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Travel Behaviour of Seniors in an Aging Population: An Exploratory Study of Trip Chains and Modal Preferences in the Greater Metropolitan Area of Sydney

By

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ABSTRACT: Three concurrent demographic shifts, the aging of the population, and increase in incomes and an increase in health of senior citizens, are likely to cause significant changes to travel demand structures. An increasing proportion of the population will have both relatively high levels of free time which afford the opportunity to undertake a range of activities and the financial and physical capability to carry out these activities. Hence, it is essential to understand how demand for private and public transport may evolve with respect to these fundamental demographic changes. This paper utilises travel demand data to examine this issue, highlighting the likelihood that, as the population continues to age, traffic demand is likely to increase across times of day, impacting the population as a whole through increases in the scope and scale of traffic congestion. A healthy, relatively older and relatively wealthy population is shown to be likely to continue its reliance on the private vehicle, contrary to a traditional belief that, as people age, their demand for travel wanes, along with their personal use of automobiles relative to the use of public transport.

KEY WORDS: ***Mobility, accessibility, travel demand, ageing***

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1. Introduction

Better aging is the combined result of health and lifestyle improvements and thus, longer life expectancy. With the aging of the population comes the need to re-evaluate service availability and public policies. In the context of transport, the aging population not only means that there will be greater numbers of car dependent older people in the future, but more people will enter a stage in their life when they choose to, or are compelled to, no longer drive. Family and social support networks may not be able to cater to all the travel needs of seniors, and thus reliable, safe and frequent transport services may be the only way of serving their mobility and accessibility needs, especially when these individuals do not have access to a car.

Despite the political attention that the issue of the aging of the population has gained, travel behaviour of seniors and the elderly has not been explored in a way that enables a more comprehensive understanding of this segment of the population's travel needs. This paper describes results from part one of a study that is investigating the travel behaviour of age cohorts, especially those aged 65 years and over, in the Greater Metropolitan Area of Sydney. Travel data from the Sydney Household Travel Survey were amalgamated into trip chains, rather than individual trips, to better understand the complete travel activity, in order to establish the role of access, egress and main modes in the outbound and inward bound trips, and the implied benefits of more flexible modes of transport. Section 1 presents an overview of the literature on transportation for the elderly; Section 2 describes the method employed to construct the trip chains; Section 3 presents the results and focuses on the travel behaviour of the population aged 65 years and over; Section 4 discusses the results in light of the findings in the literature, and Section 5 importantly highlights areas for ongoing research.

2. Background

Australia, along with many western nations, is undergoing a marked demographic shift; its population is aging. The most populous states in Australia have the greatest populations of older persons and this trend will continue into the future. The population of persons aged 65 and over in 2003 represented 13 percent of the population in New South Wales. By 2016, this number is expected to be greater than the population of people aged 0 to 14 years for the first time. In addition, the greatest increase of older people is projected to be for those 85 years and older; forecast to be eight times greater than the 2002 old people population (ABS, 2004). These statistics highlight the importance of understanding the travel patterns and needs of the current older population and making inferences, where appropriate, on the transportation needs of future generations of the elderly.

2.1 Travel Patterns

Greater car dependency amongst older persons is evident in the United States, Australia and Europe (Gantz, 2002; Rosenbloom, 2001; Donaghy *et al.*, 2004; Tacken, 1998). In addition, older drivers are the fastest growing segment of the driving population, in terms of license rates and distances travelled (Okola and Walton, 2003; Rosenbloom,

2003; Banister and Bowling, 2004). Young seniors[1], those aged 65 to 74 years, are travelling longer distances, are making more trips and the purposes of these trips are now more varied (Banister and Bowling, 2004; Rosenbloom, 2001; Rosenbloom and Morris, 1998; Burkhardt *et al*., 1998; Hu and Young, 1999; Tacken, 1998). Commuter trips, once made by public transport, are now non-work trips made by the automobile (Rosenbloom, 2001).

