up-to-date review of the literature emphasizing the travel behavior of young adults/millennials and older adults. Existing reviews

mainly focused on different aspects of travel behavior of older adults. For example, Graham et al. (2018) reviewed literature on the travel behavior of rural older adults, Luiu et al. (2017) explored existing literature based on barriers and factors causing seniors' unmet mobility needs, and Haustein and Siren (2015) compared how different studies used various combinations of demographic, health, or transport-related attributes to segment older population into homogenous groups. Only one review was conducted on young adults, which synthesized evidence on their licensing decline and the influencing factors (Delbosc and Currie, 2013a).

The current study differs from these previous studies as it not only reviews the literature on young and older adults' travel behavior, but also provides a comparison of travel behaviors and associated factors between the two generations. In addition, this review explores the factors and determinants that contribute to shaping the travel characteristics of each generation. The scoping review framework proposed by Arksey and O'Malley (2005) and developed by Levac et al. (2010) was adopted to achieve this goal. A set of the existing literature are shortlisted based on selection criteria (discussed in the next section) and explored. The broader set of travel-behavior-related attributes explored in this study include mode choice, license-holding status, car ownership, other mobility tool ownership (i.e., bike, transit pass), trip frequency, trip distance, and use of alternative transport service, as well as shared mobility options (i.e., taxi, ridesharing, community transport).

Based on the overall objective, this study will answer two research questions. First, what factors are associated with the travel behavior of young adults/millennials and older adults and do they differ between the two generations? Second, what future research directions can be derived? That is, what are the research gaps and research agendas that need to be addressed?

2.2 Methods

Literature Search: As the focus of this paper is to synthesize recent progress in the literature, published literature in the English language from 2010 to 2018 are included in this review. Four databases were searched for relevant literature: Transport Research International Documentation (TRID), Web of Science, Ovid databases, and SPORTDiscus. The search was conducted between March–April 2019. A combination of different keywords was used to search within the databases. Keywords included: generational differences, travel behavior/behaviour, trip pattern, seniors, older adults, baby boomers, millennials, young adults, university students, mobility, mobility options, automobile, driving, driving license, driving cessation, mode choice, transit use, walking, biking, life course, life events, demographic variation, cohort analysis, geographic variation, urban/suburban/rural, residential location, accessibility, living arrangement, technology adoption, smartphone adoption, alternative transport solution, ridesharing, shared mobility, Uber/Lyft, lifestyle, sustainability, perceptions and attitudes.

Literature Inclusion/Exclusion Criteria: All searched literature were exported to the bibliographic software EndNote. Duplicates were removed. The screening process involved three stages: i) initial selection was made by screening the titles based on the identified keywords, ii) secondary screening of abstracts for keywords and texts, and iii) final selection was completed by reading the full studies. This review of the literature considered the following inclusion and exclusion criteria:

Included:

- English language studies.

- Travel-behavior-related studies that either considered generational differences or focused on a specific generation (baby boomers/seniors/older adults, millennials/young adults).
- Studies where the age of the sample population is 16 years or over.
- Studies that considered attributes of daily travel behavior—specifically, mode choice; trip distance; trip frequency; use of alternative transport; ridesharing; and mobility tool ownership: driver's license, car, bike, transit pass.
- The studies were conducted in developed countries.

Excluded:

- Studies that focused on the travel behavior of the overall population.
- Tourism-related studies, long-distance travel, maritime travel, air travel, and railway travel.
- Studies related to generation-specific travel-support smartphone application development and the use of automotive or electric vehicles.
- Accident-, injury-, and fatality-related researches.
- Studies that focused on health conditions, health-related attributes, and/or physical activity.

Stages of Search and Retrieval Process: Figure 2.1 shows the stages of the search and retrieval process for this study. The initial search with the different combinations of keywords in four databases resulted in 19,545 references. After removing duplicates (in many cases multiple versions of the same study), 1,585 studies were identified for title screening.

After screening the titles and abstracts based on the inclusion/exclusion criteria, a list of 120 studies were prepared for further review to explore their inclusion eligibility. Reference lists of the selected studies and relevant systematic and scoping reviews (e.g. Delbosc and Currie, 2013a; Haustein and Siren, 2015; Luiu et al., 2017; Graham et al., 2018) were checked and key journals (Appendix 2A) were hand searched. Other sources such as ProQuest and Google Scholar were also explored. Finally, a list of 78 studies was prepared according to the selection criteria stated above, including 66 journal articles, 9 reports and 3 conference papers.

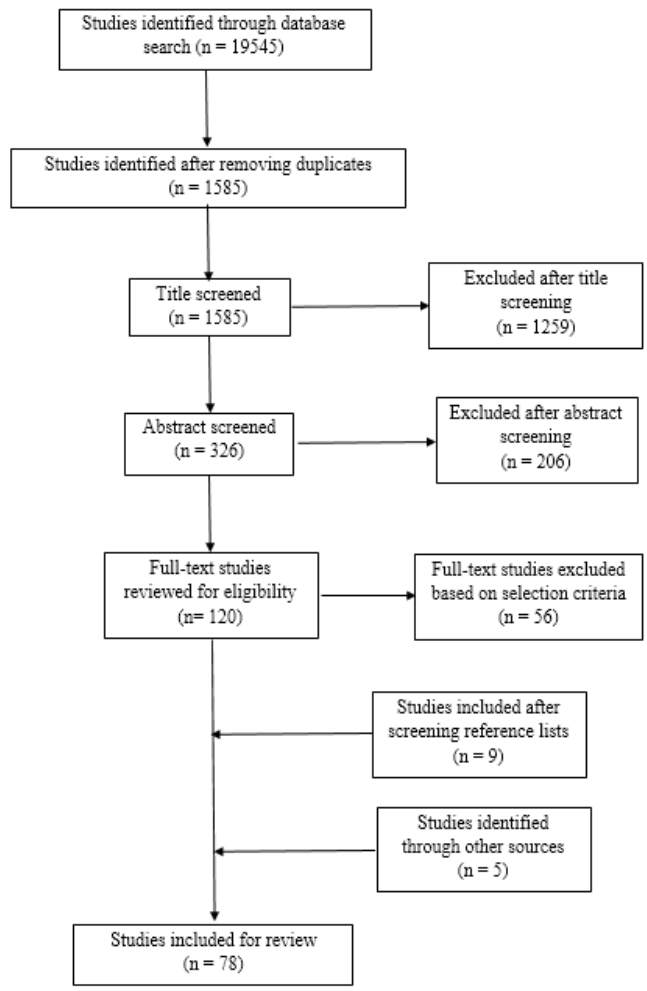

Figure 2.1: Stages of the Literature Search and Retrieval Process

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All selected literature were reviewed in detail to explore the distinct characteristics of the two generations and how different factors are associated with the travel behavior of each generation. A summary of the reviewed literature is provided in Table 2.1. The next section provides a brief description of the methodologies used in the reviewed literature. After that, an in-depth discussion of how key factors are associated with travel-related attributes in the reviewed studies is included. The final section provides key research agenda based on the selected studies.

Table 2.1: Summary of 78 Reviewed Studies

Reviewed Study	Document Type	Data Used	Method	Country of the Study	Age Group Considered	Focused Topic/Dependent Variable
Ahern and Hine (2012)	Journal paper	Qualitative	Focus group	UK	65 and over	Car use among older adults, Use of community transport service, type of trips/trip purpose
Alemi et al. (2018)	Journal paper	California Millennials Dataset 2015	Descriptive, binary logit model	US	Millennials: 18– 34; Generation X: 35–50	Adoption of on-demand ride services among millennials and generation X
Axhausen (2013)	Report	Quantitative, multiple data sources	Descriptive analysis	Germany and Britain	Born in 80s and 90s	Automobile ownership, licensing, mileage
Bailey et al. (2015)	Report	Quantitative, online survey, licensing data by VicRoads	Descriptive analysis	Australia	18–29	Reasons behind not holding a driving license
Bardazzi and Pazienza (2018)	Journal paper	Quantitative, Household Budget Survey 1997–2013, Panel data	Tobit model	Italy	Different cohorts	Lifecycle and generational effects on transport-related energy use, dependent variables— Choosing private transport, and level of fuel expenditure per adult

Reviewed Study	Document Type	Data Used	Method	Country of the Study	Age Group Considered	Focused Topic/Dependent Variable
Barnes et al. (2016)	Journal paper	Quantitative, CCHS (Canadian Community Health Survey) Healthy Aging Cycle (2008/2009)	Logistic regression	Canada	45 and over	Association between walk score, transit score, transit use, transport walking—whether associations differ across age groups and retirement status
Berg et al. (2014)	Journal paper	Qualitative (case studies) and travel diaries	Content analysis	Sweden	61–67	After transition to retirement, how mobility is influenced by individual, social, and geographical contexts
Berrington and Mikolai (2014)	Report	Quantitative, UK household study	Descriptive analysis, regression analysis	UK	17–34	Young adults' license holding, driving mileage
Blumenberg et al. (2012)	Report	Quantitative, National Household Travel Surveys	Descriptive, structural equiation model	US	15–26	Travel behavior of young adults—pseudo cohorts
Blumenberg et al. (2015)	Report	Quantitative, National Household Travel Surveys	Descriptive, factor analysis, cluster analysis	US	20–34	Millennials' travel behavior at different geographic settings
Blumenberg et al. (2016)	Journal paper	Quantitative, 1990 Nationwide Personal Travel Survey, 2001 and 2009 National Household Data	Descriptive, multi-variate model	US	Different age groups	Factors behind young adults' decline in travel
Böcker et al. (2017)	Journal paper	Quantitative, Travel diary of six days	Zero inflated negative binomial regression models, multinomial logit model	Netherland	65 and over	Seniors' and non-seniors' trip frequency and mode choice

Reviewed Study	Document Type	Data Used	Method	Country of the Study	Age Group Considered	Focused Topic/Dependent Variable
Boschman n and Brady (2013)	Journal paper	Quantitative, 2009 Travel Count Survey	Descriptive, logistic and OLS (Ordinary **least squares**) regression	US	60 and over	Seniors' travel behavior-trips, mode choice, distance, purpose
Brown et al. (2016)	Journal paper	Quantitative, 2001 and 2009 NHTS—cross-sectional dataset	Descriptive, regression analysis	US	Different birth cohorts	Transit use among youth
Buehler and Nobis, 2010	Conference paper	Quantitative, national travel surveys 1982/83 and 2001/02—cohort analysis	Descriptive, logistics regression	US and Germany	65 and over	Car use among elderly
Busch-Geertsem a and Lanzendo rf (2017)	Journal paper	Quantitative, online three-wave panel study	Descritive, binary logit	Germany	University students	Mode choice behavior of millennials
Buys et al. (2012)	Journal paper	Qualitative and quantitative	Thematic approach	Australia	55 and over	Transit and car dependency of older adults
Circella et al. (2017)	Conference paper	Quantitative, California Millennials Dataset	Descriptive	US	18–34	Millennials' travel behavior
Corran et al. (2018)	Journal paper	Quantitative, cross-sectional survey	Logistic regression	UK	Different age groups	Factors influencing elderly people's non-travel
Davis et al. (2012)	Report	Quantitative, National Household Travel Survey 2001 and 2009	Descriptive analysis	USA	16–34	Decline in driving among young adults

Reviewed Study	Document Type	Data Used	Method	Country of the Study	Age Group Considered	Focused Topic/Dependent Variable
De Paepe et al. (2018)	Journal paper	Quantitative, cross-sectional survey	Hierarchical logistic regression	Belgium	University students	Mode choice for particular activities
Delbosc and Currie (2013b)	Journal paper	Quantitative, travel survey data 1994, 1999, 2007, and 2009	Descriptive analysis, binary logistic regression	Australia	18–30	License holding of young adults
Delbosc and Currie (2014)	Journal paper	Qualitative	Online focus group	Australia	17–23	Attitudes toward cars and licensing
Delbosc and Nakanishi (2017)	Journal paper	Qualitative	Semi-structured interview	Australia	18–30	Interaction between life course and mobility preference, and attitudes toward cars of millennials
Fatmi and Habib (2016)	Journal paper	Quantitative, 2006 Transportation Tomorrow Survey	Latent segmentation-based logit model	Canada	65 and over	Ownership of multiple mobility tools—segments based on frequent trip makers and non-trip makers
Fatmi et al. (2014)	Journal paper	Quantitative, 2006 Transportation Tomorrow Survey	Latent class logit model	Canada	17–19	Mobility tool ownership among youths
Figueroa et al. (2014)	Journal paper	Quantitative, Danish National Travel Survey 2006-2011	Probit model, ordinary least square model	Denmark	Different age groups	How built environment is correlated with the travel patterns of different generations
Fordham et al. (2017)	Journal paper	Quantitative, O-D survey 1998, 2003, 2008, 2013	Pseudocohort analysis	Canada	50 and over	Public transit use among seniors
Giesel and Kohler (2015)	Journal paper	Quantitative, Mobility in Germany 2008 survey	Logistic regression, descriptive analysis	Germany	65 and over	Elderly people's daily travel, factors influencing daily short-distance travel (traveling locally)

Reviewed Study	Document Type	Data Used	Method	Country of the Study	Age Group Considered	Focused Topic/Dependent Variable
Habib (2015)	Journal paper	Quantitative, NCR's 2011 Household Travel Survey	Utility theoretic joint model	Canada	65 and over	Mode choice and travel distance of older people
Habib (2018)	Journal paper	Quantitative, travel survey of four universities in GTA	Hazard-based duration model	Canada	University students	Age of acquiring driving license, choice of not acquiring a driving license
Habib et al. (2018)	Journal paper	Quantitative, 2015 travel survey of four universities in GTA	Cross-nested logit model	Canada	University students	Choice of owning basic mobility tools (driver's license, car, transit pass, bike) or combination of basic tools
Hanson and Hildebrand (2011)	Journal paper	Quantitative, cross-sectional	Descriptive analysis	Canada	54–92	Can rural drivers meet their travel needs without a car?
Haustein (2011)	Journal paper	Quantitative, cross-sectional survey	Linear and ordinal regression analysis, cluster analysis	Germany	60 and over	Older adults' mobility by different segments
Haustein and Siren (2014)	Journal paper	Quantitative, telephone survey of 863 individuals	Descriptive analysis, ordinal regression	Denmark	Born in 1939/40	Amount of unmet mobility needs—used different segments of drivers.
Hess (2011)	Journal paper	Quantitative	Descriptive analysis	US	60 and over	How perception of distance to bus stops influence walking to bus stops among older adults
Hjorthol (2012)	Journal paper	Quantitative, Norwegian nationwide survey of activities and daily mobilities, 2010	Descriptive, logistic regression	Norway	67 and over	Older adults' mobility needs
Hjorthol (2016)	Journal paper	Quantitative, Norwegian National	Logistic regression,	Norway	18–25	Holding a driving license, access to a car

Reviewed Study	Document Type	Data Used	Method	Country of the Study	Age Group Considered	Focused Topic/Dependent Variable
		Travel Survey data from 1985 to 2009, cross-sectional	cohort analysis			
Hjorthol et al. (2010)	Journal paper	Quantitative, National Travel Survey from 1984 to 2006, cross-sectional	Cohort analysis	Norway, Sweden, Denmark	40–84	Holding a driving license, access to a car
Jones et al. (2018)	Journal paper	Quantitative, cross-sectional data, longitudinal research on aging drivers cohort study	Logistic regression	US	65–79	Driving distance by different modes, number of alternate transport sources rather than self-driving among older drivers
Klein and Smart (2017)	Journal paper	Quantitative, panel study, panel study of income dynamics	Poission panel regression: random effect model, fixed effects model	US	Born in 80s and 90s	Car ownership, car access
Kroesen and Handy (2015)	Journal paper	Quantitative, cross-sectional, LISS (Longitudinal Internet studies for the Social Sciences) panel data—used 2013 data	Linear regression	Denmark	30 or younger, and above 30	Attitudes toward car, attitudes toward public transport
Kuhnimh of et al. (2011)	Journal paper	Quantitative, National Travel Survey from 1970 to 2013, cross-sectional	Descriptive analysis	Germany and Britain	Young population of different birth cohorts	Car ownership, distance, multimodality

Reviewed Study	Document Type	Data Used	Method	Country of the Study	Age Group Considered	Focused Topic/Dependent Variable
Kuhnimh of et al. (2012b)	Journal paper	Quantitative, German Mobility Panel, German Income and Expenditure Survey for 1998 and 2008, time series data	Logistic regression, descriptive analysis	Germany	18–34	Car ownership, driving distance
Kuhnimh of et al. (2012c)	Journal paper	Quantitative, National Travel Survey	Descriptive analysis	Germany, France, Britain, Japan, Norway, US	17–29 of different decades	Driver's license, car ownership, distance
Kuhnimh of et al. (2012a)	Journal paper	Quantitative, National Travel Survey, 2002 and 2008	Descriptive analysis, multilevel regression	Germany	18–29	Driver's license, car ownership, distance
Lavieri et al. (2017)	Journal paper	Quantitative, 2014 Mobility Attitudes Survey, cross-sectional	Structural equation model	US	18–33	Mode of transport, driver's license holding, vehicle ownership
Le Vine and Polak (2014)	Journal paper	Quantitative, 2010 British national travel Surveys	Logistic regression	UK	17–29	License holding
Leistner and Steiner (2017)	Journal paper	Quantitative, cross-sectional data	Descriptive	US	60 and over	Older adults' dynamic ridesharing—ridesharing has the potential to increase mobility and accessibility
Licaj et al. (2012)	Journal Paper	Quantitative, 2005 -2006 Household Travel Survey	Logistics regression	France	16–24	Relationship between driving and socio-economic and geographical factors

Reviewed Study	Document Type	Data Used	Method	Country of the Study	Age Group Considered	Focused Topic/Dependent Variable
Mattson (2012)	Report	Quantitative, National Travel Survey of 2001 and 2010	Binary logit model, negative binomial logit model, cluster analysis	US	65 and over	Frequency of driving and number of trips
McDonald (2015)	Journal paper	Quantitative, NTS of multiple years	Regression analysis, descriptive analysis	US	19–42	Daily automobile mileage
Melia et al. (2018)	Journal paper	Quantitative, NTS 2001 and 2011	Regression analysis—fractional logit model	UK	16–34	Driving frequency, public transport use frequency
Mifsud et al. (2017)	Journal paper	Quantitative, cross-sectional survey	Descriptive, regression analysis	Malta	60 and over	Status of driving, public transport use
Mollenkopf et al. (2011)	Journal paper	Mixed method—quantitative and qualitative, longitudinal study—1995, 2000, 2005	Descriptive analysis, semi-structured interview, content analysis	Germany	55 or over	Older adults' perceptions of out-of-home mobility
Moniruzzaman et al. (2013)	Journal paper	Quantitative, Montreal's Household Travel Survey 2008	Joint discrete-continuous model, hazard based model	Canada	55 and over	Mode choice—walking, transit; trip length—car, walking, transit
Muromachi (2017)	Journal paper	Quantitative, cross-sectional survey	Ordered probit model, descriptive analysis	Japan	18–26, university students	Intention to purchase a car in future,
Nash and Mitra (2018)	Conference paper	Quantitative, cross-sectional, segmentation	Latent class logit model	Canada	University students	University students' travel behavior including attitudes, and lifestyle

Reviewed Study	Document Type	Data Used	Method	Country of the Study	Age Group Considered	Focused Topic/Dependent Variable
Newbold and Scott (2017)	Journal paper	Quantitative, General Social Survey 1998, 2005, 2010	Descriptive analysis	Canada	Different cohorts	Licensure rate, mode choice
Newbold and Scott (2018)	Journal paper	Quantitative, General Social Survey 1998, 2005, 2010	Descriptive analysis, logistic regression	Canada	Different cohorts	Mode choice, determinants of transit use
Rahman et al. (2016)	Journal paper	Quantitative, cross-sectional, nationwide survey	Descriptive analysis, ordered logit model	US	65 or over	Older adults' alternative transportation preferences
Sakaria and Stehfest (2013)	Report	Qualitative (telephone survey) and quantitative (online survey)	Descriptive	US	18–34	Millennials' lifestyle, attitudes and decision-making process related to daily travel
Schoettle and Sivak (2014)	Journal paper	Quantitative, cross-sectional survey	Descriptive analysis	US	18–39	Drivers' licensing
Simons et al. (2014)	Journal paper	Qualitative	Focus group study, content analysis	Belgium	18–25	Factors affecting transport mode for short distance travel- focus is given on cycling
Simons et al. (2017)	Journal paper	Quantitative, cross-sectional survey	Zero inflated negative binomial regression models	Belgium	18–25	Mode choice by different groups of young adults
Siren and Haustein (2013)	Journal paper	Quantitative, cross-sectional survey	Cluster analysis, descriptive analysis	Denmark	Born in 1946 and 1947	Travel habits, expectations and preferences
Siren and Haustein (2015)	Journal paper	Quantitative, longitudinal survey. 2009 and follow-	Descriptive analysis	Denmark	Born in 1946 and 1947	How retirement affects baby boomers' travel—distinguished by 'still working', 'early retirees', 'recent retirees'

Reviewed Study	Document Type	Data Used	Method	Country of the Study	Age Group Considered	Focused Topic/Dependent Variable
		up survey in 2012				
Sivak and Schoettle (2011)	Journal paper	Quantitative, Federal Highway Administration on driver's licenses, 1983 -2008	Descriptive analysis	US	Different age groups	Driving license holding by age
Truong and Somenahalli (2011)	Journal paper	Qualitative and quantitative, cross-sectional travel survey 2010	Descriptive analysis	Australia	65 and over	Daily trips, distance travelled, trip chain complexity
Truong and Somenahalli (2015)	Journal paper	Quantitative, cross-sectional survey 2010	Multinomial logistic regression	Australia	65 and over	Factors influencing frequency of using transit
Tuokko et al. (2014)	Journal paper	Quantitative, cross-sectional data, Canadian Driving Research Initiative for Vehicular Safety in Elder (Candrive II)	Descriptive analysis	Canada	70 and over	Attitudes relevant to driving restriction
Turner et al. (2017)	Journal paper	Quantitative, cross-sectional, nationwide survey 2013	Multivariate analysis	US	60 and over	Perceived alternative transport needs by older adults—driving groups vs. non-driving groups
Vale et al. (2018)	Journal paper	Quantitative, cross-sectional survey 2015	Descriptive analysis, spatial analysis	Portugal	University students	Commute mode
Van Cauwenbe	Journal paper	Quantitative, cross-sectional	Multilevel logistic regression	Belgium	60 or over	How physical environmental factors influence older adults'

Reviewed Study	Document Type	Data Used	Method	Country of the Study	Age Group Considered	Focused Topic/Dependent Variable
rg et al. (2013)						walking—amount of daily walking
Vivoda et al. (2018)	Journal paper	Quantitative	Regression analysis	US	65 and over	E-hail/ridesharing knowledge, use and level of reliance of older adults
Ward et al. (2013)	Journal paper	Qualitative	Focus group	UK	65 and over	Older adults' car use
Yang et al. (2018)	Journal paper	Quantitative, 2009 National Travel Survey	Linear regression, Logistic regression	US	65 and over	Active travel trips, public transportation trips, travel purpose, distance travelled
Zmud et al. (2017)	Report	Quantitative, multiple data sources	Descriptive analysis	Germany, US, UK, China, Japan	65 and over	Older adults' mobility patterns

2.3 Types of Reviewed Literature

Of the 78 studies selected for review, 35 were conducted in North America (22 in the US and 13 in Canada), 29 in Europe, 7 in Australia, 1 in Asia and 6 of them considered multiple countries as their study area. Thirty-four of them focused on young adults/millennials, 35 included an older adult population, and 9 investigated both younger and older age groups. Six studies applied qualitative research methodology. Four of them employed focus group discussions to explore the mobility patterns of rural older adults (Ahern and Hine, 2012), their use of alternative transport modes (Ward et al., 2013), the mode choice of young adults for short-distance travel (Simons et al., 2014), and their attitudes towards cars and licensing (Delbosc and Currie, 2014). Berg et al. (2014) followed a case study approach to explore how different individual, social, and geographical contexts impact older adults' travel behavior after retirement. By conducting in-depth semi-structured interviews of 55 individuals, Delbosc and

Nakanishi (2017) addressed the interaction between life course and millennials' travel preferences, and their attitudes toward the car.

Four studies utilized mixed methods (Mollenkopf et al., 2011; Truong and Somenahalli, 2011; Buys et al., 2012; Sakaria and Stehfest, 2013). The remaining studies (68 in total) applied quantitative techniques to explore the factors associated with travel behavior, with 50 using aggregate national or regional-level datasets. Only two studies used panel data (Busch-Geertsema & Lanzendorf, 2017; Klein and Smart, 2017), and the rest are cross-sectional, although four studies created 'pseudo panels' using cross-sectional national-level datasets (Blumenberg et al., 2012; Fordham et al., 2017; Newbold and Scott, 2017; 2018).

Among the quantitative studies, authors mostly used a combination of descriptive analysis, and/or regression analysis (mostly linear or ordinal) and/or multinomial models to describe the influencing factors of travel behavior. These studies usually explored the direct relationship between the different aspects of travel behavior and their determinants. Two studies applied structural equation modeling techniques to explore how a wide range of socio-economic (Blumenberg et al., 2012), lifestyle, and attitudinal attributes (Lavieri et al., 2017) impact different aspects of travel behavior and how both influencing factors and outcome variables are inter-related with each other. Two other studies used hazard-based formulas to explore the associated factors of mode choice and the trip lengths of seniors (Moniruzzaman et al. 2013), and mode choice and time taken to acquire a driver's license for young adults (Habib, 2018).

