Travel Behaviour, Neighbourhood Preferences & the Changing Demands of an Aging Population:

Analyzing generational differences in household location and mode choice of older adults in Montreal

Supervised Research Project
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Travel Behaviour, Neighbourhood Preferences & the Chanding Demands of an Aging Population:

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SUMMARY. Aging in place refers to ability to live in one's own home and community safely, independently, and comfortably.[1] Some neighbourhoods are more supportive of aging in place than others. There are generational differences between the baby boomer generation and their parents. Baby boomers are showing increasing preferences for accessible neighbourhoods, while exhibiting automobile dependence. Their parents' generation is more open to transit use. However, they tend to live in more inaccessible neighbourhood types. The analysis leads to recommendations for ensuring familiarity with transit for older adults, encouraging home locations in accessible neighbourhoods before 70 years of age, travel demand management for baby boomers, incentives for home relocation, and improved transit service in certain areas where seniors are aging in place.

CONTEXT + PROBLEM. The Canadian population is aging at a rapid rate and many older adults are dependent on automobiles.[2] However, as they age, some adults may be forced to cease driving, resulting in reduced mobility. Transit has the potential to act as an alternative to the automobile.[3] Unfortunately, transit is not widely used following driving cessation.[4]

The aging population has a preference to age in place. Some forecasts predict an increase in demand for suburban housing from the aging population.[5] This is problematic because automobile dependence is high and accessibility with other modes is low in suburban environments.

ANALYSIS. There were several steps to the analysis. These included:

- **Cohort analysis** of **transit mode share** over time
- **Land use classification** to identify **neighbourhood types**
- Identify **household locations** of older adults overtime using a **cohort analysis**
- **Mode share analysis** based on **neighbourhood type**

RESULTS. The following describes the major results of the analysis:

Transit Use: The parents of the baby boomers used transit at a high rate in their oldest adult years. Baby boomers are unlikely to use transit at the same high rate that their parents did in their elderly years.

Land Use Classification: Land use classification results in seven neighbourhood types. Analysis was conducted with the five most populous neighbourhood types, which are *Inaccessible Residential, Industrial with Residential, Dense & Diverse, Wealthy Single Family Homes* and *Accessible Prewar.*

Aging in Place: Many older adults in Montreal expressed a preference to age in place. This preference was especially prominent after the age of 70, in which household location was relatively stable.

Suburban Environments: The suburbanization of the aging population depends on the type of suburban environment. Generally, there was a decreasing preference for *Wealthy Single Family Home* areas and an increasing preference for *Inaccessible Residential Areas*.

Mode Choice: Automobile use was high and walking/biking rates were low in *Wealthy Single Family Home* and *Inaccessible Residential* areas. Rates of walking/biking were high in *Accessible Prewar* and *Dense & Diverse* neighbourhoods, which also had high densities and a mix of land uses. Transit use among older adults was highest in Accessible Prewar neighbourhoods.

Generational Differences: Baby boomers showed an increasing preference for *Accessible Prewar* and *Dense & Diverse* neighbourhoods. These neighbourhoods are accessible and supportive of active multimodal lifestyles. However, baby boomers exhibited automobile dependencies.

RECOMMENDATIONS TO SUPPORT AGING IN PLACE

Ensure older adults are in neighbourhoods with have access to services and amenities within walking distance before the age of 70 years old

Employ Travel Demand Management strategies in *Accessible Prewar* and *Dense & Diverse* areas to encourage transit use and lessen automobile dependency of baby boomers

Encourage the preference of older adults to leave *Wealthy Single Family Home* areas through grants or other incentives

Improve transit service in *Inaccessible Residential* areas, as the oldest adults show a preference to age here and are open to transit usage

Foster a familiarity with transit services before driving cessation

CONCLUSION. When planning for an aging population, policy makers need to acknowledge that there are generational differences in the travel behavior and household location preferences of older adults. Improving accessibility at the neighbourhood level will enable older adults to express their preference to age in place.

[1] Centre for Disease Control and Prevention. (2013). *Healthy Places Terminology*. Retrieved from https://www.cdc.gov/healthyplaces/terminology.htm.

[2] Fordham, L., Grisé, E., & El-Geneidy, A. (2017). When I'm 64: Assessing generational differences in public transit use among seniors in Montreal, Canada. Transportation Research Record.

[3] Newbold, K., Scott, D., Spinney, J., Kanaroglou, P., & Páez, A. (2005). Travel behavior within Canada's older population: a cohort analysis. Journal of Transport Geography, 13(4), 340-351.

[4] Paez, A., Scott, D., Potoglou, D., Kanaroglou, P., & Newbold, K. (2007). Elderly mobility: demographic and spatial analysis of trip making in the Hamilton CMA, Canada. Urban Studies, 44(1), 123-146.

[5] Myers, D., & Ryu, S. (2008). Aging baby boomers and the generational housing bubble: Foresight and mitigation of an epic transition. *Journal of the American Planning Association*, *74*(1), 17-33.

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PART ONE: FORWARD

> *"While the day-to-day needs of an aging population are undergoing a vast transformation, Canada's seniors are also changing the way citizens contribute to the social and economic life of their communities."*
>
> Federation of Canadian Municipalities,
> Canada's Aging Population: The Municipal Role in Canada's Demographic Shift

Seniors are now the fastest growing age group in Canada, which is represented by an aging baby boomer population. The quote presented above highlights how the aging population is facing new challenges in addressing their individual daily needs. It also suggests that Canada's aging population will have an impact on the way that communities are shaped and developed. The growth of the aging population is unprecedented and represents an extraordinary opportunity to provide age friendly communities. A fortunate advantage of providing age friendly communities is that policy

makers and planners also provide communities that are more livable for residents of all ages.

In planning for an aging population, specific challenges need to be addressed. These challenges include the supply of affordable housing, access to transportation options and provision of social services. The challenge of providing accessible transportation and addressing mobility issues among the elderly has far reaching implications. These include concerns about social isolation following driving cessation, higher accident rates among older drivers, and lack of access to services and amenities. The following Supervised Research Project (SRP) will focus the challenge of maintaining the safe and independent mobility of older adults. This will be done by looking at the travel behavior and home locations of older adults in Montreal, Canada over a 15 year time period.

This SRP is divided into four sections. This first section provides an overview and introduction to the SRP. Part Two, entitled *Generational Differences in Transit Use Among Older Adults in Montreal*, explores how different generations used transit during their older adult years in Montreal. A major finding of this Part is that baby boomers are unlikely to use transit in the same way that their parents used transit as seniors. These findings are important because, in planning for an aging population, policy makers cannot expect baby boomers to behave in the same way that previous generations did. While this Part provides important insight into the travel behavior of older adults and

the implications for transit use and service, the impact of the built environment on travel behavior is not addressed.

The relationship between the built environment and travel behavior is well established (Cervero & Duncan, 2003; Handy, Boarnet, Ewing, & Killingsworth, 2002; Saelens, Sallis, & Frank, 2003). This relationship has been extended to seniors in several studies with findings that the elderly benefit from walkable environments with amenities and services accessible within walking distance or accessible by transit (Cao, Mokhtarian, & Handy, 2010; Kim, 2011a; Michael, Green, & Farquhar, 2006). In other words, the safe and independent mobility of seniors is better maintained in built environments that are not automobile dependent. Therefore, the impact of the built environment on travel behavior of older adults warrants further exploration.

This exploration is presented in *Part Three: Generational Differences in Aging in Place & Travel Behavior by Neighbourhood Type*. This Part assesses the home location preferences of older adults in Montreal based on neighbourhood characteristics and explores the impact on travel behavior. It is focused on the concept of aging in place, which refers to the preference of aging adults to live safely and comfortably in their own home and community for as long as possible (Centre for Disease Control and Prevention, 2013). Part Three identifies patterns in the proportion of older adults living in five different neighbourhood types over a 15 year time period. The findings help assess the potential success of aging in place in Montreal and offer recommendations to

maintain the safe and independent mobility of older adults.

The final Part of this SRP, *Part Four: Policy Recommendations and Conclusions*, offers specific policy interventions that can help maintain the safe and independent mobility of the aging population. The goals of these recommendations are focused on reducing automobile dependency, encouraging an active and multimodal lifestyle and allowing seniors to express their personal preferences for home location regardless of economic or physical barriers. This final section acknowledges the unique challenges that policy makers and planners are faced with in planning for an aging population. It also emphasizes the necessity of addressing these challenges.

The interventions that promote safe and independent mobility of the aging population do not only benefit the elderly. Rather, they provide accessible, walkable and livable neighbourhoods for the community as a whole. The aging population provides an impetus, and creates the political will, to address certain issues in a way that benefits community members of all ages. The following SRP is intended to highlight the specific mobility needs of the aging population and encourage age friendly policy orientation that benefits entire communities.

PART TWO: GENERATIONAL DIFFERENCES IN TRANSIT USE AMONG OLDER ADULTS IN MONTREAL

INTRODUCTION

Between 2006 and 2011, the Canadian population increased by 5.9%, however, the number of Canadians over the age of 65 increased by 14.1% (Statistics Canada, 2015). The fastest growing age group was 60 to 64 year olds, which exhibited an increase of 29.1%. This is reflective of the aging baby boomer population (Statistics Canada, 2015). This demographic shift is not unique to the Canadian context, as it is present in many countries around the world. Such a shift presents societies with far-reaching implications for health care, finance and policy. Access to different destinations or services through different modes of transportation has been identified as a key factor in affecting the mobility of seniors and consequently their quality of life (Banister & Bowling, 2004).

Generational differences and associated travel behavior have been observed in previous studies (Grimsrud & El-Geneidy, 2014; Newbold, Scott, Spinney, Kanaroglou, & Páez, 2005). In regards to seniors, differences in travel behavior across generations are expected. Pre-World War II, cities were highly localized places, with an urban form that allowed daily requirements to be achieved either within walking distance, or through public transit. In other words, cities subsisted on the premise of low automobile ownership (Badland & Schofield, 2005). Post-war economics led to increased disposable income and decentralization of cities to suburban centers and single land uses (Frank, Engelke, & Schmid, 2003), and accordingly, a greater reliance on automobiles. Individuals born during the post-World War II period, known as the baby boomers, were born with an intimate relationship with the automobile (Coughlin, 2009; Rees & Lyth, 2005). The prominence of the automobile while growing up suggests that in later years the baby boomers will not behave like their parents' generation (Coughlin, 2009). In a study in the Minneapolis-Saint Paul region, seniors expressed their fear of losing their driver's license as they age and becoming unable to drive (R. Wasfi, D. Levinson, & A El-Geneidy, 2012). However, the cohort of seniors in this study was not part of the baby boomer population. Previous research has associated baby boomers with higher automobile trip rates (Newbold et al., 2005) and limited use of public transit (Collia, Sharp, & Giesbrecht, 2003). This higher reliance on automobiles later in life can be related to the lack of alternatives and the way planners have been developing cities,

making it difficult for older adults to relinquish driving (Kerr, Rosenberg, & Frank, 2012). Such reliance on automobiles imposes a bigger challenge for engineers and planners to better understand the differences in travel behavior, especially transit use, among cohorts of seniors. It will be important to provide the aging population with transportation services that adequately meet their needs and help in ensuring their independence.

Figure 1 displays a normalized transit mode share for those aged 20 and older for the years 1998, 2003, 2008 and 2013 for non-work trips. This data is obtained from several Montreal Origin-Destination (O-D) surveys (Agence Metropolitaine de Transport, 2003, 2008, 2013; AMT, 1998). From this data, the transit mode share for each five year age group was obtained. Then, it was normalized by the transit mode of all ages for the survey year it was extracted from and plotted on the graph. The figure is an extension of previous research (Grimsrud & El-Geneidy, 2014) which shows the lifecycle analysis of transit mode share over time. Examining transit behavioral trends across the lifecycle, we see that transit use is high among individuals in their early 20s, declines as individuals progress into their 30s and stabilizes until the age of 65, or near retirement, similar to previous studies (Brown, Blumenberg, Taylor, Ralph, & Turley Voulgaris, 2016). Following retirement, we see an increase in transit use. Retirement presents a divergent point among cohorts, where each cohort has a similar transit mode share before retirement

age, then, transit levels increase above the average (of the entire survey population) after average retirement age.

Two generational differences in transit use emerge in this figure. First, we see that the transit mode share for respondents in their 20s and 30s is highest for the more recent survey years, which confirms the trend of higher transit use among individuals in the millennial generation (born between 1980 and 2004) found by Grimsrud and El-Geneidy (2014) as well as other recent studies (Brown et al., 2016; McDonald, 2015). Previous studies have shown that millennials exhibit different travel behavior than previous generations, including a reliance on transit and non-automobile modes (McDonald, 2015) and often prefer to live in high density neighborhoods which facilitate a multimodal lifestyle (Brown et al., 2016). It is also clear from observing the figure that seniors (65+) are experiencing higher than average transit usage compared to younger adults. This is especially true for the older generations. In other words, the age group that was 75-79 in 1998 took transit more than the same age group in 2013. A second generational difference is also exhibited among seniors aged 65 and older, where in 1998 seniors used transit at much higher rates than seniors in the years 2003, 2008 and 2013. These generational differences, between the baby boomers (born between 1946 and 1965) and the generation of the parents of baby boomers (born between 1919 and 1940) are evident in this figure and requires further analysis to better understand the differences in transit usage between the cohorts.

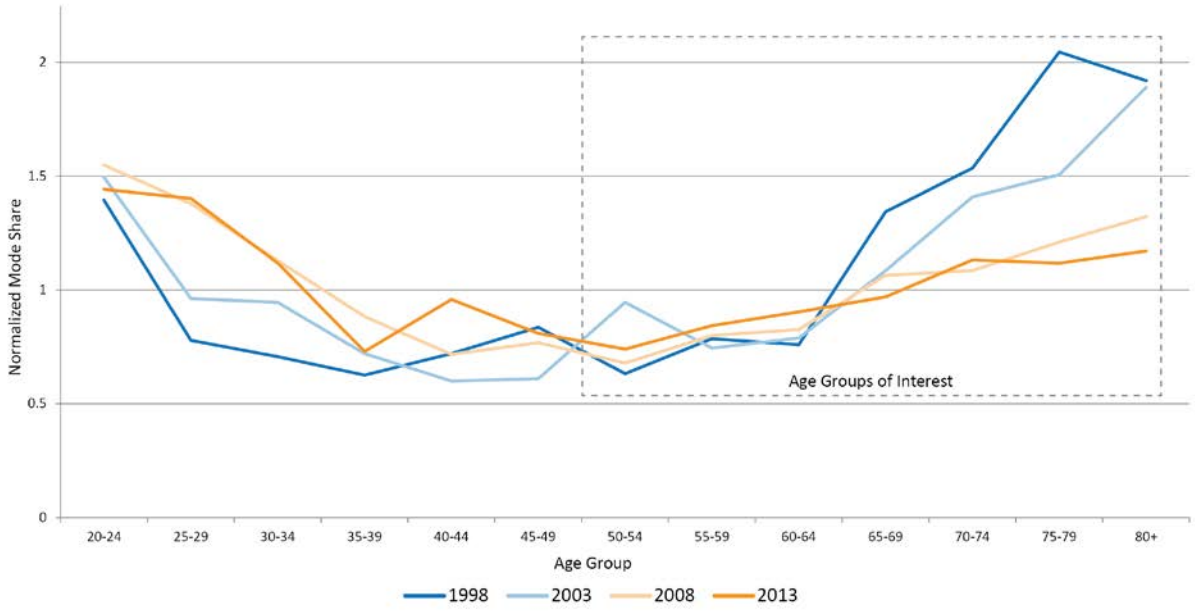

Figure 1: Transit Mode share for all ages

The main goal of this paper is to highlight patterns in public transit use among older Canadian adults (50 years and older). With this in mind, this paper assesses (1) the travel behavior of seniors, across age groups as well as between males and females, and (2) the transit mode share of six cohorts to consider travel behavior differences across generations. Generational differences in travel behavior are evaluated using a pseudo-cohort analysis of Montreal, Canada residents that are 50 years or older using the 1998, 2003, 2008 and 2013 O-D Surveys provided by the Agence Métropolitaine de Transport (AMT) (Agence Metropolitaine de Transport, 2003, 2008, 2013; AMT, 1998). This is done in an effort to examine how transit mode share changes over time, between age groups, and across generational cohorts.

The next section of this paper provides a review of the literature related to travel

behavior at lifecycle changes and the travel behavior of seniors. We then present an analysis of the transportation mode share for those aged 50 and older in all survey years. This is followed by a pseudo-cohort analysis of the transit mode share of six cohorts to determine how transit is used by different generations over time. Sub-cohorts are created to investigate the impacts of gender on transit use. Lastly, the paper ends with a discussion of the results.

LITERATURE REVIEW

There is a growing body of literature which aims to analyze public transit use during the lifecycle of individuals, especially the millennial generation (those born between 1980 and 2004) (Brown et al., 2016; Grimsrud & El-Geneidy, 2013, 2014; McDonald, 2015). These individuals are adopting a more multimodal lifestyle, which includes greater reliance on public transit as well as other non-auto modes (McDonald, 2015), as well as preference for living in dense and transit-rich neighborhoods (Brown et al., 2016). However, these individuals were found to decrease and stabilize their transit use in their 30s, implying transit agencies should aim to develop policies to retain the ridership of these individuals (Grimsrud & El-Geneidy, 2014). On the other end of the spectrum, Newbold et al. (2005) conducted a cohort analysis of travel behavior of Canadian seniors, focusing on automobile trips, and found that older Canadians are making more auto-based trips than previous cohorts.

It is well established in the literature that seniors are increasingly dependent on automobile use, due to the sprawling and auto-dependent nature of the neighborhoods that were built post-World War II. This preference for automobile use among seniors is especially strong if they have access to a car (Schmöcker, Quddus, Noland, & Bell, 2008) and where they do not have other travel alternatives. Despite physical or cognitive changes with age and their impact on driving, seniors are increasingly dependent on automobiles to meet their travel needs (Newbold et al., 2005; Rosenbloom, 2001).

Newbold et al. (2005) observed that as the Canadian population ages, driving will continue to be the primary mode of transportation and that public transit will become relatively less important if this trend continues. This is problematic as studies have found higher accident rates per distance traveled among older adults (Eberhard, 2008). The higher observed accident and death rates, may be a result of cognitive changes with age that impact their reaction time and awareness when driving (McGwin, Sims, Pulley, & Roseman, 2000), as well as increased frailty and decreased ability to recover in the event of an accident (G. Li, Braver, & Chen, 2003) . Alarming accident statistics have led to discussions about policy changes in the regulation of drivers licenses among seniors (Morris et al., 2014; Staplin & Freund, 2013). However, to ease older adults into this transition from the independence provided by driving, high quality alternative travel modes, including public transit, are needed.

Public transit can provide an alternative travel mode to driving by responding to seniors' preference for mobility independence if it meets their mobility needs and preferences (Mercado, Páez, & Newbold, 2010). However, previous research studying travel behavior of older Canadians suggests that public transit is not widely used as a replacement to driving (Newbold et al., 2005). In a study of the 2008 O-D Survey in Montreal, (Moniruzzaman, Páez, Habib, and Morency (2013)) found that the probability of walking and using transit decreases with age and retirement. Similarly, Newbold et al. (2005) found a decline in the mean number of trips following retirement, as well as

changes observed in trip-related purposes. Newbold et al. (2005) found that, over time, Canadian seniors increase their number of trips taken by public transit. However, this growth is not as large as the observed increase in automobile trips. Other factors that influence transportation behavior of seniors include geographical variability, neighborhood design, household size, income (Moniruzzaman et al., 2013), possession of a driver's license and automobile ownership (Paez, Scott, Potoglou, Kanaroglou, & Newbold, 2007).

Following retirement, fewer work-related trips have been noted (Newbold et al., 2005; Rosenbloom, 2001), and the variety of trip purposes individuals make post-retirement tend to narrow to destinations for essential purposes such as shopping and services (J. Burkhardt, 1999). Another significant change that seniors undergo is driving cessation as a result of declining health, as well as declines in finances or physical abilities. A longitudinal cohort study found that driving cessation was associated with a decrease in out of home activity (Marottoli et al., 2000). Seniors' preferences for aging in place (Cannuscio, Block, & Kawachi, 2003) and dependency on personal automobile travel raises concerns of social exclusion and reduced mobility resulting from driving cessation (R. Wasfi et al., 2012). As noted by Newbold et al. (2005), as individuals age, there is a potential for an increase in demand for public transit service. However, current trends in the travel behavior of older Canadians suggest that public transit is not widely used as a replacement to driving. Paez et al. (2007) examined mobility challenges faced

by Canadian seniors following retirement, and found that the propensity to make a trip decreased with age. Following an analysis of Americans over the age of 50 using data collected by the American Association of Retired Persons, Kim (2011b) observed that most respondents would get rides with friends or family when they ceased driving. Moreover, the author observed that respondents who lived within walking distance to public transit were more likely to choose transit. However older adults with limited or no experience with public transit before the cessation of driving were resistant to using public transit. This finding suggests that older adults should be encouraged to experience other transportation modes prior to driving cessation.

Gender differences among seniors' travel behavior have been noted. Rosenbloom and Winsten-Bartlett (2002) observed that older women make up a disproportionate amount of non-drivers, and have been found to be more likely than older males to self-regulate their driving behavior. Collia et al. (2003) compared driving behavior of older and younger American adults and found that women over 65 years of age take fewer trips per day, drive shorter distances and are more likely to report medical conditions that may limit their travel than men. Furthermore, the authors predicted an increase in older drivers on the road in the near future, which they attribute to both an aging population, as well as the anticipated trend that older women will drive in greater proportions than previous cohorts. In regards to gender differences in transit use, Rosenbloom and Winsten-Bartlett (2002) observed that women who did not drive took

a smaller percentage of their trips by public transit than male non-drivers, which the authors suggested may indicate that women are more willing to ask for rides and less willing to use public transit compared to men. However, the authors express concern that older women's reluctance to use public transit may mean that they are forgoing trips needed to maintain their quality of life. Because Canadian women tend to have a longer life expectancy (Statistics Canada, 2012) a gender imbalanced older population is expected, which may have implications for overall travel behavior.

