Seasonal Variation in Older Adults' Driving Trip Distances

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Abstract

To date very few studies have examined the difference in driving patterns between winter and non-winter driving and those that have, have primarily used self-report. The purpose of this study was to determine if there were changes in trip distance between winter/non-winter and inclement/non-inclement driving in older adults using a sub-set of Candrive participants. Candrive is a longitudinal study examining the everyday driving patterns and habits of older drivers. Participants were recruited from seven different sites in Canada (Ottawa, Toronto, Montreal, Hamilton, Thunder Bay, Winnipeg, and Victoria). In total 279 participants (of which 248 were kept for analyses of City Only Trips) were included for analysis, almost 50% were female, with an average age at enrolment of 77.5 ± 5.2 years. A total of 377,464 trips were taken on 866 different days. It was found that there was a 7% decrease in trip distance during winter when controlling for *day* and *site* when examining all trips taken by older drivers. In addition, there was a 1% decrease in trip distance during winter and a 5% increase in trip distance during rain when compared to no precipitation when controlling for *precipitation type* (or *winter* respectively), *day,* and *site,* when only looking at trips in the city. There was a minimal (albeit significant) change in trip distance associated with both winter and inclement weather conditions, suggesting that older drivers may not be adjusting their driving patterns during these conditions as much as was previously thought based on the self-report literature.

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1. Introduction

The Canadian population is aging. This is not a new or surprising revelation, but what is surprising is how much this is potentially going to affect the driving population of this country. By 2031 approximately 17% of the Canadian population will be 70 and older and 29% will be 60 and older (Statistics Canada, n.d.). With the typical older adult maintaining his or her ability to drive well into their 80s, this means the proportion of older drivers will dramatically increase over the coming years. This potential for a dramatic increase in older drivers is also coinciding with a decrease in younger drivers (Sivak & Schoettle, 2012), so to go along with our aging population we now have an aging driving population. As a society we are faced with a problem: our older adults are expected and needed to play a bigger role in the work force and in society in general, but at the same time the general population has this belief that older adults as a whole are a group of unsafe drivers. So, we as a society face a dilemma; in a world that we have designed to be personal automobile dependent, we have a significant portion of the population that we have said should not drive, but on the other hand we need to drive so they can contribute to society. What do we do? First, it is time to start educating the public, that older adults as a whole are not a group of unsafe drivers. There are some who, usually for medical reasons, are not safe to be on the road any further and therefore need to be identified. Second, we need to start to understand the driving patterns and habits of older drivers. Where and when do they drive, what are the reasons that they are driving and to what extent are their driving behaviours modified over time and between trips? There is a limited body of knowledge about the driving patterns of older adults at the present and without a significant increase in the understanding of these patterns and behaviours it will be hard for us to help older adults maintain safe driving into the future and to determine what we may need to modify to assist in this goal. This study examined the driving patterns and behaviours that are expressed over the course of a year to determine if there are changes based on seasonal and weather variations. This was the first study to look at the driving patterns of older adults over the course of a year and to determine if there were seasonal or weather conditions that cause older adults to modify their driving.

1.1. Purpose

The purpose of this study was to determine if there were changes in the driving patterns (specifically trip distance) of older adults between winter and non-winter driving as well as between non-inclement and inclement seasonal conditions over a full year. It was hypothesized that:

- There would be a decrease in trip distance during winter driving conditions and a decrease in trip distance during inclement weather conditions during both winter and non-winter. It was further hypothesized that trip distance would decrease during night-time driving regardless of season or weather conditions.
- Secondarily it was hypothesized that increased age, decreased mobility, and poorer health status would result in an even greater decrease in trip distance during both winter and inclement weather conditions.

2. Literature Review

2.1. Demographics

In 2009 in Canada, 3.25 million or 74.9% of people aged 65 years and over had a driver's license, and 200,000 or 40.7% were age 85 and over (Turcotte, 2012). With the Canadian population aging these numbers are going to increase as time goes on and more and more older adults continue driving into their later years. The discrepancy rates between male and female older drivers are expected to narrow to 1:1 by as early as 2023 (Dobbs, 2008) leading to an overall increase in older drivers. Rosenbloom (2001) noticed in other industrial nations the increasing "automobility" of seniors, essentially this is the increasing dependency of older adults on the private vehicle to meet increasing travel needs. Scott et al. (2009) proposed that there are four interrelated factors that have contributed to and will continue to shape how older adults get around in the future. The first is the car culture, the personal automobile has become a staple in our society and critical to our ability to get around. Second is suburbanization, with the movement of the population from within city limits and high density housing to the suburbs and urban sprawl, the need for the personal vehicle increased dramatically. Third was driver licensing, with the population aging and more of the younger population dependent on the personal vehicle the number of older adults with driver's licenses is only going to increase, and finally, public transportation and the general perception that there is none and what is available is not an acceptable means of transportation for seniors. The second point of suburbanization is critical. Here in Canada we are noticing a change in where older adults reside. More older adults are living outside of areas considered to have high residential density (i.e., areas that contain a lot of apartments) and therefore are living in areas that rely to a greater extent on the personal vehicle as the primary form of transportation (Turcotte, 2012). Turcotte (2012) demonstrated with the use of the Canadian Community Health Survey – Healthy Aging (2009) and Census of Population (2006) that there is still a decrease in the likelihood for older adults to live in highly car dependent neighbourhoods, but this decrease is not as great as may have been expected. For adults aged 65-74 years of age, 54% live in highly car dependent neighbourhoods, whereas 45% of those 75-84 and 40% of those 85 and older do. If this trend continues, older adults will feel the necessity to drive for longer simply due to where they reside and the personal vehicle is the only means of transportation.

2.2. Driving Outcomes

2.2.1. Crash rates

Older drivers are involved in relatively more crashes then their younger counterparts. Ryan, Legge, & Rosman (1998) demonstrated using data from The Road Injury Database from Western Australia spanning from 1989-1992 that crash rates for older adults are elevated when standardized against either per 1000 licensed drivers, or per 10^8 kilometers (km) driven. The only way crash rates were not elevated was when standardized against per 1000 population. The data from this study are now relatively old and the numbers may be out of date, but the trend still stands. Recently Langford, Koppel, McCarthy, & Srinivasan (2008) demonstrated the commonly seen and frequently quoted U-shaped curve that indicates that per 100 million km older adults have an increased crash rate, and those older adults aged 80+ have the second highest crash rate just short of the rate for 15-19 year olds. This U-shaped curve is the driving force behind most of the research done on older drivers. Janke (1991) warned against reading too much into this U-shaped curve, indicating that the increase in crash rates may simply be due to the fact that this age group drives close to home on roads with more potential conflict points. In other words older adults are more likely to spend an increased amount of time driving on roads with numerous intersections and therefore more potential sites for collisions than younger drivers who may spend more time driving on highways, and roadways with fewer intersections. This has been termed the Low-mileage bias by Hakamies-Blomqvist and Langford. Both advocate that when crash rates per 100 million kilometers are grouped by annual mileage instead of age then those with very low annual mileages demonstrate the elevated crash rates. Since older drivers tend to drive less than their younger counterparts this is a potential explanation as to why older adults and especially the oldest drivers demonstrate an increased crash rate (Hakamies-Blomqvist, Raitanen, & O'Neill, 2002; Langford, Koppel, Charlton, Fildes, & Newstead, 2006; Langford et al., 2008).

The other theory as to why older adults may demonstrate increased crash rates has been termed the frailty bias. The frailty bias essentially states that older adults due to physiological changes (e.g., decreased bone density) associated with aging are more easily injured in a crash and therefore more crashes involving older adults are reported. Usually in transportation research the crash data that are used are the crashes where police have been called and these typically occur when drivers or passengers are injured. Because of the greater "frailty" of older adults (the increased chance in them being injured) older adults are more likely to be involved in police reported crashes. The frailty bias argument is that the more likely you are to be injured in a crash, the more likely you are to have elevated crash rates, which is why we see elevated crash rates in older drivers. Li, Braver, & Chen (2003) demonstrated using data from 1993-1997 Fatality Analysis

Reporting System, 1993-1997 General Estimates System, and the 1995 Nationwide Personal Transportation survey that driver deaths per crash involvement started increasing at the age of 60 and increased steeply after age 80. Driver deaths per crash was used as the indicator for frailty and was found to explain 15-20% of the crash rate per mile for 70-74 year olds, indicating that frailty may explain some of the reason why older adults demonstrate an increased crash rate.

In terms of types of crashes that older adults are involved in they differ from those typical of younger drivers. Older adults are more likely to be involved in those involving multiple vehicles, occurring during the day, at lower speeds, at intersections, and when turning (e.g., Catchpole, Styles, Pyta, & Imberger, 2005; Cooper, 1990; Hakamies-Blomqvist, 1993; Keall & Frith, 2004; Preusser, Williams, Ferguson, Ulmer, & Weinstein, 1998; Zhang, Lindsay, Clarke, Robbins, & Mao, 2000). All of which are indicative of spending more time on residential and city streets, but not conclusive since there have been very few studies that have directly examined the types of roadways used by older adults.

2.2.2. Mobility and engagement in society

"Mobility is essential for general independence as well as ensuring good health and quality of life (generally considered to include dimensions such as physical health, psychological well-being, social networks and support, and life satisfaction and morale) by virtue of enabling continued access to essential services, activities, and other people" (Oxley & Whelan, 2008, p. 367). Webber, Porter, & Menec (2010) defined mobility as "the ability to move oneself (either independently or by using assistive devices or transportation) within environments that expand from one's home to the neighbourhood and to regions beyond" (p. 444). Essentially this definition implies that mobility is the ability to get where you want when you want, which in most cases in the 21st century involves the use of a personal vehicle. For example, Turcotte (2012) found that older adults whose main form of transportation was driving were more likely to participate in social activities during the previous week (73%) compared to those who used any other form of transportation. Dahan-Oliel, Mazer, Gelinas, Dobbs, & Lefebvre (2010) found that those adults who drove were more likely to participate in leisure activities than those who were passengers. Implying that those older adults with access to a personal vehicle were more likely to be mobile within and around the community when compared to those who did not have access. This has a major impact on physical and mental health and may be a huge contributor to why older adults are reluctant to give up driving. Donorfio, D'Ambrosio, Coughlin, & Mohyde (2009) found that driving connected participants to life and society, and Edwards, Perkins, Ross, & Reynolds (2009) found that driving status is a strong predictor of three year mortality. As well Fonda, Wallace, & Herzog (2001) found an increase in depressive symptoms in older drivers who had stopped driving, and Donorfio, D'Ambrosio, Coughlin, & Mohyde (2008a) found that those older adults with a better health status were more likely to drive more miles per week, have greater confidence in their driving, report fewer accidents, and report a greater degree of enjoyment. Indicating that driving and its relationship to quality of life is intricately linked in our car dependent society.

2.3. Driving as an Everyday Competence Model

Lindstrom-Forneri, Tuokko, Garrett, & Molnar (2010) recently proposed a theoretical framework, the Driving as an Everyday Competence Model (DEC), to explain both driving competence and performance. They defined driving competence as a “latent construct and refers to what a driver is capable of given the dynamic individual environment interaction” and driving performance as “the actual driving behaviours” (p. 284). An example for driving competence would be: does the older driver possess the mental capacity to handle driving during rush hour traffic? Whereas driving performance would be the specific behaviours used while driving in rush hour traffic, such as driving at a slower speed. The DEC is a combination of different models that have been proposed to explain everyday competence, motivation, and driving. The driving model used was Michon’s driving model, which categorizes compensatory behaviours as occurring on three levels: 1) strategic, which is trip planning (i.e., using familiar or unfamiliar roads), 2) tactical, which is adjusting aspects like speed taking into account environmental conditions, and 3) operational, which is adjusting immediate control of the vehicle (i.e., using the signal light to indicate turning).

The DEC model on the other hand looks at the impact of individual and environmental factors at the global and specific level and the interactions between them to determine actual driving performance. The DEC model also looks at those same interactions combined with the older driver’s level of competence to determine which level of Michon’s compensatory behaviours will be adopted and therefore what driving behaviours will be exhibited.

2.4. Self-regulation and Driving

Self-regulation with regards to driving has yet to be formally defined in the driving literature, but is generally considered to be a modification in driving habits and patterns to prolong driving into later age (e.g., Baldock, Mathias, McLean, & Berndt, 2006; Charlton et al., 2006; Donorfio, Mohyde, Coughlin, & D'Ambrosio, 2008b; Kostyniuk & Molnar, 2008). Donorfio et al. (2008b) found that older adults believed self-regulation was an active process that changed over time. For example, "When people are younger and in better health, self-regulation begins as a method to cope with driving conditions, external situations, and the mistakes and bad habits of other drivers. Gradually, the older driver shifts to employing increased self-regulation strategies also to compensate for recognized internal short-comings in ability and confidence in driving." (p. 330). With these perceptions taken into account it can be proposed that self-regulation in older drivers can be defined as the changes in driving patterns and habits based on perceived or actual decline in driving ability. With ability defined by Donorfio et al. (2008b) as: "the quality of being able to perform, both physically and psychologically" (p. 329).

To date most the self-regulation research looking at older drivers has been done through questionnaires or surveys, reliant on self-report of what environmental conditions or behaviours are avoided or reduced. To date Blanchard, Myers, & Porter (2010) are the only ones to have compared self-reported self-regulatory behaviours to actual objectively measured driving patterns and habits. Myers, Trang, & Crizzle (2011), Blanchard & Myers (2010), and Crizzle & Myers (2013) looked at the association of driving comfort and perceived driving abilities with objective measures of driving patterns, but not if what was reported was actually demonstrated in the objective measures.

Blanchard et al. (2010) recruited 61 older drivers between the ages of 67-92, with a valid driver's license, living in South-western Ontario, driving at least one time per week, either the sole driver of the household or shared one vehicle, and the vehicle had to be 1996 or newer. They were assessed between June and October. Participants were asked to complete the driving habits questionnaire, situational driving frequency and avoidance scales, and in a follow-up interview asked to estimate the number of kilometers they drove in the previous week. As well, two devices (the CarChip and Otto DrivingMate) were installed into the participant's vehicle to objectively measure driving patterns. In addition, a 24 hour activity diary was given to participants to record all out of home excursions. The study consisted of two visits one week apart and all questionnaires and the follow-up interview were done at the second visit after monitoring of driving patterns. In terms of actual versus self-report measures of avoided driving behaviours the results were only provided for one of the questionnaires, the Situational Driving Avoidance scale. Of the 20 situations presented only 5 of them had a large portion of participants who actually reported avoiding the driving situation. The 5 situations were: 1) bad weather (general) where 43% of those who reported avoiding driving in bad weather actually did drive over the course of the week during "bad weather"; 2) rush hour in town where 81% actually drove, although this may be due to a misunderstanding of what this situation represented because the other situation of avoiding rush hour on highway/expressways only 24% of those who report avoiding this situation actually drove on highways in rush hour; 3) left turns with traffic where 100% actually made this manoeuvre although only 3 reported avoiding this to begin with; 4) left turns with no lights/signs where 100% actually made this manoeuvre as well; and, 5) driving with passengers where 50% actually drove with passengers according to the 24 hour diary. This indicates, in terms of some strategic adjustments, that older adults are able to somewhat accurately indicate what behaviours they avoid (typically environmental or location), but in terms of more operational adaptations older adults are less sure of their driving habits (e.g., report avoiding left hand turns, but all participants ended up making left hand turns). This study calls into question what behaviours we think older adults exhibit based on the self-report studies done to date.

As mentioned above, self-regulation studies have predominantly been limited to interview or questionnaire. These studies have come up with a generally accepted list of behaviours that older drivers exhibit when compared to younger drivers. Older drivers tend to: drive less often, closer to home, in the daytime, on weekdays, and in familiar areas (e.g., Collia, Sharp, & Giesbrecht, 2003; D'Ambrosio, Donorfio, Coughlin, Mohyde, & Meyer, 2008; Keall & Frith, 2004). They also tend to avoid: driving at night, driving in bad weather, driving in rush hour, driving on highways, and making complex manoeuvres such as left hand turns (e.g., Baldock et al., 2006; Charlton et al., 2006; D'Ambrosio et al., 2008; Hakamies-Blomqvist & Wahlström, 1998; Lyman, McGwin Jr, & Sims, 2001; Oxley, Chariton, Scully, & Koppel, 2010). Donorfio et al. (2008b) found through focus groups, that the most commonly identified self-regulatory behaviours believed to change with age were: decreasing the number of overall trips, not driving at night or in inclement weather, and not driving at fast speeds. Betz & Lowenstein (2010) through the Secondary Injury Control and Risk survey sampled a total of 9,684 adults aged 18 and older of which 728 were older adults aged 75 and older. Participants were asked if they tended to avoid driving in certain conditions: driving in bad weather (59% of older adults indicated they try to avoid driving in bad weather), night (57%), long trips (49.6%), traffic (49%), and on high speed roads (33.6%).

Donorfio et al. (2008b) is an example of a newer self-regulation study that used qualitative methods to try to understand what self-regulatory behaviours older adults believe they exhibit, whereas Betz & Lowenstein (2010) used a relatively large sample size and limited options to determine in what situations older adults avoid driving. Both of these studies use some common and some different elements from typical self-regulation research. Usually self-regulation research looks at smaller sample sizes and uses questionnaires to ask participants if they tend to avoid certain conditions, and in recent years creates a score to quantify to what extent older adults self-regulate while driving. Both are missing a crucial point based on the results from Blanchard et al. (2010) in that only some of what was self-reported was actually what was observed in objective measures. This calls into question the generally accepted list of behaviours and patterns above and whether they are actually expressed in objective measures or not.

2.5. Ways of Measuring Driving Patterns

2.5.1. Questionnaire and surveys

Questionnaires and surveys have by far been the most frequently used method of measuring driving patterns, but very few of these have actually had their validity or accuracy checked (Huebner, Porter, & Marshall, 2006). For most of these questionnaires and surveys, participants were asked whether they try to avoid certain conditions or to rate the frequency in which they may drive on certain types of roads or in certain conditions. Owsley, Stalvey, Wells, & Sloane (1999) was the only paper to present the test-re-test reliability for the questionnaire used. They found that for their driving difficulty section of the questionnaire the reliability was 0.6 and the driving spaces section was 0.86, indicating that results were highly correlated. Reliability was determined by administering the questionnaire two weeks apart to a sample of 41 current drivers of varying health status and age ranging from 53 to 85 years. The driving difficulty section was designed to determine the "degree of visual difficulty experienced in specific driving situations" (Owsley et al., 1999, p. M204). The driving spaces section was designed to "address the distance respondents typically drive into their environment away from their home base over the past year" (Owsley et al., 1999, p. M204). Both of these sections take a different approach than the "typical" driving patterns research at the moment. The driving difficulty section asks participants to rank how difficult a situation was based on their visual acuity not whether they try to avoid the situation or not. The driving spaces section on the other hand does not ask the participants to guess the distance that they have driven in the past year, it asks participants if they have driven beyond their immediate neighbourhood or to distance towns and quantifies distance in that sense. Both of which may explain why the reliability was high for this questionnaire and may be more questionable for other self-report driving patterns questionnaires. However, they do not examine the validity of questionnaire.

Looking at self-report versus objective measures for driving exposure it has been found that older adults are liable to over- and under-estimate how much they drive in a week or year. Huebner et al. (2006) followed 20 participants between the ages of 62 and 81 for one week and found when participants were asked after the week how far they drove; they both under- and over-estimated the number of kilometers, with more than 30% error on average. Blanchard et al. (2010) also followed 61 participants for one week and found that they also both over and under-estimated the number of kilometers driven in the past week. Molnar et al. (2013) asked 156 participants from the OzCandrive study how many kilometers they drove per week in a normal week and compared this to the average number of kilometers driven over approximately a four month data collection period. They also found that older adults were not able to correctly estimate their weekly mileage. Finally, Staplin, Gish, & Joyce (2008) used data from the National Household Travel Survey (2001) from the United States and compared self-reported mileage with odometer readings for drivers of all ages and found that those drivers in the lowest mileage groups under-estimated and those in the highest mileage groups over-estimated their self-reported annual mileage. Given these results, using survey and questionnaire data that relies on self-report for driving patterns may not be the best method to understand how much older adults drive. A more objective measure should be used.