To take into account intra-generational heterogeneity, seven quantitative studies utilized techniques such as latent class analysis (Fatmi et al., 2014; Fatmi and Habib, 2016; Nash and Mitra, 2018) and cluster analysis (Haustein, 2011; Mattson, 2012; Siren & Haustein, 2013; Blumenberg et al., 2015) to group individuals based on different characteristics to derive their

travel patterns and associated factors. Studies using latent class analysis divided the generations into different segments based on sociodemographics (Fatmi et al., 2014) and travel characteristics (Fatmi and Habib, 2016; Nash and Mitra, 2018). Among the studies that followed the cluster analysis approach, Haustein (2012) considered multiple sets of factors such as infrastructure, socio-demographic, and attitudinal statements to groups of elderly populations to analyze their travel behavior. Three other studies defined segments of the generations based on socio-demographic characteristics (Mattson 2012), travel characteristics (Siren and Haustein, 2013), and neighborhood type and transportation system (Blumenberg et al., 2015).

The next section provides an overview of the trends in travel behavior by older and younger adults. Due to variations in age groups considered in the selected studies, no distinct age limit can be assigned to each generation. Moreover, due to the difference in survey years, the age groups may vary within the generations. In this review, the population aged 16–34 years are considered as young adults/millennials, and those aged 50 years or over are considered as older adults. The following section will discuss how different factors influence the distinct travel characteristics of these two generations. For quantitative studies, only factors that are found or mentioned as significant by the authors are included in this review. Associated factors are categorized into five different themes:

Personal attributes, which include socio-demographic characteristics such as age, gender, income, employment, studentship, etc.

Geography and built environment, including residential location such as rural, suburban, or urban; neighborhood features such as density, proximity to facilities, surrounding transport options, etc.

Living arrangement and family life, including the type of dwelling (i.e. apartment, detached house, etc.), living alone/partnered/married/with family, the presence of a child, family members living nearby, etc.

Technology adoption, including dependence on technology, mobile phone possession, the frequency of web/social media/smartphone use, etc.

Attitudes and perceptions, including individuals' lifestyle choices, attitudes, and perceptions towards different travel options and the environment.

2.4 Travel Trends among the Two Generations

Older Adults: In general, older adults tend to travel less frequently, make more short-distance trips, and walk more frequently (Buehler and Nobis, 2010; Böcker et al. 2016; Boschmann and Brady, 2013; Mifsud et al. 2017) compared to other generations. However, when facilities such as shopping and social activities are not nearby, they may need to travel longer distances. One study concluded that older adults living far from the Central Business District (CBD) travel longer distances for performing shopping and maintenance activities, as most of the activity places are concentrated within the CBD (Habib 2015). Buehler and Nobis (2010) compared the travel behavior between German and US elderly populations and found that elderly Germans tend to walk, bike, and ride transit more frequently compared to the US elderly. Regarding the use of alternatives to the car, one study suggested that older seniors are resistant towards adopting alternative forms of transportation, although increasing use of alternative forms is noticed among younger seniors (Fordham et al. 2017). Unfamiliarity with the service, not being habituated in using the service, lack of knowledge on the required technology (e.g.

smartphone applications) could be the reasons behind their lack of interest in using other modes of transport except the car (Rahman et al., 2016; Fordham et al. 2017).

Two studies found increased use of transit among some groups of older adults (Truong and Somenahalli, 2011; Mattson, 2012). The reasons identified by the authors are not having access to a car, being unable to drive due to health conditions, free travel incentives for seniors, and improvements in transit services in the study area. Conversely, there is also evidence that the probability of using transit decreases with age for older adults (Moniruzzaman et al. 2013; Truong and Somenahalli, 2015). Moreover, car ownership discourages transit ridership. Overall, transit use is low among older adults (Berg et al. 2014; Fordham et al. 2017; Moniruzzaman et al. 2013; Mifsud et al. 2017), especially among those with a car (Buys et al. 2012). Mode choice also depends on trip purpose. For example, for social activity participation, older adults use transit more frequently (Mifsud et al. 2017) and bike or walk less frequently (Habib, 2015). On the other hand, less frequent use of transit is noticed for shopping and maintenance activities (Habib, 2015).

Studies suggested that the frequency of using a car (Buehler and Nobis, 2010; Truong and Somenahalli, 2011; Mattson, 2012; Böcker et al. 2016; Boschmann and Brady, 2013; Mifsud, 2017) and holding a driver's license (Hjorthol, 2012) declines with increasing age, illustrated by a declining number of trips with increasing age. Nevertheless, the car is the prominent mode among older adults (Bardazzi, and Pazienza, 2018) and holding a driver's license is very important in order to fulfill their driving needs (Haustein and Siren, 2014). Studies mentioned several reasons behind the decrease in mobility as well as car trips such as aging (Buehler and Nobis, 2010; Fordham et al. 2017; Boschmann and Brady, 2013; Corran et al., 2018), illness or physical impairment (Buys et al. 2012; Ahern and Hine, 2012; Mollenkopf et al., 2011; Corran et

al. 2018), taking care of a family member (Mollenkopf et al., 2011), retirement (Corran et al., 2018), and decline in affordability (Buys et al. 2012; Mollenkopf, 2011). Widowhood may also shift away the mode of travel of older females from car-driver to other modes (Ahern and Hine, 2012). Still, older adults (baby boomers) are the greater users of automobiles compared to other generations, and have good access to cars, and they expect to continue this habit as they age (Siren and Haustein, 2013).

Young Adults/Millennials: The travel patterns and transportation preferences are somewhat different among younger adults. Studies indicate that they are more likely to walk, bike, and use transit (Newbold and Scott, 2017, 2018; Vale et al. 2018; Kuhnimhof et al., 2011; Kuhnimhof et al., 2012a; Davis et al., 2012). Also, millennials/young adults are more multimodal compared to other generations (Delbosc and Nakanishi, 2017; Sakaria and Stehfest, 2019; Kuhnimhof et al., 2011; Kuhnimhof et al., 2012; Bailey et al. 2015; Circella et al. 2017; Habib et al. 2018; Kuhnimhof et al. 2012b), own multiple mobility tools (Fatmi et al. 2014; Habib et al. 2018), and are open to use any mode that is most suitable for their needs (Delbosc and Nakanishi, 2017). They also tend to make fewer trips (Blumenberg et al. 2012), own or use a car less (McDonald 2015; Klein and Smart, 2017; Newbold and Scott, 2017; Kuhnimhof et al. 2011), and are less likely to hold a valid driver's license or are more likely to delay obtaining a driver's license (Davis et al. 2012; Bailey et al. 2015; Berrington and Mikolai, 2014; Sivak and Schoettle, 2011). However, their likelihoods of obtaining a driver's license (Newbold and Scott, 2017 and Berrington and Mikolai, 2014), using the car (Lavieri et al. 2017; Newbold and Scott, 2018; Berrington and Mikolai, 2014; Simons et al. 2017), being multimodal (Habib et al. 2018), and owning multiple mobility tools (Habib et al. 2018) increases with age, while share of transit use (Brown et al., 2016; Newbold and Scott, 2017) decreases with age. These patterns may be a

result of an increase in income, employment, and changes in family patterns/living arrangements, residential relocation, etc. Compared to older adults, millennials are more technology-oriented and more likely to adopt ridesharing options (Sakaria and Stehfest, 2013; Circella et al., 2017; Alemi et al. 2018).

2.5 Factors Associated with the Travel Behavior of the Two Generations

2.5.1 Personal Attributes

Table 2.2 shows the most common personal-level attributes that are associated with different aspects of travel behavior in each generation. Associated factors are almost the same for each generation, with exceptions being age and studentship status. Based on the literature, increasing age is an important determinant of changes in travel behavior of older adults, whereas other personal attributes such as income, employment, and studentship status are mostly associated with the travel behavior of younger adults. However, the level and direction of the associations are different to some extent between generations. For example, studies showed that the license-holding status of young adults is associated with gender, income, ethnicity, employment, and education status whereas, for older adults, it is mostly age and gender.

Table 2.2: Association between Travel Behavior and Different Factors

		Personal Attributes							Geography and Built Environment								Living Arrangements, Technology Adoption, and Attitudes								
Travel related Attributes		Age	Gender	Income	Ethnicity	Employment Status	Education Level	Studentship Status	Density (Population, dwelling)	Road Connectivity, accessibility, intersection density	Land-use mix	Walk Score, Transit Score	Location (Rural/Urban)	Proximity to CBD, Transit facilities	Living in condo, apartment	Living status (Alone, married/partnered)	Living near friends and family	Living with parents	Presence of a child in the household	Mobile phone possession/familiarity with the technology	Higher internet or social media use	Previous experience and perceptions	Attitudes towards travel modes
Older Adults	Mode Choice	x	x	x	x	x	x		x		x	x		x	x	x	x			x		x	x
	License-Holding Status	x	x													x							
	Trip Frequency	x	x	x	x	x	x					x		x		x	x			x			
	Trip Distance	x	x			x			x		x	x	x	x		x				x			
	Alternative Transport Services (taxi, ridesharing)		x	x	x		x									x				x		x	x

	Car Ownership	x												x	x											
	Other Mobility Tool Ownership (Bike, Transit Pass)	x			x			x						x	x	x	x									x
Young Adults	Mode Choice	x	x	x	x	x	x	x	x	x	x	x	x		x		x	x		x	x	x				
	License-Holding Status	x	x	x	x	x	x	x			x	x	x		x		x	x		x						
	Trip Frequency				x							x								x						
	Trip Distance				x							x			x			x								
	Alternative Transport Services (taxi, ridesharing)			x					x	x		x								x						x
	Car Ownership		x		x			x	x			x	x		x			x								
	Other Mobility Tool Ownership (Bike, Transit Pass)	x					x						x		x		x	x								x

Older Adults: Gender is the most common determinant that is used to describe different generations' travel behavior. Studies mentioned that there is a gender gap in travel behavior, especially among older generations, with older women less likely to drive or being less dependent on cars both as drivers and passengers compared to men (Buehler and Nobis, 2010; Levac et al. 2010; Truong and Somenahalli, 2011; Fatmi and Habib, 2016; Siren and Haustein, 2013; Böcker et al. 2017; Mifsud et al. 2017; Habib, 2015). One of the reasons could be that women travel less compared to men in general. Older women are also more likely to use car alternatives such as walking, cycling, and using transit (Truong and Somenahalli, 2011; Fordham et al. 2017; Siren and Haustein, 2013; Böcker et al. 2017; Habib, 2015; Truong and Somenahalli, 2015). One study showed an opposite finding, reporting higher rates of walking, cycling, and transit use among males compared to females (Boschmann and Brady, 2013). The study further explained that older men make a higher number of trips than women. As a result, their number of walking, cycling, and transit use, as well as car use, is higher compared to women. Men also show a higher probability of owning multiple mobility tools (Fatmi and Habib, 2016) and higher vehicle kilometers traveled (Boschmann and Brady, 2013; Hanson and Hildebrand, 2011; Zmud et al. 2017) compared to women.

Older adults usually make shorter trips and their overall trip length declines with age (Truong and Somenahalli, 2011; Mattson, 2012; Boschmann and Brady, 2013; Sivak and Schoettle, 2011; Giesel and Kohler 2015; Jones et al. 2018; Yang et al. 2018). As revealed by Moniruzzaman et al. (2013) and Yang et al. (2018), the likelihood of walking and walking trip length also declines with increasing age. The rate of decrease in license holding and access to a car with increasing age is higher for women (Hjorthol 2012; Hjorthol et al. 2010). Compared to men, older women are also found to make fewer trips and more short-distance trips as they age

(Moniruzzaman et al. 2013; Mattson, 2012; Corran et al. 2018; Giesel and Kohler, 2015; Hjorthol et al. 2010). The rate of using or having knowledge of shared mobility options, such as ridesharing services (i.e., Uber/Lyft) is very low among older adults, and use decreases with increasing age (Leistner and Steiner 2017; Vivoda et al. 2018). Though men are more likely to use these services compared to women (Jones et al. 2018; Vivoda et al. 2018), as suggested by Ahern and Hine (2012), the lower car dependency amongst women may also encourage them to use alternative transport services such as taxis, ridesharing, and community bus services.

Travel behavior also differs by ethnicity, with the reviewed studies showing that minorities are less likely to use the car and more likely to walk and bike. One study in the Netherlands suggested that in general, non-western older adults make fewer trips, travel less by car, and bike more as compared with native Dutch people (Böcker et al. 2017). In the UK, non-British nationals travel less compared with British nationals (Corran et al. 2018). Black older adults are found to travel more, and Asians are found to use transit more than other ethnic groups (Yang et al. 2018). The rate of using alternative modes such as taxis and ridesharing services is higher among whites (Jones et al. 2018; Vivoda et al. 2018), whereas racial and ethnic minority groups show a higher level of perceived need for alternative transport services (Turner et al. 2017).

Income is a strong predictor of defining travel behavior, with increasing income or rise in affordability increasing trip frequency (Truong and Somenahalli, 2011), automobility (Buehler and Nobis, 2010; Jones et al. 2018) and multimodality (Jones et al. 2018) among older adults. Also, higher income tends to decrease transit use (Truong and Somenahalli, 2011; Moniruzzaman et al. 2013; Habib, 2015) and the number of short distance trips (Giesel and Kohler, 2015). High-income older adults are less likely to realize the need for alternative transport (Turner et al. 2017) as most of them have convenient transport options available to

them. High income is also associated with older adults' possession of a higher knowledge of online ridesharing services (Vivoda et al. 2018). Similarly, employment status is associated with older adults' travel behavior. Being employed or economically active positively influences multimodality (Jones et al. 2018), automobility (Buehler and Nobis, 2010; Moniruzzaman et al. 2013; Mifsud et al. 2017), multiple mobility tool ownership (Fatmi and Habib, 2016), transit use (Moniruzzaman et al. 2013; Mifsud et al. 2017), number of trips (Moniruzzaman et al. 2013; Yang et al. 2018), trip distance (Moniruzzaman et al. 2013; Zmud et al. 2017) and lower amounts of walking or biking (Berg et al. 2014) of older generations. Similarly, Siren and Haustein (2016) found that retirement causes a decline in car use frequency and total mileage, with a greater impact for men compared to women, most likely due to fewer commute trips after retirement. Higher levels of education are associated with a decreased number of short distance trips (Giesel and Kohler, 2015) , increased use of transit (Truong and Somenahalli, 2015), and the increased probability of possessing knowledge on online ridesharing (Vivoda et al. 2018).

Studies also indicated associations among different aspects of travel behavior. For example, car ownership and holding a driver's license influences older adults' use of the car (Buehler and Nobis, 2010; Buys et al. 2012; Truong and Somenahalli, 2011; Böcker et al. 2017; Mifsud et al. 2017; Corran et al. 2018; Zmud et al. 2017). Also, higher trip frequency is associated with a higher probability of owning a car and holding a driver's license (Fatmi and Habib, 2016). On the other hand, transit-pass ownership positively affects the use of all other modes except the car (Böcker et al. 2017). Transit-pass ownership is also positively associated with less trip making (Fatmi and Habib, 2016). Having no car and no license decreases the tendency to travel more for discretionary purposes (Hjorthol, 2012). Bike and transit-pass

ownership negatively impact the number of short-distance trips (Giesel and Kohler, 2015), which can be mainly covered by walking.

Young Adults/Millennials: In the case of millennials, the gender gap in travel behavior is disappearing, indicating that the extent of variation in different of aspects of travel behavior between males and females is low compared to the older generation (Kuhnimhof et al. 2011; Kuhnimhof et al. 2012a). Compared to males, young females delay obtaining a driver's license (Habib, 2018; Habib et al. 2018; Hjorthol, 2016), own/use automobiles less (Kuhnimhof et al. 2011; Kuhnimhof et al. 2012b; Hjorthol, 2016; Axhausen, 2013; Muromachi, 2017), are less multimodal (Habib et al. 2018; Kuhnimhof et al. 2012b), and are more likely to use transit (Newbold and Scott, 2018; Habib et al. 2018). Another study found that males are less likely to be drivers and more likely to use active modes and transit (Nash and Mitra, 2018).

According to Simons et al. (2014), mode choice amongst young adults is largely dependent on vehicle ownership, travel purpose, financial cost associated with the mode, flexibility of the mode, comfort, travel time, and income. Income, employment, and education are important factors in shaping young adults' travel behavior (Axhausen, 2013). It is found that higher socio-economic status (SES) among young adults increases driving (Simons et al. 2017). Higher income also positively influences holding a valid driver's license (Delbosc and Currie, 2013a; 2013b; Habib, 2018; Berrington and Mikolai, 2014; Le Vine and Polak, 2014), driving (Licaj et al. 2012), number of car trips (Blumenberg et al. 2012), car travel/commute (Lavieri et al. 2017; Blumenberg et al. 2012; Vale et al. 2018), and car ownership/greater car access (Klein and Smart, 2017; Kuhnimhof et al. 2012b). Conversely, high income (greater than $20,000) negatively influences transit use (Newbold and Scott, 2018). Also, car ownership is found to be

low among the young adults who are financially dependent on their parents (Klein and Smart, 2017).

Life course may also impact driving behavior, with several studies suggesting that the travel behavior of millennials will change as they go through different transitions in life such as family formation and job change. For example, change in employment status influence the distance travelled by young adults (Blumenberg et al. 2016). With the transition from school to employment, an increasing number of trips by car are completed, while fewer trips are made by transit (Busch-Geertsema and Lanzendorf, 2017). Furthermore, among young adults, employed young adults are more likely to drive (McDonald, 2015; Blumenberg et al. 2012), hold a driver's license (Berrington and Mikolai, 2014; Hjorthol, 2016; Delbosc and Currie, 2013b, Le Vine and Polak, 2014; Schoettle and Sivak, 2014), have car access/ownership (Klein and Smart, 2017; Kuhnimhof et al. 2012b), make a greater number of car trips (Blumenberg et al. 2012), and have higher car travel distance (Kuhnimhof et al. 2012c). Higher education positively influences driver's license possession (Berrington and Mikolai, 2014; Hjorthol, 2016; Delbosc and Currie, 2013b; Le Vine and Polak, 2014; Schoettle and Sivak, 2014) and driving (McDonald, 2015; De Paepe et al. 2018). Studentship status shows a positive association with transit use (Newbold and Scott, 2018; Brown et al. 2016). For example, full-time students are less likely to hold a driver's license (Berrington and Mikolai, 2014; Delbosc and Currie, 2013b). In the Greater Toronto Area (GTA), graduate students further delay in obtaining licensure compared to undergraduates (Habib, 2018). Another study by Nash and Mitra (2018) found that almost two-thirds of the post-secondary students in the GTA are dependent on sustainable transport options (i.e., walking, cycling, and transit) for their day-to-day travel.

In terms of young adults' ethnicity, non-whites and immigrants are more likely to use transit (Brown et al. 2016). A similar result is found by Le Vine and Polak (2014) where migrants are seen as less likely to possess a driver's license. Alemi et al. (2018) reported that young adults of non-Hispanic origins are more likely to adopt ridesharing services.

As expected, holding a driver's license or owning a car facilitates car use among young adults (Nash and Mitra, 2018; Vale et al. 2018; De Paepe et al. 2018). The number of cars in the household (Habib, 2018; Hjorthol, 2016) and bike ownership (Habib, 2018) are positively associated with driver's license possession of young adults, indicating multimodality among young adults. Car ownership also decreases the chance of transit-pass ownership (Alemi et al. 2018). On the other hand, bike ownership facilitates biking and multimodality (Nash and Mitra, 2018).

2.5.2 Geography and the Built Environment

How geography and built environment attributes are associated with each generations' travel behavior are shown in Table 2.2. For older adults, factors are mostly associated with their mode choice and trip distance, whereas for young adults, factors are associated with their license-holding status, car ownership, and mode choice.

Older Adults: Neighborhood and built environment characteristics significantly impact older adults' travel behavior. It is found that compact designs or urban forms such as high dwelling density (Moniruzzaman et al. 2013; Fatmi and Habib, 2016; Böcker et al. 2017), high population density (Buehler and Nobis, 2010; Truong and Somenahalli, 2011; Moniruzzaman et al. 2013; Hess, 2011), high employment density (Moniruzzaman et al. 2013), high street density or connectivity (Moniruzzaman et al. 2013; Yang et al. 2018; Hess, 2011), and mixed land use

(Moniruzzaman et al. 2013; Böcker et al. 2017) stimulate transit-pass ownership, transit use, and walking, as well as short distance trips amongst the older adults. Despite this, older adults are highly car-dependent and Figueroa et al. (2014) reported very little impact of high population density and high accessibility on their car travel or car travel distance.

Neighborhood-level socio-demographic attributes also influence older adults' travel behavior. Older individuals living in neighborhoods with higher poverty levels usually make a lower number of total trips (Yang et al. 2018), and a higher number of short-distance trips (Giesel and Kohler, 2015). Also, they use transit and active transportation modes more compared with those who live in high-income neighborhoods (Yang et al. 2018). It is evident that the built environment shapes travel behavior. Physical elements such as the presence of a bus stop (Hess, 2011; Van Cauwenberg et al. 2013), street lighting (Van Cauwenberg et al. 2013), facilities within walking distance (Haustein, 2011; Van Cauwenberg et al. 2013) and neighborhood safety/crime level (Hess, 2011; Van Cauwenberg et al. 2013) influence walking. Having a rail-based transit station nearby increases the likelihood of traveling beyond the neighborhood (Giesel and Kohler, 2015). However, despite car access and transit availability, which offers an option for long-distance travel, older adults travel (mostly by car or walk) short distances within their neighborhood because of health constraints and reluctance to use transit (Berg et al. 2014). The likelihood of traveling (by all modes) within a neighborhood and making short-distance trips increases with the increase in the proportion of residential land use (Truong and Somenahalli, 2011) and also, when all necessary shops and services are within the neighborhood (Giesel and Kohler, 2015). According to the study by Yang et al. (2018), higher walk scores in the neighborhood increase the number of trips, the use of transit, and active transportation. While exploring walking for transport, it is seen that neighborhood walk score weakly influences

transport walking among older persons, whereas higher transit score strongly influences active travel (Barnes et al. 2016).

Older adults living in bigger cities are found to have less access to cars but have higher access to transit (Hjorthol, 2012). Living near public transit also facilitates older adults in fulfilling their leisure travel needs (Haustein and Siren, 2014).). Fatmi and Habib (2016) revealed that living within 10 km of regional centers increases the likelihood of owning multiple mobility tools, whereas living within 1 km of a highway exit facilitates car ownership. On the other hand, rural older adults make fewer trips (Mattson, 2012; Yang et al. 2018) compared to those who live in urban areas. They are also less likely to use transit (Ahern and Hine, 2012; Yang et al. 2018), with the main reason being the lack of transit systems or infrequent service in rural areas. In the case of urban areas, studies showed that urban living, or living in or near transit-oriented developments and CBDs decreases car use (Buehler and Nobis, 2010; Boschmann and Brady, 2013; Habib, 2015), and total distance travelled (Truong and Somenahalli, 2011; Habib, 2015; Zmud et al. 2017), and increases transit use (Truong and Somenahalli, 2015), walking (Hess, 2011), and the number of short distance trips (Boschmann and Brady, 2013). Urban areas are usually equipped with multimodal transportation system (e.g. transit, bikeway, sidewalks, etc.) and facilities such as shopping, and recreation are mostly centered within urban areas. Access to alternative modes of transport is also higher in urban areas compared to rural areas. Moreover, being closer to amenities reduces the need for long-distance travel. Similarly, studies have found that the use of transit increases if there is a transit stop near the home (Truong and Somenahalli, 2015), and the probability of transit-pass ownership increases with residential locations near subway stations (Fatmi and Habib, 2016). However, studies revealed that transit is only attractive within a certain distance. Habib (2015), for instance, reported that older adults use transit more

within a boundary of 5.35 kilometers of the CBD, with use decreasing after this distance, and lower use potentially associated with the discontinuity of transit infrastructure or less frequent transit services.

Young Adults/Millennials: Amongst millennials, transport mode preference is dependent on the type of land use and location of the home, work, and study, with millennials preferring to live in areas from where work, study, and facilities (e.g., shopping, restaurants) are easily accessible (Delbosc and Nakanishi, 2017), especially by walking, biking or transit (Davis et al. 2012). As urban areas offer this kind of mixed land uses, young adults are more willing to live in dense urban areas compared with other generations (Delbosc and Nakanishi, 2017; Sakaria and Stehfest, 2013; Blumenberg et al. 2015; Axhausen, 2013; Melia et al. 2018). Young adults living in urban areas are more likely to walk and use transit (Lavieri et al. 2017; Newbold and Scott, 2017; Blumenberg et al. 2015; Simons et al. 2017; Melia et al. 2018), make fewer trips (Blumenberg et al. 2015; Kuhnimhof et al. 2012a), have lower rates of automobile access/ownership (Lavieri et al. 2017; Delbosc and Nakanishi, 2017; Blumenberg et al. 2015; Hjorthol, 2016; Kuhnimhof et al. 2012c), show a lower probability of holding a driver's license (Lavieri et al. 2017; Blumenberg et al. 2015; Hjorthol, 2016), and are less likely to drive (McDonald, 2015; Blumenberg et al. 2015; Simons et al. 2017; Kuhnimhof et al. 2012c; Melia et al. 2018) as compared to older generations. On the other hand, due to homogenous land-use patterns, rural living encourages possession of a driver's license (Berrington and Mikolai, 2014), car use/driving (Newbold and Scott, 2017; Licaj et al. 2012; De Paepe et al. 2018), and higher driving distance (Berrington and Mikolai, 2014). The study by Nash and Mitra (2018) revealed that young adults mostly prefer to live in areas that best suit their transport mode choice. For example, their study showed that active mode users and multimodal young adults are more likely

to live in a bike-friendly neighborhood, whereas car users are more likely to live in car-oriented neighborhood or rural communities. Transit users are seen to put importance on transit proximity while selecting their residence (Nash and Mitra, 2018).