ANALYSIS

Study Context

This study focuses on the transit mode share of seniors in the Greater Montreal Area, Canada, which will hereafter be referred to as the Communauté Métropolitaine de Montréal (CMM). Montreal is the second largest city in Canada with a CMM population of 3,824,221 in 2011. The Montreal CMM is served by several transit agencies. These include the Société de Transport de Montréal (STM), which provides the island of Montreal with bus and metro service, the AMT, which provides commuter train service and overlooks several small suburban bus services for the CMM, as well as the Société de transport de Laval and the Réseau de transport de Longueuil. Every 5 years the AMT conducts an O-D Survey by telephone of residents of the CMM. These surveys are carried out in the fall and captures 5% of Montreal's CMM population. Within the survey, respondents are asked about their personal and household travel characteristics, including length of trip, mode used and trip purpose. This survey will be used in this study to understand the changes in transit mode choice and travel behavior among different cohorts of seniors over time.

Data Preparation

The data used in this research is from the Montreal 1998, 2003, 2008 and 2013 O-D surveys. Using a Geographic Information System, trips with origins or destinations outside of the CMM were removed. Additionally, all trips that did not begin at the

respondents' home were eliminated. The most common trip purpose for the remaining respondents over 60 years old was shopping. This is consistent with previous findings that work related trips decrease among older adults due to retirement of a big proportion of this population, while trips associated with shopping and services are expected to increase (Newbold et al., 2005). Therefore only trips made for the purposes of shopping, leisure, visiting friends and health were analyzed in this study. Trips made for other purposes, such as work, and multimodal trips were eliminated, to ensure consistency and uniformity of the remaining trips. The remaining trips were then coded into six modes. These were transit, automobile, automobile as a passenger, walking/biking, paratransit and other (motorcycle, taxi, and "undetermined"). Transit included trips using a bus, metro or a commuter train. Trips made by respondents 50 years or older were selected, which yielded sample sizes for each year of 18,311, 14,572, 18,996 and 27,256 for 1998, 2003, 2008 and 2013 respectively.

Travel Behavior Analysis by Age and Survey Year

In order to better understand how seniors are behaving in regards to the usage of public transit, it is important to understand their travel behavior across various modes to determine their dependence on these modes, across both age and survey years. Using the age variable of the survey, the respondents were divided into seven age groups, each including five years. The oldest age group included respondents 80 years or older. Table 1 shows the number of respondents in each age group and their mode share for

the six coded transportation modes in 1998, 2003, 2008 and 2013. This information is also shown graphically in Figure 2.

For all survey years and all age groups, automobile as a driver had the highest mode share. Automobile as a driver was at its highest mode share in 2013 at 61.5%. It peaked in 2003 for the 55-59 age group with 67.5%. Automobile as a driver had the lowest mode share for the 80+ age group in 1998 with 31.2%. The second highest mode share was automobile as a passenger. For all survey years, automobile passenger trips peaked for the 80+ age group. Generally, walking and cycling increased as respondents aged. As expected, paratransit mode share is the highest for the two oldest age groups. The 'other' category, which includes mostly taxi trips and undetermined modes, accounts for 1% of total trips taken, however the other category increases and is highest for the 80+ age groups in 1998 and 2003 with a mode share of 3.8% and 3.7% respectively.

Transit is the fourth most popular mode choice, after automobile, automobile as a passenger, and walking/cycling. Figure 2 shows that in 1998 transit use increased as respondents aged and decreased slightly for the 80+ age group. In this year, it was highest for the 75-79 and 80+ age groups at 13.3% and 12.5%. In 2003 and 2008, transit mode share also increased with age. However, it does not increase to the levels seen in 1998. It peaks at 8.1% in 2003 and 8.3% in 2008 for the 80+ age group. An increase in transit mode share with age is also seen in 2013. However, this increase is the least

dramatic of all survey years. It increased from 4.0% for the 50-54 age group to 6.4% for the 80+ age group, which only represents an increase of 2.4%. Figure 2 shows that transit use increased as respondents aged. This increase is most dramatic in 1998 and appears to be less so in the following survey years.

In all survey years, transit use was higher for the older age groups. However, this effect is most apparent in 1998 and the least dramatic in 2013. As noted above, transit can provide an alternative to automobile use and maintain the mobility and independence of seniors (Mercado et al., 2010). Yet the literature (Paez et al., 2007) and Figure 2 suggest that public transit is not being used as an alternative to driving. The findings that seniors prefer to age in place (Cannuscio et al., 2003) emphasizes the importance of providing safe alternatives to driving in the context of sprawling auto-oriented urban development. The apparent stagnation of transit use for older adults in the most recent survey year provides an impetus to further examine generational differences in transit use through a cohort analysis

1

2 **Table 1: Age Groups and Mode Shares in All O-D Survey Years**

Age Group	Year	Transit		Automobile		Auto Passenger		Walk/Bike		Paratransit		Other		Total		Age Group % of Year Total
		Share (%)	Count	Share (%)	Count	Share (%)	Count	Share (%)	Count	Share (%)	Count	Share (%)	Count	Share (%)	Count	
50-54	1998	4.1	148	66.0	2376	15.7	566	13.4	481	0.1	4	0.6	23	100	3598	19.6
	2003	4.0	102	67.4	1705	15.4	390	12.4	314	0.2	6	0.6	14	100	2531	17.4
	2008	4.3	116	64.6	1750	13.8	374	16.3	442	0.3	7	0.7	18	100	2707	14.3
	2013	4.0	146	66.7	2407	12.7	457	15.2	548	0.5	19	0.9	32	100	3609	13.2
55-59	1998	5.1	162	63.8	2020	17.4	551	12.9	407	0.3	8	0.6	18	100	3166	17.3
	2003	3.2	87	67.5	1849	16.4	449	12.2	334	0.2	5	0.6	17	100	2741	18.8
	2008	5.0	155	60.8	1868	15.9	487	17.0	521	0.5	16	0.7	23	100	3070	16.2
	2013	4.6	188	64.0	2611	14.6	596	15.7	639	0.3	12	0.8	33	100	4079	15.0
60-64	1998	4.9	163	61.5	2028	19.6	646	13.2	436	0.2	5	0.6	19	100	3297	18.0
	2003	3.4	93	64.6	1788	18.6	514	12.6	350	0.3	8	0.5	14	100	2767	19.0
	2008	5.2	192	61.2	2254	16.8	618	15.6	575	0.3	12	0.9	32	100	3683	19.4
	2013	4.9	256	63.3	3278	15.6	810	15.0	778	0.5	28	0.6	32	100	5182	19.0
65-69	1998	8.7	294	53.8	1808	22.0	740	14.5	487	0.3	10	0.7	24	100	3363	18.4
	2003	4.6	112	60.3	1461	20.4	494	13.6	330	0.4	9	0.7	18	100	2424	16.6
	2008	6.7	229	56.7	1932	17.6	599	17.4	595	0.6	20	1.0	35	100	3410	18.0
	2013	5.3	283	61.0	3256	18.4	985	14.2	759	0.5	27	0.6	31	100	5341	19.6
70-74	1998	10.0	259	52.5	1360	20.5	531	15.7	406	0.4	10	1.0	26	100	2592	14.2
	2003	6.0	124	55.4	1143	22.6	466	14.6	302	0.5	10	1.0	20	100	2065	14.2
	2008	6.8	183	55.9	1493	20.1	538	15.6	416	0.6	15	1.0	27	100	2672	14.1
	2013	6.2	249	61.8	2487	17.6	708	13.0	522	0.7	29	0.8	31	100	4026	14.8
75-79	1998	13.3	185	45.0	625	19.3	268	20.4	283	0.3	4	1.8	25	100	1390	7.6
	2003	6.4	77	52.4	629	22.2	266	14.6	175	1.4	17	3.0	36	100	1200	8.2
	2008	7.6	145	51.0	967	22.2	421	16.6	315	0.8	16	1.7	33	100	1897	10.0
	2013	6.1	154	57.7	1455	21.5	541	12.8	323	0.8	19	1.1	28	100	2520	9.2
80+	1998	12.5	113	31.2	282	25.1	227	26.1	236	1.4	13	3.8	34	100	905	4.9

	2003	8.1	68	39.2	331	27.7	234	19.7	166	1.7	14	3.7	31	100	844	5.8
	2008	8.3	130	39.9	621	24.5	382	21.9	341	2.0	31	3.3	52	100	1557	8.2
	2013	6.4	160	51.2	1279	21.6	540	15.6	389	2.5	62	2.8	69	100	2499	9.2
Total	**1998**	7.2	1324	57.3	10499	19.3	3529	14.9	2736	0.3	54	0.9	169	100	18311	100
	2003	4.5	663	61.1	8906	19.3	2813	13.5	1971	0.5	69	1.0	150	100	14572	100
	2008	6.1	1150	57.3	10885	18.0	3419	16.9	3205	0.6	117	1.2	220	100	18996	100
	2013	5.3	1436	61.5	16773	17.0	4637	14.5	3958	0.7	196	0.9	256	100	27256	100
Total		5.8	4573	59.5	47063	18.2	14398	15.0	11870	0.6	436	1.0	795	100	79135	100

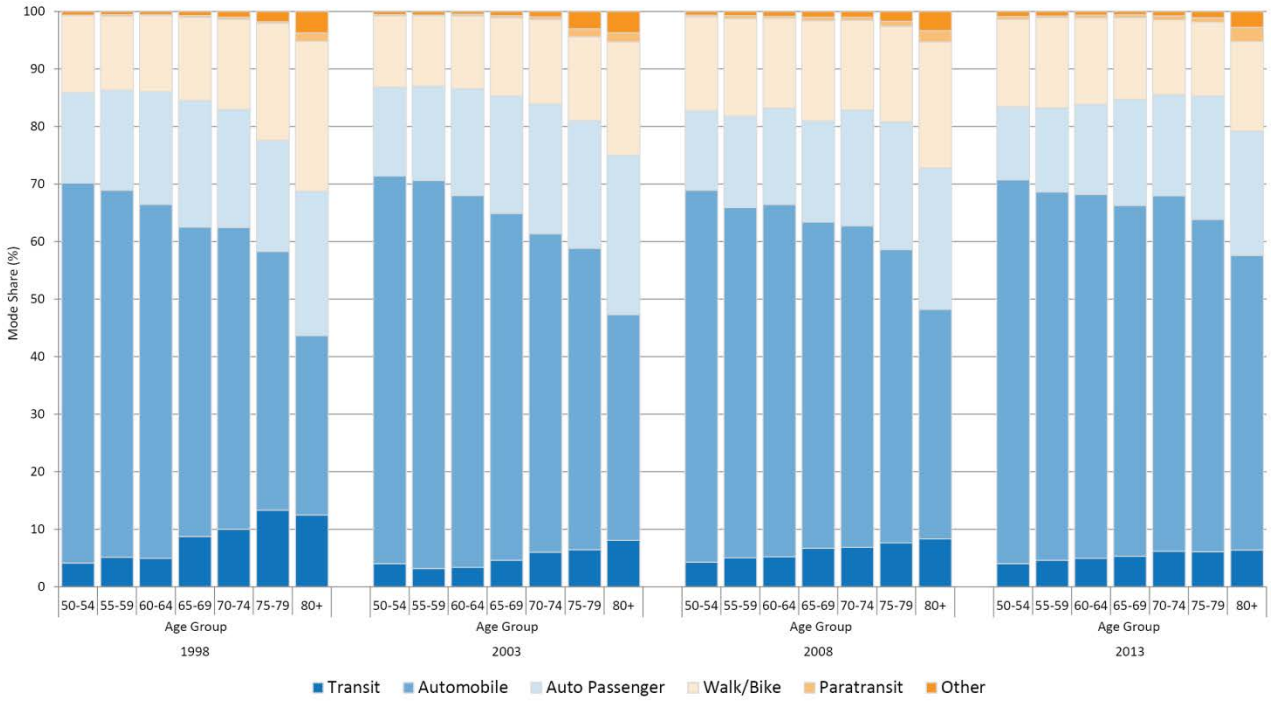

Figure 2: Age Groups and Mode Shares in All O-D Survey Years

Cohort Analysis

While the above results revealed a pattern of increased transit use for non-work trips after the age of retirement, relative differences in transit use were observed among survey years. We further examine these trends from a cohort perspective to observe transit use of older populations relative to younger ages. While longitudinal data following individuals and their travel behavior across time was not available, changes in aggregate cohort behavior is evaluated by comparing O-D survey data among cohorts. Using the above age groups, the respondents were divided into six cohorts, which are

presented in Table 2. The purpose of the cohort analysis is to follow the transportation behavior change of similarly aged respondents from 1998 to 2013. The 'pseudo-cohort' analysis method used in this study and previous research (Grimsrud & El-Geneidy, 2014; Newbold et al., 2005), provides an effective means to evaluate group behavior over time (Newbold et al., 2005).

For example, Cohort 1 includes respondents who were 50-54 years old in 2003, 55-59 in 2008 and 60-64 in 2013. Statistics Canada defines the baby boomer generation as those born between 1946 and 1965 (Statistics Canada, 2016). Therefore, the Canadian baby boomer generation is captured by Cohort 1 and partially by Cohort 2. Cohorts 5 and 6, whose respondents were born between 1929 to 1933 and 1924 and 1928, represent the oldest cohorts and oldest generations of seniors captured by this cohort analysis. These respondents are the generation of seniors that are the parents of the baby boomers. Creating these cohorts allows comparisons of transit use between generations to be made. Differences of transit mode share between generations were tested for statistical significance, using a Pearson Chi-Square significance test, and are shown in Table 2. The results of this test show that the variation in transit use in between survey years is statistically significant in all age groups, with the exception of the 50-54 age group. All other groups have p-values below the .05 threshold for statistical significance. The resulting p-values of the cohorts are also statistically

significant, with one exception being Cohort 1. For all other cohorts, the variation in transit trips in a cohort is statistically significant between survey years.

Table 2: Cohorts and Statistical Significance

	Age in 1998	Age in 2003	Age in 2008	Age in 2013	Reference
Cohort 1 Born 1949-1953		50-54	55-59	60-64	Bruce Springsteen
Cohort 2 Born 1944-1948	50-54	55-59	60-64	65-69	Bill Clinton
Cohort 3 Born 1939-1943	55-59	60-64	65-69	70-74	Harrison Ford
Cohort 4 Born 1934-1938	60-64	65-69	70-74	75-79	Mary Tyler Moore
Cohort 5 Born 1929-1933	65-69	70-74	75-79	80+	Clint Eastwood
Cohort 6 Born 1924-1928	70-74	75-79	80+		Gordie Howe

Age Groups	**Probability (p)***	**Cohorts**	**Probability (p)***
50-54	0.962	Cohort 1	0.141
55-59	0.001	Cohort 2	0.000
60-64	0.003	Cohort 3	0.000
65-69	0.000	Cohort 4	0.001
70-74	0.000	Cohort 5	0.000
75-79	0.000	Cohort 6	0.001
80+	0.000		

*Chi-squared test for difference between populations

Using data from Table 1, the transit mode share for each cohort in 1998, 2003, 2008 and 2013 was identified. Then, the mode share of each cohort was normalized by the transit mode share of the entire population for that survey year. The data was normalized to account for years in which transit mode share was exceptionally high or low. For example, in 2008 transit mode share was higher than other survey years across all age groups, perhaps due to a spike in gas prices. Once normalized, the transit mode

share can be analyzed relative to the average for that survey year. Figure 3 represents the normalized transit mode share of trips taken by the six cohorts graphically. The x-axis contains the age group and the y-axis represents the transit mode share relative to the average. The normalized mode share of the four survey years is represented by dotted lines and each cohort is represented with a solid line. Because the mode share has been normalized, when the lines are above 1, transit mode share is above the overall average for that survey year. Alternatively, when the lines are below 1, the transit mode share of that cohort is below the average. Displaying the cohort's mode share in this way allows comparisons to be made between generations. In other words, it compares the transit behavior of those who were the same age in different years.

In 2011, the average age of retirement in Canada was 63 years old (Statistics Canada, 2016). Generally, the dotted lines show that transit use is below average before retirement. It increases at retirement and then plateaus in the senior years. Figure 3 shows that Cohorts 1 to 4 had below average transit mode shares in their pre-retirement years. These cohorts appear to exhibit a change in transit behavior at retirement. The transition from pre-retirement to post-retirement is captured by Cohorts 2, 3 and 4. For all of these cohorts, transit mode share increases towards the average or above average in post-retirement years. Following retirement, transit mode share remains stable between the ages of 65 and 79. The older generations appear to level out at higher levels than the younger generations. This can be seen by comparing

Cohorts 4, 5 and 6. Cohort 4, has a transit mode share only slightly higher than the average between the ages of 65 to 79. Cohort 5, which represents an older group than Cohort 4, has a higher transit mode share for the same ages. Cohort 6, the oldest cohort, has the highest transit mode share. In other words, seniors aged 70-74 in 1998 took transit more than they did in 2003. 70-74 year old seniors took transit even less in 2008. Based on the above analysis, it can be confidently said that older cohorts used transit more in their senior years than younger cohorts did, given the statistical significance of Cohorts 4, 5 and 6. In other words, Gordie Howe used transit more than Clint Eastwood did when they were the same age. Mary Tyler Moore used transit even less. If this trend continues, it can be expected that the baby boomer generation will use transit less in their post-retirement years than older generations did, representing a challenge to maintaining the safe mobility of seniors.

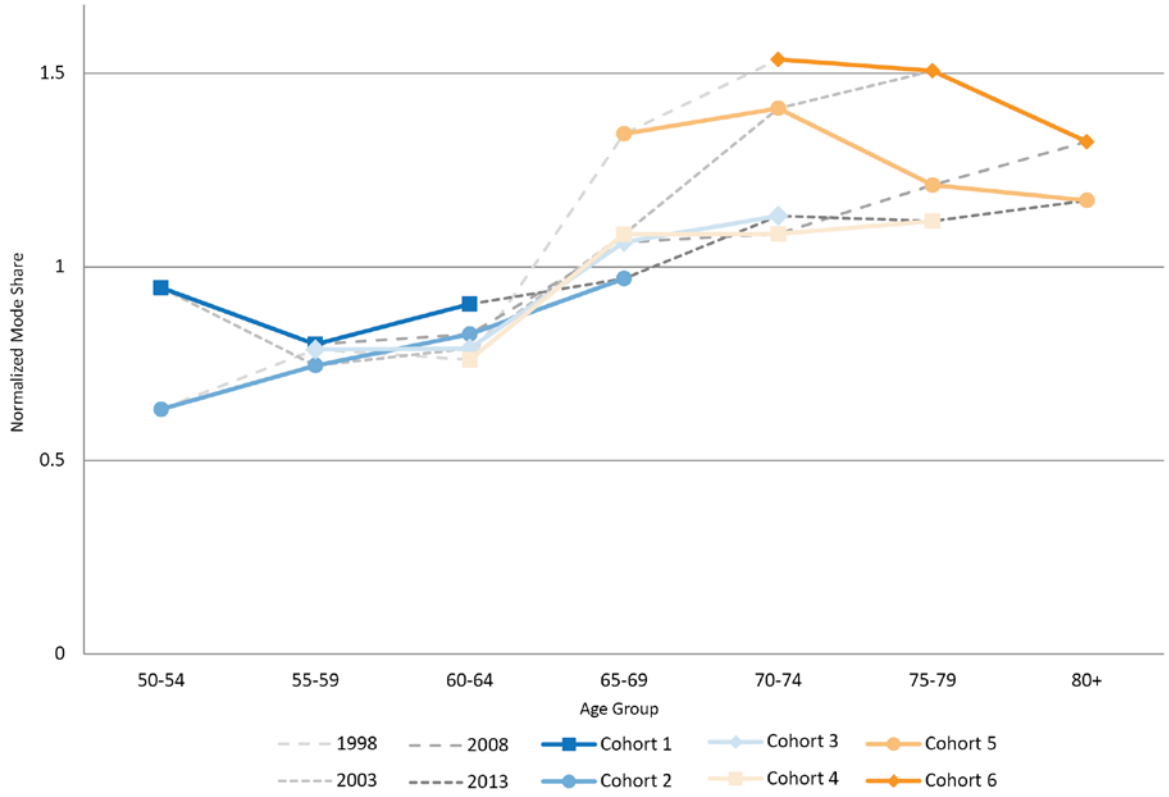

Figure 3: Transit Mode Share of Six Cohorts

Gender Differences in Transit Use

Following the review of literature regarding gender differences in travel behavior between generations of seniors, we isolated the transit use of males and females to consider differences in transit use across survey years as well as between older and younger cohorts of males and females. Figure 4 compares transit mode share of males and females for each age group in all survey years. For all age groups and all years, females have a higher transit mode share than males. The largest differences between males and females are observed in 1998. However, the transit behavior of males and females are most similar in 2013. A similar pattern to Figure 2 emerges in which transit

increases with age but increases less dramatically in more recent years. In particular, all male age groups have a transit mode share of less than 5% in 2013.