Where one lives also affects how travel is conducted. An increasing number of older people choose to retire in the suburban areas where they have lived for the majority of their adult lives (Rosenbloom, 2003; Evans, 1999; Rosenbloom and Morris, 1998; Skinner and Stearns, 1999; Lin, 1999). However, these areas are not well served by public transport, reinforcing the preference for the automobile. In addition, the loss of one's driving license, due to the increased level of disability arising from progressive aging, compounded by the lack of transport options in these areas, has been reported to negatively affect mobility. This in turn has been reported to negatively affect the quality of life of older individuals because the automobile is associated with better access, choice, freedom and independence (Burkhardt *et al*., 1998; Burns, 1999; Coughlin, 2001; Bonham *et al*., 2004; Donaghy *et al*., 2004; Rosenbloom, 2004; Rosenbloom, 2003).

The reduction in mobility, typically measured through the reduction in individual trips, rather than trip chains, however, may be misleading because certain activities may no longer be desired by the older individual. Thus, stating that a reduction in mobility, resulting from an observed reduction in individual trips, may be false, and suggests that the focus on mobility (i.e., the ease of movement) should be moved to a focus on accessibility (i.e., the ease of reaching a 'destination'). Generally, mobility is closely related to the level of service provided on the transport system[2]. Accessibility, however, is related to destinations, and therefore requires attention to urban form, land use and to the quality of destinations. Old seniors and the elderly may be able to satisfy certain accessibility needs without having to leave their homes. This is discussed in more detail later in this paper.

For the elderly, in particular, a focus on trip chaining, which reflects the door-to-door outward and return trip, is of paramount importance in revealing the capability of conventional transport modes in servicing their needs, and in imposing barriers to mobility and accessibility. Trip chains, which provide insight into the supply chain of mobility and associated accessibility of individuals, better represent the changes in these supply chains as individuals go through different stages in their lives. Trip chain analysis presents a more holistic, rather than partial, assessment of individual travel behaviour.

Trip chaining behaviour is also likely to be more dominant amongst the elderly of the future, due in part to their more active lifestyles and the ability of satisfying multiple objectives in one outing (Banister and Bowling, 2004; Metz, 2003; ECMT, 2002; Rees

[1] *Old seniors are those aged 75 years to 84 years, whilst those aged 85 years and over are referred to as the elderly (Alsnih and Hensher, 2003).*

[2] *Higher levels of service are designed to represent lower generalised costs per kilometre of travel. Thus, increases in capacity of the system tend to lead to an increase in mobility. An increase in mobility implies that the generalised cost of travel (time plus money) per kilometre is reduced; an increase in accessibility implies that there is a reduction in the generalised cost of travel per destination.*

and Lyth, 2004), which is less constrained than trips that involve a commuting activity. For example, the incidence of trip chaining amongst women is expected to increase, due to the combined roles of younger women as care takers and professionals (Donaghy *et al*., 2004; Price, 2003). This travel behaviour may be adopted in semi-retirement and full retirement, because these women may want to maintain their active lives, further reinforcing the attractiveness of the car and the unattractiveness of public transport (Price, 2003; Alsnih and Hensher, 2003; Bonham *et al*., 2004). This further emphasises the benefits of trip chain analyses.

The extant literature discusses the potential role of public transport in satisfying the future transport needs of the older population (Davey, 2004; Straight, 2003; Ritter *et al*., 2002; Okola and Walton, 2003). A major focus of the current paper is to identify the present level of public transport use, especially for people 65 years and over, in the context of trip chaining behaviour in the Greater Metropolitan Area of Sydney.