2.5.2. Video

Video in combination with GPS and vehicle computer information could provide one of the richest datasets of driving patterns and habits of older adults. The 100-car naturalistic driving study (Neale, Dingus, Klauer, Sudweeks, & Goodman, 2005) and another study by Eby, Silverstein, Molnar, LeBlanc & Adler (2012) outfitted vehicles with several different video cameras in order to capture everything that was going on around the vehicle. In order to accurately obtain location a GPS receiver and vehicle network box to obtain information on speed and location were installed in the vehicles as well.

Video alone has the limitation in that determining speed, and location are difficult. Overall video analysis can be done, but video cameras would have to be positioned strategically to capture this information and is very labour intensive to analyze.

2.5.3. Electronic monitoring devices

Marshall et al. (2007) listed the advantages and disadvantages of two different in-vehicle monitoring devices, the CarChip and FleetPulse. The CarChip is a device designed by Davis Instruments in Hayward California to collect information including: date of driving, driving time, driving distance and speed, hard or extreme breaking and accelerations (Marshall et al., 2007), average velocity of the trip, maximum velocity of the trip, and velocity for every 5 seconds of the trip (Huebner et al., 2006). In essence the device is small and unobtrusive and plugs into the on-board diagnostic II (OBDII) port of vehicles 1996 or newer. Huebner et al. (2006) found that the CarChip provides an accurate measure of overall distance travelled. The major disadvantages of the device are its inability to identify who was driving as well as the inability to determine the location of travel (Marshall et al., 2007). The FleetPulse on the other hand is a GPS enabled device designed by Netistix Technologies Corporation (Ottawa, Canada) which can measure: driving time, distance, speed, breaking, idling time, and acceleration (Marshall et al., 2007). The advantage of the FleetPulse device was that with the addition of the GPS came the ability to monitor driving patterns, and on the other hand the disadvantage of not being able to identify the driver still exists. Marshall et al., (2007) also found that older adults were open to the idea of having these electronic monitoring devices in their vehicle and found them more convenient than the pencil and paper driving diary.

In terms of driving patterns that have been examined using electronic monitoring devices here is a break down of what the studies have found using these devices (Tables 2 and 3) and which devices were used (Table 1). Crizzle & Myers (2013) had a sample of older adults with Parkinson’s disease and matched controls. Only the results of the controls are presented here. The controls were between the ages of 57 and 84 and were tested between October 2009 and August 2010. Participants had the CarChip and Otto designed by Persen Technologies installed into their vehicles for two weeks, with driving patterns averaged over one week. Results from Crizzle & Myers (2013) may not be as comparable to the rest of the studies due to their participants having a tendency to be younger than the other studies. Myers et al. (2011) looked exclusively at winter driving patterns with data collection taking place over two weeks from November 2008 to March 2009 with driving patterns averaged to one week. Participants were between the ages of 65 to 91. Blanchard & Myers (2010) looked at 61 older drivers between the ages of 67 and 92 with a purposeful sample of almost half the population being over the age of 80. Data collection took place between June and October and driving patterns were monitored over one week.

There were many similarities between these studies: distance (Blanchard et al., 2010; Blanchard & Myers, 2010; Marshall et al., 2007; Myers et al., 2011), duration, number of trips per week (Blanchard et al., 2010; Blanchard & Myers, 2010; Myers et al., 2011), number of days per week (Blanchard & Myers, 2010; Myers et al., 2011), and average radius from home (Blanchard & Myers, 2010; Crizzle & Myers, 2013; Myers et al., 2011). Unfortunately percent of trip segments spent on roadways seems to have been calculated differently between (Crizzle & Myers, 2013) and (Blanchard & Myers, 2010) and not detailed so it is hard to determine if there are any similarities between the two studies (see table 3).

Table 1. Devices used to measure driving patterns.

	Crizzle & Myers (2013)	Myers et al. (2011)	Blanchard et al. (2010)	Blanchard & Myers (2010)	Marshall et al. (2007)
CarChip	Y	Y	Y	Y	Y
Otto	Y	Y	Y	Y	N
FleetPulse	N	N	N	N	Y

Table 2. Driving pattern results.

	Crizzle & Myers (2013)*	Myers et al. (2011)	Blanchard et al. (2010)	Blanchard & Myers (2010)	Marshall et al. (2007)
N	20	46	Varied**	61	19
Days	6.1 (0.8)	4.9 (1.5)		5.2 (1.9)	
Trips	9.9 (3.3)	7.3 (3.4)	7.2 (4.0)	7.1 (3.9)	
Stops	23.9 (8.2)	16.5 (8.5)	12.9 (9.5)	14.8 (10.1)	
Distance (km)	285.7 (174.3)	156.6 (108.8)	195.3 (188.3)	164.1 (158.4)	185.6 (81.7)***
Duration (h:min)	6:3 (2:6)	4:3 (2:3)	4:1 (3:4)	4:1 (3:1)	
Average radius (km)	6.7 (5.4)	7.0 (5.7)		7.6 (7.6)	
Maximum radius (km)	37.9 (39.9)	18.04 (18.3)		21.3 (27.4)	

Note: * For Crizzle & Myers (2013) only data from the control group is presented. ** Blanchard et al. (2010) n is varied based on each calculation, for: trips n=57, stops n=58, duration n=49, distance n=31. *** Marshall (2007) distance data are from the CarChip.

Table 3. Percent of trip segments spent on different road types.

	Crizzle & Myers (2013)*	Blanchard & Myers (2010)
Residential (40 km/h)	70%	50%
City (50-60 km/h)	7.7%	88%
Rural (70 km/h)	6.3%	13%
Highway (70 km/h)	11.8%	7%
Freeway (90-100 km/h)	3.8%	5%

Note: * For Crizzle & Myers (2013) only data from the control group are presented. Proportion of trip segments were calculated differently between Crizzle & Myers (2013) and Blanchard & Myers (2010).

2.6. Driving Circumstances

2.6.1. Night

Renner, Heldt, & Swegle (2011) looked at the time and injury sustained by all adults over the age of 21 who were admitted to a level one trauma centre as a result of a motor vehicle collision between January 1, 2005 and December 31, 2010. The trauma centre serviced the central third of a Midwestern state, where 17% of all drivers were over the age of 65. They found that older adults were more likely to sustain an injury in a motor vehicle collision during the early evening, defined as between 3:00 pm and 7:59 pm, as compared to other times of the day.

Crizzle & Myers (2013) and Myers et al. (2011) looked at the characteristics of trips taken by older adults at night with a night trip defined as starting or ending after sunset or starting before sunrise. Table 4 presents the characteristics of these trips. Crizzle & Myers' (2013) participants drove more often and greater distance and duration than participants from Myers et al. (2011). This again may be due to the mean age of Crizzle's participants being 70.6 versus 77.2 for Myers (2011).

Table 4. Night driving patterns.

	Crizzle & Myers (2013)*	Myers et al. (2011)
Nights driven	2.4 (1.5)	1.9 (1.5)
Night trips	2.7 (1.9)	1.9 (1.6)
Night km	40.4 (38.5)	31.2 (39.7)
Night duration (h:min)	0:55 (0:49)	0:51 (0:55)

Note: * For Crizzle & Myers (2013) only data from the control group are presented

2.6.2. Seasons

There is only one article to date to look at what could be considered seasonal variations in driving patterns (Sabback & Mann, 2005). Twenty participants from both Northern Florida and Western New York completed a telephone survey with questions about their: driving frequency; miles driven; and climatic, seasonal, and road conditions that might affect their decisions to drive. Participants were between the ages of 63 and 90 for Northern Florida and 67 and 91 in Western New York. For inclusion into the study participants had to be over the age of 60, currently driving, and have intact cognitive status (a score of 24 or higher on the Mini Mental Status Exam). They found that 60% of Western New Yorkers reported driving less during the winter and 20% of Northern Florida participants reported driving less in various seasons, indicating that there may be some sort of seasonal variation in driving patterns especially for those in Western New York who experience adverse weather conditions such as snow, sleet and ice.

2.6.3. Weather

2.6.3.1. *Crash risk*

Weather conditions are associated with crash risk. Adverse weather conditions such as rain or snow affect road conditions, which in turn increase, crash risk when compared to dry and seasonal weather conditions. Andrey, Hambly, Mills, & Afrin (2012) found that in Canada the average relative crash risk increases by 1.6 during rainfall and 1.7 during heavy rainfall, where rainfall was defined as greater than or equal to 0.4 mm of precipitation recorded during a six hour period all in liquid form and heavy rainfall was greater than or equal to 5 mm. City specific crash risk during rainfall increased: Victoria (~1.6), Winnipeg (~2.0), Toronto (~1.5), Ottawa (~1.6), and Montreal (~1.5).

Andrey et al. (2012) also found that average relative crash risk increased by 1.9 for winter precipitation and 2.3 for heavy winter precipitation, where winter precipitation was defined as greater than or equal to 0.4 mm of precipitation with evidence of snowfall, freezing rain, or ice pellets with or without liquid rainfall, and heavy winter precipitation was grater than 2 mm. City specific crash risk increased: Victoria (~1.1 although not statistically significant due to low snow fall amounts), Winnipeg (~1.7), Toronto (~1.8), Ottawa (~2.0), and Montreal (~1.5).

Andrey (2010) found that there was a disproportionate improvement in crash risk between the years 1984 and 2002 during rainfall when compared to seasonal dry conditions; and with snowfall the crash risk followed a similar pattern to the overall general safety trend. In terms of injury, Andrey (2010) found that minimal or minor injury risk was estimated to be 74% higher during rainfall and 89% higher during snowfall compared to dry or seasonal conditions; and for major or fatal injury the risk was estimated to be 46% higher during rainfall and 52% higher during snowfall.

It should be noted that for both of these studies these are overall trends across all age groups in Canada. If we believe some of the trends presented above (i.e., that older adults are at least at a greater increase for injury and potentially crashes) then these statistics provide some reason for concern. If relative crash risk increases approximately 1.6 during rainfall and 2.1 for snowfall and casualty risk increases by approximately 75% during precipitation (Andrey et al., 2012; Andrey, 2010) then we need to understand when, where, and how older adults are driving during these conditions to understand if they are inadvertently putting themselves at an increased risk of injury.

2.6.3.2. *Driving patterns*

Kilpelainen & Summala (2007) examined the effects of weather on driving choices by surveying all drivers who stopped at one of eleven different service stations located along ordinary two-lane main highways outside urban areas in southern and middle areas of Finland. A total of 1437 drivers of passenger cars, vans, or trucks completed the questionnaire between November 2001 and February 2002 on 16 days when adverse conditions were expected. Participants were asked to: rate the current driving conditions, classify slipperiness; rate weather in relation to traffic; the perceived general accident risk; whether they had acquired weather-related information for the trip; to report their decisions before and during the trip (e.g., to drive or not drive, leave more space, slow down, etc.); and to estimate their target speed, typical headways, and overtaking frequency. They found that if driving conditions were very poor, some of the more unnecessary trips were abandoned or postponed because they found that when the forecast was for very bad weather the most common trip purposes were: commuting, work related, and errands. In addition, there was an increased likelihood that older adults (over age 60) would acquire information on road conditions as compared to younger drivers.

Myers et al. (2011) on the other hand found that older adults were more likely to drive (69%) than not to drive (31%) on days with bad weather, and participants drove in 79% of occurrences of snow and 21% of occurrences of rain. Myers also found that 67% of the sample drove on days in which weather advisories had been issued for the region. This differs from Kilpelainen & Summala (2007) prediction that older drivers would not drive during adverse weather conditions due to the fact that the main trip purposes did not particularly apply to older adults and that their trips are generally more discretionary. It should be noted that Kilpelainen & Summala (2007) made this prediction based on what trip purposes were seen during days with very poor weather conditions whereas Myers et al. (2011) were able to look at the actual driving patterns of a sample of older adults over a two week period. Myers et al. (2011) did find in agreement with Kilpelainen & Summala (2007) that trips for social or entertainment purposes were more likely to occur on days with good versus inclement weather.

2.7. Summary of Review of Literature

Andrey (2010) and Andrey et al. (2012) found an increase in crash risk during inclement weather, and the risk for injury during these conditions was also increased. To date Myers et al. (2011) was the only one to have looked exclusively at driving patterns of older adults during the winter season, but to date no one has directly measured the seasonal variations. Sabback & Mann (2005) found that older adults in Western New York reported altering their driving patterns due to seasonal variations in weather conditions suggesting that it is likely that older adults change their driving patterns based on seasonal variations in weather. Other self-regulation studies have found that older adults report that they are more likely to avoid driving if weather conditions are bad (e.g., Betz & Lowenstein, 2010; Charlton et al., 2006; D'Ambrosio et al., 2008; Hakamies-Blomqvist & Wahlström, 1998; Owsley et al., 1999; Oxley et al., 2010) indicating that it is likely older adults do alter their driving during rain or snowfall, but to what extent has yet to be determined. With driving in today's society highly linked to mobility and quality of life, it is important to understand to what extent older adults alter their driving during adverse weather conditions and therefore to what extent safety improvements need to be made to make driving in inclement weather safer for older adults and by extension the rest of the driving community.

3. Methods

This study utilized data from the Canadian Driving Research Initiative for Vehicular Safety in the Elderly (Candrive II) project. Candrive is a longitudinal study that is looking at the everyday driving patterns and habits of older drivers, as well as trying to determine what tools are available or can be developed to determine which older drivers are at an increased crash risk (Marshall et al., 2013). To do this, participants have been recruited from seven different cities across Canada.

3.1. Participants

The participants for Candrive were recruited from Ottawa, Toronto, Montreal, Hamilton, Thunder Bay, Winnipeg, and Victoria. Participants had to be 70 years of age or older at the time of enrolment, have a valid drivers license, reported driving at least 4 times per week on average during all seasons, and living in their respective city at least 10 months of the year. Participants were excluded if: they were unlikely to remain in the study for the full 5 years, they had any health conditions that would prevent them from either maintaining or having a driver’s license, or if their vehicle was not compatible with the In-Car Recording Device (ICRD). In order for participants to be considered successfully enrolled into the study: participants had to complete the baseline assessment (this assessment will be explained in greater detail in the Data Collection Section) and the ICRD had to be installed in their vehicle (the ICRD will also be explained in more detail in the Data Collection section). This led to 928 participants enrolled into the Candrive study.

For this study, additional inclusion criteria have been added. Participants must have indicated on the Baseline Assessment that they were not considering restricting or quitting driving in the next 6 months. Participants also must not have indicated at any of their follow-up appointments that they drove another vehicle. The main reason for not including participants who drove another vehicle was that we did not have access to their driving patterns in this alternate vehicle and therefore did not have a record of all of their driving over the year. Additionally, participants must have had at least 335 days of data available for analysis. Only a very small proportion of the sample had 365 days worth of driving data available. To make sure an adequate sample was available a cut of 1 month short of a year (335 days) was set. Days of driving could have been lost to simple things such as purchasing a new vehicle, a trip to the mechanic, or a device glitch (e.g., device disconnections), all of these small interruptions add up over the course of a year. So, a cut point of 335 was chosen to allow participants who would of otherwise had 365 days worth of data except for short interruptions to be included. Finally participants were excluded if greater than 10% of trips over the course of the year were missing GPS data. The most likely reason for a trip to be missing GPS data was either the trip was very short and the GPS didn't have a chance to establish a satellite connection, or there was an issue with the GPS receiver, or between the GPS and the device. If the reason for missing GPS data was due to issues with the device or the GPS receiver then this could lead to a systematic loss of GPS data and therefore a systematic loss in trips for analysis. This led to 279 participants matching these criteria (see Figure 1).

A further exclusion criterion was added to facilitate the analysis of weather data, this was to remove participants who did not live within the city limits of their respective site. Participants whose first 3 digits of their postal code indicated that they lived outside of the census 2011 population centre of their respective Candrive site were excluded.

Therefore, 248 participants were available for analysis in this second dataset (see Figure 1). Additionally all trips by these 248 participants that started and ended outside of population centre limits were also removed from this dataset.

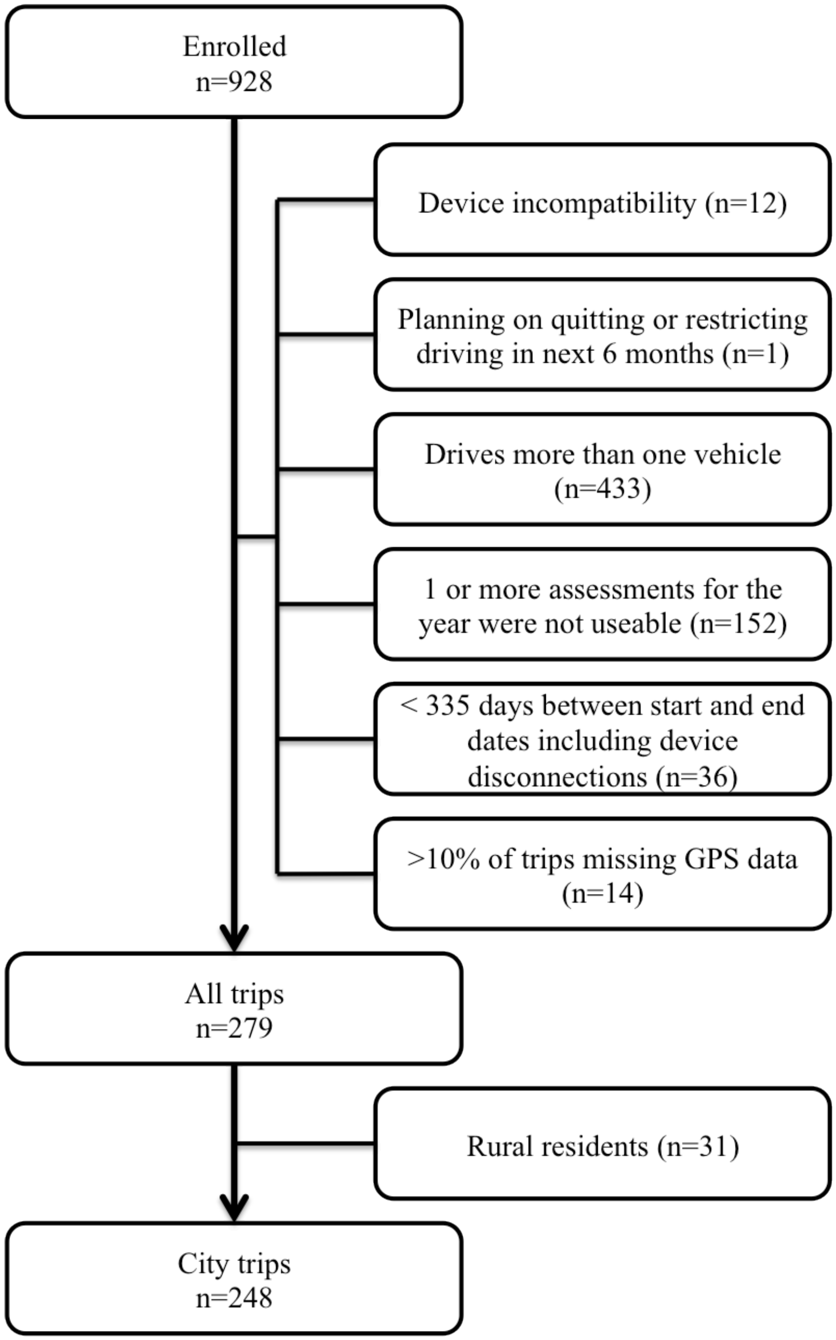

Figure 1. Participant flow chart.