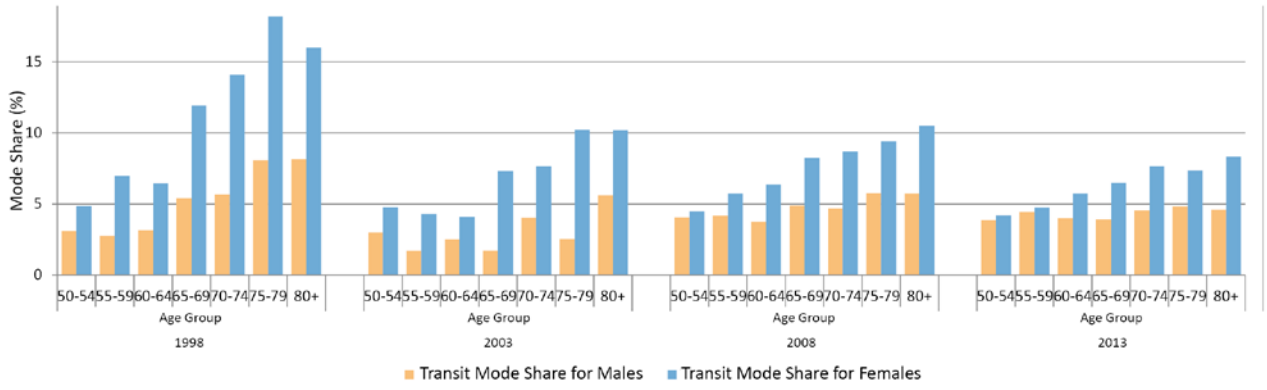

Figure 4: Transit Mode Share of Males and Females in All O-D Survey Years

Figure 5 shows the results of applying the cohort analysis to this data. Transit mode share of males was normalized by the transit mode share of men of all ages for each survey year. All male cohorts are slightly below the average in pre-retirement years. In post-retirement, transit mode shares do not deviate far from the average. There appears to be only slight variation between cohorts and between survey years in the post retirement years in males relative to females.

A clearer pattern is observed in the transit mode share of females, which is normalized by transit mode share of females of all ages. Like the male cohorts, transit use is below average before retirement. Cohorts 2, 3 and 4 rise above the average at retirement age. Cohort 4 shows a sharp rise at this point, Cohort 3 shows a less sharp

increase, and a more subtle increase is seen at this point for Cohort 2. By comparing the transit mode share of females in Cohorts 2, 3 and 4, it can be seen that transit use is increasing after retirement but is increasing to a lesser degree in younger cohorts. Overall, the transit use of older senior females is higher above the average than the transit use of older senior males. In Cohort 6, a transit mode share that is double the female average is observed, which occurred when they were 75-79 years old in 2003. Older female cohorts have a high transit mode share and diverge further from the average than their male counterparts. The younger female cohorts, who are in their pre-retirement years, behave more similarly to males.

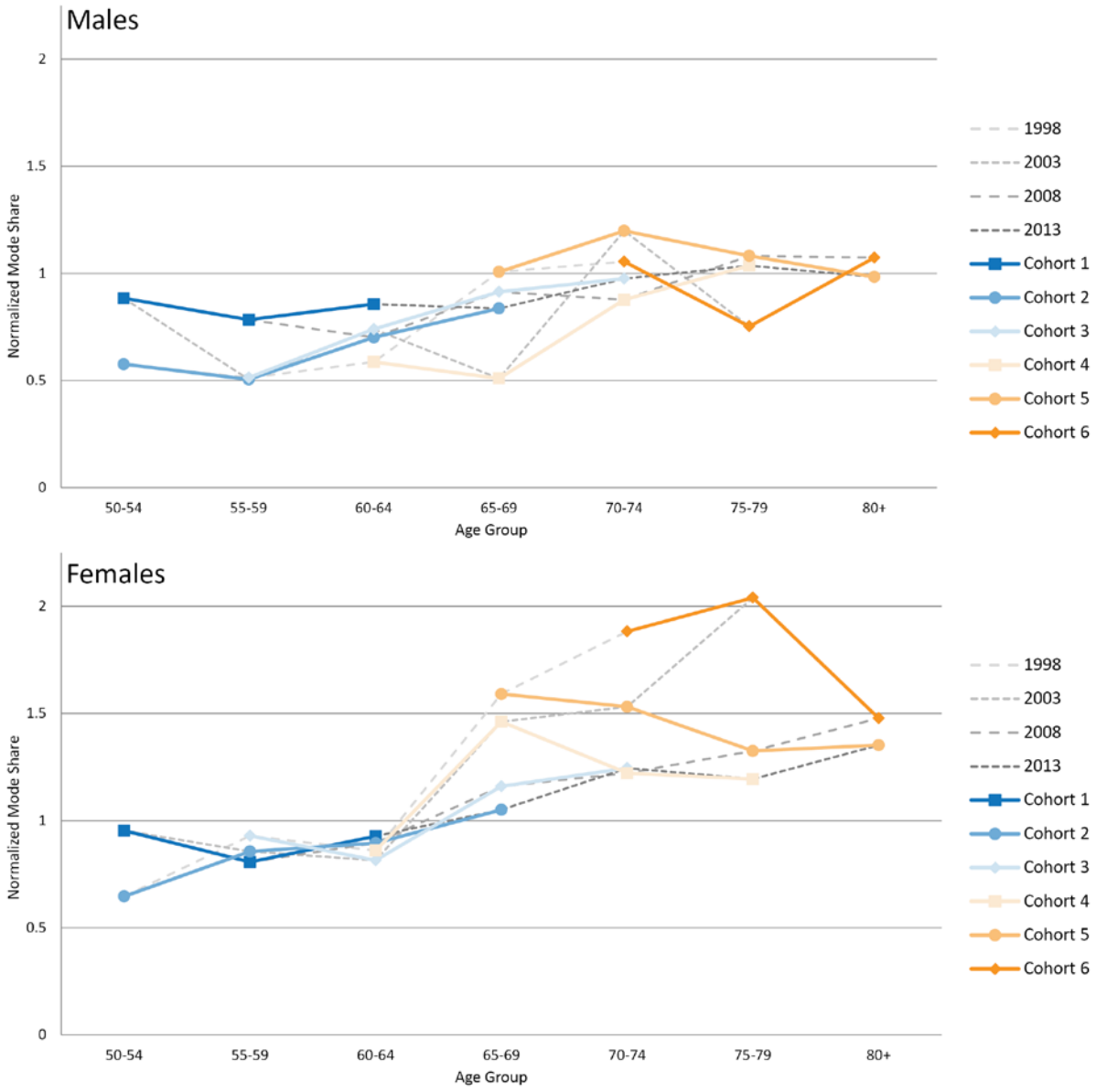

Figure 5: Transit Mode Share of Six Cohorts for Males and Females

DISCUSSION AND CONCLUSION

This study began with an analysis of seniors' travel behavior derived from O-D surveys in the years 1998, 2003, 2008 and 2013. We see that driving is the dominant mode of travel across each survey year, and in the most recent survey year we see a greater proportion of seniors that are driving at later years in life, which confirms previous research (Ritter, Straight, & Evans, 2002; Rosenbloom, 2001). In regards to transit use, we observe the opposite effect, where older seniors appear to use transit less than older groups of seniors at that age. Public transit can provide an alternative to the automobile by safely maintaining the independent mobility of seniors, while providing older individuals with a greater sense of dignity (Burkhardt, Berger, Creedon, & McGavock, 1998) and aiding older adults in the challenges faced with the cessation of driving. However, the results suggest that public transit is not as preferred and widely used in more recent survey years.

Using a pseudo-cohort analysis, we compared the transit use of older cohorts of seniors to younger cohorts. The oldest cohorts used transit at a higher rate in their older senior years than the younger cohorts did. However, the higher transit use exhibited in older cohorts is not seen in younger cohorts (Cohorts 3 and 4). The least dramatic increase in transit use post-retirement was seen in 2013. This finding is concerning because it suggests that baby boomer cohorts, who are now reaching retirement, are resistant to adopting alternative forms of travel. These results are potentially attributed

to the established transportation preferences of baby boomers (Rees & Lyth, 2005) in comparison to their parents' generation who were more dependent on public transit and continued to use transit post retirement, however to a greater degree. It has been argued that the existing transit use exhibited by older generations are not necessarily going to be shown by the baby boomer generation (Currie & Delbosc, 2010). This study corroborates previous research that the baby boomer generation has an attachment to private automobiles and that their transportation behavior as seniors will be different from previous generations. Therefore, when planning for an aging population, individuals of the baby boomer generation are expected to exhibit a less dramatic change in travel behavior following retirement than demonstrated by older generations of Canadian seniors. One way to address this issue is to actively encourage seniors to experience public transit before the cessation of driving to foster a level of familiarity and comfort with the service. This way, limited experience with public transit earlier in life is not a barrier following driving cessation.

Differences in the transit behavior of males and females were revealed in this analysis. For all age groups and all survey years, females have a higher transit mode share than males. The most significant gender differences in transit mode share were observed in 1998, where the transit mode share of women was more than double that of men. However, this gender gap in transit share decreased over survey years, and little difference in transit mode share was seen in 2013. From this analysis, gender differences

in transit behavior may be expected to diminish. The travel behavior of aging women may change, for reasons such as having fewer children to rely on for assistance (Rosenbloom & Winsten-Bartlett, 2002), as well as older women driving in greater proportions than previous cohorts (Collia et al., 2003). However, to maintain the high transit use among older women, transit agencies should consult with women to develop strategies that may facilitate their transit use, such as increased safety initiatives (R. Wasfi et al., 2012).

The elderly are not a homogenous group. Differences exist between the younger groups of seniors (i.e. 65-75 years) and seniors over 75 years of age in their travel patterns and mobility needs. The transit mode share among the two oldest cohorts (Cohorts 5 and 6) decreases towards the average for the 80+ age group. This suggests that transit no longer meets the needs of seniors who are over 80 years of age. The transit mode share of each age group by survey year shows a higher mode share for the 'other' category (i.e. taxi, motorcycle and undetermined) for respondents aged 80 years and older. This finding indicates that the oldest seniors are increasingly using alternative forms of transportation to maintain their mobility. Mobility reductions become more evident as people reach 80 years of age (Alsnih & Hensher, 2003). Perhaps as the physical mobility and cognitive functioning of older seniors decline, they are forced to use an alternative mode because, at this time, transit, as well as automobiles, may not be the most appropriate or safe option, as demonstrated by the accident rate in older

adults in previous studies, (Eberhard, 2008) as well as the physical demands of using public transit. Interestingly, Coughlin (2009) found that baby boomers have expectations that technology will help them manage their mobility as they age. This expectation may be met by the rising use of alternative forms of transportation, such as ridesharing services like Uber and Lyft. These alternatives could potentially address the changing demands of baby boomers by offering demand-based door to door transportation. However, barriers to entry for services like this include the cost and the requirement of a credit card and smart phone. Nonetheless, understanding the current barriers older adults face that might prevent or limit their transit use, as well as the use of alternatives, could provide valuable insights into the transportation needs of older seniors and how best to adapt public transit systems to an aging population.

The generational differences in travel behavior observed between the baby boomers and the parents of baby boomers reveals the importance of encouraging the adoption of multimodal lifestyles and better planning and development that facilitates less dependence on the automobile. The attachment to and reliance on the automobile may indicate a lack of familiarity with public transit, which may act as a reluctance to learn at an advanced age (J. Burkhardt, 1999).

This study indicates that as the baby boomers experience change in their physical mobility and cognitive functioning, their transportation behavior reveals a reluctance to use public transit in the years following retirement. Public transit can provide an

alternative travel mode to driving by responding to seniors' preference for mobility independence. Accordingly, transit agencies should aim to develop transit systems that account for the mobility needs and preferences of seniors, which would require an increased understanding of the nuances of aging and generational differences in the transportation behavior and mode choice of seniors.

PART THREE: GENERATIONAL DIFFERENCES IN AGING IN PLACE & TRAVEL BEHAVIOR BY NEIGHBOURHOOD TYPE

INTRODUCTION

Planning for an aging population is an increasingly relevant challenge for policy makers and planners in Canada because of the rapidly aging population. This is reflective of the aging baby boomer generation, who are now reaching retirement age. When planning for the aging population, maintaining independent mobility of the elderly will be an important consideration. It is important because reduced mobility of the elderly can be associated with concerns about social isolation and decreases in out of home activity (Marottoli et al., 2000; R Wasfi, D Levinson, & A El-Geneidy, 2012). To help address this challenge, research that focuses on the home location choices and travel behavior of older adults is necessary. This research needs to acknowledge generational differences in the behavior of the elderly. Previous research has shown that there are generational

differences in the travel behavior and transit use of older adults in Montreal (Fordham, Grisé, & El-Geneidy, 2017). While Fordham et al. (2017) alluded to the role the built environment may play in the differing travel behavior by discussing historical patterns of development. For example, neighbourhood characteristics that are typical of post-World War II development act as barriers to the mobility of older adults, who tend to be more transport deficient in sprawling suburban environments (Kim, 2011a). Alternatively, compact development that is typical of prewar development and features local shops, services and amenities is more conducive to maintaining the mobility of the aging population (Michael, Green, et al., 2006). Additional analysis is needed to further understand the roles that land use, the built environment and neighbourhood accessibility play in assessing the potential success of planning for an aging population and providing the elderly population with neighbourhoods that support safe and independent mobility.

Many older adults prefer to age in place, which refers to "the ability to live in one's own home and community safely, independently, and comfortably, regardless of age, income, or ability level" (Centre for Disease Control and Prevention, 2013). When contemplating whether or not to age in place, older adults must take into account several considerations about their home and community. The Ministers Responsible for Seniors in Canada published a guide for older adults called *Thinking About Aging in Place* that states these considerations should include whether they have access to

services within their community and whether or not they can reach services and amenities without a car (2012). In other words, the elderly must consider the role the built environment has on their mobility. The mobility of older adults can be disproportionally impacted by their built environment, which can exaggerate mobility issues (Clarke, Ailshire, & Lantz, 2009; Rosso, Auchincloss, & Michael, 2011). This suggests that the built environment can negatively impact elderly mobility and their capacity to age in place. This is evident in suburban environments, which are characterized by built environments that lead to reduced mobility in the elderly. This is problematic because some projections refer to the suburbanization of the aging population and predict that aging in place will occur in suburban environments in the near future (Golant, 2005). However, the idea that the elderly are disproportionately impacted by their built environment also implies that thoughtfully planned neighbourhoods can contribute to successful aging in place that maintains safe and independent mobility. Aging in place can be supported by the provision of accessible land uses at the neighbourhood level and providing transportation alternatives to the automobile.

There are two goals of the current research. The first goal is to identify patterns in the preference to age in place exhibited by older adults in Montreal over a 15 year time period. To do this, the paper will analyze which neighbourhood types older adults are expressing a preference for as they age. The second goal is to determine the mode

choices of older adults in different neighbourhood types over time. This research keeps in mind that planning for an aging population should allow older adults to express choice for their home location, while facilitating the preference to age in place by providing policies that support accessible neighbourhoods. Planning for an aging population should also ensure independent mobility and provision of alternatives to the automobile, including public transit.

By focusing on the concept of aging in place, the current research will analyze household location choices and travel behavior of older adults in Montreal, Canada over time. This will begin with a review of the literature related to aging in place and the impact of the built environment on travel behavior and mobility of older adults. This is followed by a description of the methods. The methods include a land use classification, cohort analysis, and identification of mode share. Then, the results of the analysis are presented. Finally, the paper will conclude with a discussion of the results and the implications for the aging population in Montreal.

LITERATURE REVIEW

Aging in Place

The concept of "aging in place" refers to the ability of older adults to live independently and safely in their current home and community comfortably for as long as possible, regardless of age, income, or ability level (Centre for Disease Control and Prevention, 2013). Aging in place is in contrast to institutionalized care. The concept of aging in place is preferred by the elderly population themselves because it can facilitate independence, mitigate social isolation and enable choice in terms of living preferences (Lawler, 2001; Wiles, Leibing, Guberman, Reeve, & Allen, 2011). Additionally, in a survey from the American Association of Retired Persons, 73% of respondents strongly agreed with the statement that they would like to stay in their current residence as long as possible (Keenan, 2010). Furthermore, in a focus group, it was found that some seniors show an attachment to their current community and neighbourhood (Wiles et al., 2011).

Successful aging in place strategies often focus on the availability and affordability of the housing stock and health care services (Lawler, 2001). However, the built environment also plays a role. Barriers to successful aging in place include limited access and automobile oriented land uses (Farber, Shinkle, Lynott, Fox-Grage, & Harrell, 2011). This is problematic as the aging population appears to show a preference for aging in place in automobile oriented suburban environments. This is illustrated by an example from the United States. With the aging baby boomer population, the American

suburbs are projected to experience a 50% increase in residents between the ages of 65 and 74 between 2010 and 2020 (Golant, 2005). Given similar historical development patterns to Canada, results in Canada could be similar. This statistic combined with the concept of aging in place suggests that the preference to age in place will result in older adults staying in suburban environments. As these suburban environments were developed around automobile use, it is important to support design and service initiatives that facilitate alternatives to the automobile for the aging population.

An alternative that could improve elderly mobility safely is automated vehicles (AVs). These driverless cars could serve as an alternative following driving cessation. A benefit of AVs is that it works with existing automobile infrastructure and does not require retrofitting or rebuilding (Reimer, 2014). Elderly adoption of this emerging technology will require training programs for the elderly in an attempt to encourage willingness to use AVs (Siulagi et al., 2016). Nonetheless, AVs represent a potential alternative to maintaining safe and independent mobility of the elderly.

Neighbourhood Characteristics and the Elderly

A growing body of literature suggests that the mobility of the elderly is disproportionately impacted by the built environment and that the built environment can exaggerate their mobility issues (Clarke et al., 2009; Rosso et al., 2011). Additionally, older adults in mobility supportive environments can have an improved quality of life (Sugiyama & Thompson, 2007). The neighbourhood that an older adult lives in becomes

increasingly important with age. Older adults travel outside of their local communities less often than their younger counterparts (Clarke et al., 2009). This emphasizes the importance of ensuring that older adults are in neighbourhoods with built environments that support their independent mobility.

Before WWII, cities were built with an urban form that was centralized and allowed daily activity to be completed locally (Badland & Schofield, 2005). Postwar cities were more decentralized and suburban neighbourhoods emerged with single land uses (Frank et al., 2003). Compact development, which is a characteristic of prewar neighbourhoods, is often associated with the three Ds: density, diversity and design (Cervero & Duncan, 2003). The three Ds are reflected in neighbourhood characteristics. These characteristics, which include a mix of land uses, street connectivity, population density, and accessibility have been linked to more active living and higher rates of transit use and walking (Cervero & Duncan, 2003; Handy et al., 2002; Saelens et al., 2003). The link has been extended to seniors in several studies. A study from 2006 used focus groups of people aged 55 years and older to analyze how neighbourhood design encourages active living. Four themes emerged, which included local shopping and services that can be accessed without a car, concerns about safety and inadequate infrastructure, the neighbourhood's attractiveness and adequate public transit. It was concluded that cities should address neighbourhood factors that keep older adults active in order to promote independent living with age (Michael, Green, et al., 2006).

Additionally, it was found that traditional neighbourhood types, in comparison to suburban neighbourhood types, are related to reductions in vehicle miles travelled by older adults (Cao et al., 2010). Researchers also found that older adults in suburban neighbourhoods are more transportation deficient (Kim, 2011a).

Older adults appear to prefer the characteristics of compact neighbourhood design. Compared to their younger counterparts, older respondents of a survey in Northern California were found to prefer living in neighbourhoods with nearby amenities and shopping, as well as compete sidewalks (Cao et al., 2010). This emphasizes the importance of compact development and the three Ds in neighbourhood design for the elderly. Maintaining independence of the elderly and allowing them to express their preference for amenity rich neighbourhoods should be the goals of policy makers who are planning for an aging population. In an attempt to help policy makers achieve this goal, the current study looks at aging in place in a way that has not been studied before. This includes looking at the type of neighbourhoods older adults are living in over time through a pseudo-cohort analysis.

Neighbourhood Characteristics and Mode Choice of the Elderly

Encouraging an active lifestyle can be important in maintaining the independent mobility of the elderly (Michael, Green, et al., 2006). One way to live actively is through walking. The built environment and land use can influence the decision to walk for older adults. For example, proximity to pedestrian streets, walking paths and trails have been

positively associated with walking in older adults (Gómez et al., 2010; Michael, Beard, Choi, Farquhar, & Carlson, 2006). Additionally, access to destinations, including places of employment, shopping and parks, has also been associated with walking in older adults (F. Li, Fisher, Brownson, & Bosworth, 2005; Michael, Beard, et al., 2006). Street connectivity and density can also influence walking behavior of the elderly. Li et al. (2005) found that walking in older adults was more likely in neighbourhoods with higher street connectivity and higher housing density. Moniruzzaman et al. (2013).also found that higher densities, as well as proximity to the CBD, made walking more likely among older adults.

Home locations in automobile oriented environments have implications for the mobility of older adults. Areas with a large percent of automobile commuters was associated with greater walking difficult for adults over the age of 75 (Clarke et al., 2009). Automobile oriented development tends to be sprawling. In sprawled development, the length of trips can increase resulting in alternative modes of transportation being unable to compete with driving (Cao et al., 2010). Previous work has discussed how, in recent years, transit has been unable to compete with the freedom and door to door service offered by the automobile (Fordham et al., 2017). Additionally, higher densities are associated with shorter automobile trip lengths for older adults, while street density increases automobile trip length (Moniruzzaman et al.,

2013). This suggests that there is potential in high densities areas to encourage a mode change from the automobile to an alternative mode.

Transit can provide an alternative to driving if it is able to meet the needs and preferences of older adults (Mercado et al., 2010). However, the results of previous work show that the popularity of transit as an alternative to automobile travel is decreasing, especially among younger cohorts of seniors (Fordham et al., 2017). It has also been argued that, if alternative modes are made competitive, traditional neighbourhood design can reduce the frequency and distance travelled in a vehicle by the elderly without sacrificing their needs or their access (Cao et al., 2010). There are elements of the built environment that can impact the decision to use transit among the elderly. Older adults are more likely to use transit if they live in areas with high built density, as well as high street density (Moniruzzaman et al., 2013). Furthermore, the perception of good transit service can result in a higher transit frequency (Cao et al., 2010).