3. Sydney Household Travel Survey

3.1 Trip Chain Formation

Given a focus on trip chain analysis, the first task is to define the set of trip chains. A trip chain is a sequence of trips that begin from a location (home in these analyses) and return to that location after none, one, or more intermediate stops of any duration. The trip chains formed were adapted from Hensher and Reyes (2000) and grouped under either work or non-work centric. Work trip chains included at least one work or work-related trip and non-work trip chains included all other trips. The work trip chain definitions were more numerous because these may involve one or more non-work trips. For example, people may drop off their children and stop for petrol on their way into work, go to the bank during their lunch break, pick up the children and then drop them off for soccer practice before finally reaching home. Trip chain types and definitions are shown in Table 1. Extra trip chains were constructed to separate car passenger trip chains from car driver trip chains. This is an especially important distinction when looking at the travel patterns of the aged. Thus, eighteen trip chains in total were constructed.

Table 1: Trip Chain Types and Definitions

Trip Chain	Definitions (Study Period is 24 Hours)
Simple Work Car Driver	Only work trips conducted and main mode of travel is car driver
Simple Work Car passenger	Only work trips conducted and main mode of travel is car passenger
Simple Work Public Transport	Only work trips conducted and main mode of travel is public transport
Complex to Work Public Transport	Involves at least one non-work trip or at least one work related trip on the way to or from work and the main mode of travel is public transport
Complex to Work Car Driver	Involves at least one non-work trip or at least one work related trip on the way to work and the main mode of travel is car driver
Complex to Work Car Passenger	Involves at least one non-work trip or at least one work related trip on the way to work and the main mode of travel is car passenger
Complex to from Work Car Driver	Involves at least one non-work trip or one work related trip on the way to and from work and the main mode of travel is car driver
Complex to from Work Car Passenger	Involves at least one non-work trip or one work related trip on the way to and from work and the main mode of travel is car passenger
Complex at Work Car Driver	First destination is work, at least one non-work or work related trip is conducted and a return trip to work is made and the main mode of travel is car driver
Complex at Work Car Passenger	First destination is work and at least one non-work or work related trip is conducted and a return trip to work is made, and the main mode of travel is car passenger
Complex from Work Car Driver	First destination is work and at least on one non-work or work related trip is made, main mode of travel is car driver
Complex from Work Car Passenger	First destination is work and at least on one non-work or work related trip is made, main mode of travel is car passenger
Simple Non-Work Public Transport	One non-work trip is made and main mode is public transport
Simple Non-Work Car Driver	One non-work trip is made and main mode is car driver
Simple Non-Work Car Passenger	One non-work trip is made and main mode is car passenger
Complex Non-Work Public Transport	More than one non-work trip is made and the main mode of travel is public transport
Complex Non-Work Car Driver	More than one non-work trip is made and the main mode of travel is car driver
Complex Non-Work Car Passenger	More than one non-work trip is made and the main mode of travel is car passenger

Source: Adapted from Hensher and Reyes, 2000.

The Sydney Household Travel Survey data required extensive transformation and recoding to convert the travel and socioeconomic information to the set of trip chains in Table 1. Trip purpose was recoded into 6 categories:

1. work - this included all work and work related trips;
2. non-work - this included all non-work related trips except for home;
3. home- trips where the purpose was to return home. This trip purpose was not recoded helping order to identify the end of a trip chain and conform to the definitions shown in table 1;
4. accompany someone
5. change of mode, and
6. drop-off/pick-up.

Trip purposes 4-6 could also have been recoded to work or non-work depending on the trip purposes of trips prior to or after this trip was conducted. They were left as they are in the database, but were recoded accordingly when developing the trip chains.

The main modes of travel used in the development of the trip chains were car driver, car passenger and public transport (bus, train and ferry; taxis were excluded). Main modes of transport were based on the number of unlinked trips using the particular modes of travel, within the trip chains. For example, if ten unlinked trips made a trip chain, and the majority of these trips were as car driver, then the trip chain was a car driver trip chain. However, if the number of car driver or car passenger trips were equal to the number of public transport trips, the trip chain was labelled as either car driver or car passenger trip chain. Car, as either driver or passenger, was given dominance over public transport in this situation because it was most likely that the car, as either driver or passenger, enabled the individual to use public transport by providing the access to this service. This was the most likely situation given the mix of transport modes within the trip chain. It was rare to find instances where the number of car passenger trips outnumbered car driver trips. Obviously, those who drive their vehicles to a destination and then become car passengers for other trips need to be dropped off where they left their vehicles, and thus drive either home or make intermittent trips along the way as car driver. Cases, however, where car passenger trips outnumbered car driver trips, led to the chain being labelled as a car passenger trip chain.