3.2. Data Collection

The following is an overview of the data collection methods for the Candrive study. For more detailed information see Marshall et al. (2013). There were other forms and tests that have been added or used over the course of the study; these will not be covered here. The following will focus on the parts of Candrive that were used for this study. Data collection for Candrive consisted of two main parts: the in-vehicle measurements of driving patterns and the annual assessments.

3.2.1. Annual assessment

An assessment was completed annually and contained a battery of different tests covering health status (past and present), cognitive functioning, vision, hearing, physical strength and flexibility, as well as in-depth questionnaires on psychosocial factors. For this study only the baseline assessment was used. The parts of the baseline assessment used were the: demographic information, driving and vehicle factors, and health status (for the specific questions see Table 5), as well as two different physical mobility-related tests. One is the Rapid Pace Walk test (RPW) where the participant walks as quickly as possible over a distance of 10 feet, turns around and then walk backs to the start point (American Medical Association (AMA), 2010; Marottoli, Cooney Jr, Wagner, Doucette, & Tinetti, 1994). The other is the Timed Up and Go test (TUG) in which the participant starts seated in a chair with his or her back flush to the back of the seat, gets up from the chair, walks 10 feet, turns around, and walks back to the chair and sits down (Podsiadlo & Richardson, 1991). Both of these tests can provide proxy measures for: lower limb strength, endurance, range of motion, and balance (AMA, 2010; Podsiadlo & Richardson, 1991). The Expanded Cumulative Illness Rating Scale (CIRS) used in the Candrive annual assessment is a self-reported list of medical conditions that were ranked from no problem to an extremely severe problem, with a numerical value associated with each ranking. The CIRS used by Candrive was adapted from Hudon, Fortin, & Soubhi (2007). The score was a sum of the rankings for the 44 different conditions. Appendix B contains a breakdown of the CIRS conditions and explanation of the rankings.

Table 5. Variables from the baseline assessment.

Section/Variable	Explanation
Demographics	
Age	Age of participant at date of baseline assessment
Gender	Male Female
Marriage	Current marital status: • Never married • Married • Common-law • Separated/Divorced • Widowed
Living	Current living arrangements: • House • Condo • Apartment • Retirement residence • Other
Education	Highest level of education completed: • Post-graduate • Degree • Diploma • Trade/Technical Certificate • High School • Grade School
Employment	Are you currently employed? • No • Part-time • Full-time
Volunteer	Are you currently involved in volunteering? • No • Part-time • Full-time

Section/Variable	Explanation
Demographics (continued)	
Availability	How available are family members/friends to drive you if needed? • Never • Sometime • Most of the time • All of the time
Health Status	
Medications	Count of the prescribed, non-prescribed, and over the counter medications
CIRS	Sum of the ranking of all the various medical conditions listed in the CIRS
Mobility	Do you use a cane? Do you use a walker? Do you use a wheelchair? Do you use a motorized scooter or wheelchair?
RPW	Rapid pace walk time to complete
TUG	Timed get up and go time to complete
Health	In general, would you say your health is: • Excellent • Very good • Good • Fair • Poor
Health compared	Compared to one year ago, how would you rate your health in general now? • Much better now than one year ago • Somewhat better now than one year ago • About the same as one year ago • Somewhat worse now than one year ago • Much worse now than one year ago

3.2.2. In-car recording device

The ICRD was the OttoView-CD data acquisition system (see Figure 2), which was developed by a Winnipeg based company Persen Technologies Inc. (PERSENTECH) and was installed into the vehicles of all participants at the time of enrolment. The ICRD consists of 6 parts: the GPS antenna, OttoView-CD device, a 2 GByte SD card, an OBDII cable, a radio frequency identification (RFID) antenna, and the keyfob (FOB). Only participants who reported having another driver use their vehicle had the RFID and FOB installed into their vehicles, otherwise all other parts were installed for all participants. The GPS antenna receives positional, speed, and Greenwich Mean Time (GMT) time and date information. The OBDII cable was connected to the vehicle's on-board computer port and allows the OttoView-CD device to collect and store information on driving time, vehicle speed, distance, and other vehicle engine data, this information was collected once per second. The RFID transmits at 125 kHz to scan and record the FOB with a 64-bit identifying code allowing for identification of the participant's trips when there was more than one driver reported. All of the data from the GPS antenna, RFID, and vehicle computer were collected by the OttoView-CD device and then stored onto the SD card. For more information on the ICRD and installation procedures please see Persen Technologies Inc. (2010).

Figure 2. Individual components of the In-Car Recording Device (ICRD); figure from PERSENTECH (2010) page 2, used with permission.

To retrieve the data, the SD card was inserted into a computer and using the Candrive-DTS utility all of the information from the GPS, vehicle's computer, and RFID can be combined with mapping information from the PERSENTECH website to create a summary file, second by second raw file, and Google Earth files. The summary file contains summary information about each trip that was taken. A trip was defined as occurring from when the ignition was turned on to when the ignition was turned off. There is also a raw file that contains all of the data that were collected for each trip and lays it out second by second. Finally the Google Earth file provides a visual representation of where the vehicle went, and a speed range at which the vehicle was travelling. These files can then be used to analyze the driving patterns of the older drivers.

3.2.3. Follow-up form

The follow-up form was completed every time a card exchange occurred, i.e., every time the SD card was changed from the device and the data uploaded. The follow-up form provides information on the driving data. This information consists of: indicating if driving cessation had occurred, vacations or stoppages in driving for any reason, distance and frequency of driving an alternate vehicle, if and frequency of an alternate driver, and finally if the vehicle had been serviced since the last card exchange. This information was used to check the OTL files when they were received. Participants were also provided with a driving log to record the trip(s) by alternate driver(s) over the time between assessments.

3.2.4. Weather data

Weather data came from Environment Canada's hourly historical weather records for each of the seven different city's from their respective airport weather stations. Airport weather stations were used because they consistently collect information on weather conditions (e.g., mainly clear, drizzle, etc.). In addition to weather conditions the hourly weather data provides information on: temperature, dew point temperature, relative humidity, wind direction, wind speed, visibility, station pressure, humidex, windchill, and weather conditions; and was usually collected once an hour on the hour mark, but may occasionally be collected more frequently and not on the hour mark exactly. In addition, an average of thirty years (1971-2000) of weather data were used to determine what could be considered normal or extreme temperatures for each city. This was in accordance with what Environment Canada does to determine their climatic norms (Environment Canada, 2013a).

3.3. Data Checking

All OTL files were sent to Winnipeg for storage and to determine data quality and future usability. To determine usability the OTL files were expanded using the Candrive-DTS utility to create the summary file, which was then compared to the Follow-up form for the corresponding participant and assessment. This information was tracked in an Access database.

3.3.1. Data usability

The data from the OTL file was determined to be useable if what was reported on the follow-up form matched the summary file, and the FOB if present looked to be working. This included stoppages in driving, the reported frequency of alternate drivers, the start and end dates (provided from the ICRD form which was used specifically to track when a card was installed and removed from the ICRD), and finally if there were no major problems with the file and all file types exported correctly. The primary issues that were present in the OTL files were:

1) device disconnections that were longer than a day and did not appear to be associated with a trip to the mechanic or it was not reported on the follow-up form that the device may have been tampered with;
2) the FOB was not detected even though it was reported that the participant was using a FOB;
3) the FOB was not recorded frequently enough (i.e., the reported frequency of the alternate driver did not match what was seen in the file);
4) trips by an alternate driver were not recorded in the driving log (i.e., the participant reported an alternate driver driving the vehicle, but there was no record as to when the alternate driver drove);
5) GPS data was missing and not due to stoppages in driving or device disconnections, likely due to the cable disconnecting;
6) significant data was missing from the file that was not explained on the follow-up form;
7) or there were unconfirmed stoppages in driving for more than a week.

All of these issues if present and unexplained on the Follow-up form or present in the file may have led to the file being marked as unusable. More detailed information is available in Table 6.

Table 6. File usability for participant.

Not Useable	Useable
Data	
Frequency of alternate driver not reported or unknown or unusual	Data missing due to device disconnections
	Missing GPS data
	Significant data missing, but what's present is useable
	*FOB stops working part way through file (marked as SOME)
	Dates flipping (exception is if dates that are incorrect are outside of the period then file is NOT useable)
Driving log	
Alternate driver >4x/week with driving log	Alternate driver <1x/month
Frequency of alternate driver <1x/week or 1-3x/week and FOB not working or no driving log present	Alternate driver with driving log <1x/week or 1-3x/week
FOB	
FOB doesn't appear to be working (visual confirmation)	FOB looks to be working (visual confirmation)

Note: *FOB is short for keyfob and used to identify trips taken by the participant if there is potential for more than one driver of the vehicle instead of using a driving log.

3.4. Filtering

Filtering was done through the Candrive-DTS utility and the Access database. A general explanation of filtering is provided here. All trips that were reported to be by the alternate driver(s) and were recorded on either the follow-up form or the driving log were entered into Access as well as the participant number and if the participant used a FOB or not. Files were then filtered based on the filter file from Access and using a minimum distance of 0.1 km and minimum time of 5 seconds. The minimum distance of 0.1 km was chosen to eliminate the 0 distance trips, to reduce the noise in the Google Earth files, and because it was impossible to be certain who drove some of these very short trips (e.g., moving vehicle in driveway).

3.5. Data Analyses

3.5.1. Winter

Winter in Canada is challenging to define. Typically, there are two widely accepted definitions of winter usually used, the meteorological and astronomical. The meteorological definition of winter is the three months consisting of: December, January and February. The astronomical definition has winter starting on the winter solstice and ending on the spring equinox (MetOffice, 2013). Both of these definitions only cover approximately 3 months of the year, which in Canada does not cover what most people would consider the "winter" season. Typically winter is thought to begin and end with snow or begin and end with cold temperatures. Both of these are relatively subjective when it comes to locations within Canada so, six definitions of winter (defined below in table 7) have been defined ranging from date of first and last snowfall, first and last date of temperatures below a certain threshold, and a combination of winter precipitation and temperatures below 0. These combinations were used to try and capture the entirety of the conditions that may cause older drivers to adjust their trip distance across all of the Candrive sites.

All trips for all participants were classified as winter or non-winter based on each of the definitions provided in Table 7. During analysis it was determined which of these definitions demonstrated a significant change in trip distance for both the All Trips and the City Only Trips datasets.

Table 7. Winter definitions.

Winter definitions	
Winter1	Start date – date of first snowfall. End date – date of last snowfall.
Winter2	Start date – date of first winter precipitation followed by 4 consecutive days of highs below 0°C. End date – fist date of last 4 consecutive days of highs below 0°C.
Winter3	Start date – first date of winter precipitation followed by 4 consecutive days of lows below 0°C. End date – fist date of last 4 consecutive days of lows below 0°C.
Winter4	Start date – first date of first 4 consecutive days of lows below 0°C. End date – first date of last 4 consecutive days of lows below 0°C.
Winter5	Start date – first day of temperatures less than or equal to halfway between the min and max lows. End date – last day of temperatures less than or equal to halfway between the min and max lows.
Winter6	Start date – first day of temperatures less than or equal to halfway between the min and max highs. End date – last day of temperatures less than or equal to halfway between the min and max highs.

3.5.2. Night

Trips from both datasets were further categorized as occurring at night or during the day. Night driving trips were defined as trips where at least a portion of the trip occurred after sunset or before sunrise (Myers et al., 2011). Sunrise and sunset were calculated using the date and the GPS coordinates from the beginning and end of the trip using the method described by Teets (2003). Essentially what this means is that each trip can be broken down into one record per second for the duration of the trip. The date and GPS coordinates for the first GPS point was used to calculate sunrise time for that particular trip and the last GPS point was used to calculate sunset time for the same trip. If the trip's start time was after the calculated sunrise time and the trip's end time was before the calculated sunset time then the trip was considered to occur during the day. If any part of the trip occurred before the calculated sunrise time or after the calculated sunset time then the trip was considered to occur at night.

3.5.3. City

City trips were defined as trips where the start and end of the trip occurred within the census 2011 population centre for the respective city or within 10km of the airport. Trips occurring around the airport were included for two reasons: 1) weather data were collected from the weather stations at each city's respective airport, and 2) because the airport in every city except Winnipeg is located outside of the population centre.

A similar method as described above for determining if a trip occurred at night was used to determine if a trip occurred within the city or not. Trips where the first and last GPS points occurred within the defined city limits were considered as occurring within the city and kept in the dataset of City Only Trips all other trips were excluded. The reason this definition was used as opposed to the entire trip occurring within city limits was to maximize the number of trips in this dataset, but also to allow for a greater variation in trip distance to determine if weather conditions were associated with trip distance.

3.5.4. Weather

The mean and standard deviation for temperature over a 30 year period was calculated to determine what the "normal" and extreme temperatures for the respective city by month would be. The Environment Canada hourly weather data from 1971-2000 were used to calculate the mean and standard deviation for each month for each city. With extreme temperatures defined as temperatures greater than or equal to two standard deviations from the average for the respective month. Appendix E provides the mean and standard deviation for each month for each city.

The yearly summary file for each participant included in the City Only driving dataset, was merged with the corresponding hourly weather data from Environment Canada. Trips with a start and end time that cross a weather data time point had the weather data for each time point averaged to determine the weather data for that trip. For example, if a trip's start time was 11:50am and ends at 12:10pm and weather was collected at 11:00am and 12:00pm then the hourly weather information for 11:00 and 12:00 were averaged to provide the weather information for that trip. Weather conditions were combined if they were different between the hours, e.g., if the weather condition at 11:00am was mostly cloudy and the weather condition at 12:00pm was snow then the trip would have the weather conditions of mostly cloudy and snow. Appendix F contains the definitions provided by Environment Canada on what each of the weather conditions are, and Table 8 provides the definitions for inclement weather and a breakdown of what weather conditions were defined as what precipitation type. Trips were then marked as occurring in either non-inclement/inclement and precipitation type based on the definitions in Table 8.

Table 8. Inclement weather and precipitation type definitions.

Precipitation definitions	
No Precipitation	Clear, cloudy, mainly clear, and mostly cloudy
Snow	Freezing drizzle, freezing rain, ice crystals, ice pellet showers, ice pellets, snow, snow grains, snow pellets, and snow showers
Rain	Drizzle, rain, rain showers, and thunderstorms
Vision Obstructing	Blowing snow, freezing fog, fog, haze, smoke
Inclement weather definitions	
Inclement1	Weather condition indicating snow or rain or a windchill value of less than or equal to -28, or a humidex value of greater than or equal to 30.
Inclement2	Inclement1 with the addition of weather conditions indicating vision obstructing precipitation
Inclement3	Inclement2 with the addition of extreme temperatures (greater than or less than 2 standard deviations from the standardized temperature, where temperature was standardized to the monthly norms for the corresponding site).

3.6. Statistical Analyses

Frequencies by site and total sample were used to characterize differences between sites and datasets at the participant level. Continuous descriptives of mean, standard deviation, median, minimum, and maximum were used to characterize differences between sites and datasets at the participant level and at the trip level.

In order to determine to what extent winter, inclement weather conditions, and night-time driving explain the variation in trip distance expressed by older adults over the course of a year, a multi-level random intercept regression was performed. For this study the outcome of interest was trip distance, which was nested within participants so in order to properly discern if trip level characteristics (i.e., weather or season) have an effect on trip distance a multi-level regression was utilised. If the main predictors of interest were only at the participant level (e.g., age, and marital status) then it would have been appropriate to aggregate the data to an average trip distance per participant and then run a multiple regression (Snijders & Bosker, 2012). The random intercept portion of the model simply allows for the resulting regression equation intercept to vary from participant to participant. SAS 9.3M0 was used for all analyses.

3.6.1. Model building

The same model building steps were used for both the dataset containing All Trips taken by the participants (n=279 participants or 377,464 trips), and the City Only Trips (n=248 participants, or 298,342 trips), and were based on the steps presented in Bell, Ene, Smiley & Schoeneberger (2013).

Step 1) The unconditional model – which is essentially running a multilevel regression with no predictors in the model just the random intercept was used to calculate the intraclass correlation coefficient (ICC) (equation 1), which is an estimation of how much between group (level 2), or between participant differences explain the variation seen in trip distance (Bell et al., 2013). The ICC in conjunction with the Wald statistic, which was used to determine if the variance coefficients were significant (Cohen & Doveh, 2005), was used to determine if multilevel regression was the appropriate test to run or if trips (level 1) could be treated as independent observations and a regular multiple regression could have been used.

Equation 1. Intraclass correlation coefficient (ICC) equation.

$$ICC = \frac{\tau_0^2}{(\sigma_0^2+\tau_0^2)}$$

Where: τ_0^2 – level 2 (participant) variance coefficient
σ_0^2 – level 1 (trip) variance coefficient
ICC – intraclass correlation coefficient

Step 2) Has two parts:

a) Fixed effect regression – or the sensitivity analysis to determine which winter and inclement weather (City Only Trips) definition would be used for the rest of the model building process. A fixed effect regression or a regular multiple regression was run with each of the different definitions of winter and inclement weather (City Only Trips) controlling for night and site without including participant in the model. The purpose of this step was to determine: if each trip was considered an independent observation to what extent does winter, weather, night, and site explain the variation in trip distance. The model with the greatest R^2 value was selected as the best model.

b) The unconditional model plus the results of the fixed effect regression – or the unconditional model plus the trip level fixed effects.

Step 3) Also has 2 parts:

a) The unconditional model plus the addition of only participant level variables into the model (e.g., age, martial status, etc.). The purpose of this step was to determine which participant level variables independent of the trip level variables explains trip distance. The model with the lowest AIC value was considered the best model.

b) The model from step 2b combined with the final model from step 3a. In essence the unconditional model plus the trip level variables, and participant level variables.

Step 4) The final model – the final combination of trip and participant level variables when controlling for site and night that best explains the variation in trip distance.

Step 2a and 3a both require the addition of variables to determine the final best-fit model. In order to do this a forward stepwise approach to model building was used. What this means is that a univariate analysis was run on all potential variables to be added. Those variables with a p-value of less than 0.30 were then added one at a time to the model, variables with resulting statistically insignificant p-values were removed from the model (i.e., p-values greater than 0.05). For example in step 3a, *age* may be the variable with the lowest p-value at 0.02, *marital status* may be the next lowest at 0.025, and finally *gender* had a p-value of 0.05. A model would be run with both *age* and *marital status* included, if both had a p-value of less than 0.05 then both would remain in the model and then *gender* would be added, but if age had a resulting p-value greater than 0.05 then *age* would be removed and the next model would contain *marital status* and *gender*. This process was repeated until a final model resulted with all variables having a p-value under 0.05.

For step 2a a similar process was taken except that when model building only one definition of winter and inclement weather (for City Only Trips) could be used in each model, and despite their p-value, *site* and *night* remained in the model. *Site* and *night* were potential confounding variables in that *site* is an additional nesting variable, i.e., participants were nested within sites, but there were not enough sites to treat it as another level in the model so it has to be controlled for during analysis. As well, with the testing sites ranging from Victoria to Montreal it was expected that there would be some difference in trip distance that could be explained solely by the fact that one trip occurred in Winnipeg versus in Toronto. Based on the literature, trip distance was expected to vary according to whether the trip occurred during the day or night and that needed to be accounted for.

In order to determine the overall final model or the model from step 4, the change in deviance or the Likelihood Ratio Test was used to compare the models. The Likelihood Ratio Test is a comparison of the change in deviance to a chi-squared distribution at the resulting change in degrees of freedom between the two models at a predetermined alpha (Peugh, 2010). In the case of this study alpha was set to 0.05.