Aging in Place and Elderly Mobility

Older adults have stated that residential relocation is not considered a substitute for the loss of driving (J Burkhardt, 1999). Relatedly, a body of literature has found that personal preference or residential self-selection may be more strongly associated with travel behavior than the built environment (Cao, Mokhtarian, & Handy, 2009; Cervero & Duncan, 2003). These findings, highlight the fact that older adults are expressing a preference to age in place. This preference to age in place may be stronger than their

preference to live in a community that helps maintain independent mobility. This emphasizes the importance of providing accessible neighbourhood types that are supportive of successful aging in place.

What is clear from the above review is that the preference to age in place can reflect a preference of the aging population to stay in suburban and automobile oriented environments. This is problematic as automobile orientation represents a barrier to successful aging in place (Farber et al., 2011). However, older adults express a stated preference for amenity rich neighbourhoods (Cao et al., 2010). Additionally, successful aging in place can be facilitated by mixed land uses and accessibility. Therefore, the goal of planning for an aging population should be to allow seniors to express their preference for certain homes, neighbourhoods and locations, while providing accessible neighbourhoods to choose from.

Rosenbloom (2010) rightly proposes that seniors are not a homogenous group. No single solution will solve mobility problems for all populations of seniors and different personal preferences, household characteristics and socio-economics all reflect different mobility needs. She also recommends solutions to help older drivers continue driving for as long as they can. Making driving safer for older drivers can help alleviate transportation deficiency (Kim, 2011a). However, these improvements should be paired with upgrades to the built environment that could alleviate the necessity of driving. These improvements could include widespread design standards, access to amenities

and maintenance of public spaces (Vine, Buys, & Aird, 2012). Alternatively, policies that encourage safe use of AVs could help maintain independent mobility in existing automobile-oriented environments.

The present study fills a gap in the literature by looking at aging in place over time through a cohort analysis and typology of neighbourhoods. It also assesses the impact of neighbourhood characteristics on the mode choice of older adults. This will allow for observations to be made about the generational differences in travel behavior and home location choices of older adults in Montreal. The results will be relevant for policy makers and planners who are planning for an aging population.

DATA ANALYSIS AND METHODOLOGY

Three pieces of analysis were conducted and will be presented in the Data and Methodology section. First, a land use classification was conducted, which included a factor analysis followed by a cluster analysis to identify neighbourhood types on the island of Montreal. Then, a cohort analysis was used to determine household locations of older adults over time. Finally, a mode share among older adults was observed for each neighbourhood type.

Land Use Classification

Land Use Classifications can be done through dichotomous or continuum approaches. However, dichotomous approaches have been criticized for generalizing characteristics (Song & Knaap, 2004) and continuum approached assume a specific spectrum. An alternative to the dichotomous or continuum approach is a typology approach. One way to classify neighbourhoods using a typology approach is through a factor cluster analysis. This has been used previously in efforts to classify neighbourhoods in Montreal (Jacques & El-Geneidy, 2014; Manaugh, Miranda-Moreno, & El-Geneidy, 2010). Creating typologies through factor cluster analysis offers an alternative to the dichotomous and continuum approaches.

The variables used for the land use classification were from a data set developed for a previous land use classification of Montreal (Jacques & El-Geneidy, 2014) and were

derived at the census tract level. The aforementioned study developed a land use classification for the Montreal region. For the present study, a decision was made to analyze only the island of Montreal rather than the entire region. This was in an attempt to have a more nuanced land use classification and eliminate census tracts with rural land uses and very low densities from the classification.

The variables in this data set were derived from the 2006 Canadian census, spatial analysis with DMTI data, and previous research (El-Geneidy, Cerdá, Fischler, & Luka, 2011). The variables reflect design, density, land use, demographics and household characteristics as well as a series of accessibility measures for census tracts on the island of Montreal. It is important to note that, when referring to accessibility, the reference to not to universal accessibility. Instead it is meant to refer to the idea of accessibility as the potential for interaction (Hansen, 1959) or, in this case, potential for access to services and amenities.

Factor Analysis

The variables from the data set described above were used to conduct a factor analysis. Factor analysis determines how the variables relate to one another and attempts to group similar variables together. The purpose of this was to identify variables that are important in describing the characteristics that make up a census tract. Variables were selected based on an eigenvalue above 1. Factor loadings above .500 or below -.500 were used to determine which variables to include. Five factors were identified

representing accessibility, single family homes, large open spaces, large blocks, and park space or industrial space. These factors help describe the density, street design, land use, and accessibility of census tracts on the island of Montreal. The variables used and factor loadings for each factor can be seen in Table 3. This is followed by a description of each factor.

Table 3: Factors, Variables and Factor Loadings

FACTORS	VARIABLES	LOADING
ACCESSIBILITY	Distance to the CBD	-0.792
	Access to Jobs by transit (gravity based)	0.842
	Access to big box stores by car (30 minutes)	0.853
	Access to food stores by car (30 minutes)	0.876
	Access to food stores by transit (45 minutes)	0.881
	Access to Restaurants by car (30 minutes)	0.889
	Access to restaurants by transit (45 minutes)	0.890
	Access to Jobs by car (gravity based)	0.898
SINGLE FAMILY HOMES	Percent Apartments	-0.867
	Percent Rented Dwelling	-0.856
	Population Density	-0.514
	Average number of people per household	0.667
	Percent Single Detached Homes	0.806
	Average number of bedrooms	0.856
	Percent Owner-Occupied Dwelling	0.856
	Average number of rooms	0.910
LARGE OPEN SPACE	Percent Open Space	0.649
	Average Block Size	0.707
	Number of cul-de-sacs	0.732
BLOCK SIZE	Percent Small Blocks (<0.016 km^2 or smaller)	-0.792
	Average Block Length (meters)	0.575
PARK OR INDUSTRIAL	Percent Industrial and Resource	-0.734
	Percent Park	0.737

Factor 1 Accessibility: This factor has a negative loading for distance to the central business district (CBD) and positive loadings for all of the accessibility measures. This means that this factor represents proximity to the CBD and high accessibility.

Factor 2 Single Family Homes: This factor is characterized by variables that reflect low densities and large single family homes. There are positive loadings for the number of single family homes, number of rooms, number of people per household and owner occupied dwellings. There are negative loadings for variables reflecting higher densities, including population density and percentage of apartments, as well as percent rented dwellings.

Factor 3 Large Open Space: The third factor represents areas with a high percent of open space and large block sizes. There is also a positive loading for number of cul-de-sacs. This factor represents large open land use and automobile oriented street design.

Factor 4 Block size: This factor has a positive loading for average block length and a negative loading for percentage of small blocks (smaller than .016km2), which represents block size.

Factor 5 Park or Industrial Use: This final factor has a positive loading for park space and a negative loading for industrial and resource land use.

Cluster Analysis

The factors described above were then used to conduct a cluster analysis. The cluster analysis groups together similar census tracts based on the factors. The goal of the cluster analysis was to identify and cluster together census tracts on the island of Montreal with similar design, density, land use, demographic and accessibility characteristics, reflected in the factors. Several iterations of the cluster analysis were

attempted. The number of segmentations was determined based on the characteristics of the factors for each cluster and by mapping the clusters. The best clustering was found with seven iterations of clusters.

Clustering resulted in seven clusters, which were given the titles Industrial with Residential, Inaccessible Residential, Auto Oriented Design, Dense & Diverse, Park Space, Wealthy Single Family Homes, and Accessible Prewar. These clusters represent different neighbourhood types on the island of Montreal. The values for each factor can be seen in Figure 6 and summary statistics can be seen in Table 4. The summary statistics in Table 4 include t-tests for significance. Values that are significantly different from the sample mean are indicated by an asterisk. This table is followed by a mapping of the clusters in Figure 7.

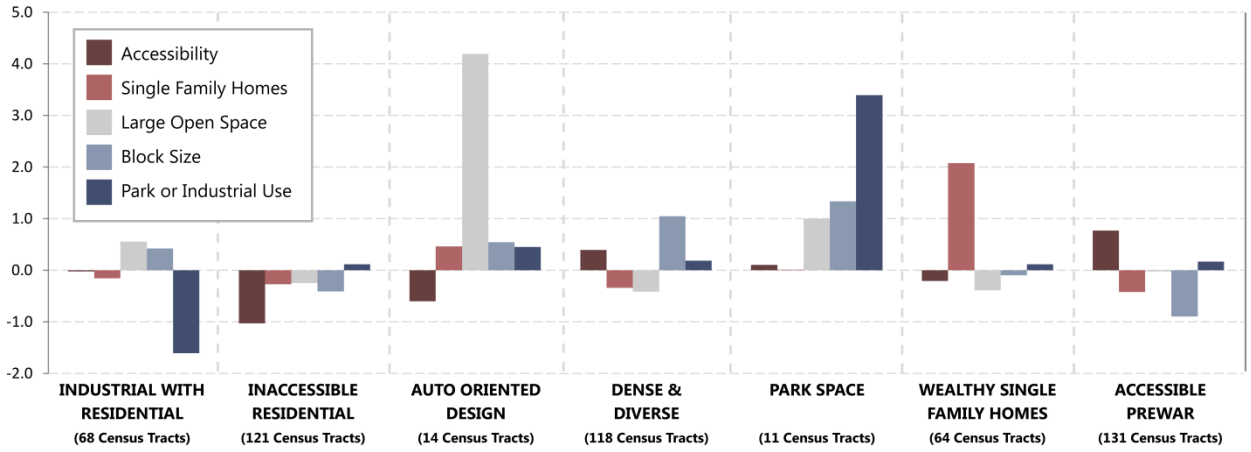

Figure 6: Results of Cluster Analysis

Table 4: Summary Statistics of Clusters

			TOTAL	INDUSTRIAL WITH RESIDENTIAL	INACCESSIBLE RESIDENTIAL	AUTO ORIENTED DESIGN	DENSE & DIVERSE	PARK SPACE	WEALTHY SINGLE FAMILY HOMES	ACCESSIBLE PREWAR
NUMBER OF CENSUS TRACTS:			**527**	**68**	**121**	**14**	**118**	**11**	**64**	**131**
PERCENT OF AREA IN ANALYSIS:			**100**	**20%**	**18%**	**21%**	**10%**	**3%**	**19%**	**9%**
DENSITY	**UNITS**	**SOURCE**	**SAMPLE MEAN**							
Population Density	Person/km^2	2006 Census	**8881**	5954*	7619*	2156*	12248*	7912	3884*	11774
Single Detached Homes	**%** of CT dwellings	2006 Census	**13**	6*	13*	46*	3*	29*	57*	1*
Apartments	**%** of CT dwellings	2006 Census	**79**	87*	78*	39	93*	67*	26	94*
People per household	Average	2006 Census	**2.8**	2.9	2.8*	3.0	2.8*	2.8	3.2*	2.6
Number of rooms	Average	2006 Census	**5.0**	4.8*	5.0*	6.2	4.6*	5.8*	7.3*	4.3*
Number of bedrooms	Average	2006 Census	**2.1**	2.1*	2.2*	2.6	1.9*	2.3	3.1	1.7*
STREET DESIGN										
Average Block Length	Meters	DMTI	**138**	148	122*	200	170	275*	130*	106*
Average Block Size	Kilometers^2	DMTI	**0.024**	0.033	0.019*	0.129*	0.023*	0.038	0.024	0.014*
Percent Small Blocks (<0.016 km2 or smaller)	Percent	DMTI	**55**	52*	62*	55	31	56	52*	75*
Number of cul-de-sacs	Count	DMTI	**3.7**	4.7*	3.2*	34.7*	0.9*	5.5	5.4	2.0*
LAND USE										
Percent Residential	Percent of CT	DMTI	**60**	33*	66*	26	66*	32	73*	61*
Percent Commercial	Percent of CT	DMTI	**4**	3	4*	0*	4	2	2*	5
Percent Industrial and Resource	Percent of CT	DMTI	**16**	50	8*	15	11*	5*	7*	15*
Percent Government and Institutional	Percent of CT	DMTI	**8**	3*	7*	9*	10	5	4*	10*
Percent Park	Percent of CT	DMTI	**7**	2*	7*	12	6	49*	7	4*
Percent Open Space	Percent of CT	DMTI	**6**	8	8	35*	2*	6	6	4*
ACCESSIBILITY										
Distance to the CBD	Meters	DMTI	**10110**	9873*	14016*	22915*	6944*	11910	16911*	4636*
Access to Jobs by car (gravity based)	Average	El-Geneidy et al 2011	**47013**	46582*	30063*	19207	53893*	38856	31335*	68012*
Access to Jobs by transit (gravity based)	Average	El-Geneidy et al 2011	**17179**	15494*	8323*	5589*	19473*	17072	9960*	28941*

			TOTAL	INDUSTRIAL WITH RESIDENTIAL	INACCESSIBLE RESIDENTIAL	AUTO ORIENTED DESIGN	DENSE & DIVERSE	PARK SPACE	WEALTHY SINGLE FAMILY HOMES	ACCESSIBLE PREWAR
	NUMBER OF CENSUS TRACTS:		**527**	**68**	**121**	**14**	**118**	**11**	**64**	**131**
	PERCENT OF AREA IN ANALYSIS:		**100**	**20%**	**18%**	**21%**	**10%**	**3%**	**19%**	**9%**
ACCESSIBILITY (CONT)	**UNITS**	**SOURCE**	**SAMPLE MEAN**							
Access to big box stores by car (30 minutes)	Average	El-Geneidy et al 2011	**108**	112*	85	57	126*	88	80*	131*
Access to food stores by car (30 minutes)	Average	El-Geneidy et al 2011	**2096**	2195*	1489	871	2557*	1656	1386*	2707*
Access to Restaurants by car (30 minutes)	Average	El-Geneidy et al 2011	**3605**	3727*	2358*	1413	4514*	2895	2349*	4781*
Access to food stores by transit (45 minutes)	Average	El-Geneidy et al 2011	**894**	835	437*	191*	1144*	739	490	1407*
DEMOGRAPHICS										
Median Household Income	CAD	2006 Census	**44835**	38062*	42476*	62962	36626*	53184	81779*	37235*
Percent Owner-Occupied Dwelling	Percent	2006 Census	**39**	33*	41*	68	27*	49	79	28*
Percent Rented Dwelling	Percent	2006 Census	**61**	67*	59*	32	73*	51	21	72*
HOUSING STOCK										
Year of Construction Pre-1946	Percent	2006 Census	**23**	20	7*	9*	31	29	15	37*
Constructed 1946-60	Percent	2006 Census	**25**	26	24*	17	33	20	26*	19*
Constructed 1961-70	Percent	2006 Census	**19**	19	28*	9*	17*	13*	21*	14*
Constructed 1971-80	Percent	2006 Census	**12**	15*	17*	12	8*	14	14*	10*
Constructed 1981-90	Percent	2006 Census	**11**	12	14	18	6*	17	15*	11
Constructed 1991-2000	Percent	2006 Census	**5**	5	6	21*	2*	4	6	5
Constructed 2001-2006	Percent	2006 Census	**4**	3	4	13*	2*	4	3	4*

*: Significantly different from sample mean at $\alpha = 0.05$

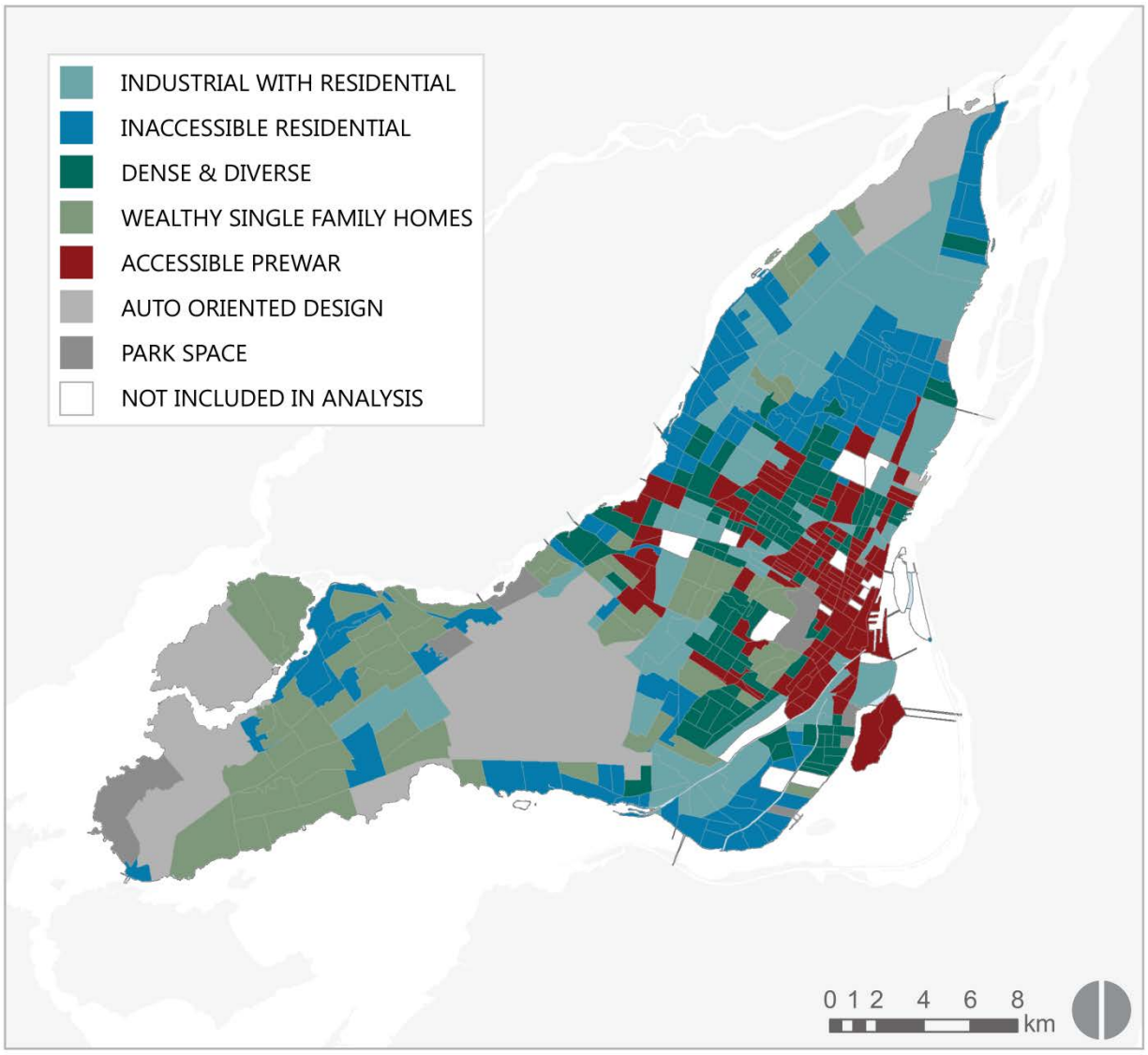

Figure 7: Map of Clusters

Cohort Analysis

The data for the cohort analysis was derived from the Agence Metropolitaine de Transport (AMT) Origin Destination (O-D) surveys from 1998, 2003, 2008 and 2013 of the Montreal region (1998, 2003, 2008, 2013). First, all respondents who were under the age of 50 were eliminated for all survey years and the household location for each

remaining individual respondent was determined. Next, GIS software was used to observe which land use classification cluster, or neighbourhood type, each respondent lived in during the time they were surveyed. Finally, all respondents were put in to 5 year age groups.

Using five year age groups, six cohorts were identified. Table 5 shows the ages of the six cohorts in each survey year. For each age group, the proportion of respondents living in each neighbourhood type was determined. For example, for the 2013 survey, there were 6911 respondents aged 50-54. 756 of those respondents lived in Industrial with Residential areas. Therefore, 10.9% of that age group lived in this neighbourhood type in 2013. Table 6 shows the number of respondents, as well as the proportion of respondents, living in each neighbourhood type. Figure 8 shows this proportion for each age group and each survey year. Using the data from Table 6 and Figure 8, the proportion of older adults living in each neighbourhood type was identified for each cohort over time. The purpose of this is to follow similarly aged respondents over a 15 year period in an attempt to identify patterns over time and between generations. The results of the cohort analysis will be presented in the Results section.