Change in residential location can occur due to professional reasons such as transition into work life, change in income and job, as well as personal reasons such as moving in with a partner, and the birth of a child. This also influences mode change among young adults as found by Busch-Geertsema and Lanzendorf (2017), in that the mode change rate is higher (almost double) among movers as compared with non-movers. An increase in income can increase the chance of buying a car and moving to suburban locations. Similarly, change in transit accessibility within residential and job locations and the distance between activity points (e.g., home, job, shopping, and school) increases the chance of mode change among young adults (Busch-Geertsema and Lanzendorf, 2017). Young adults' mode choice also depends on the neighborhood's street quality, accessibility to facilities, weather, and perceived safety such as secure bike parking (Simons et al. 2014). For example, widely spaced road intersections positively influence car ownership (Habib et al. 2018). Proximity to public transport options from home increases the likelihood of delaying driver's license possession (Habib, 2018; Le Vine and Polak, 2014), transit-pass ownership (Habib et al. 2018) and bike ownership (Habib et al. 2018). In addition, the existence of a good-quality and accessible transit service decreases car access (Hjorthol, 2016), and license possession (Lavieri et al. 2017; Habib, 2018), and increases the likelihood of commuting by transit (Lavieri et al. 2017; Brown et al. 2016). The likelihood of using the ridesharing services among young adults is also positively associated with auto accessibility (Circella et al. 2017; Alemi et al. 2018), urban living, and higher land-use mix (Alemi et al. 2018).

Compared to any other modes, young adults use transit more frequently when it is available and accessible to them (Habib, 2018). Transit provision is highly correlated with higher density (e.g. population density, urban density)—with higher population density encouraging transit-use and licensure delays (Habib, 2018), and decreased car travel (Figueroa et al. 2014); whereas high employment density in the neighborhood encourages car ownership (Habib et al. 2018) for young adults. Neighborhood-level socio-demographic characteristics such as living in higher income neighborhoods increase the likelihood of owning a driver's license (Fatmi et al. 2014), driving a car (Licaj et al. 2012), and decreases the likelihood of transit-pass ownership (Fatmi et al. 2014). Poor levels of neighborhood walkability influence early licensure (Habib, 2018) and car commutes (Vale et al. 2018), whereas higher residential density increases transit commutes (Lavieri et al. 2017; Brown et al. 2016) and decreases the likelihood of driver's license possession (Le Vine and Polak, 2014).

Location of university/college campuses may also influence young adults' commute behavior. Suburban campus locations and low multimodal accessibility decrease the number of students walking and increase the number of car commuters, whereas living near a campus reduces car commutes (Vale et al. 2018). In the Greater Toronto Area (GTA), living far from the university campus (especially outside the City of Toronto) encourages early licensure (Habib, 2018) and discourages transit-pass ownership (Habib et al. 2018) and multiple mobility tool ownership (Habib et al. 2018). Also, living near a subway station positively influences transit-pass ownership, and living near a highway exit positively influences car ownership and driver's license possession among young adults in the GTA (Fatmi et al. 2014). In downtown areas, how young individuals possess different mobility tools such as driver's license, car, or bike, and use transit and active modes of transport is somehow complex and perhaps reflects individuals'

socio-economic status and socio-demographic aspects. For example, the study by Habib et al. (2018) indicated that despite having full transit coverage, living in downtown Toronto discourages transit-pass ownership but encourages either possession of a driver's license (on its own) or possession of a driver's license and bike ownership together as a composite mobility tool among post-secondary students. According to the authors of the study (Habib et al. 2018), the quality of bike infrastructure along with easy access to carsharing and bikesharing options and transit facilities within the GTA core (i.e., downtown Toronto) enabled students to be multimodal and not rely on a specific mode for their commute.

2.5.3 Living Arrangements and Family Life

How different factors such as living arrangements, family life, technology adoption, lifestyle, attitudes, and perceptions towards travel are associated with travel behavior are displayed in Table 2.2. Living status (Alone/Married/Partnered) is a strong predictor of the travel behavior of the older generation, whereas, young adults' travel behavior is mostly associated with whether they are living with parents or not, and the presence of a child. Technology adoption and attitudes towards travel options and the environment are mostly associated with young adults' travel behavior, whereas perceptions and experiences of travel options are associated with older adults' travel behavior.

Older adults: Married or partnered older adults are more multimodal (Jones et al. 2018), own multiple travel tools (Fatmi and Habib, 2016), use taxi and ridesharing services more (Jones et al. 2018; Vivoda et al. 2018), and travel less frequently (Corran et al. 2018; Yang et al. 2018) compared to single older adults. Also, studies indicated that older adults living with a partner or in multi-person households have a lower amount of unmet leisure travel needs (Haustein and

Siren, 2014). The authors further explained that perhaps living with more people either decreases the need for outside socialization or increases the number of chances to get a ride. Two studies concluded that older adults who are from a larger household are more likely to make fewer trips (Mattson, 2012; Corran et al. 2018). Living with others also decreases the probability of walking and using transit, but increases trip distances by car, potentially due to an increase in shared responsibility and a greater need to use a car (Moniruzzaman et al. 2013). On the other hand, the death of a partner can influence mode change, especially from car to transit (Ahern and Hine, 2012; Mollenkopf et al. 2011).

To meet their travel needs, whether they live alone or not, older adults rely on and get support from friends and family living nearby (Hjorthol, 2012), which is also common in rural settings (14; Hanson and Hildebrand, 2011). Those who live alone usually make a higher number of car trips (mostly as a driver) and use transit less (Truong and Somenahalli, 2011; Truong and Somenahalli, 2015). Also, having adult children living nearby (Truong and Somenahalli, 2015) or someone else who drives them regularly (Habib, 2015) increases the number of car trips (as a passenger) amongst older adults, and decreases their frequency of transit use. Retired older adults are also found to provide informal care to their parents, children, and grandchildren—which again, increases their car use frequency (Siren and Haustein, 2015). However, those who are non-drivers and do not have family members living nearby to support them show a higher level of perceived need for alternative transport services (Siren and Haustein, 2015).

Older adults living in apartments or condos are found to prefer transit when it is more accessible to them (Habib, 2015). In urban areas with greater transit coverage, those who live alone show a lower probability of owning a driver's license and car, and a higher probability of owning a transit pass (Fatmi and Habib, 2016).

Young Adults/Millennials: The travel behavior of young adults/millennials is mostly driven by their living arrangements and family life patterns. Living with parents, living in shared accommodation, or being in larger households encourages transit use (Blumenberg et al. 2012; Brown et al. 2016) and discourages driving (McDonald, 2015; Vale et al. 2018; Berrington and Mikolai, 2014), carpooling (Blumenberg et al. 2012), and driver's license possession (Habib, 2018; Le Vine and Polak, 2014). Nash and Mitra (2018) found that living with parents is positively associated with car and transit use and negatively linked with the active mode use associated with commuting to university, a finding that is potentially related to the suburban/rural location of their parents' houses, which results in longer commutes. Those who live with parents or are from larger households are also found to own multiple mobility tools (Habib et al. 2018), although they only use one or two modes for their regular commute (Nash and Mitra, 2018; Habib et al. 2018). On the other hand, living alone, with a partner, roommates, and someone from the same generation increases the likelihood of owning a driver's license (Habib et al. 2018), although car ownership is low among the single-person households (Kuhnimhof et al. 2012b), potentially reflecting a lack of affordability. Compared to those who live with parents, young adults who are partnered/married and/or living with their own child tend to be drivers (Licaj et al. 2012), hold a driver's license, and drive higher mileage (Berrington and Mikolai, 2014). Also, young adults who are single and not living with parents tend to live in urban areas (Blumenberg et al. 2015) and those who live in apartments or condos (which are usually in the core of the city) are more likely to delay obtaining a driver's license (Habib, 2018).

Young women who are living with a partner, have a child, and are looking after a family are less likely to drive and hold a driver's license compared to those who live with their parents (Berrington and Mikolai, 2014). Young individuals without children are more likely to live

where transit is available (Sakaria and Stehfest, 2013), whereas parenthood decreases the use of transit for day-to-day travel (Lavieri et al. 2017; Newbold and Scott, 2018). Life events such as marriage, becoming parents, and living with one's own child influence the modal shift from sustainable transportation options (Delbosc and Nakanishi, 2017), and encourage driving (Berrington and Mikolai, 2014), driver's license holding (Lavieri et al. 2017; Delbosc and Currie, 2014; Berrington and Mikolai, 2014; Hjorthol, 2016) and car ownership (Lavieri et al. 2017; Sakaria and Stehfest, 2013; Hjorthol, 2016). The reason could be the change in travel needs due to the family extension, residential relocation, the rise in affordability, and personal preference. However, young adults may still prefer to live in urban areas even after a change in life stage as Sakaria and Stehfest (2013) reported that though millennials who are parents are highly likely to buy a car, very few of them are moving to suburbs, which indicates that they are continuing some of their previous travel behaviors.

2.5.4 Technology Adoption

Older Adults: Relatively few studies explored the relationship between technology use and travel behavior among older adults. According to the studies, mobile phone possession is associated with a higher number of trips, higher distance traveled (Truong and Somenahalli, 2011), and higher transit use (Truong and Somenahalli, 2015), as well as car use (Haustein, 2011). However, car users tend to have greater access to the internet as compared to transit users (Haustein, 2011). Familiarity with technology is also important for older adults, as trip-making behavior is found to be influenced by the level of familiarity with smartphone technology and online ridesharing services (Leistner and Steiner, 2017).

Young Adults/Millennials: Millennials or young adults are highly technology-oriented and are frequent social media and smartphone users (Circella et al. 2017; Alemi et al. 2018). They prefer to use online services instead of traveling (Davis et al. 2012; Schoettle and Sivak, 2014). To save travel time, they also show preference towards being flexible with respect to activity locations and times by using digital resources (Sakaria and Stehfest, 2013). Greater internet or social media use is associated with higher transit use (Delbosc and Currie, 2014; Sakaria and Stehfest, 2013; Blumenberg et al. 2012; Davis et al. 2012; Kroesen and Handy, 2015) as they can use their electronic devices to perform online tasks as well as connect to social media while using transit. Tech-dependent lifestyles also reduce vehicle ownership (Lavieri et al. 2017) as well as carpooling (Blumenberg et al. 2012). Higher frequency of being engaged in information and communication technology (ICT)-based gaming negatively influences a car purchase, while higher social media usage positively influences millennials' decision to purchase a car in the future (Muromachi, 2017). The study further explained that while being engaged in gaming decreases the intention to travel, the use of social media increases the intention to travel for face-to-face communications and visit new places. On the other hand, the use of online ridesharing services (i.e., Uber/Lyft) reduces walking, biking and transit use (Circella et al. (2017).

The reasons behind not holding a driver's license or reduction in driving among young adults could be the reduced need for commuting due to teleworking (Bailey et al. 2015) and online shopping (McDonald, 2015). However, one study showed that those who work from home have higher driving mileage compared to those who work outside but don't drive to work (Berrington and Mikolai, 2014). This can be supported by the findings of Delbosc and Currie (2013a;2013b; 2014) where the authors mentioned that driving or travel can't be substituted by

e-communication, rather, they encourage face-to-face communication, which eventually increases travel.

2.5.5 Attitudes Towards and Perceptions of Travel Options and Environment

Older adults: Older adults' perceptions and experiences of transport modes influence their travel behavior. Studies revealed that satisfaction with a transport mode influences the use of that particular mode (Mollenkopf et al. 2011). Similar findings are observed for the use of online ridesharing (Vivoda et al. 2018). Even in rural areas, previous experience in using alternative transport modes influences the rate of using alternative transport (Ward et al. 2014). How older individuals perceive different aspects of travel, especially distance, can also influence the probability of choosing a transport mode. Findings by Hess (2011) revealed that perception of distance to bus stops influences transit ridership and walking to transit. It is seen that those who perceive distance to facilities from their residence to be short are more likely to walk (Van Cauwenberg et al. 2013). The levels of awareness and familiarity of the services also influence the perceived need for and use of alternative transport services (Rahman et al. 2016; Turner et al. 2017).

Haustein (2011) found that a positive attitude towards walking and transit decreases car use. The study also revealed that positive attitude toward cycling increases cycling, and that pro-transit attitudes increase transit use. Attitudes towards different modes may also be dependent on the individual's travel characteristics, such as driving status. For example, non-drivers show more positive attitudes toward all modes of transport compared to ex-drivers (Haustein and Siren, 2014). Another study by Tuokko et al. (2014) suggested that those who have restricted driving show more negative attitudes towards driving, whereas those who have not restricted

their driving show positive attitudes towards driving. Interestingly, Rahman et al. (2016) found that compared to non-drivers, drivers are more positive about adopting alternative transport modes when they will not be in a condition to drive. Perhaps, non-drivers already have arrangements to fulfill their travel needs.

Young Adults/Millennials: Attitudes play a vital role in shaping young individuals' travel behavior. Among young adults, those who live downtown or nearby consider the environment, cost saving, convenience, and health impacts while making transportation decisions (Sakaria and Stehfest, 2013). Those who are technology-oriented, pro-environment, and seek variety in life are more likely to adopt online ridesharing services (Alemi et al. 2018). Pro-environment attitudes also increase the chance of using active modes and being multimodal (Nash and Mitra, 2018) and decrease driving (Davis et al. 2012). Changing attitudes toward mobility have decreased driving among millennials (McDonald, 2015). However, pro-car attitudes, for example, considering that the car gives independence (Busch-Geertsema and Lanzendorf, 2017) and safety compared to other modes (Nash and Mitra, 2018) strongly influence the use of a car. Lavieri et al. (2017) revealed that pro-car attitudes positively impact car ownership, while pro-environment attitudes negatively impact car ownership. Following a sustainable lifestyle and using sustainable modes while in university reduces the probability of mode change in work life (Busch-Geertsema and Lanzendorf, 2017). On the other hand, young adults seem to be more flexible in their attitudes toward travel modes than previous generations as they are ready to adopt modes that best suit their purpose (Delbosc and Nakanishi, 2017). To them, owning a car is not a symbol of luxury, but a symbol of adulthood and maturity instead (Delbosc and Currie, 2014). However, attitudes towards the previous mode (i.e., feeling restricted in using transit, walking, and biking) significantly impact mode change while transitioning to employment from

studentship (Busch-Geertsema and Lanzendorf, 2017). Also, the experience of using a particular mode earlier in life may influence travel behavior in the future as evidenced by Muromachi (2017), who revealed that travel to school by bike positively influenced ownership intentions, and travel by rail negatively influenced the intention to buy a car in future (Muromachi, 2017). Also, those who consider car as a less attractive product show a lower likelihood of buying a car in future (Muromachi, 2017).

2.6 Future Research Prospects

It is beyond the scope of this study to propose a comprehensive research agenda, but several future research directions can be drawn from this literature review. Consequently, this study recommends the following six topics that require further investigation.

First, for both generations, there is a need to explore the combined and separate effects of how multiple factors impact travel behavior. Although studies on travel behavior widely recognize its relationship with socio-demographic and built environment characteristics, it is not yet well-established how living arrangements, attitudes and perceptions, and use of technology influence travel behavior. Significant differences may exist between each generation's lifestyles, living arrangements and attitudinal factors, which should be incorporated in future travel behavior studies. Additionally, further thoughts and analysis are needed to explain the complex inter-relationships among associated factors and travel behaviors.

Second, residential location and its association with the stages of life events should be explored to understand the change in travel behaviors of different generations over time. Individuals make travel decisions (particularly commuter routes) based on their residential as well as work locations. Important research questions to be explored include: What differences

exist between urban and rural older adults in fulfilling their travel demand(s)? Do retirement, financial strain, living alone, not being able to drive, and having no transport support from friends and family influence residential relocation for travel? Are there any intentions to move near services or transit facilities when they are no longer able to drive?

On the other hand, for millennials, changes in life events (i.e., change in household composition or employment) can result in a change in residential location as well as travel patterns. Though the presence of children influences travel behavior, the number of children per household in developed countries is declining. Even after changes in life stages, millennials or young adults may like to stay in urban areas because of lifestyle preferences. For those who are living with their parents, residential location type (urban/rural) can be the same for many of them, as they are already living in suburban/rural areas. In the future, they may continue some of their current travel habits even after owning a car and may not follow the same car-dependent lifestyles of the previous generation. Future research should explore how life cycle influences travel choices, with questions including whether young adults will continue their travel behavior (and especially their use of public transit) as they age and progress through the different stages of the life cycle, and whether there will be any change in preference for residential location type because of life-stage change and to what extent.

Third, the employment and economic status of both generations should be taken into account as transportation choice is highly correlated with economic forces (Klein and Smart, 2017). Compared with the previous generation, the average age that young adults join the workforce is higher than for older generations, with younger adults more likely to work part time and to continue schooling to a later age (Delbosc and Currie, 2013a; 2013b). Furthermore, older generations may continue to work even after the typical retirement age to remain active or to

avoid financial burden. Future research should investigate these key questions: What is the role of economic forces in shaping each generation's travel behavior? How will it evolve in future? Will being employed after retirement age impact older adults travel behavior? What changes in travel patterns (especially in commuting) are expected if there is a change in employment and income conditions of the young generation? Does change in fuel price impact automobility? How do changes in insurance policy, parking policy, and driving laws impact travel behavior?

Fourth, health-related attitudes such as health-consciousness and preferences for active transportation choices may impact individuals' travel behavior, especially mode choice. More evidence is needed on how perception and experience of transportation options influence the current and future travel behavior of each generation. Important questions to be answered through future research include: What role do transport-related attitudes play in shaping travel behavior? Does health consciousness impact mode choice? Will perceptions and attitudes towards travel options change as generations age? How and to what extent do changing attitudes impact travel behavior?

Fifth, research is needed on the role of technology adoption in shaping each generation's travel behavior. Among older adults, the level of technology adoption as well as using online services are very low, although familiarity with technological solutions is increasing (Leistner and Steiner, 2017). Future research should investigate the emerging trends in travel behavior as a result of technology adoption. Shared mobility options and their impact on each generation's travel patterns need to be explored further. Research questions to be addressed include: To what extent are emerging technologies influencing travel behavior? How do different shared-mobility options influence the travel behavior of young adults? Will older adults adopt shared-mobility options, especially online ridesharing and carsharing to fulfill their travel demands? What are the

challenges to overcome to make formal ridesharing a viable alternative transport option for older adults when they are no longer able to drive?

Sixth, neither the older nor the younger generations are homogenous. To consider intra-generational heterogeneity, researchers should disaggregate different generations as much as possible based on their unique features. Haustein and Hunecke (2013) discussed different segmentation approaches for travel behavior analysis and suggested that individuals can be segregated based on their travel behavior, socio-demographic characteristics, geographic location, life stages, lifestyles, and attitudes. For example, older adults can be divided into sub-groups by significant age-related mobility events, such as reaching the age of 80 in Ontario, Canada, when older adults are required to renew their license every two years. Large datasets and/or big data would be more useful to apply segmentation approaches as it will scale-up the sample size and thus, the statistical power of the sub-groups. The key question to be explored is whether the travel behavior of different generations varies across sub-groups based on different attributes.

2.7 Conclusions

Based on the recent evidence from developed countries, this study summarizes the travel trends among young and older adults. Seventy-eight studies were explored to document the factors that influence the unique travel characteristics of each generation. Associated factors of travel behavior are divided into five themes: personal attributes, geography and built environment, living arrangements and family life, technology adoption, and perceptions and attitudes towards travel options and environment. Travel aspects that are focused on in the reviewed literature are mode choice, trip distance, trip frequency, use of alternative transport,

ridesharing, and, mobility tool ownership: driving license, car, bike, and transit pass. Based on the reviewed literature, it can be concluded that differences exist between generations in terms of travel behavior and the factors that influence their travel characteristics. However, this review only explored the direct effects of the factors on the travel behavior of older and young adults.

This study also highlighted future research directions. To address those research challenges, both quantitative and qualitative research methods can be applied. For travel behavior analysis, interactions between socio-demographic, locational characteristics, life stages, and attitudes should not be ignored. There is a need to explore the complex relationships between travel characteristics and associated factors. Some of the reviewed studies recommend the use of more advanced research methods, such as Structural Equation Models (SEM) to address the complex causality between variables. Qualitative methods such as focus group discussion and the case-study approach will be useful to investigate the underlying theory behind those complicated relationships. This study also found the need for longitudinal data to explore the changes across generations. Lastly, to implement target group-specific interventions, individuals of different generations should be segmented into different groups based on a combined consideration of socio-demographic characteristics, geographical and built environment related variations, living arrangements, and attitudes, which will reduce the complexities and heterogeneity within the target generation.

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Appendix 2A

List of the journals that were hand-searched:

1. Transport Research Part A: Policy and Practice
2. Transport Research Part C: Emerging Technologies
3. Transportation
4. Travel Behavior and Society
5. Journal of Transport Geography
6. Transportation Research Record
7. Journal of Transport and Land Use
8. Transport Reviews
9. Transport Policy

Chapter 3

A comparison of Young and Older Adults' Attitudes and Preferences toward Different Travel Modes and Residential Characteristics: A Study in Hamilton, Ontario

3.1 Introduction

Auto-oriented culture is widely recognized as unsustainable and unfavourable in the sustainable and inclusive planning paradigm, mainly because of environmental damage such as greenhouse gas emissions and noise levels (Abrahamse et al. 2009; Bastian et al. 2016). However, in North America, the personal automobile dominates the road transportation system and automobiles are the central means to participate in social, economic, recreational, and cultural activities (Schouten et al. 2021). In Canada, four in every five persons use an automobile for their commute (Statistics Canada 2017a).

To increase the use of more sustainable transport modes (e.g., walking, biking, transit and electric vehicles), the federal government has developed policies and strategies such as the '2017-2020 Departmental Sustainable Development Strategy' and launched several programs to encourage low- and zero-emission vehicles at the mass level (Transport Canada 2019). The policy commits to understanding the existing trends and vulnerabilities within the road transportation system and improving the well-being of Canadians along with implementing the 2030 Agenda by the United Nations and its Sustainable Development Goals (SDGs) (Transport Canada 2019). Through these, Canada aims to develop an accessible and sustainable

transportation system by addressing the needs of different age groups, genders, and persons with disabilities (Government of Canada 2020).

Conversations are ongoing over the 'peak car' phenomenon over the past decade, with research suggesting that young adults are less reliant and less likely to use automobiles for their transport needs (van Wee 2015) and that they are instead more likely to use alternative modes, including active travel modes and public transportation (e.g., Blumenberg et al. 2012; Kuhnimhof et al. 2012; Delbosc and Nakanishi 2017). This is partly evidenced by a lower rate of licensure among young adults (e.g., Delbosc and Currie 2013; Bailey et al. 2015). Reasons for less reliance on the personal automobile include ownership costs, including fuel costs (van Wee 2015; Bastian et al. 2016), the complexity of obtaining a driver's license and affording an automobile, and their preference for living in urban areas where public transit is easily available (Thigpen and Handy 2018; van Wee 2015; Blumenberg et al. 2017; Lee 2021).

On the other hand, older adults born in the post-World War II era (i.e., between 1945 and 1964) have spent their lives in a society where mobility was characterized by automobiles and long-distance travel (Coughlin 2009). While growing up in this period, the automobile's prominence made this generation of older adults more auto-dependent (Fordham et al. 2017). In Canada, even in the most densely populated neighborhoods, older adults who are 65 years and over prefer to drive (Turcotte 2012). Work by Newbold and Scott (2017; 2018) suggested that older Canadian adults will continue to be auto-oriented, and driving will remain their primary mode of transportation.

Compared to older adults, today's young adults (18 - 34 years) are still less auto-oriented at their early life stages (Delbosc and Nakanishi 2017; Wang 2019). A sustainable travel behavior-related policy question would be whether young adults will continue with the same

travel behavior in the later stages of their life? That is, will young adults remain less reliant on the personal automobile, or will their behavior increasingly echo older adults, with a preference for the personal car?

To date, evidence is mixed. While delays in obtaining higher education, family formation and having children are the main reason behind the distinctive travel patterns of young adults (Delbosc and Nakanishi 2017), they are likely to become more auto-oriented as they age, enter the labor market and form families (Blumenberg et al. 2016; Busch-Geertsema and Lanzendorf 2017). Studies show that automobile use among young adults increases with age and is higher among young families than young couples without children (Delbosc and Currie 2014; Kuhnimhof et al. 2012). Similarly, Newbold and Scott (2017) suggested that the automobility profile of young Canadian adults will increasingly echo that of older adults in the future.

Reducing automobile dependency is the prerequisite for developing a sustainable transportation system. Steg (2005) suggested that behavioral change is required to reduce automobile dependency. An investigation of how attitudes and perceptions of different transportation modes are associated with the transportation choices of various socio-demographic groups will help policymakers better understand public inertia and, therefore, allow them to initiate relevant and effective policy measures (Corpuz 2007). Numerous studies have been conducted regarding automobile usage trends, especially in terms of socio-demographic and spatial characteristics and how it relates to automobile ownership, driver's license possession, number of trips made by automobiles, vehicle kilometers traveled, etc. (e.g., Fordham et al. 2017; Blumenberg et al. 2012; Kuhnimhof et al. 2012). On the contrary, psychological factors such as perceptions and attitudes towards different modes and how these attributes are associated with transport mode use, especially automobile use, have received comparatively less attention

(Arroyo et al. 2020). However, these attributes are critical, especially in terms of automobility behavior, as they are highly likely to be influenced by perceptions and attitudes individuals hold related to flexibility, convenience, comfort and safety offered by automobiles (Paulsen et al. 2014). Also, attitudes towards residential location choice and preference may impact individuals' automobility behavior (Ettema and Nieuwenhuis 2017).

This study aims to address several gaps in current research regarding the automobility behavior of young and older adults. Using Hamilton, Ontario, as a case study, this study focuses on two crucial demographic groups: young adults (18 – 34 years) and older adults (65 years and over). As attitudes and perceptions towards automobility behavior residential location preferences have been explored to a limited extent and especially in the Canadian context, the study has investigated these attributes and how they impact the automobility behavior of young and older adults. To the best of the authors' knowledge, there are only a few studies that focused on these two cohorts' automobility behavior based on the same sets of attitude and perception-related variables in the same geographic context. To explore these ideas, the study conducts bivariate analyses to understand the exclusive relationship between attitudes, perceptions, preferences, and automobility behavior. The study contributes to the understanding of i) how attitudes and perceptions towards transportation modes and preferences towards residential characteristics shape both young and older adults' automobility behavior, and ii) whether any difference exists between young and older adults' attitudes, perceptions and preferences in general and by their automobility behavior.