Equation 2. Likelihood Ratio Test equations

$$\Delta \text{ Deviance} = \text{Deviance}_{\text{Full}} - \text{Deviance}_{\text{Reduced}}$$
$$\Delta \text{ df} = \text{df}_{\text{Full}} - \text{df}_{\text{Reduced}}$$

Where: Deviance – -2 Log Likelihood
df – degrees of freedom
Full – model with the most variables
Reduced – model with the least variables

4. Results

4.1. Participants

4.1.1. All trips

Of the 279 participants available for analysis 25% were from Ottawa (site 1), 14% from Toronto (site 2), 10% from Montreal (site 3), 14% from Hamilton (site 4), 10% from Thunder Bay (site 5), 11% from Winnipeg (site 6), and 15% from Victoria (site 8). Almost half of the participants (49%) were female, and the average age at the time of enrolment was 77.5 ± 5.2 years. Fifty-four percent of all participants reported still living in a house, while 56% reported being single due to either divorce, separation, being widowed or were never married. Thirty-nine percent had achieved some level of university education, and 53% reported volunteering full- or part-time. While 34% of all participants reported never or only sometimes having friends or family available to drive them, 20% of those were also single.

In terms of health, 23% reported their health status as excellent, and 53% reported it as very good. The average number of medications reported being taken was 4.7 ± 2.9 and the average CIRS score was 10.9 ± 5.0. The average times to complete the Rapid Pace Walk and Timed Up and Go tests were 6.8 ± 1.7 seconds and 10.4 ± 2.4 seconds respectively. For a breakdown of participant descriptives by site please see Tables 9 and 10. Appendix G provides a breakdown of participant level descriptives for the participants included in the City Only dataset, but the descriptives were essentially the same.

Table 9. Categorical participant level descriptives (%) by site (All Trips).

	Site							Total
	1	2	3	4	5	6	8	
N*	72	38	29	39	28	30	43	279
Gender								
Male	56	39	48	59	32	60	53	51
Female	44	61	52	41	68	40	47	49
Marital status								
Married/Common-law	56	32	38	51	25	47	47	44
Widowed/Separated/Divorced/Never married	44	68	62	49	75	53	53	56
Living arrangements								
Apartment/Condo/Retirement residence	38	63	45	38	43	47	51	46
House	63	37	55	62	57	53	49	54
Education								
Post-graduate degree	10	18	24	18	11	13	21	16
Degree	31	39	24	13	21	7	19	23
Diploma/Trade/Technical certificate	28	13	10	23	7	20	21	19
High/Grade School	32	29	41	46	61	60	40	42
Volunteer								
Don't volunteer	49	39	55	56	32	47	47	47
Volunteer	51	61	45	44	68	53	53	53
Family								
Never/Sometimes	33	53	45	31	25	30	21	34
Most of the time	43	18	24	33	43	37	40	35
All of the time	24	29	31	36	32	33	40	31
Health								
Excellent	22	18	31	33	25	3	28	23
Very good	61	63	48	46	50	50	44	53
Good/Fair/Poor	17	18	21	21	25	47	28	24

Note: *All values are percentages of site total except for N which is the number of participants (site 1 = Ottawa, site 2 = Toronto, site 3 = Montreal, site 4 = Hamilton, site 5 = Thunder Bay, site 6 = Winnipeg, site 8 = Victoria).

Table 10. Continuous participant level descriptives by site (All Trips)

	Site							Total
	1	2	3	4	5	6	8	
N*	72	38	29	39	28	30	43	279
Age (years)	78.8 (5.2)	76.5 (5.0)	76.4 (5.2)	77.8 (5.1)	77.6 (5.3)	77.1 (5.1)	77.1 (5.4)	77.5 (5.2)
# of Meds	3.9 (2.8)	5.0 (2.6)	4.4 (3.2)	5.8 (3.1)	5.6 (2.8)	4.5 (2.4)	4.6 (2.8)	4.7 (2.9)
CIRS	10.3 (4.9)	11.0 (4.5)	8.9 (5.5)	12.3 (5.3)	10.4 (4.5)	13.4 (5.3)	10.6 (4.7)	10.9 (5.0)
RPW (s)	7.4 (1.3)	6.5 (1.5)	5.8 (1.2)	7.6 (2.4)	7.2 (1.6)	6.0 (1.4)	6.1 (1.4)	6.8 (1.7)
TUG (s)	10.8 (1.9)	10.1 (2.4)	9.8 (2.2)	9.6 (3.5)	10.5 (1.6)	10.6 (2.8)	10.9 (2.0)	10.4 (2.4)

Note: *All values are average (standard deviation) except for N which is the number of participants (site 1 = Ottawa, site 2 = Toronto, site 3 = Montreal, site 4 = Hamilton, site 5 = Thunder Bay, site 6 = Winnipeg, site 8 = Victoria).

4.2. Winter

The dates encompassed for data collection ranged from June 29, 2009 to Nov 18, 2011 or 872 days. Table 11 provides the start and end date of data collection and the number of days for each site.

Table 11. Date range and number of days with trips by site.

Site	Start	End	Days
All	29Jun09	18Nov11	872
Ottawa	29Jun09	18May11	688
Toronto	07Aug09	18Nov11	833
Montreal	14Sep09	14Jul11	668
Hamilton	03Sep09	20Jul11	685
Thunder Bay	16Jul09	27Jun11	711
Winnipeg	04Sep09	01Sep11	727
Victoria	27Aug09	13Jun11	655

The percentage of days that were defined as winter ranged from 26-58 for Ottawa, 20-58 for Toronto, 21-62 Montreal, 25-64 Hamilton, 28-57 Thunder Bay, 30-55 Winnipeg, and 0-69 for Victoria. Appendix H provides a breakdown of the date range for each definition of winter as well as the percentage of days defined as winter.

4.3. Trip Descriptive Characteristics

4.3.1. All trips

There were 377,464 trips occurring on 866 days with an average trip distance of 7.9 ± 4.0 km ranging from 0.1 – 628.5 km with a median distance of 3.5 km. Table 12 provides a breakdown of the number of trips, mean and standard deviation, as well as the minimum, median and maximum trip distance in km.

Table 12. Number of trips and trip distance descriptives, by site (All Trips).

Site	n*	N*	Mean	Std.	Median	Min	Max
All	279	377464	7.9	4.0	3.5	0.1	628.5
1	72	100066	8.2	3.8	3.5	0.1	441.4
2	38	46970	8.6	3.6	3.3	0.1	475.6
3	29	38888	9.8	5.3	3.1	0.1	551.7
4	39	52047	8.9	4.7	3.7	0.1	558.2
5	28	43428	6.2	2.4	3.5	0.1	385.2
6	30	38110	7.5	4.4	4.1	0.1	628.5
8	43	57955	5.9	1.8	3.4	0.1	398.2

Note: *All values are in kilometers, except for N which is the number of trips and n which is the number of participants (site 1 = Ottawa, site 2 = Toronto, site 3 = Montreal, site 4 = Hamilton, site 5 = Thunder Bay, site 6 = Winnipeg, site 8 = Victoria).

4.3.2. City trips

There were 298,342 trips occurring on 866 days with an average trip distance of 5.1 ± 1.6 km ranging from 0.1 – 206.6 km with a median distance of 3.2 km. Table 13 provides a breakdown of the number of trips, mean and standard deviation, as well as the minimum, median and maximum trip distance in km.

Table 13. Number of trips and trip distance descriptives (City Trips).

Site	n*	N*	Mean	Std.	Median	Min	Max
All	248	298342	5.1	1.6	3.2	0.1	206.6
1	59	67989	4.9	1.5	3.1	0.1	90.3
2	38	42715	6.0	2.0	3.3	0.1	206.6
3	23	27128	5.7	2.3	2.8	0.1	75.9
4	35	38534	5.1	1.3	3.1	0.1	156.2
5	25	36996	4.1	1.0	3.3	0.1	84.8
6	26	31480	5.2	1.3	3.8	0.1	167.4
8	42	53500	4.9	1.3	3.3	0.1	74.3

Note: *All values are in kilometers, expect for N which is the number of trips and n which is the number of participants (site 1 = Ottawa, site 2 = Toronto, site 3 = Montreal, site 4 = Hamilton, site 5 = Thunder Bay, site 6 = Winnipeg, site 8 = Victoria).

4.4. Winter vs. Non-winter

4.4.1. All trips

Figure 3 provides a graphical representation of average trip distance for each participant by winter or non-winter for each of the six definitions of winter. There was a trend towards non-winter trips having a greater trip distance than winter.

4.4.2. City trips

Figure 4 provides a graphical representation of average trip distance for each participant by winter or non-winter for each of the six definitions of winter. Again there was a bit of a trend for non-winter trips having a greater trip distance than winter trips, but it was less distinct than what was seen in the All Trips dataset.

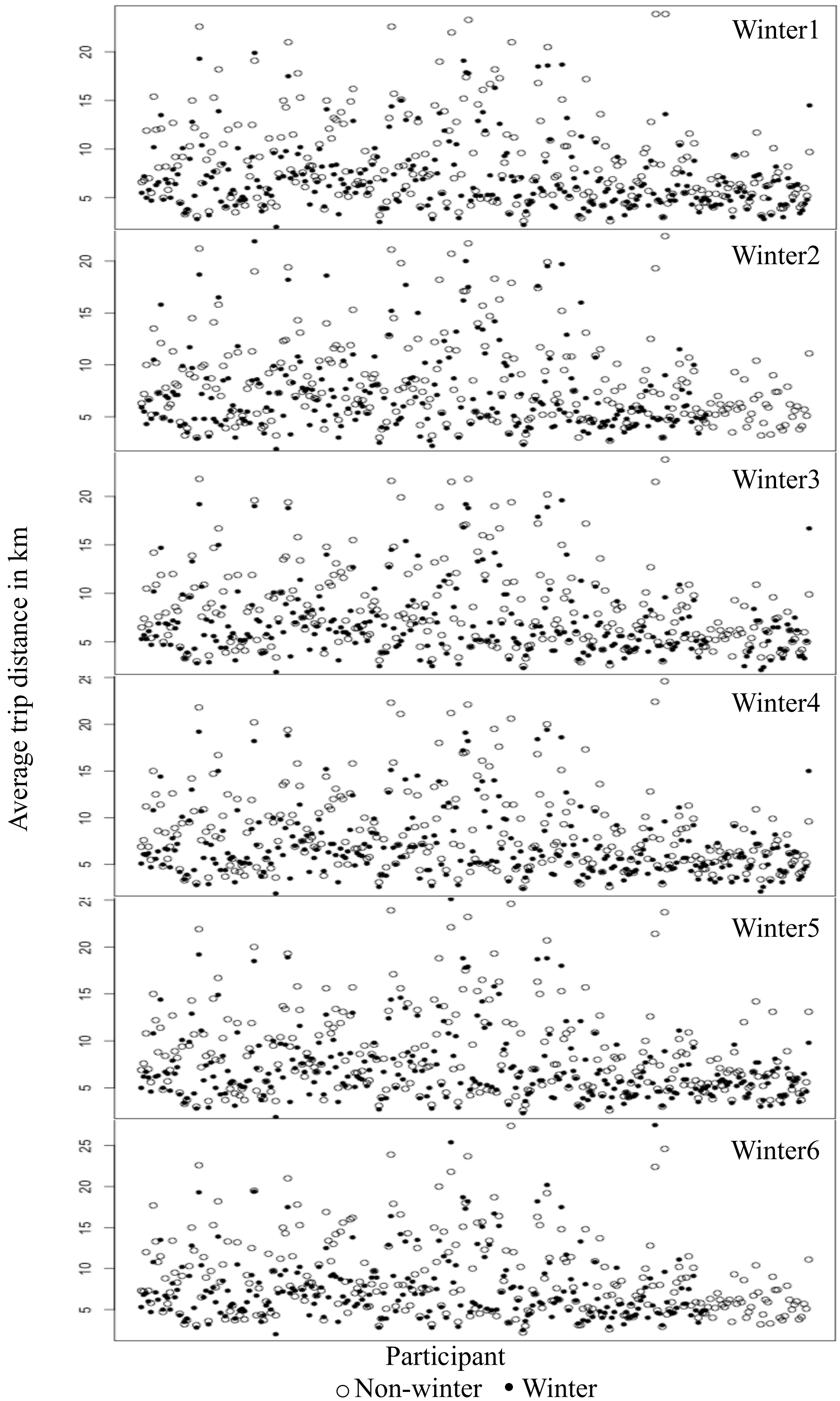

Figure 3. Average trip distance per participant in winter and non-winter for each definition of winter (All Trips).

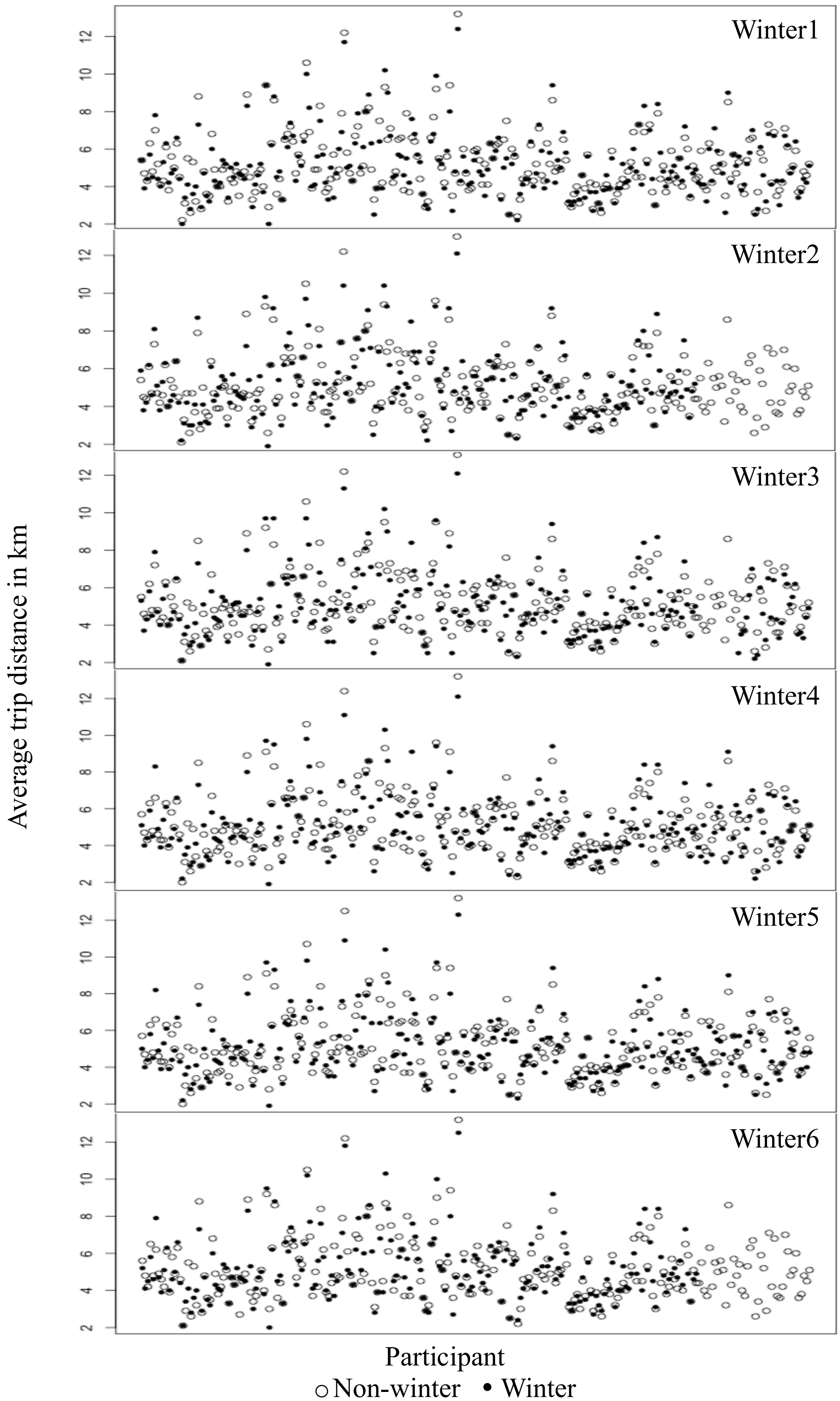

Figure 4. Average trip distance per participant in winter and non-winter for each definition of winter (City Trips).

4.5. Day vs. Night

4.5.1. All trips

Figure 5 provides a graphical representation of average trip distance for each participant by day or night. It seems to show that there was a trend for average trip distance at night to be longer.

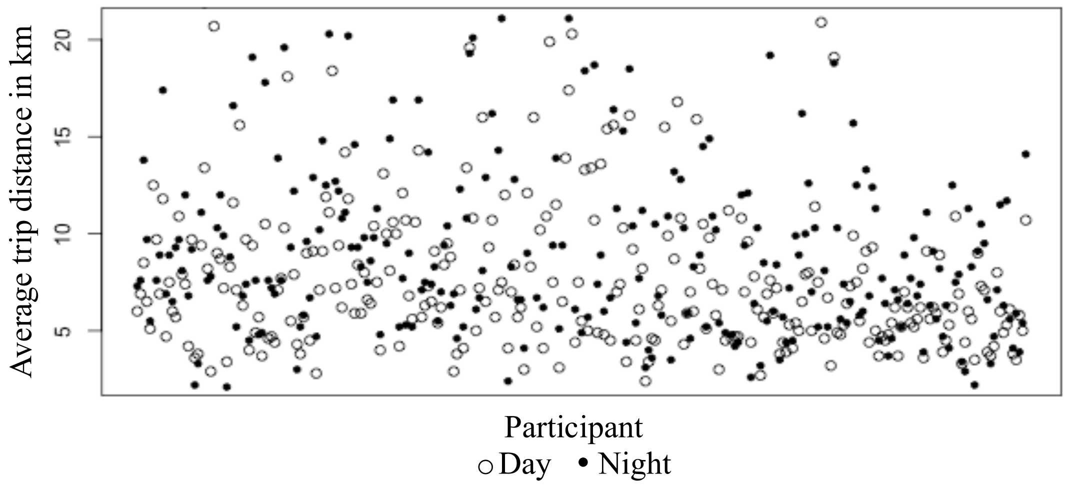

Figure 5. Average trips distance per participant in day vs. night (All Trips).

4.5.2. City trips

Figure 6 provides a graphical representation of average trip distance for each participant by day or night. It seems to demonstrate a more obvious trend for trips at night to be longer than trips during the day then what was seen in the All Trips dataset.

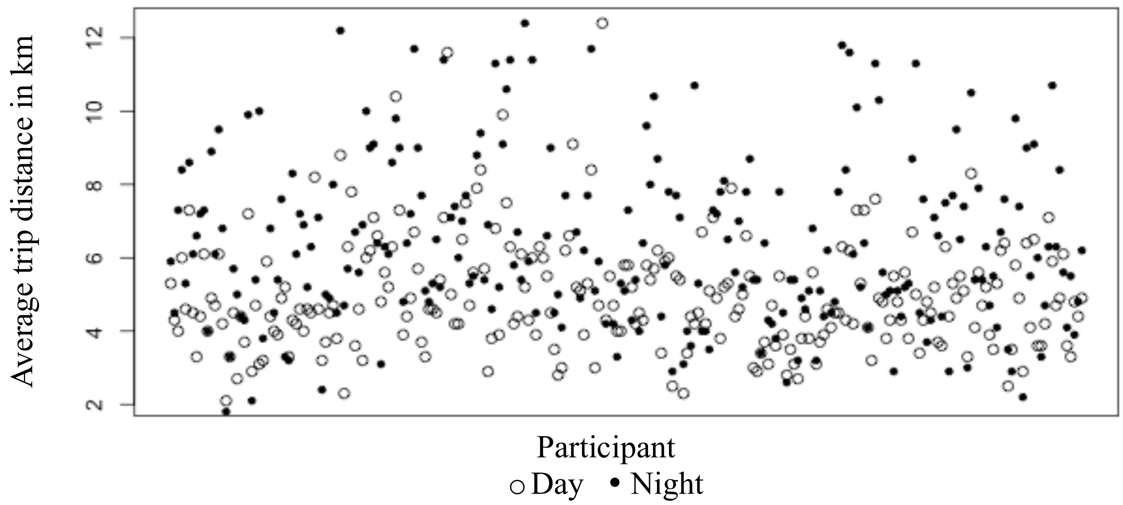

Figure 6. Average trip distance per participant during day vs. night (City Trips).