Table 5: Cohorts and References

	Age in 1998	Age in 2003	Age in 2008	Age in 2013	Reference
Cohort 1 Born 1949-1953		50-54	55-59	60-64	Bruce Springsteen
Cohort 2 Born 1944-1948	50-54	55-59	60-64	65-69	Bill Clinton
Cohort 3 Born 1939-1943	55-59	60-64	65-69	70-74	Harrison Ford
Cohort 4 Born 1934-1938	60-64	65-69	70-74	75-79	Mary Tyler Moore
Cohort 5 Born 1929-1933	65-69	70-74	75-79	80+	Clint Eastwood
Cohort 6 Born 1924-1928	70-74	75-79	80+		Gordie Howe

Table 6: Land Use Classification Clusters and Age Groups

		INDUSTRIAL WITH RESIDENTIAL		INACCESSIBLE RESIDENTIAL		AUTO ORIENTED DESIGN		DENSE & DIVERSE		PARK SPACE		WEALTHY SINGLE FAMILY HOMES		ACCESSIBLE PREWAR		TOTAL
Year	Age	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count
1998	50-54	593	11.9	1332	26.8	91	1.8	929	18.7	58	1.2	1076	21.7	886	17.8	4965
	55-59	440	12.2	1017	28.2	69	1.9	691	19.2	39	1.1	771	21.4	581	16.1	3608
	60-64	431	12.9	927	27.8	64	1.9	613	18.4	55	1.6	668	20.0	580	17.4	3338
	65-69	391	12.2	971	30.3	54	1.7	690	21.5	39	1.2	540	16.9	517	16.1	3202
	70-74	338	12.6	767	28.5	34	1.3	618	23.0	38	1.4	398	14.8	497	18.5	2690
	75-79	205	11.4	560	31.1	23	1.3	406	22.6	36	2.0	247	13.7	323	17.9	1800
	80+	154	9.4	470	28.7	29	1.8	391	23.8	18	1.1	224	13.7	354	21.6	1640
2003	50-54	563	11.6	1355	27.9	121	2.5	964	19.8	77	1.6	919	18.9	858	17.7	4857
	55-59	445	12.0	1090	29.4	80	2.2	685	18.5	51	1.4	711	19.2	647	17.4	3709
	60-64	345	11.3	890	29.1	71	2.3	609	19.9	56	1.8	566	18.5	521	17.0	3058
	65-69	334	13.0	767	29.9	48	1.9	550	21.5	41	1.6	414	16.2	407	15.9	2561
	70-74	280	11.7	716	29.8	47	2.0	503	20.9	36	1.5	371	15.5	448	18.7	2401
	75-79	168	10.4	501	31.2	38	2.4	332	20.6	21	1.3	261	16.2	287	17.8	1608
	80+	190	11.7	483	29.8	43	2.7	375	23.1	14	0.9	203	12.5	314	19.4	1622
2008	50-54	687	11.6	1649	27.8	144	2.4	1273	21.4	60	1.0	943	15.9	1186	20.0	5942
	55-59	545	11.0	1353	27.3	96	1.9	1023	20.6	52	1.0	816	16.5	1074	21.7	4959
	60-64	574	12.4	1362	29.4	88	1.9	995	21.5	60	1.3	658	14.2	892	19.3	4629
	65-69	500	13.6	1110	30.2	61	1.7	742	20.2	46	1.3	516	14.1	696	19.0	3671
	70-74	405	13.1	965	31.1	50	1.6	656	21.2	36	1.2	436	14.1	551	17.8	3099
	75-79	310	12.5	808	32.6	35	1.4	527	21.2	39	1.6	276	11.1	486	19.6	2481
	80+	364	11.7	977	31.4	43	1.4	700	22.5	33	1.1	334	10.7	662	21.3	3113
2013	50-54	756	10.9	1773	25.7	239	3.5	1546	22.4	116	1.7	1214	17.6	1267	18.3	6911
	55-59	676	10.5	1643	25.6	188	2.9	1498	23.3	95	1.5	1086	16.9	1235	19.2	6421
	60-64	652	10.8	1581	26.3	146	2.4	1397	23.2	84	1.4	998	16.6	1164	19.3	6022
	65-69	609	12.1	1330	26.4	99	2.0	1138	22.6	74	1.5	828	16.5	954	19.0	5032
	70-74	447	11.8	1011	26.6	80	2.1	828	21.8	61	1.6	632	16.6	739	19.5	3798
	75-79	339	12.0	901	31.9	53	1.9	594	21.0	36	1.3	382	13.5	518	18.3	2823
	80+	449	11.6	1226	31.6	78	2.0	851	21.9	61	1.6	558	14.4	655	16.9	3878

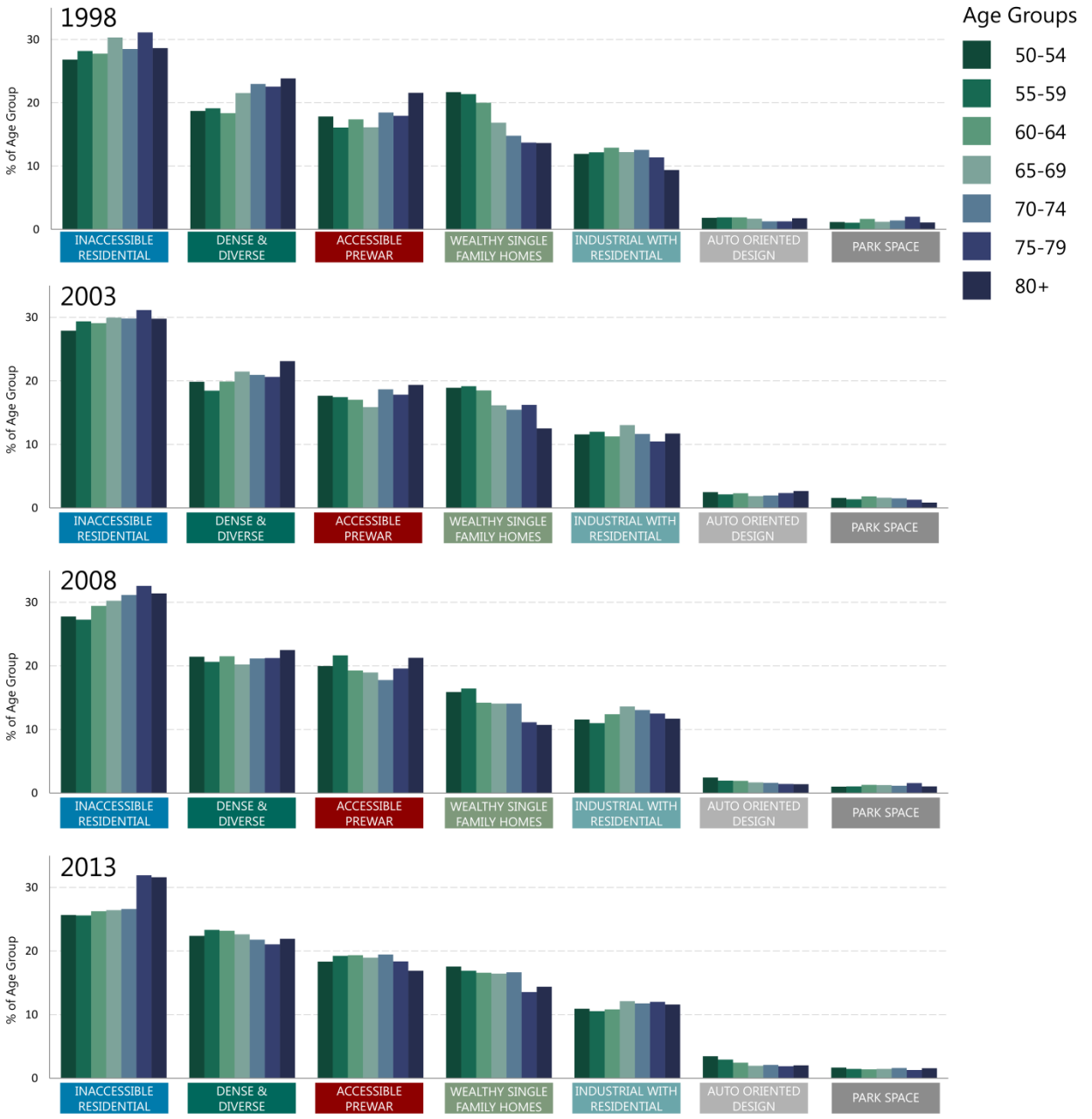

Figure 8: Age Groups and Clusters for Each Survey Year

Table 6 and Figure 8 show that it is most common for adults over the age of 50 to live in Inaccessible Residential areas. On average, 29% of adults over the age of 50 on the island of Montreal lived in this neighbourhood type from 1998-2013. The proportion of older adults in Inaccessible Residential areas increases for the 75-79 and 80+ age

groups. This is especially true in 2013, in which there is a 5.3% increase in the proportion of older adults living here between the 70-74 and 75-79 age groups. The next most common neighbourhood type for older adults to live in is Dense & Diverse areas in which 21% of adults over 50 years old live on average for all survey years. In 1998, this neighbourhood type became more popular with age. However, in 2013, it became less popular with age. A similar pattern is observed for Accessible Prewar areas, which is the third most populous neighbourhood type with 18% of adults over 50 years old on average. The proportion of older adults living in Accessible Prewar areas peaks at 22% in 1998 for the 80+ age group. The neighbourhood type with the fourth highest proportion of older adults is Wealthy Single Family Homes. For all years, the proportion of older adults living in these areas decreases in between the 50-54 and 80+ age groups. In 1998, the share of older adults living in Wealthy Single Family Home areas decreased from 22% to 14%, which represents a change of 8%. However, in 2013, this decrease is from 18% to 14%, representing only a 4% decrease. Finally, Industrial with Residential areas, while fluctuating slightly, remains fairly stable in all survey years. On average, 12% of older adults live in Industrial with Residential areas. This proportion is highest in 2008 for the 65-69 age group at 13.6% and lowest in 1998 for the 80+ age group at 9.4%. On average, only 2.0% and 1.4% of adults over the age of 50 lived in Auto-Oriented Design and Park Space areas respectively. Therefore, additional analysis on these two neighbourhood types will not be presented.

Mode Share

The next step of the methodology is to observe the actual travel behavior of the elderly in the different neighbourhood types for each survey year. The purpose of this is to determine the impact that the characteristics of each neighbourhood type have on the travel behavior of older adults in Montreal. To do this, the AMT's O-D data from 2013 was used. First, O-D survey respondents aged 50 years and older were extracted from the data. Trips made for purposes other than shopping, leisure, visiting friends and health, as well as multi-modal trips, were eliminated. Non home based trips were also eliminated. Trips taken by bus, metro or commuter train were coded into one variable called transit. The other modes that were analyzed include automobile as a driver, automobile as a passenger, walking/biking, paratransit and "other," which included taxi, motorcycle and "undetermined" modes. This is consistent with the methodology used in Part Two. Next, GIS software was used to identify each trip origin, which was also the home location of the respondents. Then, home based trips were grouped together based on the seven neighbourhood types identified in the land use classification. Mode share was determined for each five year age group.

Table 7 displays the mode share for each age group in every survey year and in each neighbourhood type. With the exception of Accessible Prewar areas, the automobile as a driver is the most common mode. It is highest for Wealthy Single

Family Homes, where it peaks in 2013 at an average of 69% for all adults over 50 and all years, and increases over time. Automobile use is the least common in Dense & Diverse and Accessible Prewar areas, with 41% and 35% respectively for all adults over 50 and all years. Riding in an automobile as a passenger is about 20% in Industrial with Residential, Inaccessible Prewar and Wealthy Single Family Home areas. Alternatively, automobile as a passenger is about 15% in Dense & Diverse and Accessible Prewar areas. Dense & Diverse and Accessible Prewar areas have the highest rates of walking and biking. For all years and all age groups, Accessible Prewar areas have a 35% mode share of walking and biking, rivaling automobile use. Walking and biking have a higher mode share in the more recent years in this neighbourhood type. Rates of walking and biking are lowest in Wealthy Single Family Home areas at about 8% for all years and ages. Transit rates are highest in Accessible Prewar areas, where transit rates were the highest in 1998. Both Industrial with Residential and Dense & Diverse have transit rates of about 12%. While these rates remain fairly stable in Dense & Diverse neighbourhoods, they drop in Industrial with Residential areas from 14% in 1998 to 9% in 2013. Inaccessible Residential areas also experience a decrease in transit use from 11% to 8%. Transit use is lowest in Wealthy Single Family Home areas, where transit mode share is between 3% and 4% for adults over 50 in all years.

Table 7: Mode Share by Age Group and Neighbourhood Type

			TRANSIT		AUTOMOBILE AS A DRIVER		AUTOMOBILE AS A PASSENGER		WALK/BIKE		PARA-TRANSIT		OTHER		
	Year	Age Group	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	TOTAL
INDUSTRIAL WITH RESDIENTIAL	1998	50-54	17	8.9	96	50.0	34	17.7	41	21.4	0	0.0	4	2.1	192
		55-59	16	9.2	86	49.7	32	18.5	37	21.4	1	0.6	1	0.6	173
		60-64	14	7.2	102	52.3	38	19.5	40	20.5	0	0.0	1	0.5	195
		65-69	36	15.5	106	45.7	46	19.8	42	18.1	0	0.0	2	0.9	232
		70-74	38	20.8	75	41.0	26	14.2	43	23.5	0	0.0	1	0.5	183
		75-79	23	25.8	26	29.2	14	15.7	21	23.6	1	1.1	4	4.5	89
		80+	10	19.6	15	29.4	8	15.7	14	27.5	0	0.0	4	7.8	51
	2003	50-54	15	9.8	87	56.9	22	14.4	29	19.0	0	0.0	0	0.0	153
		55-59	12	8.2	78	53.4	24	16.4	32	21.9	0	0.0	0	0.0	146
		60-64	11	7.8	67	47.5	29	20.6	32	22.7	1	0.7	1	0.7	141
		65-69	14	8.3	91	54.2	36	21.4	25	14.9	1	0.6	1	0.6	168
		70-74	12	8.1	72	48.3	34	22.8	28	18.8	1	0.7	2	1.3	149
		75-79	9	12.0	24	32.0	20	26.7	18	24.0	0	0.0	4	5.3	75
		80+	7	11.7	14	23.3	14	23.3	20	33.3	0	0.0	5	8.3	60
	2008	50-54	13	7.9	88	53.3	20	12.1	43	26.1	1	0.6	0	0.0	165
		55-59	16	9.9	69	42.9	27	16.8	44	27.3	2	1.2	3	1.9	161
		60-64	29	14.7	84	42.6	25	12.7	55	27.9	0	0.0	4	2.0	197
		65-69	33	13.3	114	46.0	42	16.9	56	22.6	2	0.8	1	0.4	248
		70-74	14	7.8	87	48.6	36	20.1	36	20.1	5	2.8	1	0.6	179
		75-79	17	12.9	55	41.7	23	17.4	32	24.2	2	1.5	3	2.3	132
		80+	16	14.2	35	31.0	23	20.4	35	31.0	1	0.9	3	2.7	113
	2013	50-54	20	11.0	94	51.6	27	14.8	38	20.9	0	0.0	3	1.6	182
		55-59	16	8.0	92	46.2	34	17.1	55	27.6	0	0.0	2	1.0	199
		60-64	22	8.4	155	58.9	25	9.5	55	20.9	3	1.1	3	1.1	263

			TRANSIT		AUTOMOBILE AS A DRIVER		AUTOMOBILE AS A PASSENGER		WALK/BIKE		PARA-TRANSIT		OTHER		
	Year	Age Group	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	TOTAL
		65-69	21	7.2	152	52.1	54	18.5	58	19.9	5	1.7	2	0.7	292
		70-74	21	9.1	127	54.7	50	21.6	32	13.8	0	0.0	2	0.9	232
		75-79	15	9.9	77	51.0	32	21.2	24	15.9	2	1.3	1	0.7	151
		80+	13	8.1	68	42.2	39	24.2	31	19.3	4	2.5	6	3.7	161
INACCESSIBLE RESIDENTIAL	1998	50-54	33	7.4	284	64.0	61	13.7	61	13.7	2	0.5	3	0.7	444
		55-59	39	8.3	273	58.1	77	16.4	78	16.6	0	0.0	3	0.6	470
		60-64	35	7.2	266	54.6	116	23.8	66	13.6	0	0.0	4	0.8	487
		65-69	69	11.8	285	48.6	146	24.9	76	12.9	4	0.7	7	1.2	587
		70-74	52	11.4	246	53.8	94	20.6	60	13.1	0	0.0	5	1.1	457
		75-79	48	16.8	120	42.1	59	20.7	53	18.6	0	0.0	5	1.8	285
		80+	38	20.2	65	34.6	34	18.1	45	23.9	2	1.1	4	2.1	188
	2003	50-54	23	6.1	250	66.8	58	15.5	42	11.2	1	0.3	0	0.0	374
		55-59	15	3.9	251	65.9	56	14.7	52	13.6	1	0.3	6	1.6	381
		60-64	19	4.8	258	64.8	64	16.1	55	13.8	2	0.5	0	0.0	398
		65-69	31	7.9	209	53.6	82	21.0	63	16.2	3	0.8	2	0.5	390
		70-74	31	8.1	213	55.8	83	21.7	50	13.1	2	0.5	3	0.8	382
		75-79	16	6.7	126	52.7	65	27.2	22	9.2	3	1.3	7	2.9	239
		80+	16	10.5	62	40.8	42	27.6	28	18.4	1	0.7	3	2.0	152
	2008	50-54	23	6.3	229	62.9	43	11.8	65	17.9	2	0.5	2	0.5	364
		55-59	37	8.6	242	56.1	89	20.6	54	12.5	4	0.9	5	1.2	431
		60-64	43	7.6	313	55.3	110	19.4	93	16.4	1	0.2	6	1.1	566
		65-69	46	8.4	285	52.1	105	19.2	97	17.7	6	1.1	8	1.5	547
		70-74	58	11.0	266	50.5	107	20.3	87	16.5	3	0.6	6	1.1	527
		75-79	32	8.8	173	47.7	71	19.6	74	20.4	3	0.8	10	2.8	363
		80+	30	9.4	127	39.9	75	23.6	65	20.4	11	3.5	10	3.1	318

			TRANSIT		AUTOMOBILE AS A DRIVER		AUTOMOBILE AS A PASSENGER		WALK/BIKE		PARA-TRANSIT		OTHER		
	Year	Age Group	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	TOTAL
	2013	50-54	26	6.1	283	66.1	59	13.8	56	13.1	3	0.7	1	0.2	428
		55-59	32	6.3	304	59.7	81	15.9	83	16.3	2	0.4	7	1.4	509
		60-64	57	8.6	363	54.8	109	16.4	120	18.1	8	1.2	6	0.9	663
		65-69	50	7.2	455	65.2	115	16.5	68	9.7	5	0.7	5	0.7	698
		70-74	43	8.2	321	60.9	100	19.0	57	10.8	4	0.8	2	0.4	527
		75-79	32	7.4	237	55.1	100	23.3	56	13.0	2	0.5	3	0.7	430
		80+	41	8.4	237	48.3	109	22.2	76	15.5	13	2.6	15	3.1	491
DENSE & DIVERSE	1998	50-54	32	10.4	140	45.6	43	14.0	85	27.7	1	0.3	6	2.0	307
		55-59	40	14.2	136	48.4	33	11.7	67	23.8	2	0.7	3	1.1	281
		60-64	36	11.4	132	41.8	54	17.1	90	28.5	0	0.0	4	1.3	316
		65-69	74	18.1	155	38.0	73	17.9	101	24.8	1	0.2	4	1.0	408
		70-74	67	18.5	134	36.9	56	15.4	100	27.5	2	0.6	4	1.1	363
		75-79	31	15.8	61	31.1	32	16.3	65	33.2	3	1.5	4	2.0	196
		80+	17	11.4	38	25.5	27	18.1	58	38.9	2	1.3	7	4.7	149
	2003	50-54	21	7.9	139	52.3	41	15.4	62	23.3	1	0.4	2	0.8	266
		55-59	23	10.1	99	43.6	36	15.9	64	28.2	3	1.3	2	0.9	227
		60-64	25	9.0	127	45.8	32	11.6	86	31.0	3	1.1	4	1.4	277
		65-69	26	10.1	114	44.2	47	18.2	67	26.0	1	0.4	3	1.2	258
		70-74	35	15.5	89	39.4	38	16.8	58	25.7	1	0.4	5	2.2	226
		75-79	13	8.8	58	39.5	21	14.3	50	34.0	1	0.7	4	2.7	147
		80+	15	11.5	32	24.6	29	22.3	42	32.3	4	3.1	8	6.2	130
	2008	50-54	27	8.9	146	48.0	32	10.5	95	31.3	1	0.3	3	1.0	304
		55-59	40	11.7	144	42.1	49	14.3	103	30.1	1	0.3	5	1.5	342
		60-64	42	11.2	164	43.7	41	10.9	117	31.2	3	0.8	8	2.1	375
		65-69	44	11.9	150	40.7	43	11.7	130	35.2	2	0.5	0	0.0	369

			TRANSIT		AUTOMOBILE AS A DRIVER		AUTOMOBILE AS A PASSENGER		WALK/BIKE		PARA-TRANSIT		OTHER		
	Year	Age Group	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	TOTAL
		70-74	36	11.8	120	39.5	47	15.5	95	31.3	1	0.3	5	1.6	304
		75-79	28	13.6	57	27.7	38	18.4	77	37.4	2	1.0	4	1.9	206
		80+	23	10.2	62	27.4	48	21.2	75	33.2	6	2.7	12	5.3	226
		50-54	44	10.8	186	45.5	41	10.0	127	31.1	4	1.0	7	1.7	409
		55-59	53	10.7	232	46.8	50	10.1	153	30.8	3	0.6	5	1.0	496
		60-64	65	10.9	285	47.9	67	11.3	170	28.6	3	0.5	5	0.8	595
	2013	65-69	60	10.2	226	38.5	79	13.5	208	35.4	6	1.0	8	1.4	587
		70-74	64	15.1	179	42.1	49	11.5	116	27.3	5	1.2	12	2.8	425
		75-79	28	9.5	131	44.4	50	16.9	76	25.8	6	2.0	4	1.4	295
		80+	48	14.3	120	35.8	59	17.6	91	27.2	5	1.5	12	3.6	335
WEALTHY SINGLE FAMILY HOMES		50-54	7	1.8	288	74.6	63	16.3	26	6.7	0	0.0	2	0.5	386
		55-59	8	2.4	219	66.4	71	21.5	30	9.1	1	0.3	1	0.3	330
		60-64	11	3.4	233	71.3	60	18.3	22	6.7	0	0.0	1	0.3	327
	1998	65-69	14	3.9	230	63.5	76	21.0	41	11.3	0	0.0	1	0.3	362
		70-74	17	6.6	158	61.7	60	23.4	19	7.4	0	0.0	2	0.8	256
		75-79	15	10.1	90	60.8	29	19.6	13	8.8	0	0.0	1	0.7	148
		80+	8	10.1	39	49.4	14	17.7	14	17.7	1	1.3	3	3.8	79
		50-54	8	3.3	184	75.7	32	13.2	17	7.0	0	0.0	2	0.8	243
		55-59	3	1.1	219	76.8	42	14.7	20	7.0	0	0.0	1	0.4	285
		60-64	6	2.4	185	73.4	47	18.7	13	5.2	0	0.0	1	0.4	252
	2003	65-69	11	4.6	155	64.9	51	21.3	17	7.1	1	0.4	4	1.7	239
		70-74	9	4.6	139	70.6	35	17.8	11	5.6	0	0.0	3	1.5	197
		75-79	9	7.0	69	53.9	36	28.1	5	3.9	3	2.3	6	4.7	128
		80+	3	3.2	52	55.9	27	29.0	9	9.7	2	2.2	0	0.0	93
	2008	50-54	2	1.0	153	75.0	36	17.6	12	5.9	0	0.0	1	0.5	204