3.2 Literature Review: The role of attitudes and perceptions in understanding automobility behavior

According to Azjen (2005), attitudes can be defined as "a feeling of (un)favourability towards a particular object or behavior". In travel behavior research, the background of considering attitudes and perceptions lies within the social-psychology domain, especially within the theory of planned behavior (Ajzen 1985). According to that theory, an individual's perceptions and attitudes can influence their behavior. For a specific behavior (e.g., modal choice), specific attitudes (e.g., positive or negative attitudes) related to that particular behavior are more likely to be strongly associated. The more positive feelings individuals possess towards a behavior, the higher their intention becomes, and thus, they are more likely to conduct the behavior or vice versa (Ajzen 2005; 1985).

Studies have recognized the role of attitudes, perceptions and preferences in predicting travel behavior. Ibrahim (2003), for example, indicated that each transport mode has its own unique set of attributes. Attitudes towards different modes not only depend on users and non-users, but also on travel purpose, suitability, the practicality of a particular mode and ease of travel (Ibrahim 2003). Similar findings have been reported by Beirao and Cabral (2007), where their study suggested that choice of transportation mode depends on individuals' lifestyle preference, travel purpose, the perceived service performance of each transport mode and situational variables.

Attitudes and intentions towards automobile use are highly associated with current and future automobile use (e.g., Abrahamse et al. 2009; Zhu et al. 2012). Arroyo (2020) found that positive attitudes toward walking and biking decrease automobile use and individuals' social networks can influence their personal values towards different mode use. A study in Scotland found that those who perceive automobiles as a convenient mode of travel are more likely to use

automobiles (Anderson and Strading 2004). Also, willingness to shift towards sustainable mode choice was low among automobile users (Anderson and Strading 2004). Similar findings have been found by Guiver (2007), with automobile users possessing positive attitudes towards automobiles and negative attitudes towards bus use. The author concluded that attitudes towards a transportation mode can differ between users and non-users of that mode. Also, having a preference towards traveling alone reduces the probability of using other modes that need to be shared with others and makes individuals more inclined towards using private vehicles (Lavery et al. 2013).

While exploring the motivations behind automobile use, Steg (2005) and Lois and Lopez-Saez (2009) found that automobile users put more emphasis on symbolic and emotional aspects of automobile ownership rather than instrumental factors (e.g., speed, flexibility and convenience). In contrast, while exploring the difference between the experience of a transportation mode and their aspired mode concerning freedom, enjoyment and happiness, Lira and Paez (2021) found that active mode users show less dissonance than auto users in Santiago, Chile, whereas transit users show the highest dissonance. While exploring university students' commute behavior in Hamilton, Ontario, Canada, Lavery et al. (2013) found a high influence of demographic, attitudinal and locational factors on the availability and feasibility of different modes. Their study suggested that living in dense areas (i.e., dwelling density) increases the probability of having options to use multiple modes, whereas residing in less dense or suburban areas offers only a few transportation modes to the university students – resulting in a higher probability of auto use and lower probability of transit use among the students living in suburban areas.

In terms of demographic differences, studies have shown that perceptions and experiences of older adults with transport mode influence their travel behavior. For example, higher satisfaction with a particular transportation mode increases the likelihood of using the same among older adults (Mollenkopf et al. 2011). Similar findings are observed for the use of online ridesharing by automobiles – those who are more satisfied with the service are more likely to use it (Vivoda et al. 2018). Haustein (2012) found that a positive attitude towards walking and transit decreases automobile use among older adults.

In terms automobile use among young adults, Zhou and Wang (2019) found that young adults show less favorable attitudes toward automobile use. They seem to be more flexible in their attitudes toward different travel modes than other age groups and more likely to use modes that best suit their travel purposes (Delbosc and Nakanishi 2017). Rather than aesthetic/ affection, young adults in Melbourne, Australia, have been found to put more emphasis on the instrumental values (e.g., convenience, flexibility) of automobile ownership (Delbosc and Currie 2014). On the other hand, Zhu et al. (2012) found that non-instrumental factors (e.g. status symbol, aspiration to own) are more influential in determining automobile ownership among college students in Beijing, China.

Conversely, positive attitudes towards automobiles such as independence (Busch-Geertsema and Lanzendorf 2017) and safety (Nash and Mitra 2019) compared to other modes are likely to influence automobile use among young adults. Also, pro-car attitudes increase automobile ownership/ intention to own (Verma et al. 2016). Attitudes towards the previous mode (i.e., feeling restricted while using transit, walking, and biking) significantly impact mode change while transitioning from studentship to employment (Busch-Geertsema and Lanzendorf 2017).

Existing studies have widely explored perceptions and experiences of transportation modes while exploring the automobility patterns of older adults. In contrast, technology adoption and attitudes towards transportation modes and the environment are mostly explored while investigating young adults' automobility behavior (Jamal and Newbold 2020). Except for Thigpen and Handy (2018) and Zhou and Wang (2019), all other automobility studies have focused either on young or older adults' attitudes and preferences. Each study was conducted in different geographic locations; therefore, geographic and cultural contexts were different – even available transport options and infrastructure can be different from location to location, influencing the travel behavior and related attitudes and perceptions of the local residents differently. Therefore, context-specific research is needed to develop greater insights into travel behavior of any geographic location and formulate relevant policy. To address this gap, this study has considered the same sets of perceptions and attitudinal attributes to explore the automobility behavior of young and older adults of Hamilton.

3.3 Survey, Data and Method

Situated at the western end of Lake Ontario and about 60 km west of Toronto, Hamilton's 2016 population was 536,917 (Statistics Canada 2017b). With a median age of 42.1 years in 2016, it was the oldest of Canada's ten largest municipalities (Statistics Canada 2017b; Hamilton Community Foundation 2019), and is ageing rapidly. As of 2016, 17.3% of the city's population was aged 65 and over. Between 2006 and 2016, the number of individuals aged 65 years and above increased from 75,395 to 92,910, an increase of 23% — nearly four times greater than Hamilton's overall population growth (6.4%) (Hamilton Community Foundation 2019). Another 6% of the city's population was aged 60-64 in 2016, meaning that almost 23% of adults have

already aged into the 65+ demographic (City of Hamilton 2019). In terms of young adults, 20% of Hamilton's population was between 20 – 34 years in 2016 (Statistics Canada 2019). In total, nearly half of Hamilton's population either belongs to the older or young adults' age group. According to its 'Growth Related Integrated Development Strategy 2 (GRIDS 2), Hamilton plans to create more jobs and attract more working population to the city in the next 30 years (City of Hamilton 2021). As a result, along with the increase in older adults/ ageing population, Hamilton is supposed to have an increasing number of young adults in the coming years.

According to the Transportation Tomorrow Survey (TTS) (i.e., Regional Household Travel Survey), 2016, in the city of Toronto, Ontario, 57% of the trips were made by automobiles (as drivers and passengers). In contrast, for the city of Hamilton, Ontario, the percentage was 82% in 2016 and 84% in both 2011 and 2006 (Ashby 2018). The TTS data reveals that more trips are made by automobiles in Hamilton than in Toronto.

Data for this study was based on a customized survey conducted by Dynata Research between October and November 2019, with an equal number of young (18-34) and old adults (65+) recruited over the telephone. As both demographic groups represent a nearly similar percentage of the population of Hamilton, the study recruited an equal number of respondents from each cohort. Using a sample of 100 young and 100 older adults, the survey collected information on travel characteristics, socio-demographic characteristics, living arrangements, level of technology use, lifestyle preferences and attitudes toward transportation options. Socio-demographic characteristics included age, gender, income, education, employment, and marital status. A range of automobility behavior-related questions were collected, including automobile ownership, use of an automobile as a driver or passenger, driving license possession, medical conditions that restricted driving, and frequency of driving. The survey also asked about their

most frequently used transport mode, and frequency of using transit and shared mobility services (e.g. ridesharing, ride-hauling, carsharing). The questionnaire contained information on their level of technology adoption, frequency of using technological solutions while driving and using public transit for trip planning purposes. Lifestyle preferences and attitudinal questions gathered individuals' attitudes towards transportation choices (e.g. automobile, transit, active modes) for their typical weekday trips, why and when different modes are used and why they are not used. A total of 27 lifestyle and transportation mode-related attitudinal and perception-based questions were asked on a 3-point Likert scale: Agree - Neither agree or disagree - Disagree. Additionally, the survey contained 12 statements regarding attitudes and perceptions toward driving using the same Likert scale. The survey also collected information on reasons for residential location choice (13 statements) and preferred characteristics of the residential location (28 statements) using another 3-point Likert scale: Unimportant - Neither important or unimportant - Important.

Table 3.1 presents the socio-demographic profile of the survey respondents. It is to be noted that this study didn't collect information similar to TTS. Therefore, the study only included the common information from the publicly available version of TTS 2016 in Table 3.1. As expected, more young adults are students and employed compared to older adults. Almost 89% of the surveyed older adults are retired. Sixty-five percent of the young adults were single during the time of the survey. Compared to young adults, a larger share of older adults were living alone (44%), whereas almost one-third (34%) of the young adults were living with their parents. Also, more young adults (19%) were living with roommates or similar age people compared to older adults (2%). An almost similar number of individuals from young (74%) and older adults (79%) owned a full driver's license. Similarly, nearly the same number of individuals from both cohorts

(63% young adults and 66% older adults) used automobiles as their most common mode of transportation in 2018.

Table 3.1: Socio-demographic profile

	Young Adults (n = 100) [% from TTS 2016]	Older Adults (n = 100) [% from TTS 2016]
Gender		
Male	55 [51.5%]	41 [44.5%]
Female	45 [49.5%]	59 [55.5%]
Studentship (Yes)	33 [29%]	4 [0.5%]
Employed (Yes)	73 [75.4%]	7 [11%]
Retired (Yes)	0	89
Marital Status		
Married/ Living Common-law	31	45
Widowed/ Separated/ Divorced	3	45
Single (Never Married)	65	6
Living Arrangement		
Alone	9	44
With parents	34	1
With partner/ spouse	18	33
Living with partner/ spouse and children	15	4
Living with children	4	6
Living with roommates/ similar age people	19	2
Driver's license possession (Yes)	74 [83%]	79 [76.4%]
Most common mode of transportation in 2018		
Automobile	63	66
Non-automobile	37	34

Note: Percentages of the TTS 2016 was manually calculated by the authors for each demographic groups from the publicly available version of TTS 2016 from the Data Management Group (DMG).

Chi-square analysis is used to study attitudes and perceptions towards different transportation modes and preferences towards the characteristics of residential location disaggregated by automobility behavior of young and older adults. The study labeled ‘auto users’ as those whose most common mode of transportation in 2018 was an automobile and the rest as ‘non-auto users’ – information that was directly asked during the survey.

3.4 Results

3.4.1 Auto users vs non-auto users among young and older adults

Both young and older adults are disaggregated by their automobility status (auto and non-auto users) to explore each cohort's differences in attitudes and preferences. Table 3.2 presents the results of the chi-square analysis of attitudes and perceptions towards different transportation choices for a typical weekday trip by auto and non-auto users, with only statistically significant relationships identified (at 90% or above confidence interval) to ensure brevity in the tables. Regarding attitudes and perceptions towards walking and biking, it is interesting that older auto users agreed that they are more likely to prefer walking rather than driving compared to older non-auto users (63% vs 48%). Also, older adult auto users are more likely to prefer riding a bike than older non-auto users (40% vs 16%).

Both older auto and non-auto users consider traveling by car safer than riding a bicycle, and the percentage of respondents is higher for auto users (92% vs 72%). On the other hand, compared to young adult auto users, young non-auto users prefer to bike rather than drive (21% vs 47%) and agreed that biking can sometimes be easier for them than driving (25% vs 63%). Also, compared to young adult auto users, more of the young non-auto users agreed that walking can sometimes be easier for them than driving (51% vs 79%).

Table 3.2: Chi-square analysis of attitudes and perceptions towards transportation choices for typical weekday trips

		Young Adults				Older Adults			
		Agree	**Neither Agree nor Disagree**	**Disagree**	**Chi-square**	**Agree**	**Neither Agree nor Disagree**	**Disagree**	**Chi-square**
I prefer to walk rather than drive whenever possible	Auto users	59%	6%	35%	0.828	63%	2%	35%	7.413*
	Non-Auto users	66%	8%	26%		48%	15%	36%	
Walking can sometimes be easier for me than driving	Auto users	51%	14%	35%	8.559**	48%	6%	45%	3.547
	Non-Auto users	79%	3%	18%		50%	10%	40%	
I like riding a bike	Auto users	65%	16%	19%	2.405	40%	3%	56%	8.937**
	Non-Auto users	65%	11%	24%		16%	16%	68%	
I prefer to bike rather than drive whenever possible	Auto users	21%	14%	65%	12.476***	16%	2%	82%	2.376
	Non-Auto users	47%	3%	50%		17%	3%	79%	
Biking can sometimes be easier for me than driving	Auto users	25%	10%	65%	14.383***	17%	2%	81%	4.125
	Non-Auto users	63%	3%	34%		10%	7%	83%	
Traveling by car is safer than riding a bicycle	Auto users	62%	11%	27%	3.748	92%	3%	5%	9.196**
	Non-Auto users	57%	22%	22%		74%	6%	19%	
I like public transit	Auto users	52%	11%	37%	6.329*	39%	11%	50%	5.31
	Non-Auto users	70%	14%	16%		59%	10%	31%	
I prefer to take transit rather than drive whenever possible	Auto users	14%	14%	71%	11.549***	16%	0%	84%	7.163*
	Non-Auto users	45%	11%	45%		34%	3%	63%	
Transit can sometimes be easier for me than driving	Auto users	32%	0%	68%	26.391***	20%	0%	80%	9.218**
	Non-Auto users	73%	8%	19%		39%	6%	55%	

I like driving	Auto users	87%	8%	5%	14.091***	97%	3%	0%	30.734***
	Non-Auto users	63%	14%	23%		56%	6%	38%	
I need a car to do many things I like to do	Auto users	90%	2%	8%	43.838***	95%	3%	2%	27.703***
	Non-Auto users	27%	14%	59%		53%	6%	41%	
Getting to work without a car is a hassle (answer this only if you currently work)	Auto users	84%	5%	10%	14.507***	64%	7%	29%	2.827
	Non-Auto users	53%	3%	44%		38%	0%	63%	
Getting to school without a car is a hassle	Auto users	56%	10%	34%	11.808***	38%	8%	54%	0.345
	Non-Auto users	18%	11%	71%		43%	14%	43%	
My household could manage well with one less car than it has (or with no car)	Auto users	22%	3%	75%	15.576***	28%	6%	66%	2.035
	Non-Auto users	53%	8%	39%		41%	6%	53%	
I often use the telephone or the Internet to avoid having to travel	Auto users	62%	8%	30%	2.358	62%	2%	37%	10.671**
	Non-Auto users	47%	11%	42%		37%	7%	57%	

* 90% confidence interval
** 95% confidence interval
*** 99% confidence interval

Table 3.3: Chi-square analysis of attitudes and perceptions towards driving

		Young Adults				Older Adults			
		Agree	**Neither Agree nor Disagree**	**Disagree**	**Chi-square**	**Agree**	**Neither Agree nor Disagree**	**Disagree**	**Chi-square**
Driving means you can be more independent	Auto users	92%	5%	3%	5.633	95%	3%	2%	13.167***
	Non Auto users	78%	11%	11%		83%	0%	17%	
What kind of car you own says a lot about who you are	Auto users	44%	15%	42%	6.561*	49%	10%	41%	3.586
	Non Auto users	23%	20%	57%		43%	3%	53%	
I'm not interested in driving	Auto users	8%	8%	84%	21.426***	8%	3%	89%	24.474***
	Non Auto users	44%	6%	50%		52%	3%	45%	
I can rely on other people to drive me places	Auto users	41%	6%	52%	8.571**	36%	2%	62%	9.824**
	Non Auto users	57%	16%	27%		56%	6%	38%	
I got my driving license as soon as possible	Auto users	73%	0%	27%	18.656***	75%	0%	25%	9.634**
	Non Auto users	36%	8%	56%		52%	3%	45%	
My friends got their license as soon as possible	Auto users	64%	11%	25%	2.207	82%	4%	14%	7.559*
	Non Auto users	61%	18%	21%		56%	11%	33%	
It is easy to use public transport where I live	Auto users	55%	5%	40%	10.95**	57%	3%	40%	5.772
	Non Auto users	84%	5%	11%		76%	6%	18%	
I like taking public transport	Auto users	21%	16%	63%	17.33***	25%	8%	67%	8.838**
	Non Auto users	58%	18%	24%		52%	10%	39%	
Taking public transport, walking and cycling meet my travel needs	Auto users	22%	11%	67%	22.744***	20%	2%	79%	11.872***
	Non Auto users	68%	11%	21%		41%	12%	47%	
I don't need a car to get around	Auto users	11%	5%	84%	40.09***	11%	3%	86%	22.589***
	Non Auto users	66%	13%	21%		55%	0%	45%	
I would prefer to live close to good public transport	Auto users	59%	10%	32%	11.038**	45%	14%	42%	3.682
	Non Auto users	81%	14%	5%		64%	6%	30%	

* 90% confidence interval

** 95% confidence interval
*** 99% confidence interval

Table 3.4: Chi-square analysis of preferred characteristics of residential location

		Young Adults				Older Adults			
		Unimportant	**Neither Important nor unimportant**	**Important**	**Chi-square**	**Unimportant**	**Neither Important nor unimportant**	**Important**	**Chi-square**
Living within walking distance of shopping areas?	Auto users	44%	18%	39%	6.56*	38%	6%	55%	0.671
	Non Auto users	42%	3%	55%		33%	9%	58%	
Living within walking distance of entertainment (restaurants, movies, clubs, etc.)?	Auto users	53%	11%	35%	5.74	59%	9%	32%	7.949**
	Non Auto users	39%	29%	32%		67%	21%	12%	
Having easy access to the highway?	Auto users	19%	10%	71%	15.7***	36%	14%	50%	9.846**
	Non Auto users	50%	18%	32%		63%	9%	28%	
Having good public transit service?	Auto users	37%	16%	47%	11.5***	63%	5%	33%	4.257
	Non Auto users	11%	11%	79%		44%	13%	44%	
Living in a quiet neighborhood?	Auto users	11%	15%	74%	6.6*	14%	17%	70%	7.132*
	Non Auto users	29%	18%	53%		19%	10%	71%	

Having lots of people out and about in the neighborhood?	Auto users	37%	31%	32%	1.8	27%	15%	58%	7.411*
	Non Auto users	39%	21%	39%		32%	23%	45%	
Having a high level of upkeep in the neighborhood?	Auto users	10%	19%	71%	8.06**	12%	14%	74%	6.561*
	Non Auto users	29%	8%	63%		19%	26%	55%	
Having big trees on neighborhood streets?	Auto users	24%	19%	56%	1.84	17%	11%	73%	8.868**
	Non Auto users	34%	18%	47%		28%	22%	50%	
Having a house with a large back yard?	Auto users	18%	20%	62%	9.67**	56%	10%	35%	1.803
	Non Auto users	45%	16%	39%		66%	13%	22%	
Having a house with a large front yard?	Auto users	42%	27%	31%	6.46*	72%	8%	20%	2.677
	Non Auto users	61%	29%	11%		61%	10%	29%	
Having lots of off-street parking (garages or driveways) in the neighborhood?	Auto users	13%	5%	82%	16.3**	23%	9%	68%	5.934
	Non Auto users	38%	19%	43%		29%	19%	52%	

* 90% confidence interval
** 95% confidence interval
*** 99% confidence interval

Regarding attitudes and perceptions towards transit use, 70% of non-auto users among young adults mentioned that they like public transit. However, 45% and 63% of the young and older non-auto users prefer driving over transit. Among the older non-auto users, only 39% agreed that using transit is easier than driving, whereas the percentage is higher for young non-auto users (73%). More than 70% of auto users from both young (71%) and older adults (84%) prefer driving over transit.

Regarding driving, both cohorts shared positive attitudes toward driving, especially among auto users, with 87% of the young and 97% of the older auto users agreeing that they like driving. Among non-auto users, the percentage is 63% and 56%, respectively. Also, more than 90% of auto users in both groups agreed that they need a car to do many things. Interestingly, a larger proportion of older non-auto users feel the need for a car compared to young non-auto users (53% vs 27%). To go to work and/or school, most young auto users (84% for work and 56% for school) agreed that their commute would be a hassle without a car. The percentage is comparatively lower (53% for work and 18% for school) for young non-auto users. Seventy-five percent of young auto users disagreed that their household could manage well with one less car, whereas the percentage is 39% for young non-auto users. Interestingly, more of the auto users among older adults are likely to use telephones or the internet to avoid travel than older non-auto users (62% vs 37%).

Table 3.3 contains chi-square analysis results of more specific attitudes and perceptions regarding driving for a typical weekday trip. Irrespective of their automobility behavior, older adults emphasized the ‘independence’ offered by driving. On the other hand, the number of young auto users agreeing on ‘What kind of car you own says a lot about who you are’ is almost double compared to young non-auto users (44% vs 23%). About half of the non-auto users

agreed that they are not interested in driving for both cohorts, but the other half disagreed with the statement. For both cohorts, a higher proportion of non-auto users can rely on other people to drive them to places than auto users (57% vs 41% for young adults and 56% vs 36% for older adults). As expected, auto users in both cohorts got their driver's licenses as soon as possible compared to non-auto users. The difference is higher among young adults than older adults (73% vs 36% for young adults and 75% vs 52% for older adults). Compared to auto users, young non-auto users live in areas where public transport is easier to get (84% vs 55%). Not surprisingly, more non-auto users from both cohorts like to take public transport than auto users. Non-auto users are also more likely to agree that taking public transport, walking, and cycling meets their travel needs. The proportion is higher among young adults (68% of young and 41% of older non-auto users). Similarly, only 11% of young and older auto users agreed that they don't need a car to get around, whereas 66% of the young and 55% of the older non-auto users disagreed with the statement. Among the young adults, a higher number of non-auto users prefer to live close to good public transport facilities than auto users (81% vs 59%).

Table 3.4 contains the results of chi-square analysis of preferred characteristics of the residential location of young and older adults disaggregated by automobility behavior. Although many of the comparisons were not statistically significant, a few relationships stand out. First, compared to auto users, young adult non-auto users are more likely to prefer living within walking distance of shopping areas (39% vs 55%). Second, young non-auto users prefer having a good public transit service in their neighborhood (47% vs 79%). Third, more than 70% of both young and older auto users emphasized living in a quiet neighborhood as their desired neighborhood character, and for young adults, the proportion of auto users is higher compared to non-auto users (74% vs 53%). Fourth, regardless of their automobility status, both cohorts like to

have a high level of upkeep in the neighborhood. Older adults like to have lots of people out and about in the neighborhood and big trees in the neighborhood streets, and the proportion is higher for auto users than non-auto users. On the other hand, preferences among young adults include having a house with a large backyard and lots of off-street parking, which is higher among auto users than non-auto users. Both young and older adults emphasized the priority towards easy access to highways, especially among auto users, and the proportion is higher among young auto users compared to older auto users (71% vs 50%). It is worth noting that several relationships were not statistically significant, which were presented in Table 3.5.

Table 3.5: List of the attitudes, perceptions and preference-related questions that were found not significant in the chi-square analysis

Attitudes and perceptions towards transportation choices for typical weekday trips
I like walking
Traveling by car is safer overall than walking
Traveling by car is safer overall than taking public transit
I try to limit my driving to help improve air quality
The City of Hamilton needs to build more highways to reduce traffic congestion
My work trip provides a transition between home and work (answer this only if you currently work)
Travel time is generally wasted time
I use my work trip productively (answer this only if you currently work)
The only good thing about traveling is arriving at the destination
I prefer to organize my errands so that I make as few trips as possible
The price of gasoline affects the choices I make about my daily travel
When I need to buy something, I usually prefer to get it at the closest store possible
Attitudes and perceptions towards driving for typical weekday trips

Most of my friends drive
Preferred characteristics of residential location
Having easy access to a large shopping mall?
Having easy access to downtown Hamilton?
Having recreational facilities nearby?
Having good bicycle routes beyond the neighborhood?
Having sidewalks throughout the neighborhood?
Having parks and open spaces nearby?
Having walking and bicycling trails nearby?
Having a low crime rate within the neighborhood?
Living in a neighborhood with low level of car traffic on neighborhood streets?
Having a safe neighborhood for walking?
Having a safe neighborhood for children to play outdoors?
Having good street lighting in the neighborhood?
Having diverse neighbors in terms of ethnicity, race, and age?
Having lots of interaction among neighbors?
Having neighbors with an income level similar to your level?
Having an attractive neighborhood in terms of appearance?
Having a variety of housing styles in the neighborhood?