Access and egress trips were not considered as separate unlinked trips if these were walking trips and the following trip was made by a public transport mode (bus, train, ferry). These trips were coded as linked trips due to their short duration. For example, if a person walked to a train station, then this trip was coded as a public transport access trip, and the trip purpose was to change mode of travel. Because it was a walk trip linked to the public transport trip which followed, it only counted as one trip in the trip chain.

The age group variable was recoded to correspond to the age groupings used by the Australian Bureau of Statistics and to group older ages in the manner desired. All age groups were ten year cohorts, except for the youngest age group which included ages 0 to 14 years.

Trip information was then linked into the person file to allow for the simpler interpretation and identification of the trip chains respondents undertook. Weighting procedures as developed by the NSW Transport and Population Data Centre (TPDC) were only applied after construction of the trip chains.

The data base was split into weekday and weekends to obtain travel information over the distinctly different days of the week. Cross tabulations were then performed to produce a breakdown of each type of trip chain by age group. In addition, cross tabulations were undertaken to identify the incidence of other modes within the trip chain type. This yielded important information on the incidence of public transport trips within car passenger and car driver trip chains. The results of the cross tabulations are presented in the following section.

4. Results

The results relate to the 2002 pooled data set from the Sydney Household Travel Survey using data obtained for the Greater Metropolitan Area of Sydney. This includes the Sydney Statistical Division, Illawarra Statistical Division and the Statistical Sub-division of Newcastle. Given that the survey collects travel information over a twenty four hour period, the results show information for the average weekday and the average weekend day. We present findings for the entire population of travellers, by age cohort, to gain an understanding of the travel behaviour of younger cohorts, and to speculate as to whether there are hints on the travel needs and expectations of future senior and elderly cohorts.

Table 2 summarises the split of work and non-work trip chains for the average weekday and average weekend day. Work trip chains accounted for just over 24 percent and almost 9 percent of all trip chains conducted for the average weekday and average weekend day, respectively. This is an interesting finding because, as the population ages in Sydney, the proportion of non-work chains is expected to increase, and thus an increased dispersion of road usage during all times of the day, given the dominance of car trip chains.

Table 2: Trip Chain Counts, Sydney 2002

Trip Chain (Average Weekday)	**Count**	**Percent**	**Percent of All Weekday**	**Trip Chain (Average Weekend Day)**	**Count**	**Percent**	**Percent of All Weekend**
Work Car	686336	80.7	19.6	Work Car	100,252	82.3	7.1
Work Passenger	125674	14.8	3.6	Work Passenger	20,130	16.5	1.4
Work Public Transport	38025	4.5	1.1	Work Public Transport	1,487	1.2	0.1
Total Work	850035	***100***	**24.2**	***Total Work***	***121,869***	***100***	**8.6**
Non-Work Car	1,475,337	55.6	42.0	Non-Work Car	725,596	56.3	51.4
Non-work Passenger	953,720	35.9	27.0	Non-Work Passenger	531119	41.2	37.6
Non-work Public Transport	226,656	8.5	6.0	Non-Work Public Transport	32,554	2.5	2.3
Total Non-work	***2,655,714***	***100***	**75.8**	***Total Non-work***	***1,289,269***	***100***	**91.4**
Total Weekday	***3,505,749***	**100**	**100**	**Total Weekend**	**1,411,138**	**100**	**100**