			TRANSIT		AUTOMOBILE AS A DRIVER		AUTOMOBILE AS A PASSENGER		WALK/BIKE		PARA-TRANSIT		OTHER		
	Year	Age Group	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	TOTAL
		55-59	4	1.5	202	78.0	34	13.1	18	6.9	1	0.4	0	0.0	259
		60-64	5	1.9	192	73.0	45	17.1	20	7.6	1	0.4	0	0.0	263
		65-69	11	4.1	171	64.0	53	19.9	28	10.5	2	0.7	2	0.7	267
		70-74	9	4.1	146	67.3	46	21.2	13	6.0	2	0.9	1	0.5	217
		75-79	10	6.3	100	63.3	32	20.3	13	8.2	0	0.0	3	1.9	158
		80+	8	5.9	68	50.0	36	26.5	17	12.5	3	2.2	4	2.9	136
		50-54	5	1.6	251	80.2	27	8.6	29	9.3	0	0.0	1	0.3	313
		55-59	6	1.6	290	76.1	63	16.5	20	5.2	1	0.3	1	0.3	381
		60-64	12	2.6	336	73.5	69	15.1	37	8.1	2	0.4	1	0.2	457
	2013	65-69	15	3.1	329	68.1	90	18.6	43	8.9	1	0.2	5	1.0	483
		70-74	15	4.1	242	65.8	74	20.1	31	8.4	2	0.5	4	1.1	368
		75-79	15	6.5	145	62.5	42	18.1	24	10.3	4	1.7	2	0.9	232
		80+	10	4.0	153	61.9	52	21.1	22	8.9	5	2.0	5	2.0	247
ACCESSIBLE PREWAR		50-54	38	12.5	121	39.9	35	11.6	107	35.3	0	0.0	2	0.7	303
		55-59	30	12.0	108	43.2	20	8.0	87	34.8	3	1.2	2	0.8	250
		60-64	48	15.6	114	37.1	55	17.9	81	26.4	2	0.7	7	2.3	307
	1998	65-69	60	20.5	98	33.4	41	14.0	88	30.0	1	0.3	5	1.7	293
		70-74	51	17.8	88	30.7	50	17.4	93	32.4	2	0.7	3	1.0	287
		75-79	50	26.3	46	24.2	24	12.6	65	34.2	0	0.0	5	2.6	190
		80+	22	16.4	17	12.7	29	21.6	55	41.0	3	2.2	8	6.0	134
		50-54	21	8.1	107	41.5	31	12.0	96	37.2	1	0.4	2	0.8	258
		55-59	20	8.6	108	46.6	27	11.6	75	32.3	0	0.0	2	0.9	232
	2003	60-64	18	7.7	109	46.8	32	13.7	70	30.0	1	0.4	3	1.3	233
		65-69	19	8.2	98	42.4	38	16.5	74	32.0	0	0.0	2	0.9	231
		70-74	29	12.8	80	35.2	34	15.0	82	36.1	2	0.9	0	0.0	227

		TRANSIT		AUTOMOBILE AS A DRIVER		AUTOMOBILE AS A PASSENGER		WALK/BIKE		PARA-TRANSIT		OTHER		
Year	Age Group	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	TOTAL
	75-79	16	12.3	41	31.5	22	16.9	43	33.1	3	2.3	5	3.8	130
	80+	13	11.1	29	24.8	32	27.4	35	29.9	0	0.0	8	6.8	117
	50-54	37	12.2	108	35.6	27	8.9	124	40.9	1	0.3	6	2.0	303
	55-59	38	10.6	118	32.9	38	10.6	158	44.0	3	0.8	4	1.1	359
	60-64	50	12.9	133	34.2	49	12.6	148	38.0	2	0.5	7	1.8	389
2008	65-69	70	20.2	97	28.0	42	12.1	122	35.3	2	0.6	13	3.8	346
	70-74	47	16.5	101	35.4	43	15.1	86	30.2	1	0.4	7	2.5	285
	75-79	44	19.0	75	32.5	43	18.6	57	24.7	4	1.7	8	3.5	231
	80+	34	14.0	54	22.2	50	20.6	90	37.0	4	1.6	11	4.5	243
	50-54	29	7.1	145	35.6	33	8.1	189	46.4	2	0.5	9	2.2	407
	55-59	52	11.9	145	33.1	46	10.5	184	42.0	4	0.9	7	1.6	438
	60-64	66	11.5	213	37.0	70	12.2	219	38.0	3	0.5	5	0.9	576
2013	65-69	84	15.8	196	36.9	56	10.5	187	35.2	2	0.4	6	1.1	531
	70-74	78	18.6	152	36.2	34	8.1	149	35.5	3	0.7	4	1.0	420
	75-79	43	18.2	86	36.4	32	13.6	67	28.4	1	0.4	7	3.0	236
	80+	33	12.9	87	34.0	31	12.1	80	31.3	12	4.7	13	5.1	256

RESULTS

The following section presents the detailed results of the land use classification, the cohort analysis, and mode share analysis. For each neighbourhood type three pieces of analysis will be described. First, the characteristics of the neighbourhood will be described. Second, the cohort analysis regarding the proportion of each age group living in each neighbourhood type will be shown. Lastly, the mode share for older adults in all four survey years in each neighbourhood type will be described. Results will only be presented from the five most populous land use classification clusters. Auto-oriented Design and Park Space are not included due to the small amount of older adults living in these neighbourhood types, which is on average 1.7% for all age groups.

Industrial with Residential

Industrial with Residential neighbourhood types are characterized by industry and resource with some residential use and open spaces. There is a high rental rate and below average income. Accessibility in these areas is average and 26% of the housing was built postwar between 1946 and 1960. This neighbourhood type includes 20% of the land area included in the analysis.

For all years, about 12% of adults 50 years and older in Montreal lived in this neighbourhood type. Figure 10 displays the cohort analysis for Industrial with Residential areas. Very little variation is observed in this neighbourhood type. For all

cohorts, the percent of each age group living in Industrial with Residential areas is about 12%. This remains stable for all cohorts, suggesting that adults over the age of 50 are aging in place in this neighbourhood type.

In Industrial with Residential neighbourhoods, there is a change in travel behavior from 1998 to 2013. While automobile as a driver is the most common mode choice for all years, in 1998, transit served as an alternative to driving for adults in their post retirement years. However, in 2013, adults over the age of 65 do not appear to be using transit as an alternative. Rather, they remain driving during their oldest adult years and transit use and walking/bike rates decreased. In 2013, it appears as though automobile as a passenger is serving as an alternative to automobile as a driver rather than transit.

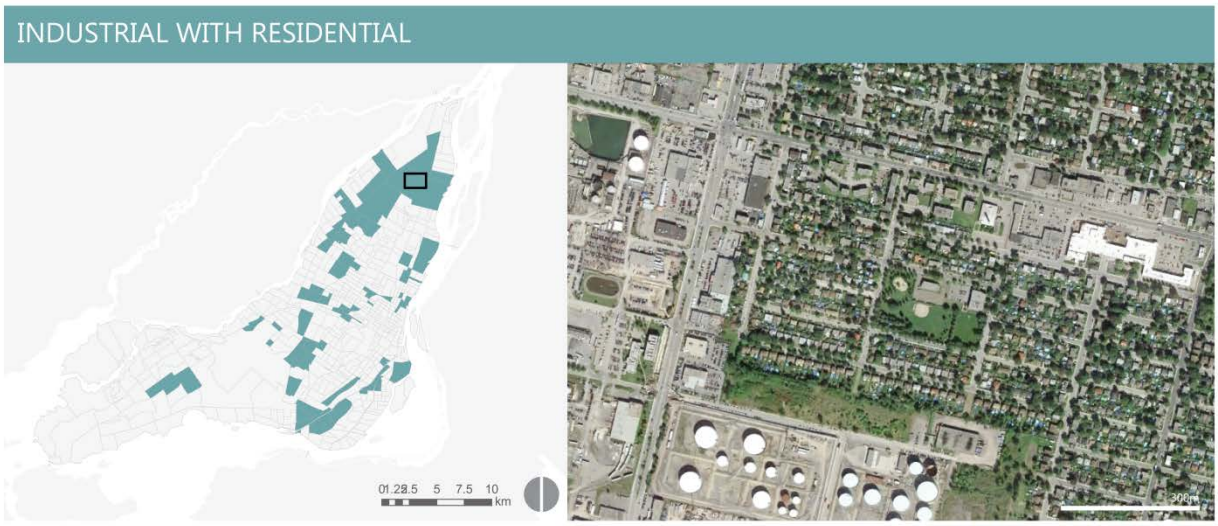

Figure 9: Industrial with Residential

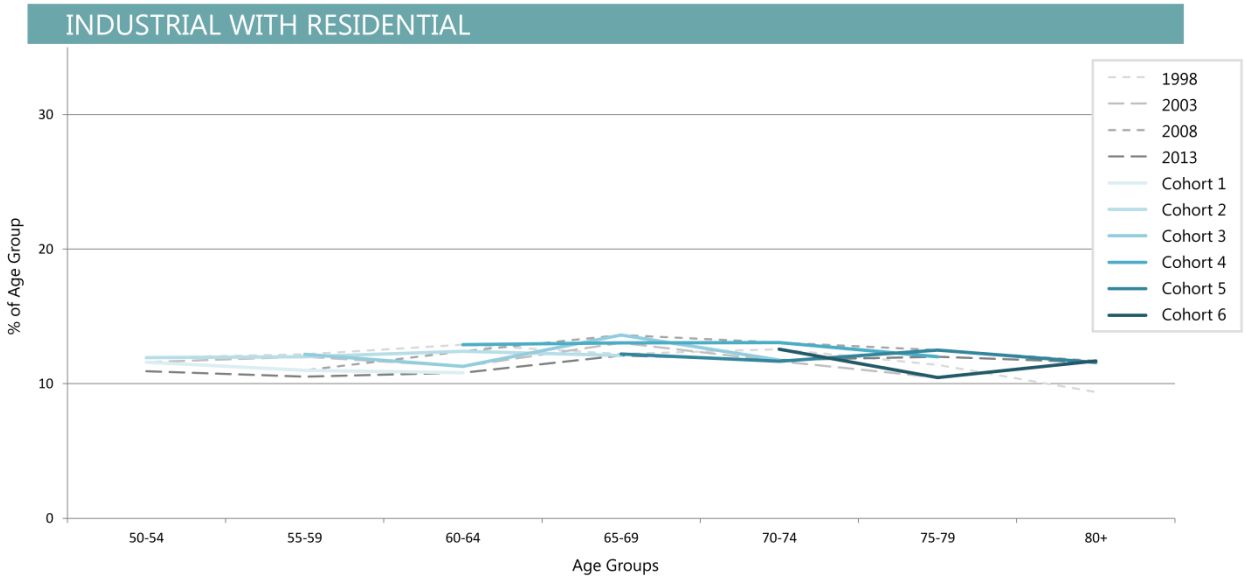

Figure 10: Industrial with Residential Cohort Analysis

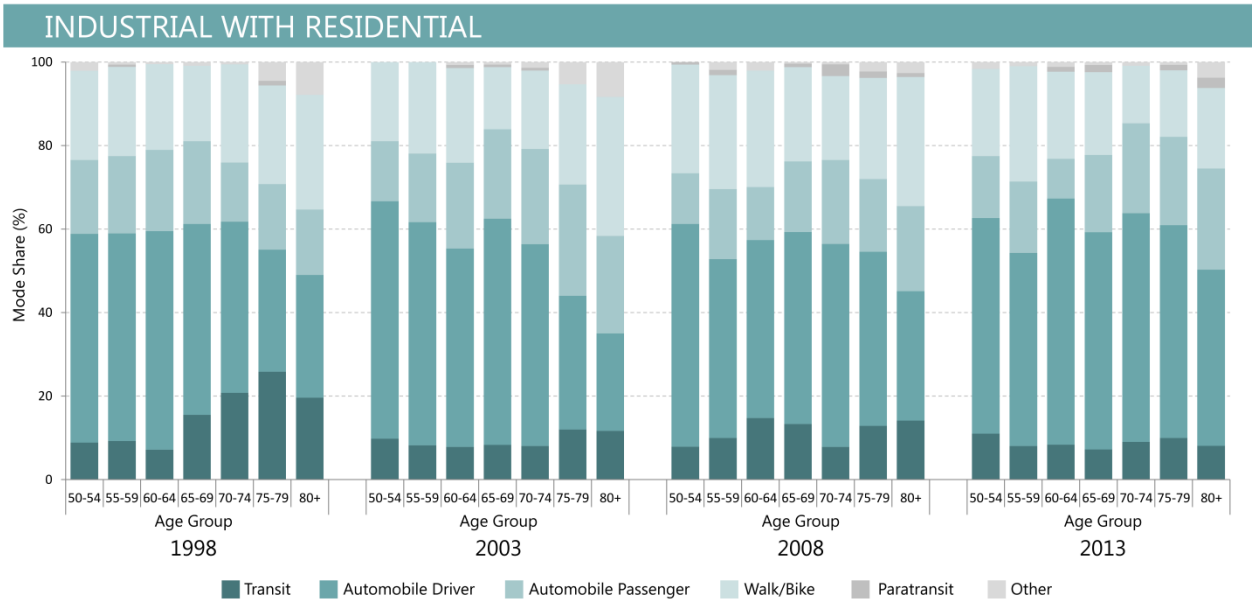

Figure 11: Industrial with Residential Mode Share

Inaccessible Residential

Inaccessible Residential areas are the least accessible neighbourhood type. The road lengths are short and the blocks are small, however, the land use is not diverse

with a large amount of space dedicated to residential use and open space. Incomes are slightly below average and more than 50% of the housing stock was built between 1946 and 1970. This neighbourhood type has an area of 87km^2, which is about 18% of the island of Montreal.

Inaccessible Residential areas are the most common neighbourhood type for older adults to live in. For all years, about 29% of adults over 50 live in this neighbourhood type. Figure 13 represents the cohort analysis for Inaccessible Residential areas. The cohort analysis reveals that Cohorts 1, 2 and 3 all experience a decrease in the proportion of adults living this neighbourhood type in 2013. However, it is a popular neighbourhood type for Cohorts 4, 5 and 6 in their 70s and 80s. This suggests that the younger cohorts, including baby boomers, are leaving this neighbourhood type in recent years while the percentage of older age groups in older cohorts, including those ages 75 and older, is higher.

Older adults in Inaccessible Residential areas behave similarly to adults in the previous neighbourhood type. Automobile is the most common mode choice and is most common in 2013 at an average of 59% for all age groups. However, in 1998, transit use was more common in the oldest adult years and was at its highest at 20% for the 80+ age group. However, in 2013, transit use was under 9% for all age groups. Additionally, in 1998, the oldest adults walked and biked at higher rates than they did in

2013. Walking/biking rates are highest in 2008, when it peaks at 20% for the 75-79 and 90+ age groups.

Figure 12: Inaccessible Residential

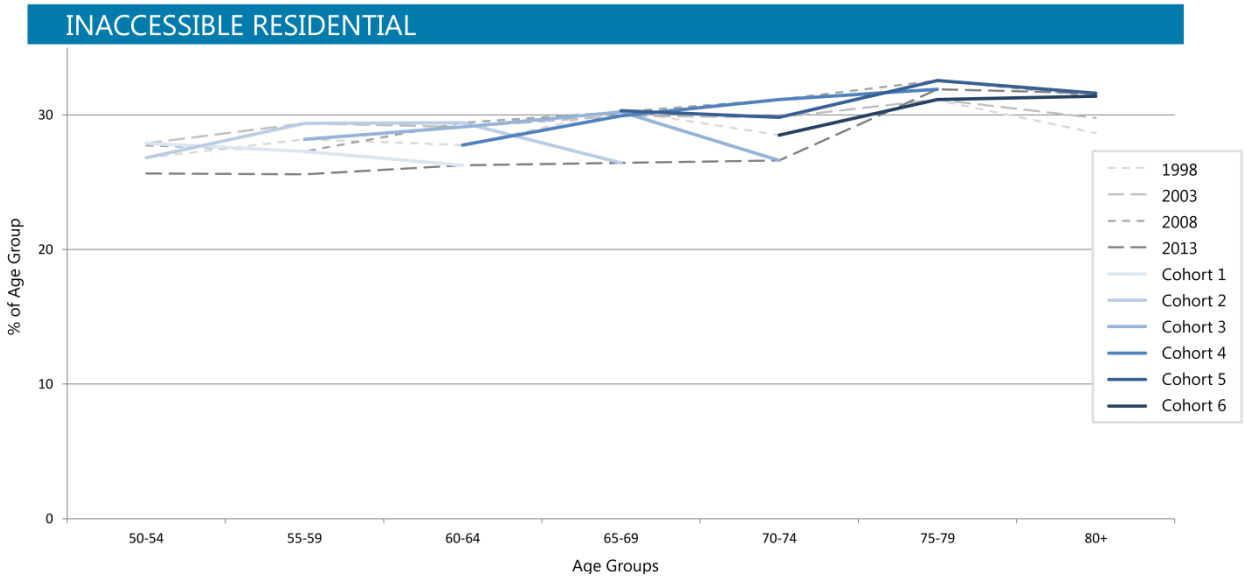

Figure 13: Inaccessible Residential Cohort Analysis

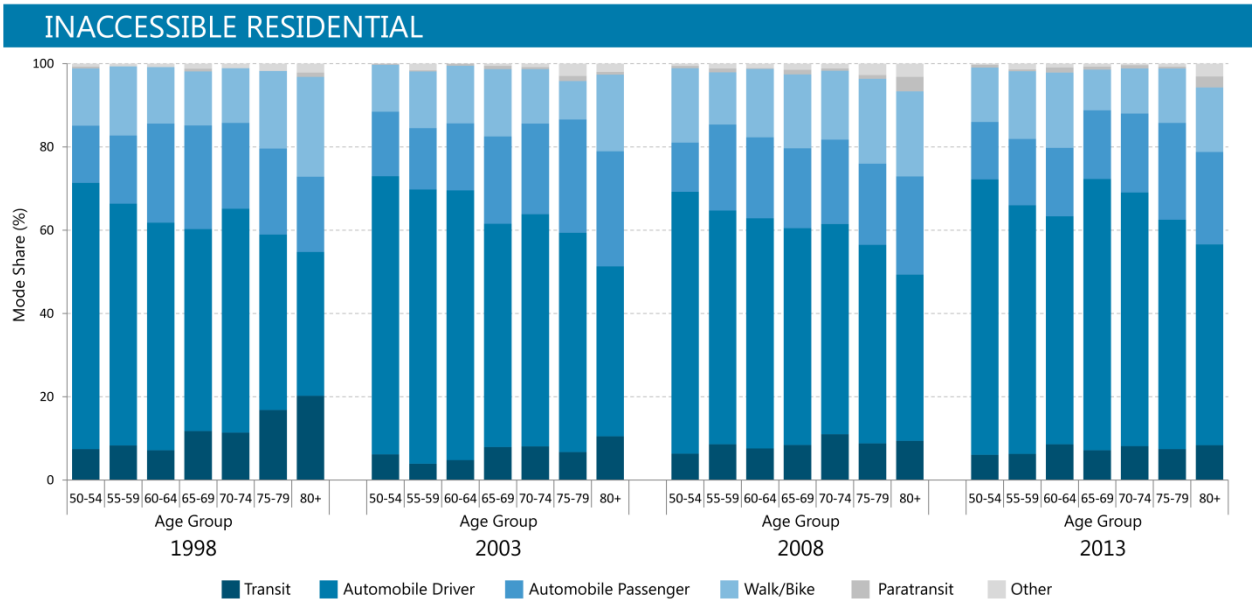

Figure 14: Inaccessible Residential Mode Share

Dense & Diverse

Dense & Diverse areas are the densest, lowest income neighbourhood type. It is mostly apartment buildings and has the highest rental rate. There are large blocks, a diverse mix of land uses and very little open space. It is accessible and close to the CBD. About 10% of the island of Montreal is a Dense & Diverse neighbourhood type.

In Dense & Diverse neighbourhoods, 20%-23% of adults over 50 in Montreal lived in this neighbourhood type from 1998 to 2013. Figure 16 shows Dense & Diverse areas as a Cohort Analysis. For Cohorts 1, 2 and 3, this neighbourhood type becomes more attractive with age, especially for the youngest cohort. For example, while Cohorts 1, 2 and 3 all increase with age, at the 60-64 age group for these cohorts, it can be seen that Cohort 2 is reaching a higher proportion at that age than Cohort 3, who were born

before Cohorts 1 and 2. Cohort 1 is reaching the highest proportion at 23%. This neighbourhood type is becoming increasingly attractive for Cohorts 1, 2 and 3 in the most recent survey year, with Cohort 1 reaching the highest proportions in this neighbourhood type. Over the age of 70 years old, there is very little fluctuation between cohorts and age groups.

In Dense & Diverse neighbourhoods, automobile use is less common than the previous two neighbourhood types. However, it is more prominent in the more recent years than in the earlier years. Nonetheless, walking and biking appears to be a common alternative to automobile use and walking/biking rates are about 30% for all years. Transit use is the highest in 1998 at 14% on average for all age groups. It then remains fairly stable at 10%, 11% and 12% in 2003, 2008 and 2013.