4.6. Inclement vs. Non-inclement Weather

4.6.1. City trips

A total of 107,674 hours' worth of weather data was collected, 23.8% met the criteria for inclement weather definition one, 26.9% met the criteria for definition two, and 30.6% met the criteria for definition three. Or 78.7% had no mention of precipitation, 8.3% recorded some form of winter or frozen precipitation (e.g., freezing drizzle or snow), 9.8% indicated some form of rain, and finally 3.2% indicated vision obstructing precipitation (e.g., blowing snow or fog). Table 14 breaks down the percent of hours classified as inclement/non-inclement and the specific precipitation type. Appendix I breaks down the percent of hours classified by each specific precipitation type (e.g., clear, snow, thunderstorms, etc.)

Table 14. Percent of hours classified as inclement weather and precipitation types.

	Site							Total
	1	2	3	4	5	6	8	
Inclement1								
Non-inclement	76.4	78.3	74.5	73.0	78.2	73.2	79.6	76.2
Inclement	23.6	21.7	25.5	27.0	21.8	26.8	20.4	23.8
Inclement2								
Non-inclement	73.2	76.0	72.4	68.0	75.7	69.6	76.8	73.1
Inclement	26.8	24.0	27.6	32.0	24.3	30.4	23.2	26.9
Inclement3								
Non-inclement	70.0	72.7	69.5	63.9	71.2	65.9	72.3	69.4
Inclement	30.0	27.3	30.5	36.1	28.8	34.1	27.7	30.6
Precipitation								
No precipitation	78.9	83.0	77.1	72.7	81.5	79.9	77.2	78.7
Snow	8.5	6.4	10.7	12.1	9.0	10.7	0.8	8.3
Rain	9.1	8.2	10.0	9.8	7.0	5.5	19.2	9.8
Vision Obstructing	3.5	2.4	2.2	5.4	2.5	3.9	2.8	3.2

Note: All hours are in percent of total hours with weather data for each respective site (site 1 = Ottawa, site 2 = Toronto, site 3 = Montreal, site 4 = Hamilton, site 5 = Thunder Bay, site 6 = Winnipeg, site 8 = Victoria).

Figure 7 provides a graphical representation of average trip distance for each participant by inclement or non-inclement weather for each of the three definitions of inclement weather. From the scatter plots alone it was hard to determine if there was a difference between average trip distance for inclement versus non-inclement weather. The same can be said for the average trip distance based on precipitation type, except there may be a trend towards increased average trip distance during vision obstructing precipitation. Figure 8 shows the average trip distance for each participant for each of the four different precipitation types.

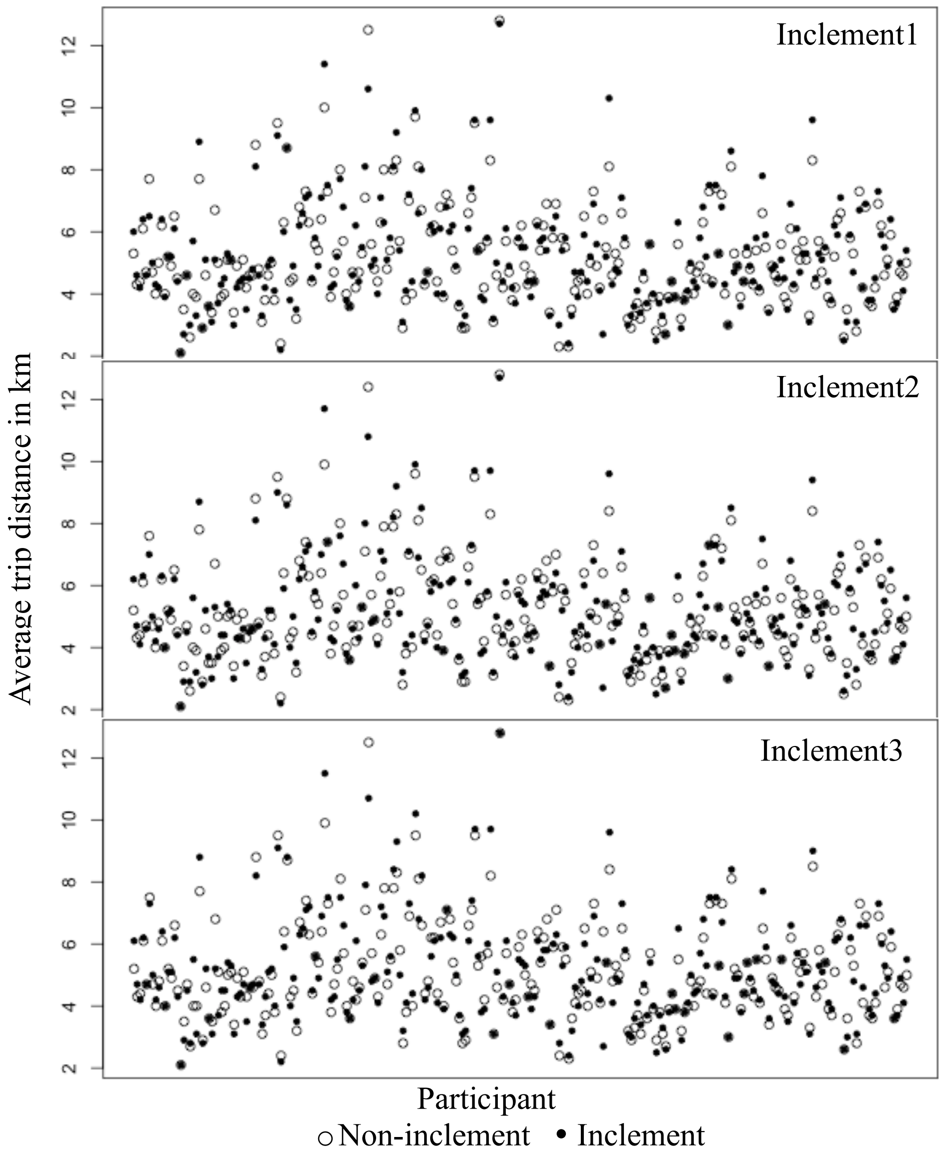

Figure 7. Average trip distance per participant in inclement vs. non-inclement weather for each definition of inclement weather (City Trips).

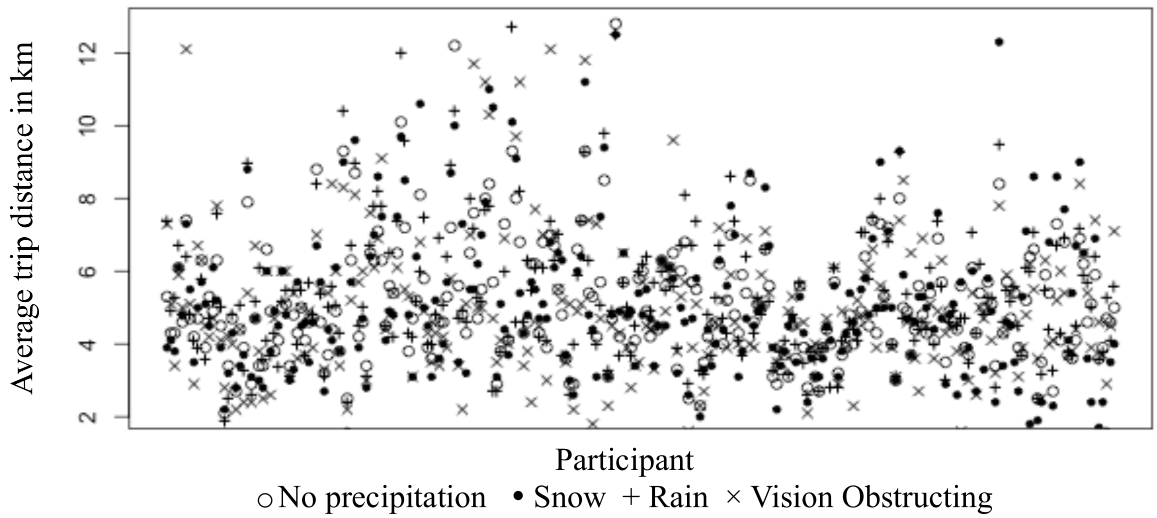

Figure 8. Average trip distance per participant in no precipitation, snow, rain, and vision obstructing precipitation (City Trips).

4.7. Multi-level Regression

4.7.1. Normality

Trip distance was the outcome or dependent variable for this analysis. As can be seen in Figure 9 trip distance had to be natural log transformed in order for trip distance to be normally distributed.

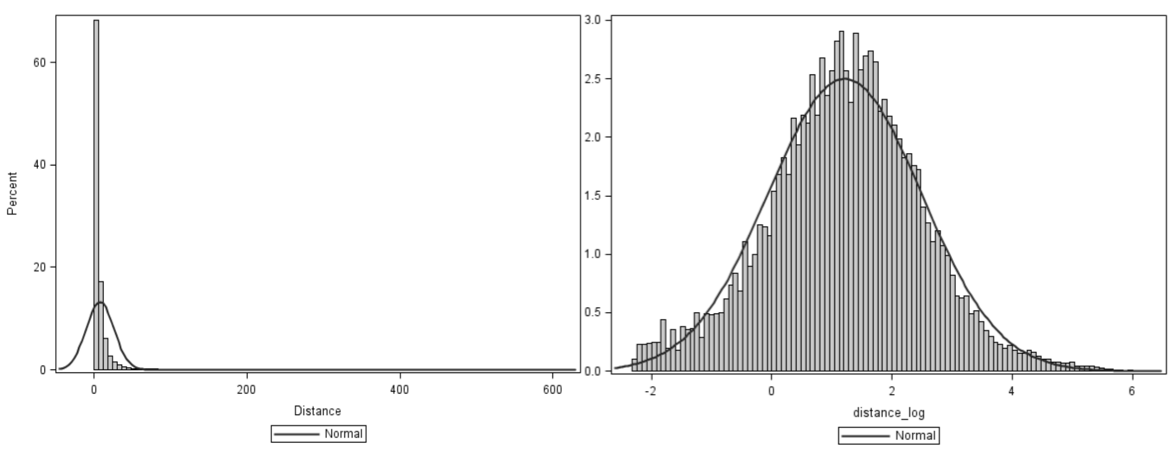

Figure 9. Histogram of trip distance and log transformed trip distance. Where the figure on the left is trip distance and the figure on the right is the natural log of trip distance.

4.7.2. All trips

4.7.2.1. *Sensitivity analysis*

Table 15 provides the results of the sensitivity analysis (step 2a). Model 4 or the model using the 4th winter definition was determined to have the highest R^2 value.

Table 15. Results of the sensitivity analysis (All Trips).

	1	2	3	4	5	6
R^2	0.009854	0.009044	0.009769	0.009987	0.009986	0.009548
Intercept	1.59***	1.57***	1.58***	1.59***	1.59***	1.61***
Winter1	-0.07***					
Winter2		-0.06***				
Winter3			-0.07***			
Winter4				-0.07***		
Winter5					-0.07***	
Winter6						-0.08***
Day	-0.35***	-0.36***	-0.35***	-0.35***	-0.35***	-0.36***
Site (ref=1)						
8	-0.13***	--	-0.13***	-0.14***	-0.10***	--
6	-0.05***	-0.05***	-0.05***	-0.05***	-0.05***	-0.06***
5	-0.10***	-0.10***	-0.09***	-0.10***	-0.10***	-0.12***
4	0.06***	0.06***	0.06***	0.06***	0.07***	0.07***
3	0.04***	0.04***	0.04***	0.04***	0.05***	0.04***
2	-0.02**	-0.01***	-0.02**	-0.02***	-0.01**	-0.01*

Note: The number of observations used for winter1, winter3, winter4, winter5 = 376157; winter2, winter6 = 376157. Where site 1 = Ottawa, site 2 = Toronto, site 3 = Montreal, site 4 = Hamilton, site 5 = Thunder Bay, site 6 = Winnipeg, site 8 = Victoria. *p≤0.1, **p≤0.05, ***p≤0.01

4.7.2.2. *Models*

Table 16 summarizes the results of the model building process where Model 1 is the unconditional means model, Model 2 is the model from step 2b or the unconditional means model combined with the results of the sensitivity analysis from step 2a. Model 3a is the final model from step 3a or the unconditional means model plus level 2 or participant level variables, and finally Model 3b is the model from step 3b or the model from step 2b combined with the model from step 3a.

To determine model 3a all participant level characteristics were added to the unconditional model in turn to determine what participant level characteristics were statistically significant predictors of trips distance without taking into account trip level variables. It was determined that marital status was the only significant predictor of trip distance.

Table 16. Model summary (All Trips).

	Model 1	Model 2	Model 3a	Model 3b
Trips	377464	376157	377464	376157
AIC	1232718	1222086	1232715	1222088
-2LL	1232714	1222082	1232711	1222080
Variance				
Level 2	0.11	0.10	0.10	0.10
Level 1	1.53	1.50	1.53	1.50
Intercept	1.22 (0.02)***	1.56 (0.04)***	1.28 (0.03)***	1.61 (0.04)***
Winter4	--	-0.07 (0.00)***	--	-0.07(0.00)***
Day	--	-0.33 (0.01)***	--	-0.33 (0.01)***
Site (ref=1)				
8	--	-0.11 (0.06)*	--	-0.10 (0.06)*
6	--	0.02 (0.07)	--	0.02 (0.07)*
5	--	-0.10 (0.07)	--	-0.66 (0.07)
4	--	0.06 (0.06)	--	0.06 (0.06)
3	--	0.04 (0.71)	--	0.06 (0.07)
2	--	0.03 (0.06)	--	0.05 (0.06)
Marital status	--	--	-0.11 (0.04)*	-0.11 (0.04)*

Note: Variance values are the variance estimate (all variances were significant at p <0.0001), and regression values are the parameter estimate (standard error). Site 1 = Ottawa, site 2 = Toronto, site 3 = Montreal, site 4 = Hamilton, site 5 = Thunder Bay, site 6 = Winnipeg, site 8 = Victoria. *p≤0.1, **p≤0.05, ***p≤0.01

From Model 1 it was determined that a multilevel model was the appropriate method for analysis, with a variance estimate for participants (level 2) at 0.11 (Z=11.65, p<0.0001) and trip (level 1) variance estimate at 1.53 (Z=434.27, p<0.0001). From the level 1 and level 2 variance the ICC can be calculated (0.11/(0.11+1.53=0.07) or 7% of the variation in trip distance can be explained by between participant differences. Meaning most of the variation in trip distance occurs at the trip level.

In order to determine the final model, the deviance (-2 Log Likelihood (-2LL)) was compared between the 4 models with the result being compared to a chi-squared distribution. Table 17 provides the results of these calculations.

Table 17. Results of the Likelihood Ratio Test (All Trips).

	Model 2 – 1	**Model 3a – 1**	**Model 3b – 2**
Δ deviance	10632	3	2
x^2	15.5	3.8	3.8
df	8	1	1
p-value	<0.0001	0.083	0.157

Note: Δ deviance = $-2LL_{Full}$ - $-2LL_{Reduced}$, x^2 is the critical value for the chi-squared distribution at x degrees of freedom (df), df = $df_{Full} - df_{Reduced}$, and p-value is the significance of comparing Δ deviance to the x^2 value.

As can be seen from Table 17 Model 2 was the resulting final model. Model 3b does not indicate a significant change in deviance indicating that this model fits no better than Model 2 meaning the addition of *marital status* adds no additional information to the model. As well, since Model 2 was the simpler of the two models it was determined that Model 2 was the final model.

4.7.2.3. *Final model interpretation*

From Model 2 we get equation 3, which can be interpreted in the following way:

- During winter there was a 7% decrease in trip distance when controlling for *day* and *site*.
- There was a 33% increase in trip distance during night-time driving when controlling for *site* and *winter*.

Equation 3. Final model (All Trips).

$$\hat{Y} = \gamma_{00} + \gamma_{10}x_{1ij} + \cdots + \gamma_{p0}x_{pij} + \tau_{0j} \Longrightarrow \hat{Y} = 1.56 - 0.07winter - 0.33day - 0.11site8 + 0.02site6 - 0.10site5 + 0.06site4 + 0.04site3 + 0.03site2 + 0.32$$

4.7.3. City trips

4.7.3.1. *Sensitivity analysis*

Table 18 provides the results of the sensitivity analysis (step 2a). Only the inclement weather definition for each winter definition with the greatest R^2 value is presented. Models with each combination of winter and inclement weather were run to determine what combination explained the most variation in trip distance when controlling for *day* and *site*. Model 6 or the model using the 6th definition of winter and precipitation type was determined to be the model with the best fit.

Table 18. Results of the sensitivity analysis (City Trips).

	1	2	3	4	5	6
R^2	0.00944	0.01009	0.00943	0.00946	0.00946	0.01012
Intercept	1.35***	1.35***	1.35***	1.35***	1.35***	1.35***
Winter1	-0.02***					
Winter2		-0.01				
Winter3			-0.02***			
Winter4				-0.02***		
Winter5					-0.02***	
Winter6						-0.02***
Precipitation (ref=0)						
Vision	0.01	0.00	0.01	0.01	0.01	0.01
Rain	0.04***	0.05***	0.04***	0.04***	0.04***	0.05***
Snow	0.00	-0.01	0.00	0.00	0.00	0.00
Day	-0.31***	-0.32***	-0.31***	-0.31***	-0.31***	-0.32***
Site (ref=1)						
8	0.00	--	0.00	0.00	0.01*	--
6	0.03***	0.03***	0.03***	0.03***	0.03***	0.03***
5	-0.06***	-0.06***	-0.06***	-0.06***	-0.06***	-0.06***
4	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***
3	0.01***	0.09***	0.09***	0.09***	0.10***	0.09***
2	0.09***	0.09***	0.09***	0.09***	0.09***	0.09***

Note: The number of observations used for winter1, winter3, winter4, winter5 = 298089; winter2, winter6 = 244590. Where site 1 = Ottawa, site 2 = Toronto, site 3 = Montreal, site 4 = Hamilton, site 5 = Thunder Bay, site 6 = Winnipeg, site 8 = Victoria. *p≤0.1, **p≤0.05, ***p≤0.01

4.7.3.2. *Models*

Table 19 summarizes the results of the model building process, the models represent the same as above in All Trips. In this case residence type was determined to be the only significant participant level characteristic to explain trip distance.

Table 19. Model summary (City Trips).