Table 3 shows the percentage profile of trip chain types for each age cohort. For people aged 25 to 64 years, the car driver trip chain, simple and complex, was the most dominant, which was not surprising. Work and non-work public transport (bus, train, ferry) trip chains represented only a small proportion of the trip chains in this age range. Given that the car is the mode of first choice for the great majority of individuals today, for commuting and non-commuting, who will progressively move into the seniors cohorts over the next 20 years, the prospects for a switch to public transport look rather bleak. Why would they switch to public transport? Even under circumstances of failing health (and/or finances), we hypothesise that solutions centred on car use (as a driver or passenger) are likely to take centre stage. Thus, continued use of the travel mode that individuals are so accustomed to is highly likely during their senior years. A particular by-product is an increase in traffic congestion, in the future, during all times of the day, reinforcing the effects of peak spreading that is already occurring, in order to preserve the benefits of the car. The growing interest in traffic congestion must recognise what is happening in the off-peak, which is likely to get worse over time.

Table 3: Percentage of Trip Chain Type for each Age Group (Average Weekday and Weekend Day)

Trip Chain Type	0-14 yrs	15-24 yrs	25-34 yrs	35-44 yrs	45-54 yrs	55-64 yrs	65-74 yrs	75-84 yrs	85 and over
Simple Work Car Driver	0.0	12.9	16.4	18.0	19.4	14.0	3.1	1.7	0.0
	0	7.3	6.0	4.9	6.1	3.1	1.0	0.0	5.2
Simple Work Car Passenger	0.0	3.6	2.0	0.8	2.1	1.0	0.2	0.2	0.0
	0	4.4	0.5	0.4	1.0	0.8	0.0	0.3	0.0
Simple Work Public Transport	0.0	0.2	0.1	0.1	0.2	0.0	0.0	0.3	0.0
	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Complex to Work Public Transport	0.0	1.6	2.4	1.3	0.9	0.4	0.1	0.0	0.0
	0	0.2	0.1	0.0	0.3	0.1	0.0	0.0	0.0
Complex to Work Car Driver	0.0	0.4	1.9	2.6	1.9	1.0	0.3	0.3	0.0
	0	0.4	0.5	0.5	0.5	0.6	0.0	0.0	0.0
Complex to Work Car Passenger	0.0	0.4	0.2	0.1	0.1	0.0	0.2	0.0	0.0
	0	0.4	0.2	0.0	0.0	0.0	0.5	0.0	0.0
Complex to from Work Car Driver	0.0	0.8	1.6	1.8	1.4	0.9	0.3	0.0	0.0
	0	0.4	0.1	0.1	0.3	0.2	0.0	0.0	0.0
Complex to from Work Car Passenger	0.0	0.8	0.9	0.4	0.5	0.2	0.0	0.0	0.0
	0	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Complex at Work Car Driver	0.0	0.9	2.5	1.0	1.5	1.3	0.1	0.0	0.0
	0	0.1	0.3	0.2	0.2	0.2	0.0	0.0	0.0
Complex at Work Car Passenger	0.0	0.1	0.1	0.1	0.1	0.2	0.0	0.0	0.0
	0	0.2	0.3	0.0	0.1	0.0	0.0	0.0	0.0
Complex from Work Car Driver	0.0	3.8	9.0	8.1	7.8	4.7	2.5	1.9	0.0
	0	2.4	2.3	3.1	3.9	2.7	1.7	0.9	0.0
Complex from Work Car Passenger	0.0	0.8	0.9	0.5	0.7	0.9	0.0	0.2	0.0
	0	0.2	0.9	0.2	0.2	0.4	0.0	0.0	0.0
Simple Non-work Public Transport	3.0	2.0	1.1	0.7	0.7	0.9	2.3	1.8	0.0
	0.5	0.4	0.8	0.2	0.6	0.9	0.1	1.5	0.0
Simple Non-work Car Driver	0.0	21.5	35.7	41.8	39.7	40.5	43.5	35.0	29.9
	0.0	26.4	41.7	49.9	48.7	46.7	46.5	44.1	21.5
Simple Non-work Car Passenger	56.4	17.3	5.3	3.0	4.3	7.6	10.8	17.1	24.5
	64.4	26.4	14.2	10.3	9.8	13.6	20.6	25.0	21.2
Complex Non-work Public Transport	7.0	12.0	2.5	1.4	1.6	3.3	10.1	13.2	16.0
	1.0	3.0	2.1	0.5	1.6	2.0	3.8	3.2	25.1
Complex Non-work Car Driver	0.0	9.3	14.8	16.0	14.3	17.2	18.8	16.6	13.2
	0.0	12.2	19.2	22.8	19.0	18.4	14.0	15.4	5.1
Complex Non-work Car Passenger	34.2	12.0	3.0	2.2	2.9	5.7	7.7	11.7	16.4
	34.1	15.3	10.7	6.9	7.8	10.3	11.7	9.6	21.9