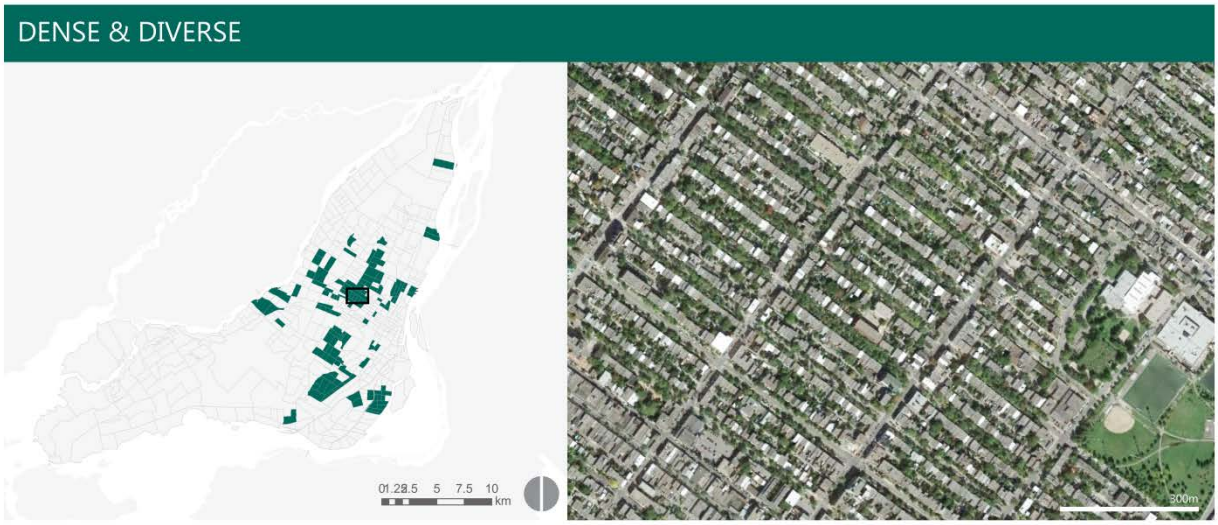

Figure 15: Dense & Diverse

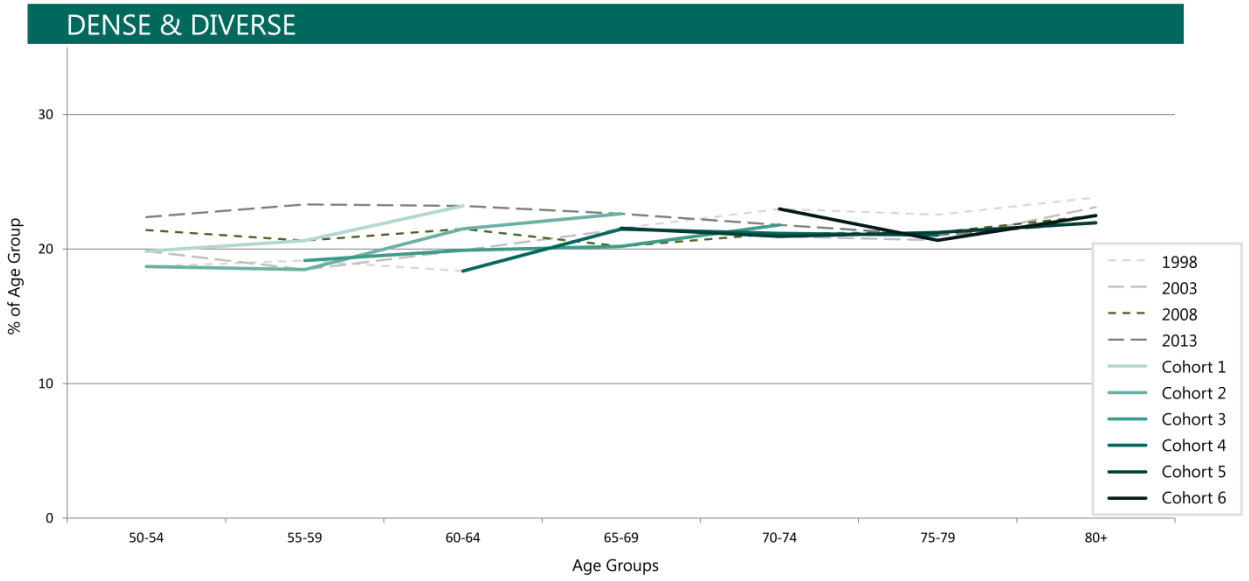

Figure 16: Dense & Diverse Cohort Analysis

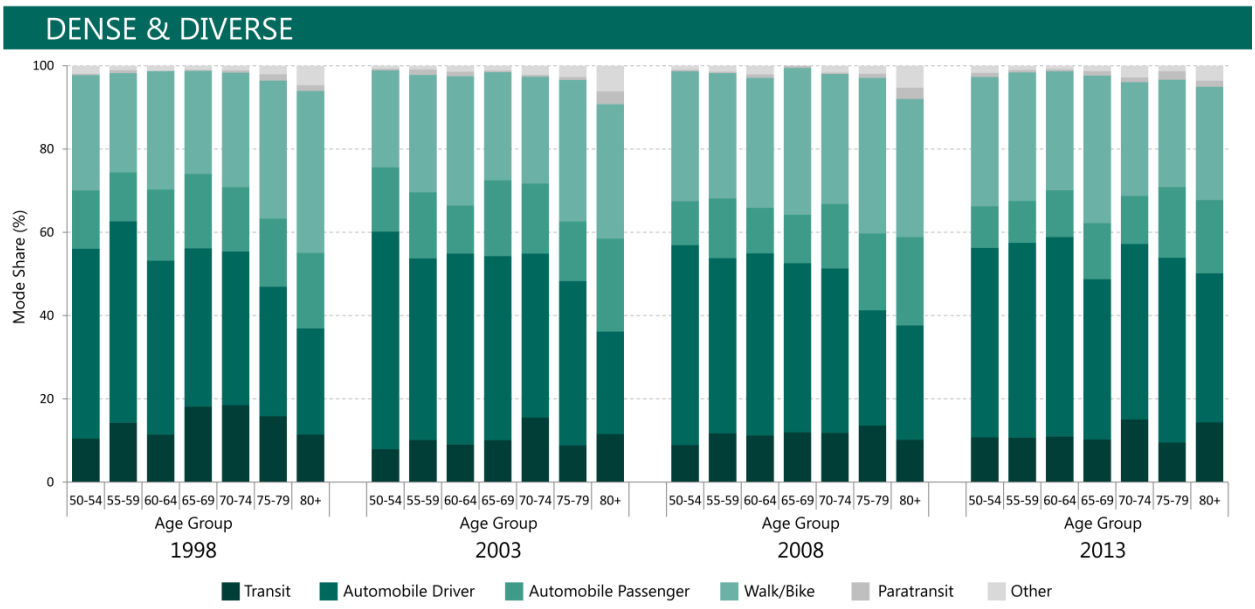

Figure 17: Dense & Diverse Mode Share

Wealthy Single Family Homes

The Wealthy Single Family Home neighbourhood type is low density, has the highest percentage of single family houses, highest incomes and highest housing ownership rate. Access is poor, census tracts in these areas are further from the CBD and

26% of housing was built postwar between 1946 and 1960. Wealthy Single Family Home areas take up about 19% of the island of Montreal.

Between 1998 and 2013, 14% to 18% of adults over the age of 50 lived in Wealthy Single Family Home areas. Figure 19 shows the cohort analysis for Wealthy Single Family Home areas. Generally, the proportion of older adults living in Wealthy Single Family Home areas decreases with age. However, there are variations between the cohorts. For example, the proportion of older adults in Cohorts 1, 2 and 3 decreases with age but increases slightly in 2013. Nonetheless, by comparing Cohorts 1, 2, 3 and 4, it can be seen that this neighbourhood type is less common for the younger cohorts. For example, in Cohort 3, 21% of those aged 55-59 in 1998 lived in Wealthy Single Family Home areas. For Cohort 2, who were the same age in 2003, 19% lived in Single Family Home areas. For the youngest cohort, Cohort 1, who were that age in 2008, only 16% lived in this neighbourhood type. This pattern is observed during these cohorts' 50s and 60s.

Automobile use is the highest in Wealthy Single Family Home neighbourhoods, where it is highest in 2013 and peaks for the 50-54 year age group at 80.2%. Automobile use decreases with age in this neighbourhood type and is 61.9% for the 80+ age group in 2013. Additionally, the oldest age groups ride in automobiles as passengers more than the younger age groups. This neighbourhood type has the lowest transit use. For all years, transit use increases with age. However, overall, transit use

increases to lower levels in the more recent years. Wealthy Single Family Home areas also have the lowest rates of walking/biking.

Figure 18: Wealthy Single Family Homes

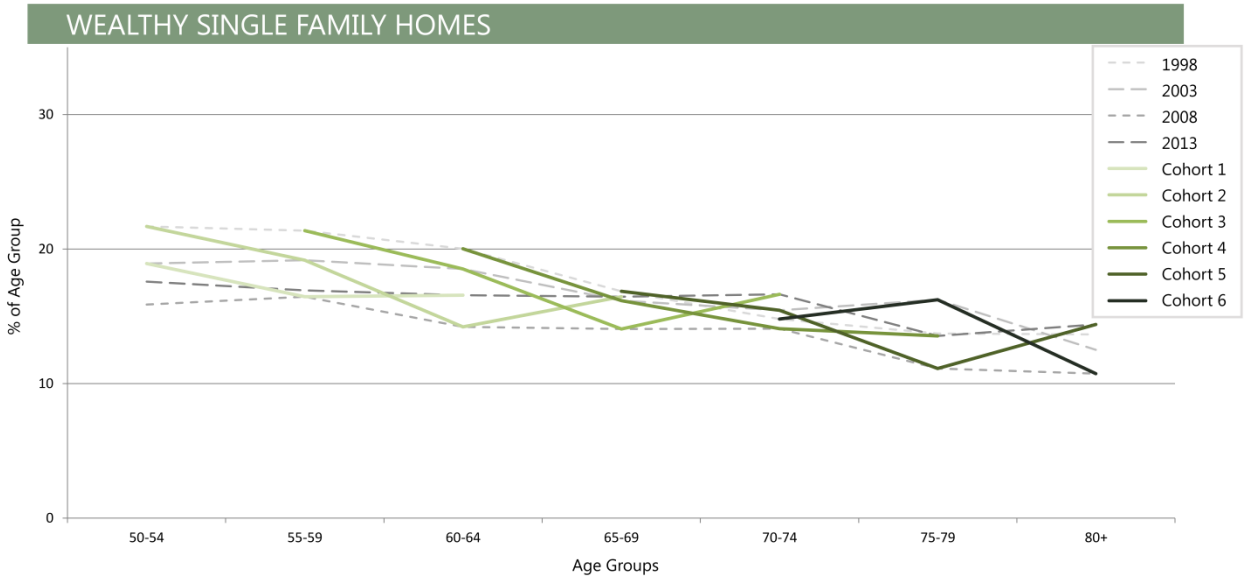

Figure 19: Wealthy Single Family Homes Cohort Analysis

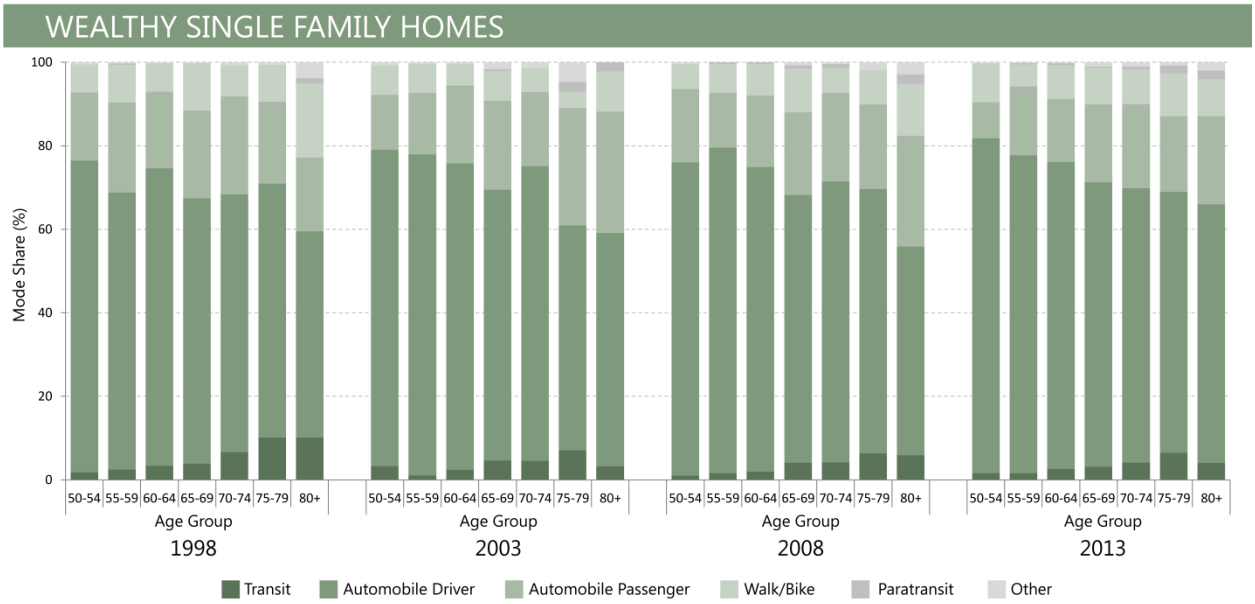

Figure 20: Wealthy Single Family Homes Mode Share

Accessible Prewar

Accessible Prewar areas are the most accessible type of neigbourhood. Densities are high, road lengths are short, blocks are small and there is a diverse mix of land uses. Census tracts in these areas are the closest to the CBD on average and 37% of housing was built prewar, before 1946. Accessible Prewar areas take up about 9% of the island of Montreal.

Accessible Prewar areas are home to 18%-20% of adults over 50 in Montreal from 1998-2013. Finally, Figure 22 shows Accessible Prewar areas. Generally, this neighbourhood type is fairly stable over time. However, it appears to be more popular with the younger cohorts as they age. This can be seen by comparing Cohorts 1, 2 and 3 during the 50-54, 55-59 and 60-64 age groups, during which Cohort 1 had the highest

proportion in this neighbourhood type and age group, while Cohort 3 had the lowest of these cohorts.

Accessible Prewar areas have the highest rates of walking/biking as well as transit. Walking and biking rates are 34% in 1998 and 37% in 2013. Walking/biking decreases with age while transit use increases with age. Transit use was highest in 1998 and peaked at 26% for the 75-79 age group. Automobile use is the lowest in this neighbourhood type. In 1998, automobile use as a driver decreased with age and in 2013 it remains fairly stable between the age groups.

Figure 21: Accessible Prewar

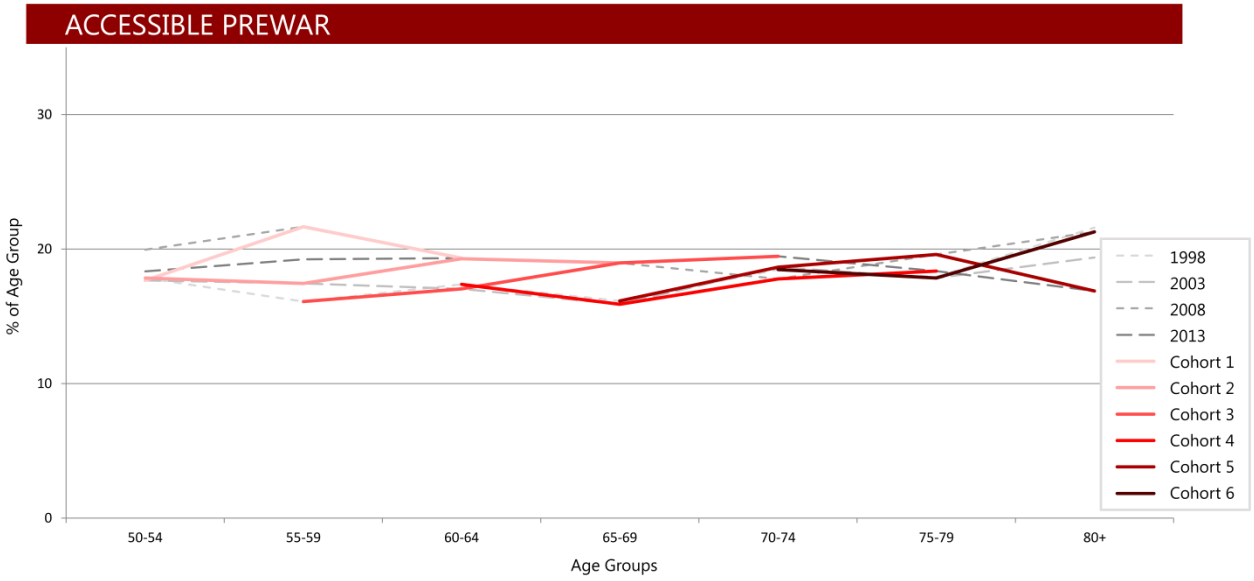

Figure 22: Accessible Prewar Cohort Analysis

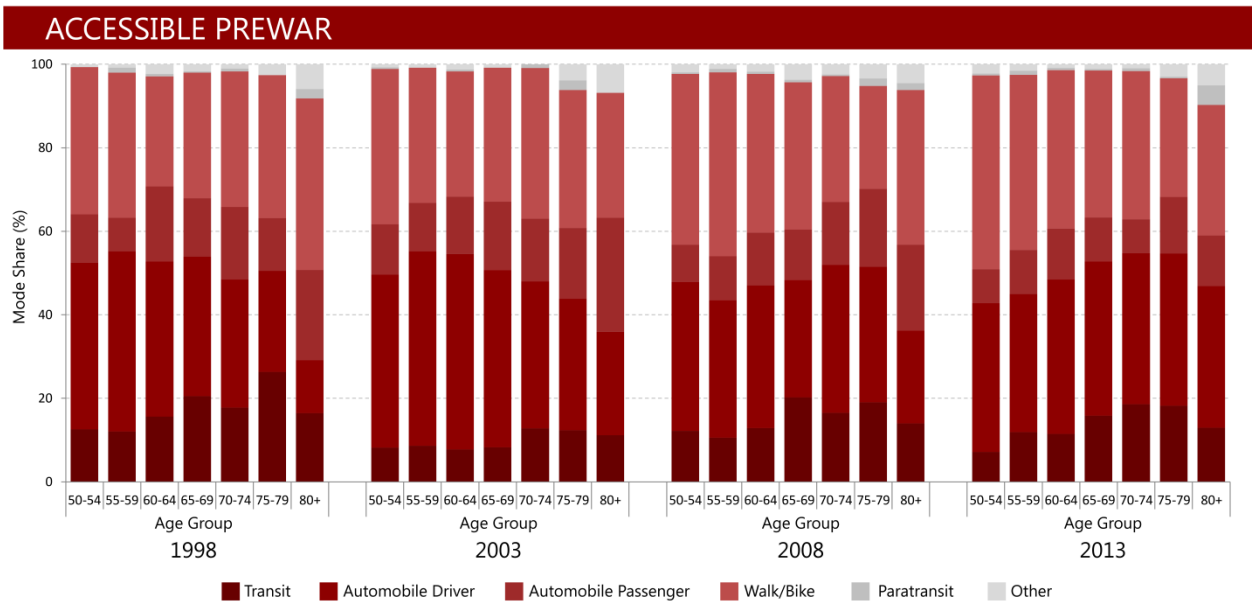

Figure 23: Accessible Prewar Mode Share

DISCUSSION

The above data analysis first identified different neighbourhood types in Montreal through a land use classification. This was determined by a factor-cluster analysis, which resulted in seven neighbourhood types. Then, a cohort analysis was applied to the land use classification to determine where specific age groups were living in 1998, 2003, 2008 and 2013. Finally, mode share was determined for the neighbourhood types in 1998, 2003, 2008 and 2013 to determine the impact of the built environment on mode choice. The goal of this analysis was to identify patterns and make observations about the proportion of cohorts of older adults over time and the mode choices in each neighbourhood type.

Aging in Place in Montreal

Aging in place in Montreal takes on varying characteristics in the different neighbourhood types and between different cohorts. A general trend for most neighbourhood types, with the exception of Wealthy Single Family Home areas, is that there is little change in proportion of seniors living in a particular neighbourhood type after 70 years of age. Therefore, for most neighbourhoods, it appears as though the preference to age in place takes effect by 70 years of age. Though, in Industrial with Residential areas, there is very little variation in the proportion of older adults living here, for all age groups. This may suggest that, for this neighbourhood type, the

tendency to age in place begins at an earlier age. However, after the age of 70, there is little variation in the proportion of adults in most neighbourhood types. After this point, the resistance to leaving a home and attachment to community identified by previous research (Keenan, 2010; Wiles et al., 2011) takes effect. The cohort analysis shows that, while there is some movement in home locations before the age of 65 years old, older cohorts are aging in place after 70 years old. An implication of this finding is the importance of attracting older adults to accessible and livable neighbourhood types that facilitate independent living before this age. This would allow older adults to express their preference to age in place, while maintaining independence and mobility.

Mode Choice of Older Adults in Different Neighbourhood Types

Different neighbourhood types have different effects on the travel behavior of older adults. For example, automobile use is most common in Wealthy Single Family Home areas and Inaccessible Residential areas. These two neighbourhood types also have the lowest walking/biking rates. The association between automobile use and walking difficulty in older adults (Clarke et al., 2009) is apparent in these neighbourhood types, where the rate of walking is low.