3.4.2 Young vs older adults' attitudes, perceptions and preferences

The previous section compared the associations between automobility behavior and attitudes, perceptions and preferences within each cohort. However, this section explores whether there any difference between the two cohorts regarding their attitudes, perceptions and

preferences towards different transportation modes and residential locations regardless of automobility behavior. Chi-square analysis results are presented in Tables 3.6, 3.7 and 3.8. A general observation from Table 3.6 (where attitudes and perceptions towards transportation choices for typical weekday trips by cohorts are presented) is that more young adults prefer to walk, and bike compared to older adults. For example, among young adults, 87.1% agreed that they like walking (vs 78.1% of older adults) and 64.6% agreed that they like riding bikes (vs 36.7% of the older adults). However, when respondents were asked about their preferences and attitudes towards different attributes of automobility compared to biking, the majority of both age cohorts showed positive attitudes and preferences towards autos and driving, and the percentage is higher for older adults than young adults. For example, 76.7% of older and 58.6% of young adults believe that traveling by auto is safer than riding bicycles. Also, 18.7% of older and 40.4% of young adults agreed that biking can sometimes be easier for them than driving – indicating that even after having preferences and positive attitudes towards autos and driving, more young adults show positive attitudes towards biking than older adults. Regarding their attitudes and preferences towards walking, 61.4% of the young adults agreed walking can sometimes be easier for them than driving, whereas the percentage is 47.3% of the older adults. Compared to young adults, a higher percentage of older adults agreed that traveling by car is safer than walking (43.3% vs 22%). Regarding transit, although almost half of both cohorts mentioned that they like public transit, only a few (around 29% in both cohorts) prefer taking transit rather than driving. Compared to older adults, more young adults (ranges from 1.5 – 2 times higher) consider travel time as a wasted time, prefer to organize their errands in such a way to make as few trips as possible, use the telephone and internet to avoid travel, and prefer to get to the closest store possible fur purchases, suggesting that they would prefer to make fewer trips.

Table 3.6: Chi-square analysis of attitudes and perceptions towards transportation choices for typical weekday trips (older vs young adults)

	Older adults			Young adults			Chi-square
	Agree	**Neither Agree nor Disagree**	**Disagree**	**Agree**	**Neither Agree nor Disagree**	**Disagree**	
I like Walking	78.10%	3.10%	18.80%	87.10%	8.90%	4.00%	12.827***
Walking can sometimes be easier for me than driving	47.30%	8.60%	44.10%	61.40%	9.90%	28.70%	5.015*
Traveling by car is safer overall than walking	43.30%	8.90%	47.80%	22.00%	22.00%	56.00%	12.486***
I like riding a bike	36.70%	7.80%	55.60%	64.60%	14.10%	21.20%	23.711***
I prefer to bike rather than drive whenever possible	18.00%	2.20%	79.80%	30.30%	10.10%	59.60%	10.199***
Biking can sometimes be easier for me than driving	18.70%	3.30%	78.00%	40.40%	7.10%	52.50%	13.503***
Traveling by car is safer than riding a bicycle	76.70%	4.40%	18.90%	58.60%	15.20%	26.30%	8.796**
I like public transit	41.90%	11.60%	46.50%	58.00%	12.00%	30.00%	5.738**
I prefer to take transit rather than drive whenever possible	28.90%	0.00%	71.10%	28.70%	11.90%	59.40%	11.698***
Transit can sometimes be easier for me than driving	26.60%	2.10%	71.30%	46.00%	4.00%	50.00%	9.171**
Getting to work without a car is a hassle	53.50%	9.30%	37.20%	73.80%	6.00%	20.20%	5.358*
Travel time is generally wasted time	30.80%	10.80%	58.50%	48.80%	9.50%	41.70%	5.079*
The only good thing about traveling is arriving at the destination	28.60%	17.90%	53.60%	51.10%	9.60%	39.40%	4.69*

I prefer to organize my errands so that I make as few trips as possible	39.70%	6.30%	54.00%	63.00%	8.00%	29.00%	10.27***
I often use the telephone or the Internet to avoid having to travel	34.30%	2.90%	62.90%	64.90%	6.20%	28.90%	12.638***
When I need to buy something, I usually prefer to get it at the closest store possible	54.20%	2.80%	43.10%	67.00%	8.20%	24.70%	7.456**

* 90% confidence interval
** 95% confidence interval
*** 99% confidence interval

Table 3.7: Chi-square analysis of attitudes and perceptions towards driving (older vs young adults)

	Older adults			Young adults			Chi-square
	Agree	**Neither Agree nor Disagree**	**Disagree**	**Agree**	**Neither Agree nor Disagree**	**Disagree**	
Driving means you can be more independent	80.20%	0.00%	19.80%	75.00%	8.30%	16.70%	7.568**
What kind of car you own says a lot about who you are	60.00%	4.40%	35.60%	61.90%	12.40%	25.80%	4.92*
I'm not interested in driving	47.30%	6.60%	46.20%	32.30%	12.50%	55.20%	5.09*
I can rely on other people to drive me places	73.60%	2.20%	24.20%	54.00%	11.00%	35.00%	10.191***
My friends got their license as soon as possible	41.10%	4.20%	54.70%	58.90%	6.30%	34.70%	7.689**
I don't need a car to get around	58.30%	2.40%	39.30%	31.00%	13.00%	56.00%	16.796***

* 90% confidence interval
** 95% confidence interval
*** 99% confidence interval

Table 3.8: Chi-square analysis of preferred characteristics of residential location (older vs young adults)

	Older adults			Young adults			Chi-square
	Unimportant	**Neither Important nor unimportant**	**Important**	**Unimportant**	**Neither Important nor unimportant**	**Important**	
Having parks and open spaces nearby?	39.40%	20.20%	40.40%	21.60%	7.20%	71.10%	18.891***
Having walking and bicycling trails nearby?	40.60%	16.70%	42.70%	25.80%	15.50%	58.80%	5.702**
Living in a quiet neighborhood?	45.80%	16.70%	37.50%	23.20%	21.20%	55.60%	11.181***
Living in a neighborhood with low level of car traffic on neighborhood streets?	21.30%	20.20%	58.50%	21.60%	9.30%	69.10%	4.73*
Having a safe neighborhood for walking?	25.30%	26.30%	48.40%	13.10%	12.10%	74.70%	14.295***
Having good street lighting in the neighborhood?	16.70%	22.90%	60.40%	10.00%	12.00%	78.00%	7.188**
Having lots of people out and about in the neighborhood?	13.40%	17.50%	69.10%	27.30%	21.20%	51.50%	7.471**
Having lots of interaction among neighbors?	21.90%	16.70%	61.50%	34.30%	25.30%	40.40%	8.651**
Having neighbors with an income level similar to your level?	18.90%	11.60%	69.50%	38.00%	25.00%	37.00%	20.638***
Having an attractive neighborhood in terms of appearance?	18.80%	17.70%	63.50%	42.00%	25.00%	33.00%	19.391***

Having a high level of upkeep in the neighborhood?	16.10%	21.50%	62.40%	30.00%	19.00%	51.00%	5.228*
Having big trees on neighborhood streets?	23.20%	27.40%	49.50%	31.30%	13.10%	55.60%	6.409**
Having a house with a large front yard?	21.10%	17.90%	61.10%	33.00%	21.00%	46.00%	4.869*
Having lots of off-street parking (garages or driveways) in the neighborhood?	18.80%	30.20%	51.00%	35.40%	15.20%	49.50%	9.864***

* 90% confidence interval

** 95% confidence interval

*** 99% confidence interval

Looking into Table 3.7 for specific attitudes and preferences towards driving, the majority of respondents emphasized independence (80.2% of older and 75% of young adults) and status symbols (60% of both cohorts) associated with car use. Although 47.3% of the older adults agreed that they are not interested in driving, the percentage is only 32.3% for the young adults. Similarly, although 58.30% of the older adults agreed that they don't need a car to get around, the percentage is 31% for young adults.

Table 3.8 presents the preferences toward residential characteristics of both cohorts. A general observation is that more young adults prefer parks, open spaces, and walking and biking trails near their residences compared to older adults. Similarly, more than three-fourths of the young adults emphasize safety in the neighborhood while walking and having good street lighting. More of the young adults prefer living in a quiet neighborhood with a low level of car traffic.

On the older hand, compared to young adults, more of the older adults prefer to have lots of people out and in the neighborhood and lots of interactions among the neighbor. Similarly, they also prefer to have an attractive appearing neighborhood, a house with a large front yard, a high level of upkeep among the neighbors, and neighbors with a similar income level. Although there are some differences in each cohort's preferred residential characteristics, half of both generations prefer to have lots of off-street parking (garages or driveways) in the neighborhood.

3.5 Discussion and Conclusion

Following exploratory analysis, this study provides insights into how attitudes towards transportation modes and preferred residential characteristics influence the automobility behavior of older and young adults. Additionally, the objective was to explore whether any difference

exists between older and young adults' regarding attitudes, perceptions and preferences by their automobility use. Using Hamilton, Ontario as a case study, exploratory analysis suggests that marginal differences exist between these two cohorts.

While results demonstrate the importance of the automobile among older adults, auto users in both cohorts show almost similar attitudes towards different transportation modes. Also, non-auto users in both cohorts show similar attitudes. The study findings suggest that although young non-auto users like transit and are positive about walking and biking, their attitudes towards transit and driving indicate future automobile use tendency. A general observation is that positive attitudes towards cars and driving among young adults increases if they have a job or more responsibilities. Young auto users emphasized the instrumental values such a safety, ease, convenience, and flexibility that an automobile offers, and non-auto users aspire to use automobiles in the later stages of their life for the same reasons. For both age groups, non-auto users showed interest in driving, and the older adults who don't drive feel the need for a car more than the young adults. Previously, Moniruzzaman et al. (2015) found that a higher number of auto trips are associated with a lower number of walking trips among older adults in Montreal, Canada. In contrast, in this study, older auto users' mentioned that they prefer to walk and bike rather than driving. However, their actual behavior indicates that their most common mode of transportation is the automobile, indicating a dissonance between older auto users' preference and actual travel behavior, echoing the findings from Lira and Paez (2021).

In terms of preferred characteristics of the residential location, young non-auto users are more likely to prefer to have good transit service within the neighborhood and live within walking distance of shopping areas. In general, older auto users' preferences towards residential characteristics indicate their desire for suburban living in a quiet neighborhood, big trees in the

neighborhood, a high level of upkeep in the neighborhood, neighborhood activity, and easy highway access. For young adults, studies claimed that they are more likely to prefer urban living; however, recent studies showed that after getting a job or family formation, a majority of young adults are leaving urban areas (e.g., Busch-Geertsema and Lanzendorf 2017; Lee 2021). In Hamilton, while exploring the young auto vs non-auto users' preference towards residential characteristics, the study found that preferences among young auto users' include having a high level of upkeep in the neighborhood, a house with a large backyard, lots of off-street parking and easy access to highways – suggestive of a preference for suburban living. This indicates the likelihood of a shift in residential location preference from urban to suburban living, echoing the older age group's preferences, therefore, greater auto dependency among young adults.

Our study also suggests that young adults showed positive attitudes towards auto use and driving regardless of their automobility status. The general observation is that although they are more optimistic about walking and biking than older adults, they also show positive attitudes and preferences towards auto use and driving, similar to older adults. Similarly, in terms of preferred characteristics of the residence, compared to older adults, more of the young adults emphasized the walking and biking conditions near their preferred residences. However, similar to older adults, half of the young adults put importance on having lots of off-street parking in the neighborhood – which again establishes young adults' preference towards auto-oriented lifestyle. The study results also indicated that young adults are more likely to make fewer trips, travel shorter distances for errands, and use online alternatives to avoid travel. Although this study can't specifically suggest that young adults are making a less number of trips and traveling shorter distances, it indicates that even if they make fewer and shorter trips in the future, most of their travel will be conducted by automobiles.

The limitations of study include small sample size, its focus on one city, and its cross-sectional nature. However, to the best of the authors' knowledge, none of the previous studies explored these two age groups' automobility behavior based on the same set of attitude and perception-related variables in the same geographic context. Further, given that the data was collected in the pre-COVID-19 era, it would be interesting to conduct the same study in the post-COVID era to explore whether any changes in attitudes and perceptions towards transportation modes and preferences towards the characteristics of residential location have occurred between different age groups due to COVID-19.

Nevertheless, the findings of the study suggest that young adults' travel behavior is shifting towards an auto-oriented culture. At the same time, they show positive attitudes towards walking and biking. It seems that if they have the options available, most young adults will choose the automobile over other transport modes. On the other hand, older adults are mainly auto-oriented. Transportation policies should consider these changing dynamics of travel behavior among different generations. As attitudes and preferences influence travel behavior to a greater extent, future studies should explore how attitudes and preferences can be modified to promote sustainable travel options. For example, as individuals emphasized the positive attributes of automobiles, policymakers can focus on the detrimental impacts of automobiles such as fuel costs, pollution, etc. and provide disincentives to discourage auto use. Also, to promote sustainable modes of transport, the negative aspects such as lack of accessibility, availability, convenience, longer travel time, etc. should be addressed and improved and promoted among the users through awareness, provision of the facilities and incentives.

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Chapter 4

An Analysis of Automobility Behavior in Hamilton, Ontario

4.1 Introduction

Millennials have become an important target group for promoting sustainable modes of transport, with evidence from several studies suggesting that their travel patterns and transportation preferences differ compared to other generations. Although the start and end points for different generations are somewhat arbitrary, this study considered those who were born between 1980 and 2000 as the millennial generation following the work of Newbold and Scott (2017). Millennials are more likely to bike, walk, and use transit (Brown et al. 2016; Davis et al. 2012; Grimsrud and El-Geneidy 2014; Newbold and Scott 2018) and less likely to drive (McDonald 2015; Kuhnimhof et al. 2012; Klein and Smart 2017) than earlier generations. Studies also found millennials to be multimodal, often owning multiple mobility tools and choosing transportation modes based on their trip purpose and mode preference (Delbosc and Nakanishi 2017; Ralph 2017; Circella et al. 2017, Azimi et al. 2021). Compared to older adults, they also own fewer automobiles, use them less (Klein and Smart 2017; Zhong and Lee 2017), and are less likely to hold a valid driver's license or are more likely to delay obtaining a driver's license (Davis et al. 2012; Hjorthol 2016). On the other hand, older adults (65 years and older) are highly auto-dependent (Scott et al. 2009), and some studies anticipate that they will remain so in the future (Newbold and Scott 2018).

However, this does not necessarily mean that millennials are less auto-oriented as most of those studies were conducted based on data before millennials were in the workforce. Studies

based on more recent data that capture millennials in the labor force indicate that they are not as multimodal and sustainable mode-oriented as anticipated, suggesting that millennials are increasingly becoming auto-oriented and showing travel patterns and choices similar to their preceding generations (Garikapati et al. 2016; Klein and Smart 2017; Krueger et al. 2020; Lee et al. 2020; Newbold and Scott 2017; 2018).

While exploring the reasons underlying why millennials have postponed their adoption of previous generations' travel patterns, studies suggest that millennial's delayed independent lifestyles as the main reason which is characterized by living with their parents in their twenties and thirties, pursuing higher education, entering the full-time workforce later, and delays in forming new households and having children (Polzin 2014; Garikapati et al. 2016; Delbosc and Nakanishi 2017). In addition, millennials' preference for urban living and their exposure to the 2007-08 economic recession are suggested as the main factors behind the decline of their automobility, which may have contributed to differences, compared to older adults, in activity-travel patterns, residential location, and lifestyles (Polzin 2014; Delbosc and Ralph 2017; Pendyala et al. 2019).

One important policy question in the last decade was whether millennials' less-auto-oriented behavior of the past will persist as they age (Wang 2019; Wang and Wang 2021). Recent studies using longitudinal data from North America show that this is not the case, although some changes can be expected (e.g., Ralph 2017; Newbold and Scott 2018; Wang 2019). Although the percentage is still less than their preceding generations, recent studies have found a significant portion of millennials marry at earlier ages, often live in single-family homes, commute alone, live in suburban locations, and rely on personal automobile as their common mode of transport similar to their preceding generations (Circella et al. 2017; Ralph 2017;

Lavieri et al. 2017). In the United States, 30% of the millennials were found to be living with a spouse and child in 2019, whereas the percentage was 40% for Generation X (those born approximately between 1965 and1979), 46% for baby boomers (those born approximately between 1946 and 1964), and 70% for the Greatest Generation (those born before 1946) when they were the age millennials are now (Barroso et al. 2020). Blumenberg et al. (2019) found that although young adults in the United States are more likely to live in urban areas compared to older adults, the number of young adults moving to the suburbs is growing. The researchers concluded that their analysis does not support the hypothesis that young adults are abandoning suburban living for city life, which is supposed to impact their travel behavior in a more sustainable way than that of previous generations.

Studies based on the General Social Survey (GSS) on Time Use in Canada argued that millennials will increasingly have similar automobility profiles to previous generations in terms driver's license possession and number of auto trips (Newbold and Scott 2017; 2018). In their study, Giallonardo (2017) argued that millennials' automobile use patterns could not be explained by socioeconomic and demographic characteristics to the same extent as those of Generation X – suggesting a significant cohort effect or the effect of the overall life experiences, social conditions and circumstances experienced by the millennial generation to define their auto use in the in the Greater Toronto and Hamilton Area.

Using a sample of millennials and older adults in Hamilton, Ontario, this study extends current work by comparing the automobility behavior of millennials and older adults (65 years and older). Automobility behavior is defined according to four attributes related to automobile use: having a valid driver's license, number of automobiles in the household, using automobile as a common mode of transport, and using an automobile as a driver. Hypotheses explored

concern whether the two generations' attitudes and preferences toward transportation modes and residential location characteristics, in addition to their living arrangements and sociodemographic characteristics, affect their automobility behavior and whether any differences exist in how these factors impact each generation's automobility behavior.

4.2 Literature Review: Why do we need a generational lens to explore automobility behavior?

Canadians are aging rapidly. By 2031, nearly one in four Canadians will be 65 years or older (Statistics Canada 2017), indicating the need for policy interventions in different sectors such as transportation, housing, social services, and healthcare. On the other hand, millennials, represent 25% of Canada's population (Statistics Canada 2017). As unique travel behavior traits exist among generations, transportation planners and policymakers must understand how travel behavior will evolve into the future to inform transport infrastructure investment decisions and policy making (Garikapati et al. 2016; Pendyala et al. 2019). Although recent studies claim that the millennial generation's travel patterns might not as distinct from older generations as previously thought, their travel patterns are still expected to be more sustainable compared with those of previous generations. Even focusing only on these two generations (millennials and older adults), the need for generation-specific transportation policy is noticeable. For example, for older adults, provision of age-friendly transportation options is needed to support active ageing, including ensuring their access to health and social facilities and keep them remain engaged within their community. On the other hand, for millennials, measures should be taken to keep them engaged within their current sustainable travel pattern and reduce the likelihood of their increased automobile dependence in future.

In contrast to millennials, the travel behavior of older adults (65 years and older) is characterized by greater automobile use and auto-dependency (Hough et al. 2008), higher rates of holding a driver's license, and limited use of transit (Buehler and Nobis 2010; Newbold and Scott 2017; Fordham et al. 2014, Chudyk et al. 2017). Automobility behavior among older adults is influenced by declining health with aging, with the potential for driving cessation (Siren and Haustein 2013; Moniruzzaman et al. 2013; Yang et al. 2018). The death of a partner also influences older adults' automobility behavior, especially among older females where a change from car to public transit use has been noted (Mollenkopf et al. 2011; Ahern and Hine 2012). However, due to health and safety issues, including driving cessation among older adults, alternatives such as appropriate age-friendly transport infrastructure and services and accessible mobility environments should be available (Mercado et al. 2010; Cui et al. 2017) to avoid mobility loss, social exclusion, and disempowerment (Sheller 2004; O'Hern and Oxley 2015; Pantelaki et al. 2021).

On the other hand, millennials' current travel needs and patterns are seemingly different compared to older generations. However, studies (e.g., Ralph 2017; Busch-Geertsema and Lanzendorf 2017; Newbold and Scott 2018; Wang 2019; Lee et al. 2020) suggest that millennials' sustainable travel behavior will change to a greater extent compared to their current state and will follow (in some cases, already following) the same travel patterns of older generations as they navigate transitions through their life course, such as family formation and job change. For example, Blumenberg et al.'s (2016) study suggested that a change in employment status is a significant factor behind young adults' change in travel behavior. They also stated that although young adults have traveled less distance (in terms of daily person-kilometers of travel) than preceding generations during their early adulthood, we should not

expect them to behave the same at later stages of their lives once they achieve life-course milestones. Wang and Wang (2021) and Wang and Akar (2020) suggested that millennials' life-course milestones have a higher contribution to their driving distances than any other factors. Other studies also suggested that millennials usually follow previous generations' travel patterns when their life-course milestones, such as family formation or extension, residential moves to suburban or exurban areas, rise in income, and change in personal preferences, are achieved (Circella et al. 2017; Delbosc and Nakanishi 2017; Hjorthol 2016; Klein and Smart 2017; Ralph 2017; Newbold and Scott 2018; Wang 2019; Lee et al. 2020). Several studies that adopted the mobility biography (an approach to explore changes in travel behavior over the trajectories of life events) to explore the intersectionality of life course and travel behavior of millennials suggest that life-course milestones and childhood experiences influence millennials' travel behavior (e.g., Konietzka and Neugebauer 2023; Van Acker et al. 2020; Delbosc and Nakanish 2017).

According to Brown et al. (2016), many millennials have stayed, for an extended period, in urban neighborhoods with good transit services during their adulthood, whereas older North Americans grew up under rapid post-World War II industrialization and have spent their lives in a society characterized by automobility and long-distance travel (Coughlin 2009). Most older adults also grew up and currently live in suburban and rural settings where transportation systems are predominantly auto-oriented (Rosenbloom 2012). They prefer to 'age-in-place' (Pruchno 2012) indicating a reluctance to change residential location. In the United States, older adults living in urban areas are unsurprisingly more transit-oriented than their suburban counterparts (Lee et al. 2014), whereas in Canada, even after living in dense neighborhoods, older adults prefer to drive (Turcotte 2012), and driving is likely to remain their primary mode of

transport in the future (Newbold and Scott 2018). The findings of Smart and Klein (2018) suggest that individuals who have been exposed to and used better quality public transportation services during their youth are more likely to maintain sustainable transportation choices during the later stages of their lives. Thus, compared to older adults, millennials are expected to make more sustainable transportation choices in the future.

Millennials have also been exposed to rapid technological evolution while growing up more so than any previous generation – a factor that may have played a distinct role in shaping the cohort's lifestyle, preferences, values, and attitudes (McDonald 2015). Millennials are more technology-oriented than older generations, including their greater use of technology-induced transport support solutions such as smartphone apps and ride-sharing options (e.g., Uber, Lyft) (Alemi et al. 2018; Circella et al. 2017; Lee et al. 2020; Wang and Akar 2020; Jamal and Habib 2020; Jamal et al. 2021). In recent years, studies found that the use of information and communications technologies (ICT) is an important factor in shaping millennials' travel behavior (Hong and McArthur 2019; Wang and Wang 2021).

A substantial portion of the millennial cohort is already in the workforce, and others will enter soon. As they make up the largest living age cohort in North America (22% and 25% in the United States and Canada, respectively), their travel behavior will have a large impact on future transportation options, related facilities, services, and infrastructure, and therefore, travel demand (Myers 2016; Circella et al. 2017). On the other hand, older adults are retiring, and their trip patterns mostly consist of non-work trips. Alemi et al. (2018) found that differences exist between millennials' and previous generations' travel behavior, and this difference is also noticeable when they analyzed the generational cohorts by urban and non-urban residency. The findings of Wang and Akar (2020) suggested that millennial automobility behavior is strongly

associated with residential location choice and life-cycle events rather than an increase in wealth and income like older generations.

After an extensive review of the current literature on millennials and older adults' travel behavior, Jamal and Newbold (2020) concluded that differences exist between these two generations' lifestyles, living arrangements, residential locations, and attitudes and preferences toward transportation modes and the environment, which, consequently, have the potential to differentially impact their travel behaviors. Thus, it is important to develop an understanding of the travel behaviors among different generational cohorts and quantify their impact on current and future travel demand from diverse policy perspectives such as transportation infrastructure development, urban form interventions, provision of age-friendly transport options, transport facilities in residential locations, and promotion of e-commute and shared mobility options from congestion and environmental perspectives.

Although a large literature has explored millennial and older adults' travel behavior separately, several gaps exist. First, in terms of attitudes and preferences towards transport options, studies on young adults have emphasized attitudinal questions (e.g., attitudes towards automobile, environment, etc.), whereas, for older adults, studies mostly considered how their perception and experiences with different travel options influence their travel behavior (Jamal and Newbold 2020). Based on the available literature, it is difficult to understand different generations' travel behavior based on the same attitudinal determinants, as different studies considered different variables for different generations.

Second, although the role of sociodemographic attributes are widely recognized within the transportation literature, there is a paucity of research concerning how living arrangements, attitudes, and preferences influence travel behavior. To date, most studies have used household

travel surveys that rarely capture living arrangements, the roles of attitudes and preferences towards transportation options and preferred residential location characteristics. Only a limited number of available studies suggest significant impact of lifestyles and living arrangements on older adults' and millennials' travel behavior (e.g., Ahern and Hine 2012; Moniruzzaman et al. 2013; McDonald 2015; Brown et al. 2016).

Third, most previous studies focused either on millennials/young adults' or older adults' travel behavior. Only a few studies explored generational differences in the same geographic and temporal contexts (e.g., Circella et al. 2017; Newbold and Scott 2018; Wang 2019; Wang and Akar 2020; Wang and Wang 2021) – however, their focus was at the national level, not the city or local level. Although such studies were conducted in developed countries, geographic contexts can differ locally in terms of demographic composition and land-use patterns. Even available transport options and infrastructure can differ from one area to the next, influencing the residents' travel behaviors differently (Krueger et al. 2020). Therefore, context-specific research is needed to develop more relevant insights into the travel behavior of any geographic location and formulate appropriate policy.

This study addresses these gaps by simultaneously focusing on millennials and older adults and how different factors may impact their automobility behavior differently. First, the study contributes to the literature through a survey designed to capture millennials' and older adults' automobility behavior based on the same attributes using Hamilton, Ontario as a context. Second, along with sociodemographic characteristics, the study explores the role of living arrangements, attitudes and preferences towards transportation options, and residential location characteristics to explore these two generations' automobility behavior.