	Model 1	Model 2	Model 3a	Model 3b
Trips	244842	244590	244842	244590
AIC	730015	727624	730017	727627
-2LL	730015	727620	730013	727620
Variance				
Level 2	0.08	0.08	0.08	0.08
Level 1	1.15	1.14	1.15	1.15
ICC	0.07	0.06	0.07	0.06
Intercept	1.10 (0.02)***	1.31 (0.37)***	1.06 (0.03)***	1.26 (0.04)***
Winter6	--	-0.01 (0.00)**	--	-0.01 (0.00)**
Precipitation (ref=0)				
Vision	--	0.01 (0.01)	--	0.01 (0.01)
Rain	--	0.05 (0.01)***	--	0.05 (0.01)***
Snow	--	0.00 (0.01)	--	0.00 (0.01)
Day	--	-0.29 (0.01)***	--	-0.29 (0.01)***
Site (ref=1)				
6	--	0.12 (0.07)*	--	0.11 (0.65)*
5	--	-0.07 (0.07)	--	-0.07 (0.07)
4	--	0.04 (0.06)	--	0.03 (0.06)
3	--	0.12 (0.07)*	--	0.12 (0.07)*
2	--	0.14 (0.06)**	--	0.16 (0.06)**
Residence type	--	--	0.07 (0.04)*	0.08 (0.04)**

Note: Variance values are the variance estimate (all variances were significant at p <0.0001), and regression values are the parameter estimate (standard error). Site 1 = Ottawa, site 2 = Toronto, site 3 = Montreal, site 4 = Hamilton, site 5 = Thunder Bay, site 6 = Winnipeg. *p≤0.1, **p≤0.05, ***p≤0.01

From Model 1 it was determined that a multilevel model was the appropriate method for analysis with a variance estimate for participants (level 2) at 0.08 (Z=9.97, p<0.0001) and trip (level 1) variance estimate at 1.15 (Z=349.74, p<0.0001) and an ICC of 0.07 (0.08/(0.08+1.15=0.07). Or same as in All Trips 7% of the variation in trip distance can be explained by between participant differences. The Likelihood Ratio Test was done again and the results are presented in Table 20.

Table 20. Results of the Likelihood Ratio Test (City Trips).

	Model 2 – 1	Model 3a – 1	Model 3b – 2
Δ deviance	2391	3	2
x^2	18.3	3.8	3.8
df	10	1	1
p-value	<0.0001	0.083	0.157

Note: Δ deviance = $-2LL_{Full}$ - $-2LL_{Reduced}$, x^2 is the critical value for the chi-squared distribution at x degrees of freedom (df), df = $df_{Full} - df_{Reduced}$, and p-value is the significance of comparing Δ deviance to the x^2 value.

As can be seen from Table 20 Model 2 was the resulting final model. Again the addition of the participant level variable *residence type* creates no better fit of the model.

4.7.3.3. *Final model interpretation*

From Model 2 we get equation 4, which can be interpreted in the following way:

- During winter there was a 1% decrease in trip distance when controlling for *precipitation type*, *day*, and *site*.
- During vision obstructing precipitation there was a 1% increase in trip distance, 5% increase during rain, and no change during snow when controlling for *winter*, *day*, and *site*.
- There was a 29% increase in trip distance during night-time driving when controlling for *precipitation type*, *site* and *winter*.

Equation 4. Final model (City Trips).

$$\hat{Y} = \gamma_{00} + \gamma_{10}x_{1ij} + \cdots + \gamma_{p0}x_{pij} + \tau_{0j} \Longrightarrow \hat{Y}\text{=1.31 - 0.01winter + 0.01vision + 0.05rain + 0.00 winter - 0.29day+ 0.12site6 - 0.7site5 + 0.04site4 + 0.12site3 + 0.14site2 + 0.28}$$

5. Discussion

There is a growing amount of evidence suggesting that self-report is not the most valid method to determine the driving patterns of older adults. Yet, this is the method primarily used. Huebner et al. (2006) and Blanchard et al. (2010) both followed participants for one week using a CarChip and both found that when participants were asked how far they drove over the course of the week they both over- and under-estimated. Staplin et al. (2008) found using odometer readings that those drivers in the lowest mileage groups under-estimated and those in the higher mileage groups over-estimated their annual mileage. These results call into question the use of self-report to determine the mileage driven by older drivers regardless of the time frame utilized. Blanchard et al. (2010) took the whole self-report versus actual debate one step further and is the first study to look at if older drivers actually avoid what they say they avoid. Of interest for this study was that Blanchard et al. (2010) found that 43% of those older drivers who reported avoiding driving in bad weather actually did drive during bad weather.

Unfortunately though, most of the research on self-regulation uses self-report to determine what behaviours/driving patterns older drivers reduce as they age. The most commonly identified and related to this study are: avoid driving at night, avoid driving in bad/inclement weather (e.g., Baldock et al., 2006; Charlton et al., 2006; D'Ambrosio et al., 2008; Donorfio et al., 2008b, Hakamies-Blomqvist & Wahlström, 1998; Lyman, McGwin Jr, & Sims, 2001; Oxley, Chariton, Scully, & Koppel, 2010), decreasing the number of overall trips (Donorfio et al., 2008b), and avoid taking long trips (Betz & Lowenstein, 2010).

This study is the first to examine a full year of driving for a sample of older adults across Canada, to determine if older drivers reduce their trip distance based on seasonal or weather conditions. It can be argued that trip distance does not really capture self-regulation, since trip distance does not capture if drivers choose to avoid making a trip. This is true, but it can also be argued that trip avoidance and reduction in trip distance are both behaviours captured using Michon's model of compensatory behaviours at the strategic level. Indicating that both are valid compensatory behaviours when taking into account the external and individual factors presented in the DEC model. Suggesting, that if older drivers really do self-regulate to the extent that the self-report literature indicates (e.g. Betz & Lowenstein (2010) found of the 728 older adults sampled 59% of them indicated they try to avoid driving in bad weather), then when older drivers drive during these adverse weather conditions then a reduction in trip distance should be seen since they are staying closer to home.

5.1. Trip Level

Based on the self-report literature it was hypothesized that trip distance would decrease during both winter and inclement weather conditions. During winter compared to non-winter there was a 7% decrease in trip distance when controlling for *site* and *night* for All Trips, where winter was defined as starting on the first date of the first four consecutive days of lows below 0°C and ending on the first date of the last four consecutive days of lows below 0°C. For City Only Trips there was a 1% decrease in trip distance when controlling for *site*, *night* and *precipitation type*. In this case winter was defined as starting on the first day of temperatures less than or equal to halfway between the minimum and maximum highs and the end date was the last day of temperatures less than or equal to halfway between the minimum and maximum highs. This suggests that older drivers do avoid taking some of the longer trips that they would typically take during the non-winter months (e.g., trips to the cabin), but in terms of city driving there is very little change in trip distance. This is not really a surprise, as it is not really an option to hibernate all winter, especially with winter lasting approximately 5 months of the year.

Unfortunately all of the studies that objectively measured driving patterns (Crizzle & Myers (2013), Myers et al. (2011), Blanchard et al. (2010), Blanchard & Myers (2010), and Marshall et al. (2007)) only present distance as distance per week so results from this study were not comparable. Although, looking at the distance per week seen in Myers et al. (2011), which was the only other study to look at winter driving, and comparing it to the other studies (Crizzle & Myers (2013), Blanchard et al. (2010), Blanchard & Myers (2010), and Marshall et al. (2007)), there seems to be a minimal decrease in average weekly distance between winter and non-winter driving. It must be noted that this was purely seen by looking at the reported average weekly distance presented in Table 2 from each of the studies.

Looking at inclement weather, or in this case precipitation type, it was found that there was only a statistically significant change in trip distance during rain or summer precipitation (i.e., drizzle, rain, thunderstorms, etc.) when compared to no precipitation (i.e., clear, cloudy, mostly cloudy, mainly clear conditions). During city driving there was a 5% increase in trip distance suggesting that rain does not cause older drivers to drive shorter distances, but maybe prevents older drivers from using alternative forms of transportation (e.g., bus, family/friends, walking). That being said there was a large discrepancy between the number of trips that occurred during the rain compared to no precipitation suggesting older drivers do try to avoid driving during rainy conditions. The increase in trip distance could also be attributed to for example, older drivers making trips to the mall across town on rainy days as opposed to clear days when they go to the corner store and come home and garden.

There were no differences in trip distance seen between snow and no precipitation or vision obstructing precipitation and no precipitation. Which was similar to what Myers (2011) found, that older adults were more likely to drive (drove on 69% of occurrences of bad weather) than not to drive (did not drive on 31% of occurrences of bad weather). Or, participants drove in 79% of the occurrences of snow and 21% of the occurrences of rain. Suggesting that older drivers drive during the winter regardless of weather conditions, which corresponds to a certain extent with what was found in this study that trip distance does not change based on winter (snow) precipitation.

Finally one of the most interesting results of this study is that there was an increase in trip distance at night compared to daytime driving. For All Trips there was a 33% increase in night-time distance when controlling for *winter* and *site*; and a 29% increase in trip distance when controlling for *winter*, *site*, and *precipitation type* for city driving. This although interesting, does make some sense. It could be that trips taken at night might be more discretionary, but may take someone further from home than they would normally travel (e.g., watching a grandchild's hockey game). Games usually occur in the evening and at various rinks around the city or other cities and towns, causing the driver to venture outside of what may be their normal driving radius to watch the game. There were still a substantially greater number of trips taken during the day compared to at night. So, despite the increase in trip distance during night-time trips, most trips by older adults still occur during daylight hours.

5.2. Participant Level

Gagnon et al. (unpublished) compared the whole Candrive sample population (all 928 participants) to drivers from the Canadian Community Health Survey – Health Aging (CCHS HA), and found that on most characteristics the samples were comparable. One exception was place of residence in that more of the CCHS HA sample were rural residents and therefore a greater proportion lived in private houses as compared to the Candrive sample. In terms of frequency of driving Candrive participants reported driving more than the CCHS HA sample. Both of these differences can be explained by the enrolment criteria for Candrive in that participants had to report driving at least 4 times per week at enrolment, and eligibility was limited to those who resided close to or in the cities involved in the study.

Interestingly enough, participant level characteristics did not seem to help explain the variation seen in trip distance. An intraclass correlation coefficient of 7% for All Trips and City Only Trips indicates that the variation in trip distance was demonstrated at the trip level opposed to the participant level. What this means is that looking at each individual trip within each participant, characteristics such as age or marital status were not useful in predicating trip distance when controlling for *winter*, *site*, *night*, and *precipitation type*. This makes sense because if the grocery store is 5km away it does not matter if you are 40 or 90 years of age if you choose to drive, it is still going to be 5km. If the outcome had been number of trips or if the data had been aggregated then there is the potential for participant level characteristics to play more of a role. It could be that older drivers self-regulate by choosing to drive or not rather than moderating their driving distance based on their participant level characteristics.

5.3. Limitations

There are several limitations of this study. The biggest is the main outcome variable chosen for analysis. Trip distance is not something that has been typically used as an outcome in most driving research, number of trips per week or distance per week would have provided more information on if self-regulation was occurring in the manner suggested in the self-regulation research. That being said, trip distance was chosen for a couple of reasons:

1) Determining if self-regulation was or was not occurring was not the primary goal of this study, this study was a first glance at the driving data coming from the Candrive project and was being used as a way to see what driving patterns were expressed by older drivers and trip distance provides a glimpse into this.
2) Trip distance was a variable already calculated and allowed for the focus to be on determining how to properly analyse the data instead of manipulating it and then missing some of the intricacies that were present in a dataset that contains over 300,000 trips and has trips nested within participants nested within sites, occurring in different weather conditions in different sites, over the course of different years.

The second major limitation involves the covariates that were used; site, winter, night, and precipitation type (when applicable). These were fairly superficial covariates, as demonstrated by the very low R^2 value from the sensitivity analysis. Indicating that these covariates do not explain much of the variation in trip distance and that there are other factors that are more predictive of trip distance. The most glaring one is trip purpose (e.g., shopping, visiting friends/family, travel, etc.). The primary reason this was not controlled for is that trip purpose was not collected. Considering the data for this study came from Candrive, which was a 5 year-long study, it would have been impossible to ask participant to record the reason they were taking every trip over the course of 5 years. However, by using the GPS data and looking at trip end locations, this could have been approximated and may have explained a much greater portion of the variation seen in trip distance.

Another major limitation is the definitions used to define winter and inclement weather. These definitions were created in an attempt to have a definition of winter and inclement weather that would be consistent across sites. With sites ranging from Montreal to Toronto to Winnipeg to Victoria and places in-between, it is acknowledged that there is a strong possibility (and potentially proven by the fact that a different definition was used for the All Trips and City Only datasets) that using a definition of winter and inclement weather that was more suited to each sites' "normal" conditions may have led to different results. The problem then becomes what definition of winter would be used for each site, which is why several definitions were proposed, and a sensitivity analysis was used to determine which definition would be used for the rest of the analyses. Additionally everyone perceives what winter and inclement weather are differently, and that perception is probably what drives changes in driving patterns more so then an arbitrary definition of winter proposed by an outsider.

It also should be noted that road conditions were not taken into account in this analysis. There are no databases that contain historical records on road conditions especially within cities. The reason that this is important is that even though weather was accounted for road conditions may not always be related to weather. For example, in Winnipeg it could be perfectly clear, but the roads could be extremely slippery due to temperature and wind polishing the roads. On the other hand, it could be snowing with relatively low visibility, but the road conditions are actually less hazardous than on some cold clear days. This phenomenon may also contribute to the explanation of why there was no change in trip distance during snow in city driving (i.e., even though it was snowing out the road conditions were better (or perceived to be better) then during the very cold clear days.

Finally the data for this study came from a few different locations so the ability to perfectly merge the driving data with weather data and to perfectly classify a trip as occurring within city limits was limited by the sources of data. Classifying trips as occurring within city limits or not was simply done to allow the weather data to be merged with the most appropriate trips. For example, weather data was only collected from one location for each of the different sites, meaning if a trip was occurring near this location then the chances the weather data was completely accurate for that trip goes up. If the trip occurs on the other side of the city or outside of the city and far from the weather station then there was a chance that the weather occurring there was different and the weather associated with that trip was wrong. Using the 2011 census population centre boundaries as a way to define if a trip occurs within the city was simply a means to reduce the chances that the weather data associated with that trip was completely wrong. The other issue with the weather data was that it was only collected once per hour. Weather can change quickly and it is possible that weather conditions were not captured (e.g., a quick 5 minute rain shower); but that being said Environment Canada hourly weather data from the Airport weather stations was the best method available for collecting weather data retrospectively.

5.4. Strengths

There are many limitations with this study in terms of where the data came from, how it was merged and so forth, but the fact that this study is the first to look at a year's worth of driving patterns and to look at individual trip level variation is a major strength. Every other study to date using objectively measured driving data has been about two weeks in duration and had the data collected averaged between those two weeks (the exception being Molnar et al., 2013). This study is the first study to not aggregate any of the trip level data, which meant that the increase in trip distance at night was noticed, and might have otherwise been missed if the data were aggregated to the week level.

This study is also the first one to look at a year's worth of data. Meaning that this is the first true glimpse into the driving patterns that older drivers express as opposed to the snapshots that are achieved with data collection phases of a couple of weeks. It also allowed for a true within participant comparison between winter/non-winter and inclement/non-inclement weather conditions instead of a matched pair design which would have been the only other way to do this analysis using the data collection period by other studies.

Finally the sample size for this study is more than four times the Blanchard & Myers (2010) study and close to double the sample size from Molnar et al. (2010). As well the data comes from seven different sites across Canada giving the results better generalizability to the entire population.

5.5. Future Directions

The current study has not even scratched the surface of what is possible with this data. Future analyses could include the aggregation of the data to week units (i.e., weekly distance) to allow for a comparison to previous research. The addition of trip destination as a substitute for trip purpose (e.g., a trip to the bank could be categorized as errand versus a trip to a residential location could be classified as visiting friends or family) and run the current analyses again to determine if more or less of the variation in trip distance is explained by season or inclement weather conditions. The current analyses could be repeated using number of trips per week to see if there is any sort of avoidance of certain conditions being expressed.

In terms of answering a similar question to the one in this study in a completely different manner trip matching within participants could be used to determining if there are changes in routes based on season and weather conditions. Trips within participants could be matched based on start and end location during various weather conditions or seasons to see if there is a change in routes used.

In terms of exploring the driving patterns of older adults further, variables such as radius from home, average speed, time of day, etc., could be calculated to provide a much more in depth analyses of older drivers' driving patterns. Really the potential directions for analyses with this data are limited mostly by the creativity of the researchers and the ability to find people with the skill set needed to work with this data.

6. Conclusion

This study provides a first preliminary glance at the driving patterns of older adults across one year specifically looking at winter versus non-winter and differences between precipitation types. There is no other comparable literature to determine if what was seen here is an anomaly or generalizable to the rest of the older driver population. However, it does further call into question the generally accepted list of behaviours that older drivers exhibit in the self-report self-regulation literature (e.g., avoiding driving in bad weather and driving less during the winter). For these participants not much self-regulation was seen in the sense of a decrease in trip distance associated with adverse driving conditions suggesting again that self-report may not be the best method for determining the driving patterns of older adults. As a result, it should be noted to policy makers, health care professionals and researchers to take it with a grain of salt if an older driver reports self-regulating their driving in response to adverse weather conditions. As a society we likely need to adjust our perceptions of older adults driving patterns and therefore how we plan and develop policies that affect drivers in general and more specifically older drivers.

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Appendix A: Manitoba Consent Form

Research Project Title: Candrive II Longitudinal Driving Study

Researchers: Dr. Michelle Porter, Linda Johnson

Sponsor: Canadian Institutes of Health Research

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

Summary of Project

Background of Study. Of all age groups, older persons who drive motor vehicles have one of the highest crash rates per km driven, and when involved in motor vehicle crashes have the highest rate of serious injury, disability and death. The reason for this is not necessarily age, but rather the accumulation of medical and functional conditions that affect both driving as well as one's ability to recover from traumatic events. There have been few previous studies that have identified the risk factors for older driver involvement in motor vehicle crashes. If these risk factors were known, this information would help drivers, their families and physicians possibly improve the safety of all road users.

Purpose and Design. The researchers conducting this study are attempting to determine the risk factors that are associated with older driver involvement in motor vehicle crashes. They are comparing the characteristics of older drivers with their driving records. One thousand drivers age 70 and older will be enrolled, and followed for five years in several cities in Canada. Results from this study will help with the development of an in-office decision tool to help physicians identify older drivers who may need further assessment of their driving ability.

Study Procedures. Participants in this study will be asked to complete an annual assessment of approximately ***2 ½ to 3 ½ hours,*** which will include answering questions, performing paper and pencil tests and completing portions of the physical examination (i.e., testing of balance, flexibility, strength, vision and hearing) with the study associate. This assessment will be repeated on an annual basis. Research staff will also make phone contact with the participants every four months and review their medical condition(s) and driving.

Persentech device. We will also be using a global positioning system (GPS) device from Persentech. This device will be installed at your first visit, and this installation will take only a few minutes (20 minutes, depending on the vehicle). The device can be used to record several details about trips. For example, it can be used to measure the distance and time of each trip, as well as where those trips are. It can also measure speed as well as high or extreme braking and acceleration rates. Finally, it can also make a number of measurements of how the motor is performing (similar to the readings your mechanic uses). This device will be kept in your car for the duration of the study. Every four months research staff will remove and replace the memory card from the device to download your information.

This device itself has four parts: a GPS antenna, a plug for the vehicle computer, a main receiver for data, and a receiver on the steering column (if needed). All of these parts are connected by wires to the main receiver which will be attached to existing connectors under the steering column. In order to install this equipment in your vehicle we will use the vehicle's computer plug, which is typically found below the steering column, this is the one that is used by mechanics to diagnose problems with vehicles. The small GPS antenna will be mounted on the dash using a suction cup. It will be connected to the main receiver which will be wired to connectors under the steering column. All wires will be inserted into existing spaces in the vehicle to prevent them from interfering with your driving. If one of these wires should become loose, please inform the research staff immediately.

If there are other drivers using the same vehicle, we will give you a key fob to identify when you are driving the vehicle. It is only necessary for us to review and measure your driving habits and not other drivers using the vehicle. Please make other drivers aware that their driving will be recorded, even though we will not be analyzing their data. The key fob will be attached to your key chain. The key fob receiver will be attached to the steering column in close proximity to the ignition, using double-sided tape.