Alternatively, walking/biking rates are higher in neighbourhoods with high densities, access to destinations and proximity to the CBD, which is typical in the travel behavior of older adults (F. Li et al., 2005; Michael, Beard, et al., 2006; Moniruzzaman et al., 2013). Specifically, walking/biking rates are higher in Accessible Prewar areas and

Dense & Diverse areas. Having an active lifestyle can be important in maintaining independent mobility of the elderly (Michael, Green, et al., 2006). In Accessible Prewar and Dense & Diverse areas, the accessible land use is supportive of an active lifestyle by offering destinations within walking distance. This is important because older adults leave their neighbourhoods less often than younger people (Clarke et al., 2009). Providing destinations within walking distance at the neighbourhood level can help meet the needs of older adults by improving neighbourhood accessibility and promoting active lifestyles.

The finding that older adults in Accessible Prewar areas are using transit the most is consistent with previous research that transit use is higher among older adults living in areas with high built density and street density (Moniruzzaman et al., 2013). It was previously argued that if alternative modes are competitive with automobile travel, it can reduce the vehicle miles travelled by older adults without sacrificing their needs (Cao et al., 2010). This appears to be happening in Accessible Prewar neighbourhoods, where older adults have more active and multi-modal travel behavior. This means they are less dependent on the automobile and transit appears to be meeting their mobility needs as they age.

However, in Wealthy Single Family Home areas, the alternative to driving for older adults appears to be riding in an automobile as a passenger. While driving in an automobile is the most common mode for all age groups in this neighbourhood type

for all years, it does decrease with age. The mode that increases the most with age is automobile as a passenger. The oldest adults in Wealthy Single Family Home areas are seeking rides rather than using alternative modes independently. This is similar to the idea that in sprawled development, driving trips are longer, making alternative modes incompatible with driving (Cao et al., 2010). Transit is an unlikely alternative to driving in this neighbourhood type.

Aging Baby Boomers

An important goal of this research is to determine which neighbourhood types baby boomers are displaying a preference for. The baby boomer generation is captured by Cohorts 1 and 2, who were born between 1949-1953 and 1944-1948 respectively. The analysis shows that there are certain neighbourhood types that these Cohorts are showing increasing preference for and decreasing preference for. Cohorts 1 and 2 show an increasing preference for Dense & Diverse neighbourhoods and Accessible Prewar neighbourhoods compared to other cohorts. The positive implication of this is that these two types of neigbourhoods are the most accessible and have a diverse mix of land uses. The preference for these neighbourhood types may reflect the preference for amenity rich neighbourhoods exhibited by older adults (Cao et al., 2010). Alternatively, Cohorts 1 and 2 are showing a decreasing preference for Inaccessible Residential and Wealthy Single Family Home neighbourhood types. Both of which have poor accessibility. As poor access acts as a barrier to aging in place (Farber et al., 2011), it is

an encouraging finding that a preference is shown for accessible neighbourhoods from Cohorts 1 and 2. It appears as though Cohorts 1 and 2 are seeking more accessible neighbourhood types before the preference to age in place is solidified at 70 years of age.

The baby boomer population in Montreal has an increasing preference for accessible neighbourhood types, including Accessible Prewar and Dense & Diverse areas. Overall, these two neighbourhood types have the least automobile oriented land uses and the smallest mode share of automobile use over time. However, baby boomers have a preference for automobile travel. This raises a question of whether or not baby boomers will be able to adopt more multi-modal lifestyles as they move to more accessible neighbourhoods. On one hand, the older adults increase their transit use in these neighbourhood types as they age. Baby boomers could potentially be willing to adapt their travel behavior and become less automobile dependent in these neighbourhood types. On the other hand, baby boomers have shown automobile dependence and older adults with little experience with transit are less likely to use transit as an alternative as they age (Kim, 2011c). Considering the oldest adults are most impacted by their built environment (Clarke et al., 2009; Rosso et al., 2011), there is potential for behavior change from the baby boomer population as they age in accessible neighbourhoods. Based on the current study, conclusions cannot be made about whether or not these baby boomers will adapt their travel behavior to their built

environment. However, Accessible Prewar and Dense & Diverse areas may benefit from travel demand management strategies targeted at older adults that encourage renouncing automobile use and promote transit use. Since, higher densities are associated with shorter automobile trip lengths and street density increases automobile trip length (Moniruzzaman et al., 2013), there is potential in these neighbourhood types to encourage a mode change. Transit accessibility is high in these neighbourhood types and transit is competitive with automobile travel. Behavior change could be facilitated through travel demand management strategies.

Aging in Suburban Environments

Predictions have been made about the suburbanization of the aging population (Golant, 2005). However, in Montreal, the tendency to age in place in the suburbs depends on the type of suburban environment. Both Wealthy Single Family Home and Inaccessible Residential areas share suburban characteristics. However, patterns in the proportion of older adults living in these two neighbourhood types over time are different. On one hand, Wealthy Single Family Home areas exhibit some of the typically suburban characteristics that act as barriers to successful aging in place, including poor accessibility and automobile orientation (Farber et al., 2011). In this neighbourhood type, the proportion of older adults living here decreases with age. There are positive and negative implications of this. The positive implication is that older adults experience more transportation deficiency in suburban environments (Cao et al., 2010; Kim, 2011a).

Therefore, the tendency to leave this neighbourhood type is beneficial for the maintenance of independent mobility of the elderly. The negative implication of this finding is that this neighbourhood type is not supportive of the preference to age in place, perhaps due to its poor accessibility. Older adults living in Wealthy Single Family Home areas may be resistant to leaving an inaccessible neighbourhood due to an attachment to the community and home. In this case, the departure from Wealthy Single Family Home areas is out of necessity, not preference.

On the other hand, Inaccessible Residential areas also share some suburban characteristics, including poor accessibility, distance from the CBD and automobile use. In this case, older adults, specifically Cohorts 4, 5 and 6, appear to be expressing a preference to age in place in this suburban neighbourhood type. A concerning finding is that Inaccessible Residential areas are the most popular neighbourhood type for adults aged 50 years old and older. Notably, between 27% and 33% of adults aged 70 years or older lived in this neighbourhood type for all survey years. This is concerning because it is the least accessible neighbourhood type, scored poorly on all accessibility measures and has an increasing automobile dependence in recent years. A notable difference between Wealthy Single Family Home areas and Inaccessible Residential areas is found in the demographics. Wealthy Single Family Home areas are represented by the highest incomes and home ownership rates, while Inaccessible Residential neighbourhoods have below average incomes. Both neighbourhood types have poor accessibility. It could be

that residents of Wealthy Single Family Home areas have the means to seek out neighbourhoods that are more accessible and more supportive of aging in place, while residents of Inaccessible Residential neighbourhood types are unable to express preference for more accessible neighbourhood types.

In Wealthy Single Family Home areas, the automobile is the dominant mode of transportation for older adults. Automobile as a driver decreases with age and automobile as a passenger increases. This travel behavior, along with this neighbourhood type being auto-oriented and sprawling, suggests that older residents of this neighbourhood type are susceptible to transportation deficiency due to their dependence on automobiles and auto-oriented land uses (Kim, 2011a). However, this is not a common neighbourhood type to age in place in and many older residents are leaving these areas as they age. This poses a potential problem for the aging population in Wealthy Single Family Home areas that remain in this neighbourhood type. The built environment is auto-oriented and travel behavior is automobile dependent. If a small proportion of the elderly live here they may be especially vulnerable to transportation deficiency, particularly if they are unable to drive. The oldest adults remaining in this neighbourhood type may attempt to drive longer than is appropriate because of the lack of alternatives. Additionally, if driving cessation occurs, the emotional impact of being forced to stop driving could be exaggerated. However, provision of alternatives that meet the mobility needs of the elderly may be unlikely in this neighbourhood type

because of the decreasing number of older adults living here and low densities. To maintain the mobility of the oldest adults remaining in Wealthy Single Family Home areas, alternative and accessible modes of transportation should be available that are able to compete with the convenience of automobile travel that the adults in this neighbourhood type are accustomed to.

The oldest adults in Cohorts 4, 5 and 6 are expressing preference to age in place in Inaccessible Residential areas. This neighbourhood type also has the highest proportion of adults who are 50 years or older on the Island of Montreal. Inaccessible Residential areas have a high automobile mode share, which decreases for the oldest adults, while automobile as a passenger increases and transit remains constant. Older adults in Inaccessible Residential neighbourhood types are not using transit as an alternative to automobile use. Rather, they are turning to the automobile as a passenger. This is similar to previous research that found many adults expect to receive rides from friends and family if forced to stop driving (Kim, 2011c). Additionally, this neighbourhood type has the largest proportion of older adults living in it. Therefore, there is a large proportion of elderly in these areas who are not being provided with suitable alternatives to the automobile and are dependent on others for rides. Independent mobility is not being maintained in this neighbourhood type. Transit is not commonly used in Inaccessible Residential areas, with a transit mode share of between 6.1% and 8.6% for all age groups in 2013. However, transit was a much more commonly

used mode in 1998. To maintain mobility of the elderly, this neighbourhood type may benefit from transit service improvements that are accessible to the oldest adults, who are showing a preference for this neighbourhood type.

Implications on Elderly Mobility in Suburban Environments

While the causes of the tendency to leave Wealthy Single Family Home areas and stay in Inaccessible Residential areas are unknown, the above trend raises an interesting question about how to approach the preference to age in place in a way that maintains independence of the elderly in suburban environments. One approach would be to retrofit suburban environments to be more accessible. A meaningful change in land use and access in residential suburban neighbourhoods would be a large endeavor. It would require significant political will for this to be considered a realistic solution for the aging baby boomers. However there are additional smaller scale strategies that could address the concerns of older adults. The concerns of older adults include access to amenities without the use of a car, quality of infrastructure, attractiveness of the neighbourhood, and public transit (Michael, Green, et al., 2006). These concerns could be addressed through pedestrian-oriented street redesign, maintenance of public spaces and improvements to transit services.

Another approach to improve elderly mobility in suburban environments is the eventual proliferation of AVs. AVs have the potential to provide a safe and independent alternative to traditional automobiles for the elderly if they have elderly-friendly

interfaces and if some training is provided (Siulagi et al., 2016). Wealthy Single Family Home and Inaccessible Residential areas have existing automobile oriented land use and infrastructure. Since proliferation of AVs does not require retrofitting existing auto-oriented areas (Reimer, 2014), AVs could represent a cost effective solution for elderly mobility in suburban neighbourhood types, where transit service improvements are unlikely and meaningful land use change is unfeasible. Policy makers and planners should support policies that facilitate the proliferation of AV services in low density suburban areas, like Wealthy Single Family Home areas.

The third approach is to facilitate the move from to suburban neighbourhoods to more accessible environments through grants or other incentives. Aging in place refers to ability to age in place, regardless of income level (Centre for Disease Control and Prevention, 2013). Therefore, income level should not act as a barrier to older adults seeking out accessible neighbourhood types that support aging in place. However, senior residents of Wealthy Single Family Home areas are leaving their inaccessible neighbourhoods, while senior residents of Inaccessible Residential areas are not. Therefore, offering grants or incentives for moving out of these neighbourhoods types could allow lower income residents to seek out more accessible neighbourhood types, if preferred.

Generational Differences

Part Two showed that there are generational differences in travel behavior in regards to the transit use of older adults. Many baby boomers have lived their whole life with the convenience and flexibility of automobile travel which has made them resistant to alternative modes of transportation, including transit. However, the parents of the baby boomers have been less dependent on automobile travel and use transit to meet their mobility needs as they age. Part Three has shown that generational differences are also found in home locations. The most popular neighbourhood type for the parents of the baby boomers is Inaccessible Residential neighbourhoods, while baby boomers are increasingly seeking out Accessible Prewar and Dense & Diverse areas. The neighbourhood types that baby boomers are seeking are not automobile dependent.

This means that, when planning for the future, baby boomers are showing auto-dependent travel behavior while seeking out built environments that are not characterized by auto-dependent land uses and auto-dependent travel behavior. There appears to be a contrast in the travel behavior and home location choices of the baby boomer population. This raises an important question. If baby boomers are increasingly seeking out neighbourhoods with access to shops and services within walking distance and larger transit mode shares, will their travel behavior change as they age to become less automobile dependent?

As discussed above, there is potential for behavior change because older adults are more impacted by their built environment. This highlights the importance of

familiarizing baby boomers with alternative modes like transit. Since familiarization with this service results in a greater likelihood of using transit in later years in life (Kim, 2011c), the travel behavior of older adults may be more adaptable to their environment as they age. Baby boomers are moving to more accessible neighbourhood types in which the built environment supports alternative modes to the automobile. Therefore, if policy makers have the goal of reducing automobile dependency and increasing transit use for baby boomers, it would be beneficial to encourage transit through travel demand management strategies that can change travel behavior.

Limitations

The limitations of this study should be noted. In order to make observations about the patterns in home locations over time, some assumptions were made. First, an even sampling distribution across the island of Montreal is assumed for all survey years. Second, this analysis does not address home location change on or off of the island of Montreal. Instead, it only looks at patterns within the island of Montreal. Finally, as noted above, the reasons for older adults to remain in or leave a neighbourhood are unknown. The actual preferences of individuals are also unknown. Therefore, this analysis does not attempt to address the causes of changes in home location. Rather, the intention is to start a discussion based on observations of general patterns over time in different neighbourhood types.

CONCLUSION

The built environment can disproportionately impact the mobility of older adults and highlight mobility problems (Clarke et al., 2009; Rosso et al., 2011). However, this concept suggests that the built environment has the potential to positively impact the mobility of the elderly. In order to achieve this, land use and transportation options should be thoughtfully integrated in a way that offers services and amenities at the neighbourhood level that can be accessed by transit or walking. This way, the mobility of older adults can be maintained as they age, no matter which neighbourhood type they prefer to live in.

Generational differences exist in both the home location choices as well as the travel behavior of older adults. In planning for an aging population, it is important that policy makers acknowledge that the home location choices and travel behavior of older adults will be different from the generations before them. Baby boomers are increasingly seeking out accessible neighbourhood types and showing an automobile dependence, while their parents' generation exhibit more transit use in their oldest years and show a preference for inaccessible neighbourhoods. It is important that policy makers are willing to adapt to changing demands and varying behavior when planning for the aging baby boomer generation.

The analysis presented here suggests that older adults can exhibit preferences for different neighbourhood types, with varying neighbourhood characteristics. Some of

these neighbourhood types are more supportive than others of the preference to age in place. The definition of aging in place is “the ability to live in one's own home and community safely, independently, and comfortably, regardless of age, income, or ability level” (Centre for Disease Control and Prevention, 2013). However, the goals of policy makers who are planning for an aging population should go beyond what is suggested in this definition. These goals should include two additional interpretations. First, policy makers should provide opportunity for older adults to express their preference to age in place in their preferred home, community and neighbourhood type, regardless of where this is. Second, policy makers have the responsibility to ensure that these neighbourhoods have access to services and amenities and feature land uses that are supportive of aging in place and independent mobility. If these goals are met, the aging population will be enabled to make choices about their home locations and travel options that reflect their preference to age in their preferred neighbourhood type.

PART FOUR: POLICY RECOMMENDATIONS AND CONCLUSIONS

POLICY RECOMMENDATIONS

Each neighbourhood type in Montreal features different neighbourhood characteristics with varying access, aging patterns and travel behavior. Therefore, each neighbourhood has unique challenges in regards to maintaining elderly mobility. Similarly, the elderly are not a homogeneous group and no single transportation solution will solve all elderly mobility issues (Rosenbloom, 2010). To meaningfully maintain safe and independent mobility of older adults, several interventions directed towards land use, transit service, demand management and housing will be required.

The following will translate the findings from Part Two and Part Three into policy recommendations for improving the mobility of the elderly population in Montreal. The goals of providing transportation options for the aging population should focus on

reducing automobile dependency, encouraging an active multimodal lifestyle and allowing seniors to express their personal preferences.

Foster a familiarity with transit services before driving cessation: Programs should be implemented that encourage transit use during the early senior years. The intention of the programs should be to lessen automobile dependence and increase modal options. This way, seniors who are forced into driving cessation later in life are familiar with alternatives to the automobile.

Ensure older adults are in elderly supportive neighbourhoods before the age of 70: Older seniors may show a resistance to home relocation after the age of 70. Therefore, it is important that older adults find homes in neighbourhoods with access to services and amenities that can be reached by walking or with transit before they reach 70 years of age.

Employ Travel Demand Management strategies: Automobile dependent baby boomers are moving to multimodal neighbourhood types. In an attempt to decrease the automobile dependency of baby boomers, travel demand management strategies should be implemented in Accessible Prewar and Dense & Diverse areas. These strategies should be aimed at the baby boomer generation and should encourage adopting multimodal and active lifestyles that decrease automobile dependency.

Encourage home location change to accessible neighbourhood types: The tendency of older adults to leave inaccessible Wealthy Single Family Home areas could be

encouraged through grants and incentives. This could allow residents of inaccessible neighbourhoods, like Inaccessible Residential areas, to relocate with fewer economic barriers.

Improve transit service: The oldest seniors show a preference to age in Inaccessible Residential neighbourhoods and are open to transit use. However, transit use has decreased in recent years. These neighbourhood types would benefit from provision of better transit service that is accessible to the aging population.

Provide AVs as an alternative in low density neighbourhoods: Seeing as comprehensive land use change and transit service improvement may be unlikely in low density areas like Wealthy Single Family Home neighbourhoods, AVs could be provided as an alternative mode choice. AVs could provide a connection for the elderly in low density areas to the existing transit network.

Implement streetscape improvements: All neighbourhood types and all ages benefit from small scale streetscape improvements. These improvements include increasing sidewalk quality, pedestrian oriented design and maintenance of public spaces.

Support mobile shops: In areas where comprehensive land use change and transit service improvement in unfeasible, mobile programs can be implemented. Mobile shops and services can provide portable provision of both amenities and essential items, like groceries, and can provide a temporary community focal point in low density areas.

These policy recommendations aim to maintain the safe and independent

mobility of seniors as they age in Montreal. Figure 24 shows which neighbourhood types the recommendations would be most effectively implemented in.

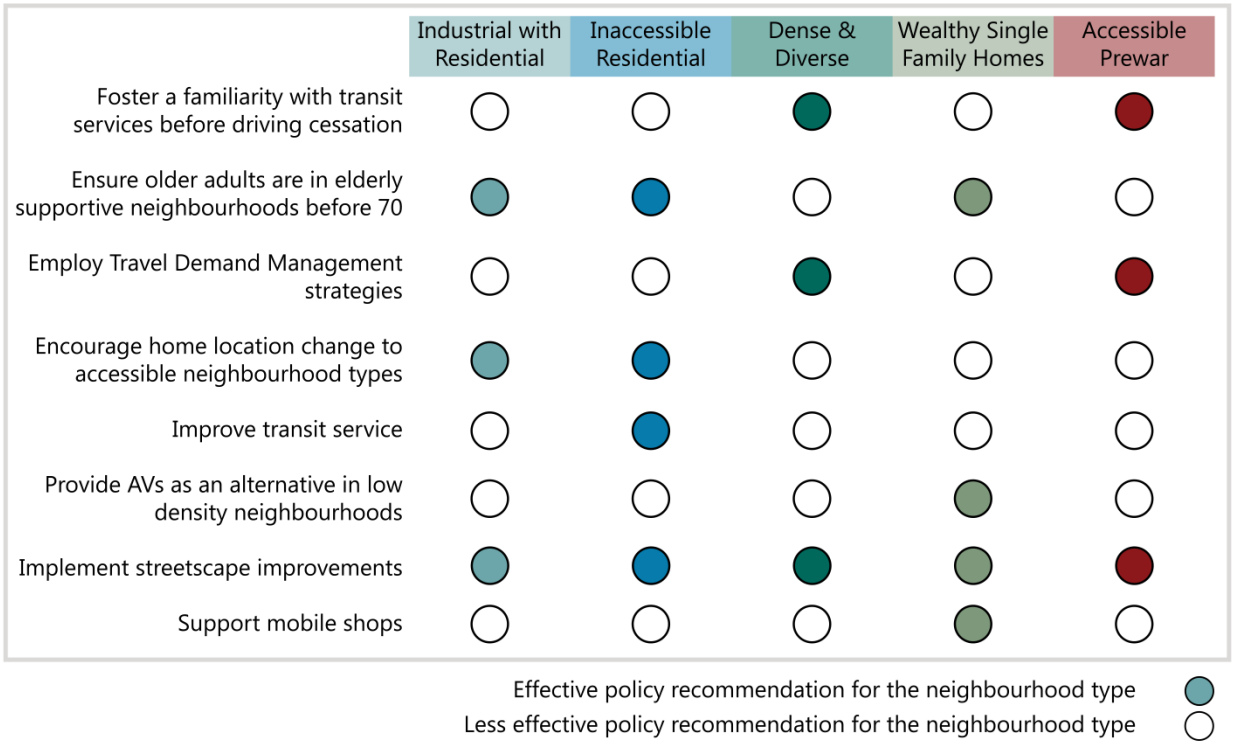

Figure 24: Policy Recommendations

CONCLUDING THOUGHTS

Planners have often been concerned with preparing for the needs of specific age groups and the changing demands of certain generations. Whether it is providing single family homes for young families following World War II, or preparing to retain the millennial generation on transit further into adulthood, policies are often implemented in an attempt to target particular groups of people. Planners and policy makers have a responsibility to address the specific needs of the aging population. The increasing

relevance of planning for an aging population provides an impetus for policy makers to implement interventions that improve accessibility at the neighbourhood level, provide multiple transportation options and decrease car dependency. In preparing for an aging population, policy makers and planners tend to provide neighbourhoods that are more accessible, walkable and livable for community members of all ages. The policy recommendations presented above do not only benefit the elderly. Rather, they have far reaching benefits for the community as a whole.

The aging baby boomers represent a growth in the senior population that is unprecedented. Addressing their specific needs is a necessity as well as an opportunity to foster support for improving accessibility at the neighbourhood level and providing multiple transportation options that encourage active living. Planning for an aging population represents sound planning practice has potential benefits for all ages.

> *"We've put more effort into helping folks reach old age than into helping them enjoy it."*
>
> Frank Howard Clark

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