4.3 Study Area, Data, and Method

Hamilton, with a 2021 population of 569,353 and a land area of 1,117 square kilometers (Statistics Canada 2022), is located at the western end of Lake Ontario. Based on the 2016 census, millennials composed 25% of the city's population while 18% of Hamiltonians were 65 years and older (older adults) with an additional 6% between 60 and 64 years old (Statistics Canada 2017), indicating that in 2020, approximately 24% of the city's population would be 65 years and older. These statistics suggest that nearly similar numbers of millennials and older adults reside in Hamilton. As both cohorts represent a similar percentage of the population in Hamilton, a similar number of respondents were recruited from each cohort when the survey was administered by Dynata Research[1] between October and November 2019. Dynata uses a survey panel consisting of individuals (i.e., survey panelists) willing to participate in surveys on topics in exchange for incentives. The surveys are invitation only and a sample based on a client's criteria, closely matched to the recent census and social benchmark of the geographic area considered (Dynata n.d.), is delivered. Although there is a possibility of low generalizability, this type of sampling offers time savings and less uncertainty in data collection, and experienced survey respondents who are usually familiar with different survey formats and questions (Abotalebi et al. 2020). The panel nature of convenience samples is also useful in terms of testing social and scientific theories and formulating hypotheses for future studies (Coppock and McClellan 2019).

For a sample of 100 millennials and 100 older adults (aged 65+) living in Hamilton, the survey collected information on travel characteristics, sociodemographic characteristics, living arrangements, level of technology use, lifestyle preferences, and attitudes toward transportation

[1] https://www.dynata.com/

options. Sociodemographic characteristics included age, sex, income, education, employment, and marital status. A range of automobility behavior-related questions were collected – namely, household automobile ownership, automobile usage as a driver or passenger, driver's license possession, medical conditions restricting driving, and frequency of driving. The survey also asked respondents about their most frequently used transport mode and frequency of using public transit and shared mobility services (e.g., ride sharing, car sharing). Lifestyle preferences and attitudinal questions gathered individuals' attitudes towards transportation choices (e.g., automobile, transit, active modes) for their typical weekday trips, why and when different modes are used and why they are not used. A total of 27 lifestyle and transportation mode-related attitudinal and preference-based questions were asked on a 3-point Likert scale: Agree - Neither agree nor disagree - Disagree.

Additionally, the survey contained 12 statements concerning attitudes and preferences toward driving using the same Likert scale. The survey collected information on reasons for residential location choice (13 statements) and preferred characteristics of the residential location (28 statements). A more detailed analysis of the attitudes and preferences toward transportation modes and residential location characteristics is available in the study by Jamal et al. (2022).

Table 4.1 presents sociodemographic profiles of the survey respondents, according to generation. In terms of sex ratio, 55% of sampled millennials and 41% of sampled older adults were male whereas, the male-female ratio of Hamilton's population in 2016 was 51:49 and 44:56 for millennials and older adults, respectively (Statistics Canada 2017). A comparison of demographic characteristics and driver's license possession between the sample and 2016's Transportation Tomorrow Survey[2] is provided by Jamal et al. (2022) and concludes that the

[2] A regional household travel survey conducted in the Greater Toronto and Hamilton Area every five years, coinciding with the Canadian census.

Hamilton sample is reasonably representative of Greater Toronto and Hamilton Area's millennials and older adults in terms of sex, student status, employment, and drivers' license possession. As shown in Table 4.1, millennial respondents are mostly students and employed compared to older adults who are mostly retired. Sixty-five percent of millennials were single at the time of the survey. Forty-four percent of older adults lived alone, whereas almost one-third (34%) of millennials lived with their parents. A higher number of millennials (19%) lived with roommates or similarly aged people compared to older adults (2%). Similar proportions of millennials (83%) and older adults (79%) held valid driver's licenses. Almost the same proportion of individuals from both cohorts used automobiles as their common mode of transport in 2018, the previous year of the survey (63% millennials and 66% older adults), and were drivers (69% millennials and 70% older adults). The average number of automobiles was higher for households with millennials (1.94) compared to older adults (1.13).

Table 4.1: Sociodemographic profiles of millennials and older adults

	Millennials (n = 100)	**Older Adults (n = 100)**
Sex		
Male	55	41
Female	45	59
Student Status (yes)	33	4
Employed (yes)	73	7
Retired (yes)	0	89
Marital Status		
Married/Living common-law	31	45
Widowed/Separated/Divorced	3	45
Single (never married)	65	6
Prefer not to answer	1	4
Living Arrangement		
Alone	9	44
With parents	34	1
With partner/spouse	18	33
Living with partner/spouse and children	15	4

Living with children	4	6
Living with roommates/similar age people	19	2
Prefer not to answer	1	10
Valid driver's license[*] (yes)	83	79
Most common mode of transportation in 2018		
Automobile	63	66
Other mode	37	34
Using automobile as a driver (yes)	69	70
Number of automobiles in the household		
0	18	21
1	17	51
2	33	22
3	17	06
4	15	0
Average number of automobiles in the household	1.94	1.13

[*] This includes graduated driver's licenses where an individual is permitted to drive alone with some restrictions, e.g. zero blood alcohol level. – General Social Survey 2011, Cycle 24

To develop a nuanced understanding of factors influencing automobility behavior, binomial and ordinal logistic regressions were used to reveal factors affecting the automobility behavior of millennials and older adults. We tested all relevant variables collected in the survey (e.g., sociodemographic characteristics, trip attributes, living arrangements, attitudes, preferences, etc.) as to their relationships to the dependent variables. A series of interaction effects between cohort (millennials) and selected independent variables were also tested. The interaction variables were used in the models to reveal whether living arrangements, attitudes, and preferences impact differently the automobility behavior of millennials and older adults. Variables included in the final models were statistically significant (10% significance level), except for a few that were retained as their cohort interactions significantly impacted the dependent variable in question, offering valuable insights regarding cohort effects. A Variance Inflation Factor (VIF) test was conducted for all models to check the magnitude of multicollinearity among the predictors. Only predictors with VIF values up to five were considered.

Binomial logistic regression models explored factors associated with having a valid driver's license, using automobile as a common mode of transport, and using an automobile as a driver. Ordinal logistic regression was used to explore the covariates associated with the number of automobiles in the household. Factors examined included living arrangements, travel-related attributes, attitudes and preference toward transport options and residential characteristics, and sociodemographic characteristics.

4.4 Results

Table 4.2 reports the binomial logistic regression results for having a valid driver's license. Regardless of generation, those who self-rated their health as 'very good or excellent' have a higher likelihood of holding a valid driver's license. Also, those who self-rated their technology adoption as 'high' are more likely to possess a valid driver's license. Auto users are more likely to have a valid driver's license compared to non-auto users, and a higher number of vehicles in the household increases the likelihood of holding a valid driver's license.

Regarding attitudinal variables, regardless of generation, those who prefer to walk rather than drive whenever possible are less likely to hold a valid driver's license whereas those who agreed that they like driving are more likely to hold a valid driver's license.

In terms of cohort interaction, the results indicate that among millennials, those who agreed that they prefer to walk rather than drive whenever possible are most likely to hold a valid driver's license, and millennials who did not agree with the statement are least likely to hold a valid driver's license. On the other hand, older adults who agreed with the statement have the lowest likelihood of holding a valid driver's license compared to older adults who disagreed and millennials in general. Millennials who disagreed that they like driving have the lowest

propensity to hold a valid driver's license whereas older adults who agreed with the statement have the highest likelihood of holding a valid driver's license.

Table 4.2: Binomial logistic regression analysis of having a valid driver's license

Variables	Coefficient	P-value	Odds ratio
Intercept	-2.490	0.005	0.083
Sociodemographic characteristics			
Millennial	-1.531	0.280	0.216
Self-rated health (very good/excellent)	1.288	0.042	3.626
Self-rated level of technology/smart device adoption (high)	2.418	0.014	11.219
Travel related attributes			
Most common mode of transportation (automobile)	3.390	0.000	29.674
Number of vehicles in the household	0.906	0.010	2.473
Attitudes toward transportation modes and preference toward the residential location			
I prefer to walk rather than drive whenever possible (agree)	-1.788	0.057	0.167
Millennials × I prefer to walk rather than drive whenever possible (agree)	4.369	0.004	78.954
I like driving (agree)	2.926	0.002	18.644
Millennials × I like driving (agree)	-2.503	0.066	0.082
McFadden pseudo-*R-squared*	0.604		
AIC	98.358		
Number of observations	200		

The number of automobiles in the household was modeled using ordinal logistic regression, with results presented in Table 4.3. In contrast to the available literature, millennial households are more likely to have more automobiles than older adults. Also, student status is positively associated with number of automobiles in the household. Households with more adults (above 16 years) are more likely to have a higher number of automobiles. Low-income households of both generations are more likely to have fewer automobiles than higher-income households. Individuals who primarily use the auto for their daily trips are more likely to reside in households with more automobiles than those who do not use automobiles regularly.

Regardless of generation, households of those who mentioned that they need a car to do many things are more likely to have a greater number of automobiles.

In terms of cohort interactions with living arrangements, households of millennials living with a partner/spouse have fewer automobiles compared to millennials not living with a partner/spouse. In fact, households of millennials who are not living with a partner/spouse have the highest propensity of having a higher number of automobiles compared to all other households. Focusing only on older adults, results suggest that those with a partner/spouse are more likely to have a higher number of automobiles in their household compared to older adults living without a partner/spouse.

In terms of dwelling type, millennials living in apartments have fewer automobiles in their households compared with millennials who live in other types of dwelling. In terms of effect size, millennials living in other types of dwellings have the highest propensity to have a higher number of automobiles in their household among all other groups. Among the households of older adults, those who live in other types of dwellings are more likely to have more automobiles compared with those who live in apartments.

In terms of cohort interactions with attitudinal statements, millennials who did not agree that it is easy to use public transit where they live have the highest propensity to have a higher number of automobiles in their household compared with millennials who mentioned the opposite and older adults in general. Focusing on the households of older adults, those who agreed with the statement have fewer automobiles compared to those who did not agree that it is easier to use public transport from their residence.

Table 4.3: Ordinal logistic regression model of the number of automobiles in the households

Variables	Coefficient	P-value	Odds ratio
Sociodemographic characteristics			
Millennials	2.269	0.000	10.836
Household income (no income or less than CAD 40,000)	-1.022	0.010	0.340
Student (full time)	1.916	0.007	6.885
Number of adults (above 16 years old) in the household	0.667	0.000	1.900
Living with a partner/spouse	0.508	0.233	1.554
Millennials × Living with a partner/spouse	-1.554	0.026	0.210
Living in an apartment	-0.557	0.200	0.602
Millennials × Living in an apartment	-1.316	0.051	0.246
Travel related attributes			
Common mode of transportation (automobile)	1.525	0.000	4.043
Attitudes toward transportation modes and preference toward the residential location			
I need a car to do many things I like to do (agree)	0.900	0.027	2.683
It is easy to use public transport where I live (agree)	-0.090	0.844	0.943
Millennials × It is easy to use public transport where I live (agree)	-1.257	0.046	0.255
Threshold coefficients:			
0|1	0.937	0.049	2.398
1|2	3.519	0.000	30.782
2|3	5.798	0.000	291.390
3|4	7.551	0.000	1622.246
Log-likelihood (null)	-298.342 (df=4)		
Log-likelihood	-209.9732 (df=16)		
AIC	451.9465		
Number of observations	200		

Table 4.4 shows the results of the binomial logistic regression for auto use. The dependent variable is using an automobile as the most common mode of transport in the past year (in 2018). Results suggest that females are less likely to use an automobile compared to males, regardless of generation. Those who do not have an automobile in their household are, not surprisingly, less likely to use automobiles. On the other hand, those living alone are more likely to use automobiles than those in multi-person households where other transport options, including automobiles, would more likely be available. Similarly, those who hold a valid driver's

license and do not use public transit at all are more likely to use the auto as their most common mode of transport.

In terms of attitudes, those who are not interested in driving are less likely to use auto as their common mode of transport. Surprisingly, those who stated that they prefer to walk rather than drive are more likely to be auto-users, although this may reflect a decision based on trip distance.

Turning to cohort interactions with attitudinal factors, millennials who agreed that taking public transport, walking, and cycling meet their travel needs, have the lowest likelihood to use an automobile as the most common mode of transport compared to older adults in general and millennials who disagreed with the statement. Although older adults who agreed with taking public transport, walking, and cycling to meet their travel needs have a higher likelihood of using the automobile compared to older adults who disagreed, the effect size is lower compared to that of millennials (-1.722 vs -4.413, respectively). Regarding preferred characteristics of residential location, millennials preferring to live in neighborhoods with lots of off-street parking (garages or driveways) are more likely to use the automobile as a common mode of transport compared to millennials not agreeing with the statement, and older adults. On the other hand, older adults who did not agree with the statement have the lowest propensity to use the automobile as a common mode of transport compared to those who agreed and millennials.

Table 4.4: Binomial logistic regression analysis of automobile use (dependent variable = most common mode of transportation in 2018: automobile)

Variables	**Coefficient**	**P-value**	**Odds ratio**
Intercept	-1.755	0.151	0.173
Sociodemographic characteristics			
Millennials	0.008	0.993	1.008

Sex (female)	-2.204	0.000	0.110
Living alone	1.218	0.077	3.380
Travel related attributes			
No/zero vehicle in the household	-2.15	0.016	0.116
Valid driver's license possession	2.544	0.002	12.733
Transit use (not at all)	1.965	0.001	7.138
Attitudes toward transportation modes and preference toward residential location			
I prefer to walk rather than drive whenever possible (agree)	1.263	0.016	3.537
I'm not interested in driving (agree)	-2.595	0.003	0.075
Taking public transport, walking and cycling meet my travel needs (agree)	0.033	0.972	1.033
Millennials × Taking public transport, walking and cycling meet my travel needs (agree)	-2.699	0.021	0.068
I prefer to have lots of off-street parking (garages or driveways) in the neighborhood (agree)	0.397	0.567	1.487
Millennials × I prefer to have lots of off-street parking (garages or driveways) in the neighborhood (agree)	1.854	0.081	6.386
McFadden pseudo-*R-squared*	0.563		
AIC	140.49		
Number of observations	200		

Table 4.5 highlights the correlates of using the automobile as a driver as opposed to being a passenger. Regardless of generation, those who live alone are more likely to be drivers while traveling by automobile. Similarly, those who do not use transit at all are more likely to be a driver. On the other hand, low-income individuals and females are less likely to be a driver. Regardless of generation, living in an apartment is negatively associated with being a driver while traveling.

In terms of attitudes, those not interested in driving are less likely to be drivers while using an automobile for travel. Similarly, those who mentioned that they do not need a car to fulfill their travel needs are less likely to be drivers. Also, those who emphasized that closeness to public transit is important to them while selecting residential location are less likely to be drivers.

Regarding cohort effects on attitudes, millennials and older adults who cannot rely on other people to drive them places have higher likelihoods of using an automobile as drivers, with millennials who disagree with the statement having the greatest propensity to be a driver. In terms of preferred residential characteristics, millennials who prefer to have lots of off-street parking (garages or driveways) in the neighborhood have the greatest propensity to be a driver compared to millennials who prefer the opposite, and older adults.

Table 4.5: Binomial logistic regression analysis of using the automobile as a driver

Variables	**Coefficient**	**P-value**	**Odds ratio**
Intercept	6.028	0.000	415.021
Sociodemographic characteristics			
Millennials	1.108	0.348	3.029
Household income (no income or less than CAD 40,000)	-2.566	0.004	0.077
Sex (female)	-5.236	0.000	0.005
Living alone	3.622	0.000	37.41
Living in apartment	-1.118	0.087	0.327
Travel related attributes			
Transit use (not at all)	1.169	0.077	3.219
Attitudes toward transportation modes and preference toward residential location			
I'm not interested in driving (agree)	-3.671	0.000	0.025
I don't need a car to get around (agree)	-4.100	0.000	0.017
Closeness to public transit is important to me while selecting residential location (agree)	-1.601	0.011	0.202
I can rely on other people to drive me places (agree)	-0.791	0.315	0.453
Millennials × I can rely on other people to drive me places (agree)	-3.224	0.022	0.040
I prefer to have lots of off-street parking (garages or driveways) in the neighborhood (agree)	1.200	0.138	3.321
Millennials × I prefer to have lots of off-street parking (garages or driveways) in the neighborhood (agree)	1.985	0.099	7.728
McFadden pseudo-*R-squared*	0.657		
AIC	113.08		
Number of observations	200		

4.5 Discussion, Limitations, and Conclusion

4.5.1 Discussion

Exploring travel behavior through a generational lens can help transportation planners and policymakers make informed decisions about infrastructure and services such as investing in age-friendly transportation infrastructure and programs, providing active transportation, expanding public transportation networks, or initiating affordable transit policies. This study explored hypotheses related to whether millennials' and older adults' attitudes and preferences toward transportation modes and residential location characteristics, in addition to their living arrangements and sociodemographic characteristics, affect their automobility behavior and whether any differences exist in how these factors affect each generation's automobility behavior.

The results of this work raise several generation-specific hypotheses and questions that need further testing with larger data sets and in different contexts. First, does sex and generational differences in living arrangements impact automobility behavior? Our results suggest that females are less likely to be auto-oriented than their male counterparts. Similarly, living arrangements (i.e., living alone or with a partner or living in an apartment) appear to impact the number of automobiles in households, automobile use as a common mode of transportation and using automobile as a driver. Both predictors could be associated with the ability to access and share different mobility tools along with the geographic location of the household relative to public transit.

Second, does life-cycle stage impact automobility behavior? One of the results that differs from previous studies is that students and millennials are more likely to reside in households with a higher number of automobiles than older adults. A possible reason could be that because of their delayed life-cycle and economic conditions, many of today's millennials are

still living with their parents (Delbosc and Nakanishi 2017). In this study, 34% of the millennials were living with their parents. Therefore, the number of automobiles in the households may be reflective of living with their parents. We also found that the number of adults living in households is positively related to the number of automobiles in the households and the descriptive analysis suggests that the average number of automobiles is higher in households with millennials compared with older adults. When millennials form a household and start living separately from their parents, they might be less likely to have automobiles or drive less (Polzin 2014; Garikapatu et al. 2016; Delbosc and Ralph 2017, De Vos and Alemi 2020). Our study supports this, with the results suggesting that millennials who live with a partner/spouse and are living in apartments are likely to reside in a household with fewer automobiles whereas millennials living without a partner/spouse and living in other types of dwellings (except apartments) have the highest propensity to reside in a household with a higher number of automobiles.

Third, how important are attitudes and preferences toward transportation modes and residential location characteristics as an influence on automobility behavior? Similarly, is there a difference in how they influence each generation's automobility behavior? Our results suggest that there is an association between automobility behavior with attitudes and preferences towards transportation modes and locational characteristics and also there is a difference in their extent of impact (i.e. positive/ negative association). For example, attitudes and preferences towards sustainable travel behavior (e.g., "I prefer to walk rather than drive whenever possible", "I'm not interested in driving", "Taking public transport, walking and cycling meet my travel needs", "I don't need a car to get around", "Closeness to public transit is important to me while selecting

residential location") may differentially influence both generations. Millennials' positive attitudes and preferences toward sustainable travel behavior and living near transit influence them to be less auto-oriented compared to older adults. On the other hand, the preference towards off-street parking expressed by millennials in their residential neighborhood is likely to increase their auto-dependency compared to older adults.

Similarly, does each generation show similar automobility behavior based on the same attitudes and preferences? Results of the cohort interactions show that older adults who disagreed that they like driving are more likely to hold a valid driver's license compared to millennials. Also, older adults who agreed that taking public transport, walking, and cycling meet their travel needs are more likely to use an automobile as a common transportation mode compared to millennials who agreed with the statement and older adults who disagreed. For the number of automobiles in the household, older adults who agreed with the statement have fewer automobiles compared with millennials who agreed with the statement. These counterintuitive findings suggest that depending on the attitudes and preferences, there is a group of older adults who are more mobile and multimodal compared to other groups and in addition to automobiles, they use non-automobile modes. The possible underlying reasons could be unavailability or unaffordability of an automobile to older adults (Nobis 2007), preference towards being multimodal, or preferring modes that are accessible and suit the travel purpose.

Overall, the study results suggest that compared to older adults, millennials' interactions with living arrangements, attitudes, and preferences influence automobility behavior to a greater extent – meaning that millennials' automobility behavior is more likely to be influenced by their living arrangement, attitudes towards transportation modes, and preferences towards locational

characteristics supporting standpoints of McDonald (2015), Giallonardo (2017), Jamal and Newbold (2020), Wang and Akar (2020), and Konietzka and Neugebauer (2023).

Fourth, are there differences between personal preferences and actual behavior regarding automobility behavior of both cohorts? The results suggest that millennials who did not agree with the statement that they prefer walking over driving have a higher likelihood of not holding a valid driver's license. On the other hand, regardless of generation, those who agreed with the statement show a higher likelihood of using automobiles as a common mode of transportation. Although we cannot explain this mismatch specifically in our context, De Vos (2018) suggested four possible reasons behind the mismatch between the preferred transport mode and actual transport modes choice such as a lack of skills to use the preferred mode, a lack of transportation options, the presence of transportation barriers, and the presence of travel habits with certain modes. On the other hand, Sheller (2004, p. 22) suggests that despite being aware of the environmental and health benefits of sustainable transportation options (e.g., transit, cycle, walk, etc.), "too many people find automobiles too comfortable, enjoyable, exciting, even enthralling." The underlying reason is that the automobile has been deeply embedded in developed countries and reinforced by physical structure, specifically road networks and living environments, along with gender roles, family formation, urbanism, national identity, and transnational processes (Sheller 2004).

Based on the study, we can suggest that although there are several similarities in how different factors affect the automobility behavior of millennials and older adults, there are also differences between and within the effects. As noted by Sheller (2004), 'auto culture' or 'auto dependency' is a complex outcome of housing conditions, engagement in labor markets,

changing patterns of gender role and family formation, and the place of transportation in values, perceptions, preferences, and attitudes that form a strong emotional component. Similarly, our analysis suggests that depending on their living arrangements, attitudes, and preferences, each generation's automobility behavior can differ from one another.

Based on our investigation, we can conclude that millennials in Hamilton are not less auto-oriented than older adults. Millennials living with parents may have access to their family-owned or leased automobiles compared to those who are living alone. In our study, 65% of the millennials are single and 34% are living with their parents. In Canada, 34.7% of millennials live with their parents (Statistics Canada 2017). In future, automobility behavior may be further complicated by higher education, recession and COVID-19. Many older millennials started their careers during the Great Recession of 2008 to 2009, facing severe employment and a housing market crisis (Delbosc and Ralph 2017; Mawhorter 2017). Since 2020, younger millennials are facing economic instability due to COVID-19 and another housing market crisis. According to a recent report by Statistics Canada (2020), millennials are facing higher consumption expenditures than preceding generations due to high housing and utility costs. The report also stated that during COVID-19, employment rates among millennials fell more sharply compared to older generations in service-producing industries as millennials tend to comprise a higher share of the workforce in those industries. In addition, millennials will soon no longer be in the 'young adults' category and may be moving out of high-density urban neighborhoods after achieving life-course milestones (Wang and Akar 2020) – which is also uncertain for millennials in Hamilton due to the sudden price escalation in the housing market during the COVID-19 period (The Financial Post 2020; The Hamilton Spectator 2021). Eventually, these events will

impact their behavior both as a consumer in the economy and commuter along with discretionary travel. Their automobility behavior may change in the future again depending on other factors as well. Although further exploration with larger samples is needed, results of our study suggest that millennials' automobility behavior depends on their sociodemographic, living arrangement, and attitudes towards travel and locational preferences. Even if we assume that their attitudes and preferences will remain the same in the future, they may become more auto-oriented compared to now due to changes in their sociodemographic and living arrangements. Therefore, planners and policymakers should take initiatives to help them make more informed decisions on sustainable mode choices by providing information, incentives, appropriate infrastructure, and accessible services.

4.5.2 Limitations

The study is limited methodologically by its small sample size and cross-sectional nature, with the need to explore millennials' and older adults' travel behavior based on a larger and multi-year dataset. The sample size restricts the study's potential to explore millennials' and older adults' travel behavior by applying advanced analytical methods such as structural equation modeling (SEM) to explore the interrelationships among the four automobility characteristics. To be specific, due to the sample size, the study was unable to explore the interrelationships among the outcome variables such as possession of a valid driver's license, using an automobile as a common mode of transport, using an automobile as a common mode of transport and using an automobile as a driver along with the predictor variables that impact the outcome variables. SEM may offer a more complex relationship as driver's license may mediate a household's auto ownership and individuals' use of automobile as drivers.

Second, in terms of the questionnaire, we used a 3-point Likert scale to capture attitudinal and preference-related variables. Our intention was to use them as predictor variables and therefore, we collapsed them and used them as dummy variables in our models for ease of interpretation. If ordinal variables are to be used as dependent variables or latent constructs in SEM models, it is recommended to use 7-point Likert scale for reliable results (Taherdoost 2019).

Third, the study focused on subjective measurements as predictor variables such as attitudes and preferences toward transportation modes and residential location characteristics. Although the survey asked for postal codes, it was optional to respond. Twenty-five percent of respondents did not share their postal codes. As a result, objective measurements such as built-environment-related characteristics and accessibility characteristics were excluded from the analysis given the lack of geographic detail for a significant portion of the respondents.

Fourth, the survey collected information on the number of automobiles in the household. It did not ask who owns the automobile. If we had specific information on whether a millennial or an older adult owned an automobile, we would be able to explore whether millennials' ownership of automobiles is different or similar to that of older adults. Also, this information would allow us to more explicitly identify whether millennials residing in households with a higher number of automobiles are reflective of their parents' ownership of automobiles.