At the end of the study the equipment will be removed from the vehicle and there will be no costs associated with this.

Release of Information. In order to compare the measurements described above with driving performance, it is necessary to obtain from Manitoba Public Insurance before and after enrolment in the study, participants' driving records and the reports of any motor vehicle collisions participants were involved in. We will also be obtaining relevant claims information held by Manitoba Public Insurance related to collisions. In accordance with the written agreement governing release of information which exists between the University of Manitoba and Manitoba Public Insurance in Manitoba, individual driving records and collision reports will not be shared with or transmitted by the investigators to government ministries, agencies, or other organizations external to Candrive unless required by law (i.e., under a subpoena). This information will only be used for the purposes of the Candrive study. Individual driving records and collision reports will be destroyed 15 years after you enroll in the study. Should you wish to verify the accuracy and completeness of your records, you may do so in Candrive offices with study staff present to assist with the interpretation of the data.

Description of Tests. The testing will involve answering questions, as well as performing paper and pencil tests. These will examine general information (age, gender, etc.), health status, medical diagnoses, driving, sleep, thinking abilities, and memory. We will ask that you bring in all containers for your prescription and over-the-counter medications and supplements, so that we can document their details. In addition, physical tests will also be performed (height, weight, balance, flexibility, strength, vision, hearing, reaction time and mobility). All of these tests in the laboratory will take about 2 ½ to 3 ½ hours, as mentioned above. In addition to these laboratory tests, we will also ask you to answer some questionnaires at home. The questions will be related to your health and driving, and will take approximately 40 minutes. You will receive the package of questionnaires when you meet with us in the laboratory, and then you will take them home and complete them within 2 weeks. We will ask you to mail the package of completed questionnaires back to us using the self-addressed stamped envelope that we will provide to you.

Length of Study. This study will last five years. We will ask that you to come to our lab once per year unless there are any changes to your health requiring further assessment. You are encouraged to contact study staff if you develop major health changes between assessment times. This may require all or part of the assessment described above to be repeated. We also encourage you to contact us if you plan to change or service your vehicle or move out of the vicinity. In addition, if you have a motor vehicle accident we also ask that you contact us. At that time we will ask you about the circumstances of the accident. This will take about 15 minutes. If you decide to stop driving during the study we will conduct a 5 minute interview to discuss this.

After this annual assessment, we will make contact with you by phone every four months. At that time we will briefly (15 minutes) ask you some questions about your current health and whether you have had any changes. We will also ask you whether your driving routines have changed since the previous visit. During this phone call, we will also make arrangements to meet with you at the University (or if necessary a more convenient location) to retrieve and replace the memory card of the device in your car. This is an easy procedure and will only take ten minutes.

If we cannot reach you during the study, we will phone the alternate contact listed on the Confidential Personal Data form. We ask that you receive permission to list this person and their phone number.

Confidentiality. If you choose to participate, all information gathered about you will be held in confidence and will be physically secured. All confidential data will be destroyed by shredding 25 years after the end of the study.

No one except the study personnel will have access to information that is identifiable to you. In particular, information that is identifiable to individual study participants will *not* be shared by Candrive with other organizations. However, if during the interview or assessment the study staff find information that is important regarding your ability to continue operating a motor vehicle safely, they are required to share this information with your family doctor. This would only be in cases where a medical condition is discovered (e.g., uncontrolled epilepsy, vision that does not meet the provincial standard). You will be notified should this be necessary. Your family physician will then evaluate whether further steps are necessary to ensure your driving safety. This may involve more in-depth assessment or management of medical problems and on occasion may require that your family physician notify Manitoba Public Insurance.

Risks. None of the interview tests have any side-effects or risks associated with them. Participants will be asked standard questions that may on extremely rare occasions be upsetting.

Even though the risk of injury is extremely low while performing the strength, balance or flexibility tests, there is a theoretical possibility for injury. If you experience any pain, dizziness or other symptoms during any part of a testing session, you should let us know and testing will be immediately discontinued. As well, even if you do not feel any discomfort, if research staff feel at any time that there is any risk associated with continuing testing then it will be stopped.

There is also the risk that the conditions that affect driving ability will be more likely to be detected compared to the general public. Please see the confidentiality section above for more details. This may require more advanced assessment and ultimately could result in the loss of a driving license.

There is a remote possibility that the small magnet in the antenna on the dash could potentially affect an internal compass in your vehicle, if it has one. Please inform us if you do have an internal compass and we will try to position the antenna as far from the compass location as possible. However, we cannot assume any risks for inactivating your compass. We will make every effort to not harm your vehicle in any way during the installation and removal of equipment, however, this is a possibility that small areas in discreet locations may be discoloured or marked.

Benefits of the Study. There are no proven direct benefits to individual participants associated with participation in this study. It is possible that the clinical examination may detect medical problems that could increase an individual's risk for crashing. In the case of these types of medical problems which need to be checked by law, the family physicians will be notified, as described above.

After the study has ended and data has been analyzed you will be provided with your own individual results as well as a summary of the overall study. A package will be mailed to you for both.

Withdrawal from the Study. You may withdraw from this study at any time and for any reason, by writing to Candrive, phone (474-8795), email (portermm@ms.umanitoba.ca) or in person during your appointments. If you decide to withdraw, then you will not be included in additional assessments. Your study information (e.g., assessments, driving record and collision report(s)) up to and including the date of withdrawal will be retained for study purposes for 15 years. Should you agree, this data will continue to be compared to your Manitoba Public Insurance driving record for 2 years following withdrawal in the study.

Study Expenses. None. You will receive a parking pass for each visit. We will also provide you with $10 to compensate you for travel costs, etc.

CONSENT FORM FOR PARTICIPATION IN THE PROJECT

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and/or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

Dr. Michelle Porter, Principal Investigator	474-8795
Linda Johnson, Research Associate	474-7085

This research has been approved by the Education/Nursing Research Ethics Board. If you have any concerns or complaints about this project you may contact any of the above-named persons or the Human Ethics Secretariat at 474-7122, or e-mail margaret_bowman@umanitoba.ca. A copy of this consent form has been given to you to keep for your records and reference.

____
Participant's Name (print)

______________________________ ________________
Participant's Signature Date

____
Researcher and/or Delegate's Name (print)

______________________________________ _________________
Researcher and/or Delegate's Signature Date

CONSENT FORM FOR RELEASE OF INFORMATION

[1] Consent to participate in the Candrive II Study and to release Manitoba Public Insurance Driving Records to Candrive.
I have read the Information Sheet and Consent Form and have had an opportunity to ask the research staff any questions I had about the study. My questions have been answered to my satisfaction and I agree to participate in the study under the conditions described in the Information Sheet and this Consent Form.

By signing below, I agree to participate in the **Candrive II Study**, and I give Manitoba Public Insurance permission to forward to Candrive my driving record, any traffic accident report(s) where the subject was a driver, and all claims data. I also give Manitoba Public Insurance permission to forward reports of motor vehicle collisions in which I was involved, that will contain information on the time and the location of the collision, the vehicles involved, the road condition and the apparent actions and condition of the driver. Driving records and collision reports will be released to Candrive at the time of enrolment in the study for two years before study entry, each year I am in the study, as well as two years after I have completed the study. Personal details such as names will not be forwarded to Ottawa, as original records will be kept in locked cabinets of the Manitoba site at the University of Manitoba.

____
Participant's Name (print)

___________________________ ________________
Participant's Signature Date

____
Researcher and/or Delegate's Name (print)

__________________________________ _________________
Researcher and/or Delegate's Signature Date

GPS COMPONENT OF THE CONSENT FORM

[2] Consent to attach a driving monitoring device to my car.

I have been provided information regarding the Persentech device and have had an opportunity to ask the Research Associate any questions I had about the device. My questions and/or concerns have been answered to my satisfaction. In order to supplement the driving information that I can provide during the assessments, I grant the Candrive Team permission to attach a driving monitoring device known as the Persentech to my car in order to create a computerized record of my driving experience.

____
Participant's Name (print)

____________________________ ________________
Participant's Signature Date

____
Researcher and/or Delegate's Name (print)

____________________________________ _________________
Researcher and/or Delegate's Signature Date

THANK YOU

Appendix B: Expanded Cumulative Illness Rating Scale

0	No problem
1	Current mild or past significant problem
2	Moderate problem that requires first line therapy
3	Severe problem
4	Extremely severe problem

Disease/Condition
Cardiac
Chest pain or angina
Heart attack
Congestive heart failure or extra fluid on the lungs
Palpitations or an irregular heart rhythm
Problems with the valves in your heart
Heart surgery
Vascular
Blood circulation problem (peripheral atherosclerotic disease, aneurysm of the abdominal aorta)
Vascular surgery (e.g., bypass graft surgery of lower limbs, carotid endarterectomy)
High blood pressure
High cholesterol
Blood problems
Anemia, leukemia, clotting problems, OR any problem affecting the blood cells, spleen or the lymphatic system
Respiratory
Asthma, emphysema bronchitis
Smoking (pack years)
Eyes and Ears
Cataracts
Glaucoma
Macular degeneration
Hearing problems or wearing a hearing aid
Dizziness (vertigo, fainting, loss of consciousness)
Upper Gastrointestinal
Stomach or digestive problems
Lower Gastrointestinal
Intestinal/bowel problems, intestinal hernia
Liver and Pancreas
Liver or pancreatic/gall bladder problems

Disease/Condition
Kidneys
Kidney problems
Urinary
Urinary problems (incontinence, enlarged prostate)
Musculoskeletal and Skin
Skin problems
Osteoporosis (diagnosed)
Osteo/Rheumatoid arthritis (diagnosed)
Carpal tunnel
Fibromyalgia
Neurological
Stroke (mini-stroke or TIA)
Headaches/migraines
Epilepsy, seizures
Parkinson's
Tremors
Endocrine, Metabolic
Diabetic: type 1 or 2
Diabetic retinopathy
Thyroid problems
Hypoglycemic episodes (low blood sugar)
Obesity
Psychiatric
Depression (diagnosed)
Anxiety disorder
Substance or alcohol abuse
Other
Localized weakness
Pain
Sleep apnea
Other health problems not mentioned previously

Appendix C: In-Car Recording Device in situ

Top: Otto-CD installed under the steering column.
Bottom: GPS antenna installed on the dash.

Appendix D: Follow-up Form

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FOLLOW-UP QUESTIONNAIRE

SITE #   PT ID   **Date:** dd mm yyyy

Visit : O *Year 1* O *Year 2* O *Year 3* O *Year 4* O *Year 5*

Followup: O *4 Month Follow-up* O *8 Month Follow-up* O *Annual*

O NO DEVICE IN VEHICLE

1. **As you know one of the main goals of our study is to assess driving patterns. The first thing we need to confirm is whether or not you are still driving.**

   Are you still driving? O No O Yes

   1a. If no, are you intending to return to driving? O No O Yes

   If not returning to driving, please also complete the Driving Cessation Questionnaire.

2. **Since your last Candrive appointment, which was approximately 4 months ago, have you stopped driving your vehicle for any period of time (e.g. did you go on vacation or stop driving because of changes in your health, etc.)?** O No O Yes

   2a. ***If yes, for how long was this interruption in your driving?***

   O < 1 week O 1-4 weeks O > 4 weeks and < 2 months O 2 - 4 months O > 4 months

   2b. ***If yes, please indicate the date(s) and reason(s) for the interruption in your driving: (attempt for approximate date)***

Reason(s) for interruption	DATE (s) (not driven)		
O Vacation/Travel	O Unknown	From: __/__/____ (dd mm yyyy)	To: __/__/____ (dd mm yyyy)
O Surgical Procedure	O Unknown	From: __/__/____ (dd mm yyyy)	To: __/__/____ (dd mm yyyy)
O Changes in your health	O Unknown	From: __/__/____ (dd mm yyyy)	To: __/__/____ (dd mm yyyy)
O Accident/collision	O Unknown	From: __/__/____ (dd mm yyyy)	To: __/__/____ (dd mm yyyy)
O No access to vehicle	O Unknown	From: __/__/____ (dd mm yyyy)	To: __/__/____ (dd mm yyyy)
O Seasonal stoppage	O Unknown	From: __/__/____ (dd mm yyyy)	To: __/__/____ (dd mm yyyy)
O Driving Suspension	O Unknown	From: __/__/____ (dd mm yyyy)	To: __/__/____ (dd mm yyyy)
O Other, specify: ______	O Unknown	From: __/__/____ (dd mm yyyy)	To: __/__/____ (dd mm yyyy)

Comments:

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FOLLOW-UP QUESTIONNAIRE

SITE # ____ PT ID ____ **Date:** ____ dd ____ mm ____ yyyy

Candrive — Driving research for older adults. Au volant de la recherche sur les aînés.

Visit: O *Year 1* O *Year 2* O *Year 3* O *Year 4* O *Year 5*

Followup: O *4 Month Follow-up* O *8 Month Follow-up* O *Annual*

3. During the past 4 months, did you drive any other vehicle on a regular basis? O No O Yes

3a. If yes, please indicate how frequently:

- O unknown
- O greater than or equal to 4 times per week
- O 1-3 times per week
- O less than weekly
- O less than monthly

3b. Please estimate the distance travelled in any other vehicle you may have driven (in the past 4 months):

- O < 100 km
- O 100-499 km
- O 500-999 km
- O 1000-1999 km
- O > 2000 km

3c. Did you drive another vehicle temporarily for a block of time during the past 4 months (e.g. vacation rental or car loan for repairs)? O No O Yes

If yes, please indicate the date(s) and estimate distance(s) you drove in this vehicle.

From: __/__/____ (dd mm yyyy) To: __/__/____ (dd mm yyyy) O Unknown date(s) ____ km O Unknown distance

From: __/__/____ (dd mm yyyy) To: __/__/____ (dd mm yyyy) O Unknown date(s) ____ km O Unknown distance

If participant does NOT have an RFID antenna, complete questions #4 below.
If participant DOES have an RFID antenna, go directly to question 5.

4. In the past 4 months, has anyone else driven your vehicle on any occasion? O No O Yes

4a. If yes, how often did this person(s) drive your vehicle?

- O unknown
- O greater than or equal to 4 times per week
- O 1-3 times per week
- O less than weekly
- O less than monthly
- O one occasion (e.g. accidental/unusual occurrence)

FOLLOW-UP QUESTIONNAIRE

SITE # ____ PT ID ____ **Date:** ____ dd ____ mm ____ yyyy

Visit: O *Year 1* O *Year 2* O *Year 3* O *Year 4* O *Year 5*

Followup: O *4 Month Follow-up* O *8 Month Follow-up* O *Annual*

Candrive — Driving research for older adults. Au volant de la recherche sur les aînés.

4b. Date(s) and time of day this person drove your vehicle (fill in all that apply):

From: __/__/____ (dd mm yyyy) To: __/__/____ (dd mm yyyy)	O Unknown date(s)	O Morning O Afternoon O Evening O Unknown
From: __/__/____ (dd mm yyyy) To: __/__/____ (dd mm yyyy)	O Unknown date(s)	O Morning O Afternoon O Evening O Unknown
From: __/__/____ (dd mm yyyy) To: __/__/____ (dd mm yyyy)	O Unknown date(s)	O Morning O Afternoon O Evening O Unknown
From: __/__/____ To: __/__/____ (dd mm yyyy)	O Unknown date(s)	O Morning O Afternoon O Evening O Unknown

4c. Did you record these trips in the Secondary Driver Log?

O always O almost always O seldom O not at all

Complete questions 5, only if participant DOES have an RFID antenna.

5. Did anyone else use your keys WITH the Candrive key fob during the past 4 months?

O No *If no, go to 5d*
O Yes

5a. If yes, how often was it shared?

O unknown
O greater than or equal to 4 times per week
O 1-3 times per week
O less than weekly
O less than monthly
O one occasion (e.g. accidental/unusual occurrence)

SITE # ____ PT ID ____ **Date:** ____ ____ ____ (dd mm yyyy)

Candrive — Driving research for older adults. Au volant de la recherche sur les aînés.

Visit: O *Year 1* O *Year 2* O *Year 3* O *Year 4* O *Year 5*

Followup: O *4 Month Follow-up* O *8 Month Follow-up* O *Annual*

5b. Do you know the date(s) that the key fob was shared? O No O Yes

Date(s) (if known) and time of day the key fob was shared (fill in all that apply):

Date	Time of day
From: __ __ / __ __ / __ __ __ __ (dd mm yyyy) To: __ __ / __ __ / __ __ __ __ (dd mm yyyy)	O Morning O Afternoon O Evening O Unknown
From: __ __ / __ __ / __ __ __ __ (dd mm yyyy) To: __ __ / __ __ / __ __ __ __ (dd mm yyyy)	O Morning O Afternoon O Evening O Unknown
From: __ __ / __ __ / __ __ __ __ (dd mm yyyy) To: __ __ / __ __ / __ __ __ __ (dd mm yyyy)	O Morning O Afternoon O Evening O Unknown
From: __ __ / __ __ / __ __ __ __ (dd mm yyyy) To: __ __ / __ __ / __ __ __ __ (dd mm yyyy)	O Morning O Afternoon O Evening O Unknown

5c. Did you record these trips in the Secondary Driver Log?

O always O almost always O seldom O not at all

5d. Did any other person drive your vehicle using keys WITHOUT the Candrive key fob? O No O Yes

5e. If yes, how often?

- O unknown
- O greater than or equal to 4 times per week
- O 1-3 times per week
- O less than weekly
- O less than monthly
- O unusual occurrence (e.g. one or two occasions)

Date (if known) and time of day of trip(s) (fill in all that apply):

Date	Time of day	Date	Time of day
From: __ __ / __ __ / __ __ __ __ (dd mm yyyy) To: __ __ / __ __ / __ __ __ __ (dd mm yyyy)	O Morning O Afternoon O Evening O Unknown	From: __ __ / __ __ / __ __ __ __ (dd mm yyyy) To: __ __ / __ __ / __ __ __ __ (dd mm yyyy)	O Morning O Afternoon O Evening O Unknown

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FOLLOW-UP QUESTIONNAIRE

SITE # ____ PT ID ____ **Date:** ____ dd ____ mm ____ yyyy

Visit: O *Year 1* O *Year 2* O *Year 3* O *Year 4* O *Year 5*

Followup: O *4 Month Follow-up* O *8 Month Follow-up* O *Annual*

Candrive
Driving research for older adults.
Au volant de la recherche sur les aînés.

5f. Were there any problems with the RFID antenna? O No O Yes

If yes, please describe problems and how they were handled.

____

____

____

6. Did you have your vehicle serviced by a mechanic during the past 4 months? O No O Yes

Date(s) (if known): From: __ / __ / ____ (dd mm yyyy) To: __ / __ / ____ (dd mm yyyy)

From: __ / __ / ____ (dd mm yyyy) To: __ / __ / ____ (dd mm yyyy)

6a. Have you been involved in any collisions/accidents (including fender-benders) in the past four months? O No O Yes

If yes, please also complete the Collision Factors Questionnaire.

6b. Have you had any traffic tickets in the past 4 months (excluding parking tickets)? O No O Yes

6c. If yes, fill in all that apply:

O Speeding
O Seat belt infraction
O Disobeying STOP sign
O Disobeying traffic signal (amber/red light)
O Failing to yield
O Improper lane change
O Dangerous driving. If yes specify: ______________________________
O Other: ______________________________

7. Were there any other issues with the Candrive in-car recording device? O No O Yes

____

____

____

Any additional comments about driving patterns and equipment installation:

____

____

____

____

***** STOP HERE IF COMPLETING ANNUAL ASSESSMENT*****

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FOLLOW-UP QUESTIONNAIRE

SITE # PT ID Date: dd mm yyyy

Visit : O Year 1 O Year 2 O Year 3 O Year 4 O Year 5

Followup: O 4 Month Follow-up O 8 Month Follow-up O Annual

8. For the purposes of this study, we must confirm whether or not you have developed a new medical condition that could potentially impact your ability to drive safely. In the past 4 months have you experienced or been diagnosed with any of the following?

Untreated obstructive sleep apnea or any other significant sleep disorder (e.g. falling asleep at inappropriate times during the day)	O No	O Yes
Any seizure activity	O No	O Yes
Vision problems not corrected by lenses (e.g. macular degeneration)	O No	O Yes
Heart attack	O No	O Yes
Unstable cardiac condition (eg. angina, chest pain, very fast or very slow pulse)	O No	O Yes
Stroke or transient ischemic attack (also called TIA or mini stroke)	O No	O Yes
2 or more episodes of low blood sugar (symptomatic)	O No	O Yes
Trouble with hallucinations	O No	O Yes
Any unexplained fainting spells or loss of consciousness	O No	O Yes
An episode of driving over the legal blood limit for alcohol or driven under the influence of illicit drugs/illegal drugs	O No	O Yes

8a. If you have answered "Yes" to any of the previous medical conditions, have all of these medical condition(s) been brought to the attention of your doctor or any other doctor? O No O Yes

If participant answers NO, refer to protocol.

9. Have you seen your family physician in the past four months? O No O Yes

9a. If yes, how many times?

O 1-2 times O 3-4 times O 5 or more times

9b. If yes, please indicate the reason(s): (fill in all that apply)

O Prescription renewal O Health concern: ______

O Blood pressure check O Blood work

O Annual check-up O Counselling

O Referral to a specialist O Other: ______

Comments:

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FOLLOW-UP QUESTIONNAIRE

SITE #	PT ID	Date: dd mm yyyy	

Visit : O Year 1 O Year 2 O Year 3 O Year 4 O Year 5

Followup: O 4 Month Follow-up O 8 Month Follow-up O Annual

Candrive
Driving research for older adults
Au volant de la recherche sur les aînés.

Medications

(Complete only at 4 and 8 Month Follow-up)

10. Have you had any changes in your medications in the past four months? (including a new medication, change in dosage or discontinuation of a medication) O No O Yes

10a. If yes, please document the change(s) below: (record name of drug and indicate what the change is by fill in the correct box and enter the new dosage if applicable)

Generic name of drug	*(Fill in all that apply)*	Total Daily Dosage	*Refer to list for code* Code
1. ______	O New drug O Discontinued O New dosage O Short-term O PRN	☐☐☐☐.☐☐☐ O mg O other: ____ ☐ not taken as prescribed	☐☐☐☐ O N/A
2. ______	O New drug O Discontinued O New dosage O Short-term O PRN	☐☐☐☐.☐☐☐ O mg O other: ____ ☐ not taken as prescribed	☐☐☐☐ O N/A
3. ______	O New drug O Discontinued O New dosage O Short-term O PRN	☐☐☐☐.☐☐☐ O mg O other: ____ ☐ not taken as prescribed	☐☐☐☐ O N/A
4. ______	O New drug O Discontinued O New dosage O Short-term O PRN	☐☐☐☐.☐☐☐ O mg O other: ____ ☐ not taken as prescribed	☐☐☐☐ O N/A
5. ______	O New drug O Discontinued O New dosage O Short-term O PRN	☐☐☐☐.☐☐☐ O mg O other: ____ ☐ not taken as prescribed	☐☐☐☐ O N/A
6. ______	O New drug O Discontinued O New dosage O Short-term O PRN	☐☐☐☐.☐☐☐ O mg O other: ____ ☐ not taken as prescribed	☐☐☐☐ O N/A
7. ______	O New drug O Discontinued O New dosage O Short-term O PRN	☐☐☐☐.☐☐☐ O mg O other: ____ ☐ not taken as prescribed	☐☐☐☐ O N/A

Comments:

4173351464

FOLLOW-UP QUESTIONNAIRE

SITE # PT ID Date: dd mm yyyy

Candrive — Driving research for older adults. Au volant de la recherche sur les aînés.

Visit: O Year 1 O Year 2 O Year 3 O Year 4 O Year 5

Followup: O 4 Month Follow-up O 8 Month Follow-up O Annual

Contact Information

13. Do you still have the same family physician? O No O Yes

If no, please update Confidential Personal Data Form.

14. Has your contact information and/or alternate contact information changed since your last visit? O No O Yes

If yes, please update Confidential Personal Data Form.

15. Is there any possibility your contact information will change in the next four months? O No O Yes

Advise participant to notify Candrive office at time of change.

16. Can you provide us with some suggestions or feedback that would help us improve your study experience?

____

____

____

Review/SD Card Exchange

1. **Determine if participant has any questions or concerns at this point. If yes, please address and record in comments section below.**
2. **Remind participant to contact RA if:**
   a. **They have purchased a new vehicle.**
   b. **There has been a significant change in their health status.**
   c. **They have stopped driving.**
   d. **A significant driving incident such as a collision or traffic ticket has occurred.**
3. **Reinforce necessity of using own car keys and not sharing with other drivers.**
4. **Ensure participant can locate folder containing Candrive contact information. Provide new folder if needed.**

Planned date of SD Card change: __ / __ / 2012 (dd mm yyyy) **Actual date:** __ / __ / 2012 (dd mm yyyy)

Comments:

____

____

____

Appendix E: Temperature Norms

Table E1. Temperature norms.

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	-10 (3)	-8 (3)	-2 (3)	6 (2)	13 (2)	18 (1)	21 (1)	19 (1)	14 (1)	8 (1)	1 (2)	-7 (3)
2	-6 (3)	-5 (3)	0 (2)	6 (2)	13 (2)	18 (1)	21 (1)	20 (1)	15 (1)	9 (2)	3 (1)	-3 (3)
3	-10 (3)	-8 (3)	-2 (2)	6 (2)	14 (2)	18 (1)	21 (1)	20 (1)	15 (1)	8 (1)	2 (2)	-6 (3)
4	-5 (3)	-4 (2)	1 (2)	7 (2)	14 (2)	20 (1)	22 (1)	21 (1)	17 (1)	10 (2)	4 (2)	-2 (3)
5	-14 (3)	-11 (3)	-5 (2)	3 (2)	10 (2)	14 (1)	18 (1)	17 (1)	12 (1)	5 (2)	-3 (2)	-11 (3)
6	-17 (4)	-13 (4)	-6 (3)	4 (3)	12 (2)	17 (2)	20 (1)	18 (2)	12 (1)	5 (2)	-5 (3)	-14 (4)
8	4 (2)	5 (2)	7 (1)	9 (1)	12 (1)	14 (1)	16 (1)	16 (1)	14 (1)	10 (1)	6 (1)	4 (1)

Note: Mean and standard deviations (presented in brackets) are presented in °C (site 1 = Ottawa, site 2 = Toronto, site 3 = Montreal, site 4 = Hamilton, site 5 = Thunder Bay, site 6 = Winnipeg, site 8 = Victoria).

Appendix F: Weather condition definitions

All definitions are quoted from Environment Canada (2013b) (http://climate.weather.gc.ca/glossary_e.html#weather)

Blowing snow – snow particles violently stirred up by wind to sufficient heights above the ground to reduce visibility to 10km or less.

Clear – 0 tenths of cloud covering the dome of the sky.

Cloudy – 10 tenths of cloud covering the dome of the sky.

Drizzle – fairly uniform precipitation composed of fine drops of water (diameter < 0.5mm). Drizzle drops are to small to cause appreciable ripples on the surface of still water.

Fog – a visible aggregate of minute water droplets suspended in the air at or near the surface of the earth, reducing horizontal visibility to < 1km.

Freezing drizzle – drizzle, the drops of which freeze on impact with the ground or with objects near the ground.

Freezing fog – a type of fog composed of suspended particles of ice or ice crystals 20 to 100 microns resulting from freezing of tiny supercooled water droplets. Ice fog occurs in clear, calm, stable air when temps are < -30°C.

Freezing rain – rain, the drops of which freeze on impact with the ground or with objects at or near the ground.

Haze – a suspension in the air of small particles produced by combustion.

Ice crystals – precipitation in the form of slowly falling, singular or unbranched ice needles, columns, or plates.

Ice pellets – precipitation of transparent or translucent pellets of ice, which are spherical or irregular shaped, having a diameter of 5 mm or less.

Mainly clear – 1-4 tenths of cloud covering the dome of the sky.

Mostly cloudy – 5-9 tenths of cloud covering the dome of the sky.

Rain – precipitation in the form of liquid water droplets > 5 mm.

Smoke – a suspension in the air of small particles produced by combustion.

Snow – frozen precipitation in the form of white or translucent ice crystals in complex branched hexagonal form.

Snow grains – frozen precipitation in the form of very small, white opaque grains of ice.

Snow pellets – frozen precipitation of particles or either spherical or conical ice.

Thunderstorm – a thunderstorm is a local storm produced by a cumulonimbus cloud. It is an event of relatively short duration and is always accompanied by thunder and lightning, usually with strong gusts of wind, heavy rain, and sometimes hail.

Showers – precipitation that is characterized by suddenness with which it starts and stops.

Appendix G: City Only participant level descriptives

Table G1. Categorical participant level descriptives by site (City Trips)

	Site							Total
	1	2	3	4	5	6	8	
N*	59	38	23	35	25	26	42	248
Gender								
Male	53	9	43	60	36	65	52	50
Female	47	61	57	40	64	35	48	50
Single								
Married/Common-law	53	32	39	51	28	50	45	44
Widowed/Separated/Divorced/Never married	47	68	61	49	72	50	55	56
House								
Apartment/Condo/Retirement residence	42	63	48	40	44	38	52	47
House	58	37	52	60	56	62	48	53
Education								
Postgraduate degree	8	18	17	14	12	15	19	15
Degree	34	39	30	14	16	8	19	25
Diploma/Trade/Technical certificate	25	13	13	26	8	19	21	19
High/Grade School	32	29	39	46	64	58	40	42
Volunteer								
Don’t volunteer	51	39	65	57	36	42	45	48
Volunteer	49	61	35	43	64	58	55	52
Family								
Never/Sometimes	36	53	39	31	24	23	21	33
Most of the time	44	18	30	29	44	42	38	35
All of the time	20	29	0	40	32	35	40	31
Health								
Excellent	24	18	26	37	24	4	26	23
Very good	59	63	52	43	52	46	45	52
Good/Fair/Poor	17	18	22	20	24	50	29	24

Note: *All values are percentages of site total except for N which is the number of participants (site 1 = Ottawa, site 2 = Toronto, site 3 = Montreal, site 4 = Hamilton, site 5 = Thunder Bay, site 6 = Winnipeg, site 8 = Victoria).

Table G2. Continuous participant level descriptives by site (City Trips)

	Site							Total
	1	2	3	4	5	6	8	
N*	59	38	23	35	26	26	42	249
Age (years)	79.1 (5.5)	76.5 (5.0)	76.4 (5.3)	77.8 (5.2)	77.1 (5.0)	76.6 (4.9)	77.2 (5.4)	77.5 (5.3)
# of Meds	4.0 (2.9)	5.0 (2.6)	3.3 (3.0)	5.6 (3.0)	5.9 (2.7)	4.0 (2.1)	4.7 (2.8)	4.7 (2.8)
CIRS	10.2 (4.9)	11.0 (4.5)	8.6 (4.8)	12.3 (5.6)	10.5 (4.3)	12.7 (4.7)	10.6 (4.7)	10.9 (4.9)
RPW (s)	7.4 (1.3)	6.5 (1.5)	5.9 (1.3)	7.7 (2.5)	7.3 (1.9)	6.4 (1.5)	6.1 (1.4)	6.8 (1.8)
TUG (s)	11.0 (2.0)	10.1 (2.4)	9.8 (2.3)	9.8 (3.6)	10.6 (1.7)	10.6 (3.0)	10.9 (2.0)	10.5 (2.5)

Note: *All values are average (standard deviation) except for N which is the number of participants (site 1 = Ottawa, site 2 = Toronto, site 3 = Montreal, site 4 = Hamilton, site 5 = Thunder Bay, site 6 = Winnipeg, site 8 = Victoria).

Appendix H: Winter Definitions

Table H1. Winter date range (winter centreed years).

Site	2009-2010		2010-2011		2011-2012		Days*
	Start	End	Start	End	Start	End	%
Winter1: S – date of first snowfall, E – date of last snowfall							
1	29Nov09	09May10	22Oct10	21Apr11	--	--	50
2	01Dec09	09May10	21Nov10	18Apr11	17Nov11	18Nov11	37
3	22Oct09	09May10	30Oct10	21Apr11	--	--	56
4	15Oct09	18Apr10	25Nov10	22Apr11	--	--	49
5	10Oct09	07May10	21Oct09	02May11	--	--	57
6	08Oct09	03May10	29Oct10	13May11	--	--	55
8	13Dec09	12Mar10	19Nov10	01Mar11	--	--	29
Winter2: S – date of first winter precipitation followed by 4 consecutive days of highs below 0, E – first day of last 4 consecutive days of highs below 0							
1	11Dec09	16Feb10	05Dec10	25Mar11	--	--	26
2	16Dec09	12Feb10	06Dec10	24Mar11	--	--	20
3	15Dec09	14Feb10	04Dec10	24Feb11	--	--	21
4	16Dec09	14Feb10	04Dec10	24Mar11	--	--	25
5	01Dec09	22Feb10	01Dec10	24Mar11	--	--	28
6	01Dec09	28Feb10	16Nov10	24Mar11	--	--	30
8	--	--	--	--	--	--	
Winter3: S – first date of winter precipitation followed by 4 consecutive days of lows below 0, E – first date of last 4 consecutive days of lows below 0							
1	06Dec09	27Mar10	31Oct10	05Apr11	--	--	39
2	06Dec09	24Aar10	01Dec10	27Mar11	--	--	27
3	06Dec09	25Mar10	04Dec10	28Mar11	--	--	33
4	06Dec09	24Mar10	25Nov10	31Mar11	--	--	34
5	10Oct09	07May10	21Oct10	19Apr11	--	--	55
6	08Oct09	25Mar10	11Nov10	17Apr11	--	--	45
8	--	--	19Nov10	23Jan11	--	--	10
Winter4: S – first date of first 4 consecutive days of lows below 0, E – first date of last 4 consecutive days of lows below 0							
1	14Oct09	27Mar10	31Oct10	05Apr11	--	--	47
2	04Dec09	24Mar10	31Oct10	27Mar11	--	--	31
3	16Oct09	25Mar10	19Nov10	28Mar11	--	--	43
4	04Dec09	24Mar10	31Oct10	31Mar11	--	--	38
5	09Oct09	07May10	21Oct10	19Apr11	--	--	55
6	08Oct09	25Mar10	28Oct10	17Apr11	--	--	47
8	02Dec09	24Dec09	19Nov10	23Feb11	--	--	18

Site	2009-2010		2010-2011		2011-2012		Days*
	Start	End	Start	End	Start	End	%
Winter5: S – first day of temps less than or equal to halfway between the min and max lows, E – last day of temps less than or equal to halfway between the min and max lows							
1	12Oct09	30Mar10	03Nov10	15Apr11	--	--	48
2	11Oct09	10Mar10	21Oct10	22Apr11	23Oct11	18Nov11	43
3	14Oct09	10May10	03Nov10	19Apr11	--	--	56
4	11Oct09	10May10	31Oct10	21Apr11	--	--	56
5	22Oct09	28Apr10	05Nov10	19Apr11	--	--	50
6	13Oct09	26Mar10	17Nov10	14Apr11	--	--	43
8	06Oct09	30May10	16Oct10	17May11	--	--	69
Winter6: S – first day of temps less than or equal to halfway between the min and max highs, E – last day of temps less than or equal to halfway between the min and max highs							
1	30Sep09	09May10	22Oct10	21Apr11	--	--	58
2	11Oct09	11May10	02Oct10	16May11	01Oct11	18Nov11	58
3	14Oct09	09May10	22Oct10	05May11	--	--	62
4	11Oct09	13May10	03Oct10	17May11	--	--	64
5	10Oct09	27Mar10	28Oct10	27Apr11	--	--	49
6	10Oct09	25Mar10	28Oct10	01May11	--	--	48
8	--	--	--	--	--	--	

Note: *Days is the percentage of days captured by each definition of winter over the total data collection period for each site respectively. Where site 1 = Ottawa, site 2 = Toronto, site 3 = Montreal, site 4 = Hamilton, site 5 = Thunder Bay, site 6 = Winnipeg, site 8 = Victoria.

Table H2. Temperatures (°C) used to define winter definitions 5 and 6.

Site	2009-2010	2010-2011	2011-2012
Winter5: S – first day of temps less than or equal to halfway between the min and max lows, E – last day of temps less than or equal to halfway between the min and max lows			
Ottawa	-1.2	-3.1	
Toronto	2.2	2.2	1.3
Montreal	0.6	-1.3	
Hamilton	1.1	0	
Thunder Bay	-6.6	-8.6	
Winnipeg	-7.4	-6.5	
Victoria	4.5	3.4	
Winter6: S – first day of temps less than or equal to halfway between the min and max highs, E – last day of temps less than or equal to halfway between the min and max highs			
Ottawa	9.0	7.3	
Toronto	10.5	11.5	11.7
Montreal	9.4	8.1	
Hamilton	10.1	10.4	
Thunder Bay	4.8	4.9	
Winnipeg	2.4	4.0	
Victoria	17.7	14.9	

Appendix I: Hours classified by precipitation type

Table I1. Percent of hours classified as precipitation type.

	Site							Total
	1	2	3	4	5	6	8	
No precipitation								
Clear	15.8	14.8	14.1	12.9	17.6	17.4	12.3	15.0
Cloudy	17.6	16.3	20.4	13.3	14.4	17.0	14.0	16.1
Mainly clear	19.6	20.3	20.1	19.8	23.6	24.0	17.4	20.7
Mostly cloudy	25.9	31.6	22.4	26.8	25.9	21.6	334	26.8
Winter								
Freezing drizzle	0.1	0.0	0.1	0.1	0.1	0.1	--	0.1
Freezing rain	0.3	0.0	0.1	0.0	0.1	0.0	--	0.1
Ice crystals	--	--	--	--	0.0	0.8	--	0.1
Ice pellet showers	--	0.0	0.0	0.0	0.0	0.0	--	0.0
Ice pellets	0.1	0.0	0.1	0.1	0.2	0.0	--	0.1
Snow	7.8	3.4	9.8	3.9	8.6	9.0	0.7	6.2
Snow grains	0.0	0.2	--	0.0	0.0	0.1	--	0.0
Snow pellets	0.0	0.0	--	--	--	--	0.0	0.0
Snow showers	0.2	2.8	0.7	8.1	0.1	0.7	0.0	1.7
Summer								
Drizzle	0.7	0.8	1.2	0.5	0.9	0.8	1.2	0.9
Rain	7.2	4.3	7.3	2.8	4.0	2.3	16.0	6.3
Rain showers	1.2	3.2	1.9	6.7	2.3	2.5	2.6	2.9
Thunderstorms	0.3	0.2	0.2	0.3	0.2	0.4	0.0	0.2
Vision obstructing								
Blowing snow	0.1	0.0	0.2	0.4	0.0	1.2	--	0.3
Fog	8.2	5.6	4.1	11.4	5.2	5.2	8.9	7.2
Freezing fog	0.2	0.0	0.1	0.2	0.2	0.4	0.1	0.2
Haze	0.1	0.2	0.2	0.5	0.0	--	--	0.1
Smoke	0.0	--	--	--	0.0	0.2	--	0.0

Note: All hours are in percent of total hours with weather data for each respective site (site 1 = Ottawa, site 2 = Toronto, site 3 = Montreal, site 4 = Hamilton, site 5 = Thunder Bay, site 6 = Winnipeg, site 8 = Victoria).