Finally, the survey was conducted in the pre-COVID-19 era. The COVID-19 pandemic may have two significant impacts on automobility. First, the pandemic prompted changes in living arrangements, with millennials either delaying moves or returning to live with their parents. Second, many individuals shifted towards technology-oriented substitutes and telework,

which impacted travel behaviors. Research has suggested that individuals are shifting towards personal modes of transport (e.g., auto, bicycle, walk) and avoiding transportation modes that need to be shared with others (e.g., transit, ride sharing) due COVID-19 (e.g., Bucsky 2020; Hensher et al. 2021). Based on their data from 2020 in the United States, Barbour et al. (2021) found that older respondents (above 50 years old) are less likely to telework during the pandemic. In contrast, young adults (below 30 years old) showed a heterogeneous behavior towards telework and willingness to continue teleworking in the post-pandemic period depending on their nationality (American born vs others), number of children in the household, and residential location (Barbour et al. 2021). A future research direction could be to assess the impact of COVID-19 on the travel behavior of different generations in Canada and whether any heterogeneity in travel behavior has been generated within and between generations due to COVID-19.

4.5.3 Conclusion

This study highlights intergenerational differences in automobility among millennials and older adults using Hamilton, Ontario, as a case study. Being Canada's 9th and Ontario's 3rd largest city based on population, Hamilton itself can represent many North American metropolitan areas with similar population, land area, climate, land-use patterns, etc. However, each city has distinct characteristics in terms of its socio-cultural, ethnic diversity and geo-political situation along with housing stock and housing markets that can shape travel patterns differently. Also, due to limited sample and panel-based data, results from this study may not be applicable to cities with similar characteristics. Therefore, results of this study should be interpreted with caution in different locations and should be tested further with larger samples.

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Chapter 5

Developing a Typology of Daily Travelers based on Transportation Attitudes

5.1 Introduction

It is widely recognized that millennials' (born approximately between 1980-2000) travel behavior is different from that of preceding generations. Some studies suggest that millennials are more inclined toward using public transit and active transportation modes (Wang, 2019; Grimal, 2020). Alternatively, other studies have argued that millennials will follow similar travel behavior (i.e., car-oriented travel behavior) of preceding generations as they age, enter the job market, and start families (Agarwal, 2017). However, millennials are not a homogenous group, with differences in when families are started, where they live, and how they commute (Lee et al., 2020). Likewise, older adults (65+ years) are also heterogenous in their transportation behavior, particularly in terms of public transit use and walking (Scott et al., 2009; Haustein, 2012; Habib, 2015; Böcker et al., 2017).

Heterogeneity exists within each generation, and it not only depends on sociodemographic characteristics, but also on travelers' attitudes, preferences, and perceptions (Siren and Haustein, 2013; Delbosc and Nakanishi, 2017). In terms of policy implications, different travelers should be treated in different ways as they are motivated by different factors, and thus, policies will affect them differently (Anable, 2005). For example, among carless households, there might be two groups – those who are carless by choice and those who cannot

afford a car. Policies related to a reduction in car prices and car-oriented infrastructure development will encourage the latter group towards car ownership more than the former.

Therefore, there is a need to better understand how travel behavior can vary between sociodemographic groups – more specifically, how to segment daily travelers into certain categories for targeted policies and to examine their implications. Consequently, this study aims to develop a typology of travelers in Hamilton, Ontario focusing on millennials and older adults. Latent class analysis (LCA) is used to develop this typology of daily travelers. First, the relative probabilities of attitudes and perceptions toward transportation modes are used to define different travel types/groups. Second, the effects of sociodemographic and trip attributes on the likelihood of belonging to these traveler groups are analyzed.

5.2 Literature Review: Why is an attitude-based typology of daily travelers needed?

Over the last 30 years, the most prevailing approach to segmenting or categorizing daily travelers was to divide them into two groups by different transportation modes – 'captive' and 'choice,' which has been widely accepted and used in the academic literature and professional planning agencies (Jacques et al., 2013). According to the accepted definitions, choice users decide to use a transportation mode when they view that option as superior to other options, whereas captive users are assumed to have only one travel option because of the absence of alternative options, vehicle unavailability, scheduling limitations, aging, disability, income, and other personal circumstances (Beimborn et al., 2003; Srinivasan et al., 2007). In terms of transit, choice riders are the sensitive group whose mode choice may change depending on negative changes in transit services such as service cuts, addition of more stops, and longer travel and wait

times (Krizek and El-Geneidy, 2007). On the other hand, access to a vehicle or an increase in affordability may enable captive transit users to choose another mode (Krizek and El-Geneidy, 2007).

Although this segmentation approach treats captive and choice users as distinct categories, certain transportation users may not fit under either of these categories or may overlap the categories. For example, there may be individuals who live in a place with good transit connectivity and accessibility and show positive attitudes toward sustainable transportation modes than cars in terms of environmental perspectives, but still use cars as their common mode of transportation because they are used to them or would not consider using transit because they value the independence and convenience associated with the car more than any other aspects (Hoffmann et al., 2020). Also, the transportation mode captivity may vary depending on context. Mode captivity is assumed as a binary choice (e.g., car captive (yes/no); transit captive (yes/no)) whereas, in a multimodal transportation system, the extent of captivity is rather difficult to quantify as an individual may either be captive or choice user of a particular transportation mode depending on their travel purpose and subjective or psychological constructs such as attitudes, habit, and inertia (Verplanken et al., 1997; Srinivasan et al., 2007).

Psychological factors associated with different transportation modes such as attitudes, perceptions, and values have been recognized as important covariates of travel behavior (Kuppam et al., 1999; Kroesen and Chorus, 2018; Ton et al., 2020). The theoretical framework behind this understanding is based on the Theory of Planned Behavior (Ajzen, 1991), which assumes that behavior is codetermined by individuals' attitudes, intentions, and perceived behavioral control (perception of ease or difficulty of performing the behavior) (Elliott et al.,

2007). In terms of travel behavior, studies indicated that individuals adapt their travel behavior based on their attitudes, perceptions, and preferences (Anable, 2005; Bohte et al., 2009; Gehlert et al., 2013; Spears et al., 2013). It is also evident that attitudes, perceptions, and preferences have a higher impact on travel behavior compared to characteristics of the built environment (Handy et al., 2005; Jamal and Habib, 2020).

Studies have shown that transport-related attitudes and perceptions are formed by individuals' experiences with different modes at different life stages along with the impact of gender, peer pressure, cultural background, and societal norms (Davies et al., 1997; Ward et al., 2013; Spotswood et al., 2015). Past behaviors and habits also form attitudes and thus, can influence current and future travel behavior. For example, the study by Fu and Juan (2017) found that positive experiences associated with the use of public transit form pro-transit attitudes and thus increase individuals' likelihood of using transit more frequently. Studies also suggest that car ownership can be reduced if car owners can be convinced to use public transit, although this will depend on whether car owners see public transit as an attractive alternative to driving and form positive attitudes toward using transit (e.g., Brown et al., 2003; Thøgersen, 2006). Muromachi (2017) explored the impact of transportation modes used for school travel on university graduates' intention to buy a car in the future and found that experiences of using bicycling and public transit significantly impact university graduates' car purchase intentions. Underwood et al. (2014) explored the effect of childhood and teenage experiences on the formation of attitudes toward bicycling. Their study found that experiences with bicycles in childhood and teenage years differ by gender, social norms, and cultural stigmas, which influence the formation of attitudes and perceptions in adulthood differently, resulting in

different bicycling behavior among different individuals based on their experiences, attitudes, and perceptions.

Despite considerable interest by researchers, attitudinal and preference-related data have not been extensively used in travel behavior analysis (Spears et al. 2013; Ton et al. 2020). Studies identified two main reasons for that. First, the unavailability of attitudes, perceptions, and preference-related data in traditional household travel surveys (Kuppam et al. 1999; Ton et al. 2020; Jamal et al. 2022). Second, difficulties in forecasting these variables compared to sociodemographic and trip attribute data, especially in terms of establishing a causal relationship between attitudinal variables and travel behavior (Kroesen et al., 2017; Kroesen and Chorus, 2018). As a result, attitudes, perceptions, and preference-related data are often ignored for travel behavior forecasting purposes (Kuppam et al. 1999; Kroesen and Chorus, 2018).

Transportation mode-specific attitudes and perceptions are needed to be studied as "general attitudes cannot be expected to be a good predictor of specific actions directed at the attitude object" (Ajzen, 2008). Although limited by numbers, available studies exploring attitudes and travel behavior interactions have generally focused on how transportation mode-specific attitudes impact individuals' travel behavior (Heinen et al. 2011; Kroesen and Chorus, 2018). What is often overlooked in travel behavior analysis is how attitudes, perceptions, and preference-related transportation factors together define traveler types and how these traveler types distinctively exist among different sociodemographic groups. Among the limited studies exploring traveler types as an alternative to traditional 'captive' and 'choice' user-based daily traveler segmentation, Jacques et al. (2013) identified four traveler types characterized by true captivity, dedication, utilitarianism, and convenience using a *k*-means clustering approach. The

study acknowledged that there might be "varying levels of preference and practicality" within the same traveler type, which has been observed in the dataset they used. The study also indicated that two individuals may experience the exact same circumstances, and have the same level of resources and access to different transportation options, but still may belong to different travel groups depending on their travel experience, satisfaction, and trip purpose. Anable (2005) used cluster analysis to segment a population of daily travelers into six types - 'malcontented motorists,' 'complacent car addicts,' 'die hard drivers,' 'aspiring env'talists,' 'car-less crusaders,' and 'reluctant riders' - to explore potential mode switchers. . Individuals' travel characteristics and attitudes and beliefs were used for this purpose. A study by Haustein (2012) identified four distinct types of older adults based on their mobility patterns, sociodemographic characteristics, and attitudes and perceptions. The types identified were 'captive car users,' 'affluent mobiles,' 'self-determined mobiles,' and 'captive public transport users.' The findings of both studies (Anable 2005; Haustein 2012) suggest that each traveler type is distinct in their character and different traveler groups need to be motivated in different ways to optimize their chances of influencing mode choice behavior.

Other studies also developed travelers' typologies; however, most of them did not consider attitudes, perceptions, and preferences. For example, using travel dairy data, Vij et al. (2013) identified three modality styles of individuals using a latent class choice model in Karlsruhe, Germany: 'habitual drivers,' 'time-sensitive multimodals,' and 'time-insensitive multimodals.' Using the same methodology, another study by Vij et al. (2017) identified five daily traveler types in the San Francisco Bay Area: 'complete car dependents,' 'partial car dependents,' 'car-preferring multimodals,' 'car desisting multimodals,' and 'car independents.'

Ralph (2017) used data from the US National Household Travel Survey (NHTS) and identified four daily traveler types among millennials: ‘drivers,’ ‘long-distance trekkers,’ ‘multimodals,’ and ‘car-less.’ On the other hand, Molin et al. (2016) and Krueger et al. (2018) developed daily traveler classes based on sociodemographic and trip characteristics and explored those classes as a function of attitudinal and perception-related statements.

The attitudes-based daily traveler typology developed in this paper groups daily travelers based on their psychological constructs. From the market research perspective, consumers’ attitudes toward available competing brands play a very important role in their buying decisions (Ajzen, 2008). Similarly, in travel behavior analysis, individuals’ attitudes and perceptions toward different transportation modes will impact their decision to choose or not choose a transportation mode. Additionally, as noted by Anable (2005), segmenting travelers only by their sociodemographic and trip attributes and excluding attitudinal attributes can lead to the misinterpretation of individuals’ behavioral tendencies as those groups are not necessarily homogenous. For example, a group of young car users can show higher values in one particular attitudinal statement whereas another group of young car users can show lower values in the same attitudinal statement. Grouping them into the same group called ‘young car users’ will make these two groups of young car users homogenous in terms of that attitude. Therefore, attitudes-based typology is needed as individuals belonging to the same sociodemographic group can show heterogeneous behavior in terms of attitudes.

5.3 Materials and Methods

5.3.1 Data

The study uses survey data collected by Dynata Research between October and November 2019 in the City of Hamilton, Ontario. Hamilton is located at the western end of Lake Ontario, with a 2021 population of 569,353 and a land area of 1,117 square kilometers (Statistics Canada, 2022). Based on the 2016 census, 25% of the city's population were millennials (Statistics Canada, 2017). On the other hand, 18% of Hamiltonians were 65 years and older (older adults) and 6% were between 60 and 64 years old (Statistics Canada, 2017), indicating that in 2020, approximately 24% of the city's population would be aged 65 and older.

Participants were recruited over the telephone. As almost the same proportions of millennials and older adults (65+ years) reside in Hamilton (Statistics Canada, 2017; Hamilton Community Foundation, 2019), the survey collected a sample consisting of an equal number of millennials and older adults – 100 participants per cohort. Information collected included travel characteristics, sociodemographic characteristics, living arrangements, lifestyle preferences, and attitudes toward transportation options. More details of the survey, sampling strategy, sample representativeness, information collected, and correlations between different attitudinal statements and the demographic cohorts are available in studies by Jamal et al. (2022; 2023).

The survey collected a total of 39 lifestyle and transportation mode–related attitudinal and perception-based statements on a 3-point Likert scale: (1) Agree; (2) Neither agree nor disagree; and (3) Disagree. Eighteen of these statements were directly related to transportation choices, attitudes, and perceptions, which are used to develop the latent classes or the measurement model for this study.

5.3.2 Methodology

5.3.2.1 Latent Class Analysis (LCA)

Latent class analysis (LCA) was used to identify different homogenous groups in the data. LCA models utilize observed data to identify unobserved or latent variables, and thus, divide the sample into mutually exclusive categories or latent classes (Hagenaars & McCutcheon, 2002; Eshghi et al. 2011). The conditional class membership probability is estimated in LCA and individuals are assigned to their most likely class based on this conditional probability and item response probability (Henry and Muthén, 2010).

More specifically, in the LCA model, the class membership probabilities and the indicator response probabilities are estimated (Lanza et al. 2007). There are two parts to the LCA model: i) the measurement model and ii) the structural model. The measurement model states the relationship between the observed indicators and the latent classes. In this study, attitudinal statements are used as observed indicators to define the latent classes.

Furthermore, each individual has a probability of belonging to a particular latent class depending on their individual characteristics. These individual characteristics are considered as active covariates in the structural model, which are independent variables to explore the likelihood of each variable belonging to each latent class. In this study, after multiple iterations of the covariates, the LCA model was finalized with the highest number of significant variables (at least 10% significance level). For some traveler types, not significant variables were kept in the model as they were found significant for other traveler types.

5.3.2.2 Selecting the optimal model

One of the challenges when conducting LCA is selecting the optimal number of latent classes for the model (He and Fan, 2018; Bönisch et al., 2021). The goodness of fit test statistics were examined for 2 to 6 latent class models to determine the optimal number of latent classes (Table 5.1). Comparing the Log-likelihood and AIC values of the 5 models developed, the Class 6 model seems to be the best model. In terms of BIC values, the Class 3 model has the lowest value. In terms of entropy value, both Class 4 and Class 5 models seem to have the optimal number of classes.

In addition to the model fit indices, the relative interpretability of the acquired class solution is a requirement for model selection (Bönisch et al., 2021). A relatively smaller sample size in this study has limited the selection of models with a higher number of latent classes. Although in terms of model-fit statistics, the Class 6 model offered better results, the structural model showed no significant covariates. Similar results were observed for the structural models of the Class 5 model. In terms of interpretability, the Class 4 model offered more significant variables compared with the Class 3 model (see Table 5.4). Therefore, based on the relative interpretability of the structural model, the Class 4 model was selected as the optimal model.

Table 5.1: Goodness of fit statistics for LCA models containing two-six classes

	Class 2 model	**Class 3 model**	**Class 4 model**	**Class 5 model**	**Class 6 model**
Log-likelihood:	-1955.74	-1864.08	-1811.22	-1763.61	-1724.21
AIC:	4003.48	3876.16	3826.44	3787.22	3764.42
BIC:	4155.43	4120.61	4163.37	4216.64	4286.34
Entropy:	0.91	0.94	0.95	0.95	0.94
Prevalence for latent Classes					
Class 1	26.66%	42.75%	25.73%	12.16%	14.10%

Class 2	73.34%	24.93%	24.78%	28.50%	13.69%
Class 3		32.32%	14.87%	11.50%	31.98%
Class 4			34.62%	20.58%	15.58%
Class 5				27.27%	10.90%
Class 6					13.75%

In this study, sociodemographic and travel characteristics are independent variables (active covariates) for the structural model. Table 5.2 shows the descriptive statistics of variables used in the LCA model and Figure 5.1 shows the graphical representation of the LCA model developed for this study.

The R package 'glca' (Kim et al., 2022) was used for this analysis. We estimated five latent class models and based on the relative interpretability of the structural models, the Class 4 model was selected for this study (see Table 5.1 for more details).

Table 5.2: Descriptive statistics

Indicator variables	**Older adults**	**Millennials**	**Total**
All statements are binary (Agree)	**(%)**	**(%)**	**(%)**
I like driving	81%	77%	78.6%
Driving means you can be more independent	85%	84%	85.6%
I'm not interested in driving	22%	21%	21.4%
I can rely on other people to drive me places	42%	47%	44.3%
Taking public transport, walking and cycling meet my travel needs	27%	40%	33.3%
I don't need a car to get around	25%	32%	28.4%
Getting to work without a car is a hassle	12%	66%	38.8%
My household could manage well with one less car than it has (or with no car)	31%	33%	31.8%
I prefer to walk rather than drive whenever possible	56%	62%	58.7%
Walking can sometimes be easier for me than driving	46%	62%	53.7%
I like riding a bike	30%	65%	47.3%
I prefer to bike rather than drive whenever possible	15%	30%	22.4%
Biking can sometimes be easier for me than driving	14%	40%	26.9%
Traveling by car is safer than riding a bicycle	83%	60%	71.1%
I like taking public transport	32%	35%	33.3%
It is easy to use public transport where I live	63%	66%	64.2%

I prefer to take transit rather than drive whenever possible	21%	26%	23.4%
Transit can sometimes be easier for me than driving	26%	47%	36.3%
Covariates			
Full-time Student (Yes)	0%	11%	5.5%
Living with a partner or spouse (Yes)	33%	18%	25.5%
Living in an apartment (Yes)	51%	24%	37.5%
House ownership (Yes)	55%	39%	47.0%
Household without a car (Yes)	21%	19%	20.0%
Driver's license possession (Yes)	79%	83%	81.0%
Primary mode: Car (Yes)	66%	63%	64.5%
Transit use (Not at all)	75%	40%	57.5%

5.4 Results

The results of the measurement model or indicator (attitudinal statements) probabilities of the Class 4 model are presented in Table 5.3, which shows the relevant predictors of class formation. It is noted that although there is no threshold value or cut-off point for indicator probabilities, higher values are desirable to define the classes (Weller et al., 2020). Here, probability values of nearly 0.7 or higher are considered to define the classes.

Looking into indicator probabilities of Class 1 in Table 5.3, this can be identified as those individuals who are more likely to walk and use transit compared to driving or using a car. Based on the characteristics of Class 1, this was labeled as 'walk and transit-oriented travelers.' This traveler type does not account for biking. Class 2 was labeled as 'car-oriented commuters' as such individuals like driving, believe that it fosters more independence in terms of traveling, and getting to work without a car would be difficult. Class 3 was identified as a traveler type that likes multiple modes of transportation such as driving, walking, biking, and transit. In addition, such individuals also believe in independence associated with driving and ease of walking, biking, and transit compared to driving. This group was labeled as 'multimodal travelers.'

Although Class 4 has some similarities with Class 2 (car-oriented commuters), this group does not fit the group of commuters as no indicator related to commuting shows a higher probability of belonging to this class (also see Figure 5.2 for visualization). This becomes clearer when interpreting the results of the structural model in the next section. Class 4 was labeled as 'car-oriented travelers.'

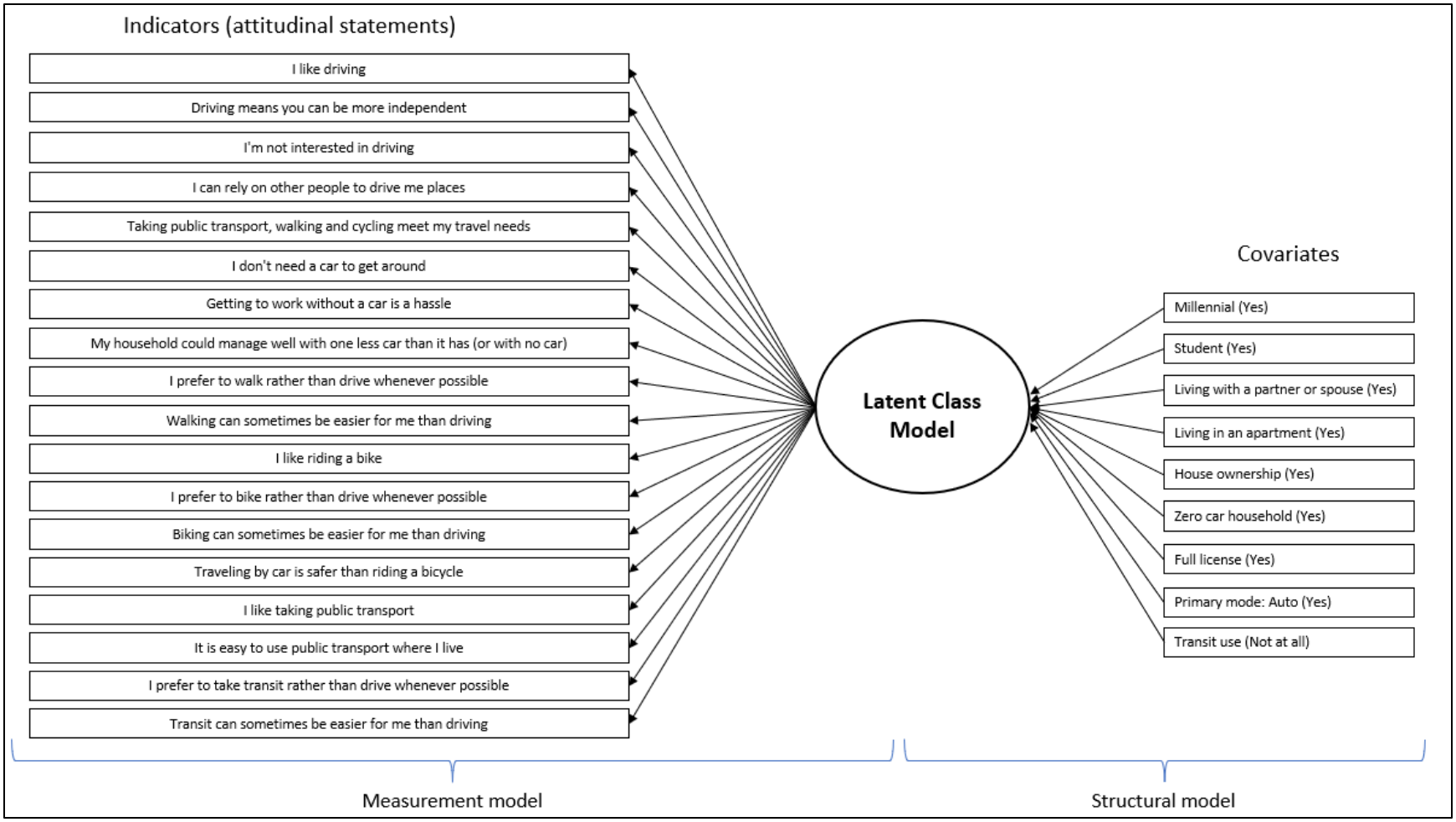

Figure 5.1: Graphical representation of the variables used to develop the LCA model

Table 5.3: Results of the LCA measurement model

	Class 1 (25.73%)	Class 2 (24.78%)	Class 3 (14.87%)	Class 4 (34.62%)
Class label	Walk and transit-oriented travelers	Car-oriented commuters	Multimodal travelers	Car-oriented travelers
All Statement are binary (Agree)				
I like driving	0.530	0.937	0.771	0.875
Driving means you can be more independent	0.653	0.964	0.861	0.927
I'm not interested in driving	0.476	0.080	0.201	0.121
I can rely on other people to drive me places	0.663	0.445	0.333	0.325
Taking public transport, walking and cycling meet my travel needs	0.843	0.161	0.400	0.049
I don't need a car to get around	0.843	0.063	0.155	0.081
Getting to work without a car is a hassle	0.179	0.883	0.485	0.147
My household could manage well with one less car than it has (or with no car)	0.564	0.196	0.389	0.194
I prefer to walk rather than drive whenever possible	0.698	0.541	0.838	0.430
Walking can sometimes be easier for me than driving	0.829	0.407	0.780	0.310
I like riding a bike	0.387	0.600	0.965	0.234
I prefer to bike rather than drive whenever possible	0.365	0.121	0.671	0.000
Biking can sometimes be easier for me than driving	0.444	0.091	0.823	0.027
Traveling by car is safer than riding a bicycle	0.574	0.674	0.581	0.897
I like taking public transport	0.767	0.177	0.301	0.137
It is easy to use public transport where I live	0.900	0.538	0.682	0.507
I prefer to take transit rather than drive whenever possible	0.625	0.117	0.153	0.062
Transit can sometimes be easier for me than driving	0.821	0.300	0.288	0.101

Note: Highlighted only those with nearly 0.70 or higher probabilities

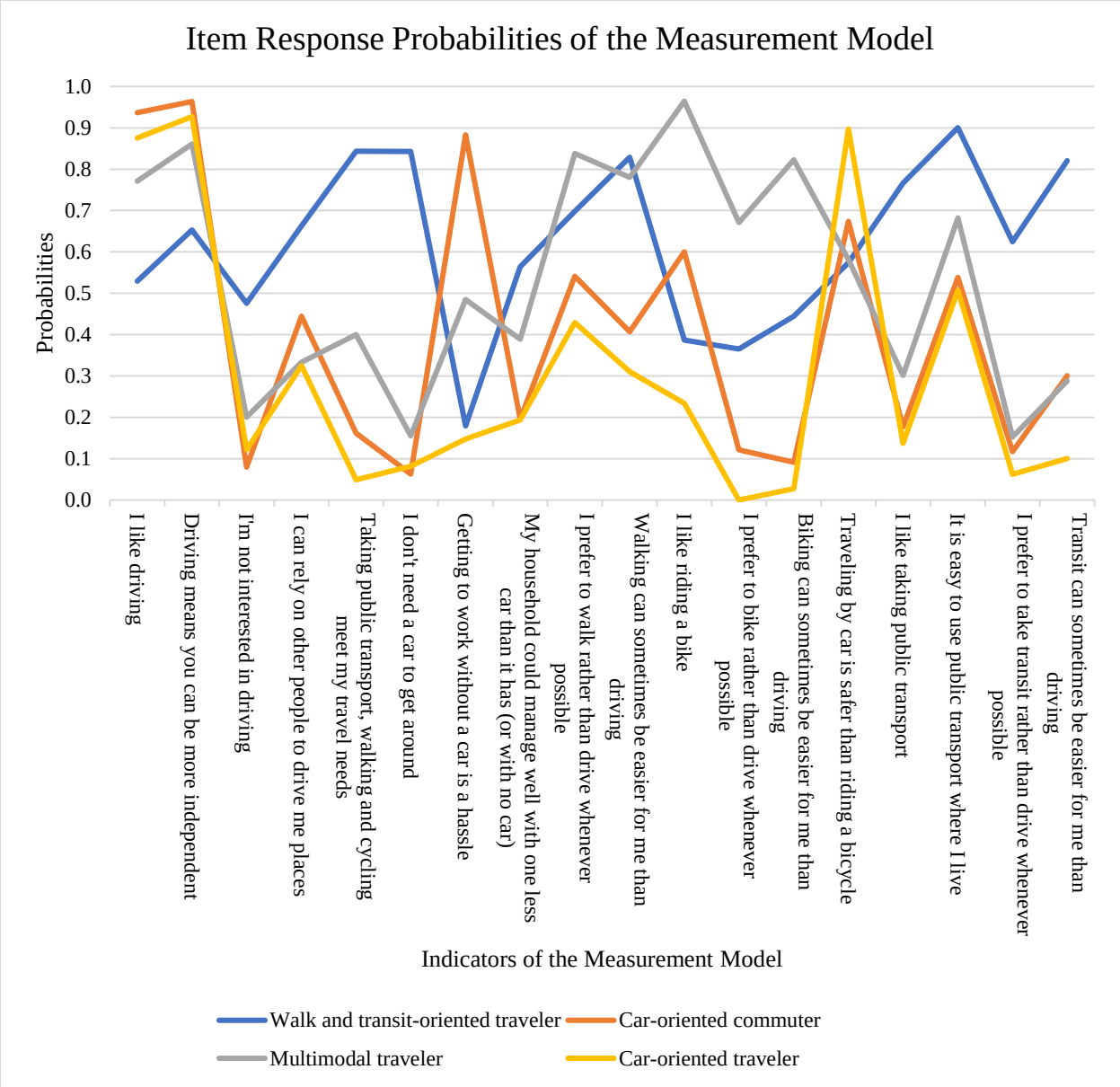

Figure 5.2: Results of the LCA measurement model

In addition to understanding travelers' typology based on their attitudes and perceptions toward transportation options, understanding factors affecting the likelihood of individuals belonging to each group is also necessary. Table 5.4 contains the results of the structural model,

which shows the covariates of the traveler typology. Here, the reference group is Class 4 or 'car-oriented traveler.' Therefore, the coefficients of different factors are interpreted for other groups in comparison with 'car-oriented traveler.'

Relative to older adults, millennials are more likely to be car-oriented commuters and multimodal travelers than car-oriented travelers. Full-time students, on the other hand, are less likely to be car-oriented commuters. These two findings suggest that when millennials enter the job market, they prefer to be car-oriented commuters.

Table 5.4: Results of the LCA structural model

	Walk and transit-oriented travelers		**Car-oriented commuters**		**Multimodal travelers**	
	Coefficient	**p-value**	**Coefficient**	**p-value**	**Coefficient**	**p-value**
Intercept	**5.261**	**0.061**	**-6.520**	**0.000**	**-1.733**	**0.000**
Millennial (Yes)	2.374	0.227	**7.147**	**0.000**	**6.289**	**0.006**
Full-time student (Yes)	-0.545	0.834	**-1.524**	**0.000**	-2.848	0.340
Living with a partner or spouse (Yes)	0.144	0.916	**2.363**	**0.000**	3.450	0.134
Living in an apartment (Yes)	**-2.714**	**0.096**	**-4.019**	**0.076**	-1.476	0.392
House ownership (Yes)	**-2.372**	**0.078**	-1.459	0.484	-1.077	0.512
Household without a car (Yes)	2.178	0.090	**-1.766**	**0.000**	2.616	0.150
Driver's license (Yes)	-4.270	0.111	**-3.562**	**0.000**	**1.387**	**0.000**
Common mode: Car (Yes)	1.858	0.275	**3.668**	**0.000**	2.444	0.221
Transit use (Not at all)	**-3.361**	**0.012**	-2.122	0.316	-2.152	0.172

In terms of living arrangements, those who live with a partner or spouse, are more likely to be car-oriented commuters. It is interesting that living in an apartment decreases the likelihood

of being a ‘walk and transit-oriented traveler’ and ‘car-oriented commuter’ compared to a ‘car-oriented traveler.’ As expected, homeowners are less likely to be ‘walk and transit-oriented travelers’ than ‘car-oriented travelers.’

In terms of trip attributes, individuals living in households without car access are, unsurprisingly more likely to be ‘walk and transit-oriented travelers’ and less likely to be a ‘car-oriented commuter’ compared to the ‘car-oriented traveler.’ Individuals with a driver’s license are less likely to be ‘car-oriented commuters’ and more likely to be ‘multimodal travelers.’ Those whose common mode of transportation is a car are more likely to be a ‘car-oriented commuter’ than ‘car-oriented traveler.’ Similarly, those who do not use transit at all are less likely to be ‘walk and transit-oriented travelers’ than ‘car-oriented travelers.’

5.5 Discussion and Conclusion

Based on a sample of millennials and older adults, this study applies latent class analysis to identify daily travelers’ types based on transportation attitudes and to explore the effects of sociodemographic and trip attributes on the probability of belonging to each of the identified traveler types. Four daily traveler types are identified – ‘walk and transit-oriented travelers,’ ‘car-oriented commuters,’ multimodal travelers,’ and ‘car-oriented travelers.’ Findings suggest that heterogeneity exists within travel-related attitudes among different traveler types. For example, there are similarities between ‘car-oriented commuters’ and ‘car-oriented travelers’ in terms of showing higher probabilities in responding ‘yes’ to the transportation-related attitudinal statements “I like driving” and “Driving means you can be more independent” and lower probabilities of responding ‘yes’ to “I'm not interested in driving” and “I don't need a car to get around” (see Table 5.3). However, their probability of responding ‘yes’ to “Getting to work

without a car is a hassle" is completely opposite. Therefore, according to the theoretical framework of the Theory of Planned Behavior by Ajzen (1991), these two traveler types' intentions behind using cars are different, which is also evident by the attitudinal responses each of the traveler types provided. The 'car-oriented commuters' emphasize more on the usefulness of cars for commute purposes, which is not the case for 'car-oriented travelers.' The 'car-oriented travelers' may not use cars for commute purposes or perhaps they do not commute at all. Hence, the policy implications to influence their travel behavior would be different as policies targeting commuters may not impact the travel behavior of 'car-oriented travelers.'

Likewise, there are similarities in terms of attitudes and perceptions toward walking and transit between the 'walk and transit-oriented travelers' and 'multimodal travelers.' However, 'multimodal travelers' also show positive attitudes toward driving and biking, which differs from the 'walk and transit-oriented travelers.' Therefore, between these two groups, measures to discourage driving will only influence the travel behaviors of 'multimodal travelers' whereas if policies offer 'walk and transit-oriented travelers' more sustainable transportation choices, they can take both soft and hard measures to encourage biking, which may also benefit the 'multimodal travelers.' Overall, travelers' typology offers insights into how variations in transportation-related attitudes and perceptions can lead to variations in travel behavior, which can also be used to identify and target effective interventions for each traveler type (Anable, 2005).

Additionally, the structural model suggests that heterogeneous traveler types exist among individuals belonging to the same generation. Millennials are more likely to belong to 'car-oriented commuters' and 'multimodal travelers.' This indicates that although millennials are

multimodal as found in other studies (e.g., Kuhnimhof et al., 2011; Grimsrud and El-Geneidy, 2014), they also like to use cars for commuting. This supports the predictions made by different studies (e.g., Agarwal, 2017; Newbold and Scott, 2018; Wang 2019; Lee et al. 2020) that millennials will more likely be car-oriented as they enter the job market.

The study also suggests that living in an apartment discourages individuals from being 'walk and transit-oriented travelers' and 'car-oriented commuters' compared to 'car-oriented travelers.' On the other hand, there is no evidence that those living in an apartment belong to the 'multimodal travelers' type. From the land-use perspective, as apartments are usually located in high-density areas, there is a general expectation that living in an apartment will encourage walking and use of transit. Perhaps due to Hamilton's land-use pattern, neighborhood characteristics, and relaxed parking policies in high-density neighborhoods (Turcotte, 2008; Craggs, 2014), individuals are less likely to be pro-walk and transit-oriented. Another interesting finding is that possession of a driver's license encourages individuals to be 'multimodal travelers' rather than being car-oriented. Therefore, in terms of policy implications, policymakers should be mindful of the fact that strict licensing procedures may not be effective in changing car-oriented attitudes among daily travelers and there is a need for alternative strategies for changing attitudes toward sustainable transportation modes such as providing safe and available infrastructure for sustainable transportation modes, promoting positive aspects of walking, biking, and using transit, etc.

While revealing different traveler types and adding to the broader literature that has explored traveler typologies, study limitations should be noted. This exploratory analysis is based on a limited sample size. Consequently, there is a need to explore traveler typologies based

on a larger and multi-year dataset. However, this study still provides evidence of the need for developing daily travelers' typology based on transportation-related attitudes for identifying the target group for transportation interventions and which factor to target for intervention.

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Chapter 6

Conclusion and Future Research

Understanding the differences in travel behavior is important because it can have a significant impact on daily travel patterns. As discussed in the previous chapters, older adults and millennials can have distinct travel patterns due to a variety of factors, including differences in their life stage, gender, income level, technology use, access to mobility tools and attitudes and perceptions toward travel. Exploring travel behavior through a generational lens is helpful for transportation planners and policymakers to make informed decisions about infrastructure and services such as investing in age-friendly transportation infrastructure and programs, provision of bike lanes, expanding public transportation networks or initiating affordable transit policies. Moreover, segmenting daily travelers by their attitudes and preferences and exploring which generation(s) fall under which segment of daily travelers can help businesses and service providers in the transportation industry to better target their consumers and tailor their products and services according to consumer needs.

6.1 Key Findings

The thesis has several findings as follows.

6.1.1 Generational Differences in Travel Behavior

The scoping review of seventy-eight studies from the developed countries suggested that differences exist between millennials and older adults' travel behavior in terms mode choice, trip distance, trip frequency, use of alternative transport, ridesharing and ownership of mobility tools

such as car, bike, transit pass, etc. Also, how personal attributes, geography (e.g., urban, suburban, and rural), built environment, living arrangements, family life, technology adoption, perceptions and attitudes toward travel options and environment influence each cohort's travel behavior are either completely different or differ in their nature of influence (i.e., positive or negative association).

6.1.2 Millennials' Shift toward Automobiles in Hamilton

Exploratory analysis from chapter 3 suggested that in Hamilton, the difference between millennials and older adults is marginal in terms of their attitudes toward driving. In general, young and older auto users both show similar attitudes towards different transportation modes. A similar trend has been seen for non-auto users among young and older adults. The findings indicated young adults' intention to shift towards an auto-oriented culture, especially when they have a job with a preference for suburban living in the future.

6.1.3 Impact of Sociodemographic Characteristics, Living Arrangements, Attitudes and Preferences Millennials and Older Adults' Automobility Behavior

Results from the regression analysis in chapter 4 suggested that females (compared to males) and low-income (compared to other income groups) individuals from both cohorts are less likely to be automobile oriented. Depending on whether a millennial or older adult lives alone, with a partner or in an apartment, differences have been observed in their automobility behaviors such as automobile use as a common mode of transportation, driving automobiles as a driver and the automobile ownership of the households. The study also found that positive attitudes and preferences toward sustainable travel behavior make both generations less auto-oriented, especially the millennials. Compared to older adults, living arrangements, attitudes and

preferences influence millennials' attributes of automobility behavior to a greater extent. Further, the study also suggested that living arrangements, attitudes and preferences can differ within each cohort; therefore, the impact on each of the attributes of automobility behavior can differ.

6.1.4 Heterogenous Traveler Types among Millennials and Older Adults

Chapter 5 used latent class analysis method to explore daily traveler types among millennials and older adults. Four daily traveler types were identified – 'walk and transit-oriented travelers', 'car-oriented commuters', 'multimodal travelers', and 'car-oriented travelers'. Findings suggested that heterogeneous traveler types existed among individuals belonging to the same generation, with the same living arrangements, and possession of a driver's license. For example, millennials showed higher likelihood of belonging to both 'car-oriented commuters' and 'multimodal travelers'. Also, living in an apartment discourages both cohorts from being 'walk and transit-oriented travelers' and 'car-oriented commuters' compared to 'car-oriented travelers'.

6.2 Policy Implications

6.2.1 Understanding the Changing Dynamics of Travel Behavior of Millennials and Older Adults

The study contributed to our broader understanding of travel behavior of millennials and older adults. The findings of this thesis demonstrated the importance of automobile among both cohorts as they showed almost similar attitudes towards different transportation modes. In terms of automobility behavior, marginal differences exist between these two cohorts. A general observation is that although young adults or millennials are more optimistic about walking and

biking than older adults, they also show positive attitudes and preferences towards auto use and driving, similar to older adults. Although there was an indication that millennials in Hamilton will make fewer and shorter trips in the future, most of their travel will be conducted by automobiles. In terms of preferred characteristics of residential areas, the study found that millennial auto-users have a preference for suburban living. This indicated the likelihood of a shift in residential location preference from urban to suburban living for millennials, echoing the older age group's preferences, therefore, greater auto dependency among millennials. Also, in terms of intra-generational heterogeneity in automobility behavior, the study indicated that there is a group of older adults in Hamilton who are more mobile and multimodal compared to other groups and in addition to automobiles, they use non-automobile modes. Policies should consider these changing dynamics of travel behavior among different generations as it was assumed previously that young adults or millennials will prefer urban living and are more likely to use sustainable modes of transportation such as walk, bike and transit.

6.2.2 Considering the Impacts of Living Arrangements on Automobility Behavior

The results of the thesis suggested that millennials' living arrangements impact their automobility behavior. For example, millennials who live with a partner/spouse and are living in apartments are likely to own fewer automobiles as a household whereas millennials living without a partner/spouse and living in other types of dwellings (except apartments) have the highest propensity to own a higher number of automobiles. Also, it has been found that millennial households, in general, are more likely to own a higher number of automobiles than older adults. This may be reflective of their parents' automobile ownerships. Due to delayed life cycle and economic constraints, many millennials are currently living with their parents. Looking

into the Canadian Census, the percentage of 20-34 years old adults living with their parents has increased from 30.6% in 2001 to 34.7% in 2016 (Statistics Canada, 2017). It is to be noted that millennials were between 20 to 35 years while the data for 2016 were collected. Having a deeper look into the census data, in Canadian Metropolitan Areas (CMA), on average, 36.2% of the millennials were living with at least one of their parents in 2016 (Statistics Canada, 2017). Compared to other CMAs, the percentage of millennials living with their parents is extensively higher in the Greater Toronto and Hamilton Area (GTHA) – Toronto (47.4%), Oshawa (47.2%), Hamilton (44.5%), and St. Catharines–Niagara (40.7%). There is a possibility that millennials living with parents had exposure to automobile use for a longer period of their life and therefore, they may have become used to with automobiles than other transportation modes. This should be taken into account while making policy decisions especially while providing sustainable transportation options and developing infrastructures keeping young generations as the target group. Because many millennials in GTHA may not make sustainable transportation choices even after moving out of their parents' home as they have become used to with automobiles. Therefore, policymaker may need to adopt other measures to attract millennials towards sustainable transportation choices.

6.2.3 Influencing Attitudes and Preferences to Promote Sustainable Travel

As attitudes and preferences influence travel behavior to a greater extent, it should be explored how attitudes and preferences can be modified to promote sustainable travel options. Also, as discussed in chapter 4, millennials are still in the earlier stages of family formation. Their automobility behavior may change depending on their change in sociodemographic characteristics, living arrangement, and attitudes towards travel and locational preferences as

they age. Therefore, planners and policymakers should take the initiatives to help them make more informed decisions on sustainable mode choices by providing information, incentives, age and ability appropriate infrastructure, and accessible services.

6.2.4. Addressing Heterogenous Behavior within the Same Generation

Results of the latent class analysis indicated that heterogeneous traveler types exist among the same generation, especially millennials. There is a group of millennials who use car for commuting and there is another group of millennials who are multimodal. There is also a group of older adults who prefer transit over car. Decision makers should consider this heterogenous behavior of different generations. Investments in new sustainable transportation infrastructures and improvements of existing transit services and bike lanes should consider how they can keep motivating current transit and active mode users into sustainable transportation choices and lower their likelihood of choosing an automobile in future and also how to attract new users from millennials and older adults to transit and active modes.

6.3 Future Research

The thesis explored the travel behavior of millennials and older adults by identifying several gaps in chapter 2 and attempting to address some of the gaps through quantitative analysis in chapters 3 to 5. However, there are several research questions that need further attention.

6.3.1 The Need for a Larger Dataset

While the Hamilton data set used in this thesis provided opportunities to explore generational differences in travel behaviors, it was limited given that it was a small sample based

on a panel of respondents along with its small sample size. The survey questionnaire itself was very extensive and the data collected can offer very useful information regarding the travel behavior of millennials and older adults. If larger samples are collected for all generations (e.g., generation Z, millennials, generation X, baby boomers, the greatest generation), the dataset will be helpful to forecast the future travel demands of different generations.

6.3.2 Understanding Intra-generational Travel for Diverse Population Groups

The study suggested that heterogeneity in travel behavior exists within each generation. It is also more likely that individuals from different backgrounds, socioeconomic classes, abilities, cultures, races, ethnicities, religions, languages, sexual orientations, and other characteristics will have different travel patterns – something to be explored in more detail for the Canadian metropolitans as they are becoming more diverse and multicultural because of immigration and new employment opportunities (Mayo, 2016; CBC News, 2017; Government of Canada, 2019).

6.3.3 Exploring the Influence of Different Cultural and Societal Norms on Intergenerational Travel Patterns

Cultural and societal norms can have a significant influence on intergenerational travel patterns. Different cultures and societies may have different expectations and norms regarding travel, including who is expected to travel, when and where they are expected to travel, and how they should travel. For example, in some cultures, older adults are expected to stay at home and not travel without company, while in others they may be more active and independent daily travelers (Dingil et al., 2019). In some cultures, men disproportionately travel by private vehicle modes, whereas women disproportionately walk and make fewer trips (Elias et al. 2008). Cultural and societal norms can also influence the types of transportation that different

generations use (Ashmore et al. 2017). For example, in some cultures, older adults may be more likely to use public transportation, while in others they may prefer to drive or be driven (Ashmore et al. 2017; Shafi et al. 2022). Understanding these influences can help policymakers and transportation providers to better serve the needs of all members of a community and develop strategies to promote greater mobility and accessibility for all generations.

6.3.4 Analyzing the Effects of Policy and Infrastructure Changes on Intergenerational Travel Behavior

Analyzing the effects of policy and infrastructure changes on intergenerational travel behavior can help researchers and policymakers understand how changes to transportation systems, land use patterns, and other factors may impact the travel habits of different generations. The findings can be used to identify potential barriers to travel for older adults, children, and other groups, and to develop strategies for addressing these barriers and challenges.

6.3.5 Study the Impact of COVID-19 on Intergenerational Travel and How it will Change in the Post-pandemic Period

Studies have observed changes in travel patterns during the COVID-19 period among different sociodemographic groups (e.g. Palm et al. 2021; DeWeese et al. 2022). Certain changes have been noticed in daily travel patterns due to COVID-19 such as an increase in telecommuting (e.g. Mohammadi et al. 2022), changes in transportation infrastructure such as the provision of more bike lanes, pedestrian walkways, and other infrastructure to support active transportation (Buehler and Pucher, 2021), preference for contactless payment options, such as digital cards and mobile payments (Zhao and Bacao, 2021), an increase in the use of ride-hailing and car-sharing services, and greater use of technology such as mobile apps and online platforms

(Monahan and Lamb, 2022). However, what is yet to explore is the long-term impact of COVID-19 on different generations' travel behavior and to explore whether the adopted behavior during COVID-19 is going to sustain in the long run and thus, how it will impact the travel behavior and overall travel demand of all generations.

6.3.6 Level of Technology Adoption by Different Generations and How it impacts their Travel Behavior

The level of technology adoption by different generations can have a significant impact on their travel behavior. Generally, younger generations tend to be more tech-savvy and more likely to adopt new technologies, while older generations may be more resistant to technology adoption or find it difficult to learn digital technologies. The availability of technology, specifically the internet and smartphones, can also be a factor that affects technology adoption, as these technologies can be more prevalent in urban areas and among higher-income groups, which can also affect the travel behavior of different generations.

6.3.7 How Travel Behavior of Different Generations is Impacted by their Health-related Attitudes and Practice

Health-conscious individuals, regardless of their age, may be more likely to choose active transportation options, such as walking or biking, over driving. They may also be more likely to plan their trips to include time for physical activity, such as walking or cycling. Conversely, individuals with chronic health conditions may be more likely to avoid certain types of transportation that may exacerbate their symptoms, such as long-distance travel by car, or travel during periods of high pollution. Also, individuals who are concerned about their mental well-being may be more likely to avoid crowded or stressful environments (e.g. Rezapour and

Ferraro, 2021), such as rush hour on public transportation, and may prefer to travel at off-peak times or to use more private modes of transportation (Harada et al. 2021). Therefore, it is important to explore health-related attitudes and practices and how it impacts travel behavior and the transportation choices of different generations.

6.4 Study Limitations

There are four main limitations that should be noted. First, the scoping review in chapter 2 contained studies between 2010 to 2018. Several studies were conducted after 2018 offering interesting insights into millennials and older adults' travel behavior, which were not included in the review of literature in chapter 2, although they were included in later papers where appropriate. Another limitation is that it was beyond the study's scope to offer a comprehensive research agenda and therefore, chapter 2 offered only six broader research agendas regarding millennials and older adults' travel behavior.

Second, the quantitative analyses conducted in this thesis are based on a limited cross-sectional and panel-based dataset, and there is a need to explore millennials' and older adults' travel behavior based on a larger and multi-year dataset. While providing a useful tool to explore hypotheses, the limited sample size also limits the study's potential to explore intergenerational travel behavior by applying advanced analytical methods such as structural equation modeling to explore the interrelationships among the several automobility characteristics. To be specific, due to the limited sample size, the thesis was unable to explore the interrelationships among the outcome variables such as using an automobile as a common form of transport, possession of a

valid driver's license, using an automobile as a driver or passenger, and number of automobiles in the household along with the predictor variables that impact the outcome variables.

Third, the thesis mostly focused on subjective measurements as predictor variables such as attitudes and perceptions. Objective measurements such as built-environment-related characteristics and accessibility characteristics were missing from the analysis as the survey had limited locational information such as street address or postal codes.

Fourth, the survey was conducted in the pre-COVID-19 era. The COVID-19 pandemic may have significant impacts in terms of millennials' living arrangements and both generations' adoption of technology-oriented substitutes and telework. Therefore, the impacts of COVID-19 on travel behavior of millennials and older adults remained unexplored in this thesis.

6.5 Concluding Remarks

This thesis aimed to explore the differences and similarities in travel behavior of millennials and older adults. When it comes to transportation planning, understanding the travel behaviors of millennials and older adults is important in order to provide safe, convenient, and efficient transportation options for both groups. Based on their unique characteristics, studies (e.g., Grimsrud and El-Geneidy, 2014; Lee et al. 2014; Fordham et al. 2017; Shrestha et al., 2017; Circella and Alemi, 2018; Hong and McArthur, 2019; Ravensbergen et al. 2022) have suggested that while planning for transportation for millennials, attention should be given to their higher use of public transportation, ride-sharing services, and other forms of alternative transportation, whereas for older adults, their mobility challenges, accessible transportation, safety, ease and convenience of transportation use should be given higher consideration.

However, studies also indicated that travel behavior among some individuals of older generations is changing – they use public transit more than the younger cohorts and their suburban counterparts (Lee et al. 2014; Fordham et al., 2017). Also, for millennials, studies (e.g., Janke et al. 2021; Hong and McArthur, 2019; Newbold and Scott, 2017; 2018; Delbosc and Nakashi, 2017) indicate that millennials are just delaying their car ownership and driving and will continue the same auto-oriented culture of their previous generations as they enter important life stages such as getting jobs, marriage, having children, etc.. Therefore, it is important to explore these changing aspects of travel behavior of millennials and older adults to make informed policy decisions.

This thesis offered a state of knowledge of travel behavior of millennials and older adults from 2010 to 2018. The findings indicate that there are differences in travel behavior of millennials and older adults in broader empirical research. Next, using cross-sectional survey data from Hamilton, Ontario, the thesis found that difference between these two cohorts is marginal in terms of their attitudes toward different transportation modes. Regression analysis suggested heterogeneous behaviors within the generations. For example, depending on whether a millennial or older adult lives alone, with a partner or in an apartment, difference existed in their automobility behavior. The study also found that positive attitudes and preferences toward sustainable travel behavior made both generations less auto-oriented, especially the millennials. Finally, based on attitudes and preferences toward transportation modes, the thesis developed four traveler types such as ‘walk and transit-oriented travelers’, ‘car-oriented commuters’, ‘multimodal travelers’, and ‘car-oriented travelers’ and found that heterogeneous traveler types

existed among individuals belonging to the same generation, with the same living arrangements, and possession of a driver's license.

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