Results in bold are for the average weekday

During the weekend period, the incidence of public transport trip chains conducted by those in the age range 25 to 64 years, declined relative to weekday activity, increasing the share of car trip chains (driver and passenger). This is the likely result of the infrequent nature of public transport services during the weekend period, and importantly suggests that the current state of public transport is not meeting the mobility and accessibility requirements of the majority of persons in the Greater Metropolitan Area of Sydney, relative to the car. Given the increasingly hectic lifestyles of individuals, and thus the increased likelihood of conducting more complex trip chains in order to fulfil their accessibility needs, travel time is likely to be one important constraint retarding the desirability of public transport, especially during the weekend period. Working individuals are unlikely to want their leisure time to be consumed by travel, unless travel itself is a recreational activity. It was not surprising to see the car being used even more by individuals aged 25 to 64 years, in order to satisfy their lifestyle needs. Importantly, these findings show the potentially bleak outlook for public transport: people in this age group mainly use the car to service their accessibility needs and public transport is predominantly used for work trips. In addition, these individuals are very likely to substitute work trips by public transport with non-work trips by the car once they enter their retirement years.

Taking a close look at the 65 to 74 age cohort, the most popular chain profile during the average weekday, shown in Table 3, was the simple non-work car driver chain. Other popular chains, for this age group, were the complex non-work car driver chain (18.8 percent) and the simple non-work car passenger chain (10.8 percent). This was not a surprising result given the dominance of the car driver chains. However, complex non-work public transport chains were also quite popular for this age group (10.1 percent). This was an interesting result because it showed that a higher proportion of people in this age group used public transport to undertake complex trip chains, in contrast to the younger cohorts. In addition Table 4 shows that only 0.3 percent and 1.4 percent of all trips within the complex non-work public transport trip chain, for the 65-74 age group, were by car as the driver or passenger, respectively. Thus, public transport was clearly a popular mode used within this particular trip chain. Importantly this suggests that older people will use public transport, for whatever reason, but presumably when no other transport options are available.

Weekend chains for this age group, also shown in Table 3, show a slight increase in the proportion of simple non-work car driver chains (46.5 percent), and a doubling of the simple non-work car passenger chains, compared to the weekday chains. This was not surprising, given that the proportion of simple non-work public transport chains decreased from the average weekday result by 2 percent. Also, the proportion of complex non-work public transport chains more than halved to 3.8 percent. The reduction in the number of public transport trip chains was likely to be due to the infrequent nature of public transport services during the weekend period. However, complex non-work car driver chains also decreased, but complex non-work car passenger chains increased. This possibly was the result of people participating in activities that involved travelling together.

Table 3 shows that the most popular trip chains for those aged 75 years to 84 years, during the average weekday were simple non-work car driver (35 percent), simple non-work car passenger (17.1 percent) and complex non-work car driver (16.6 percent). However, complex non-work public transport trip chains represented 13.2 percent of all

chains by this age group for the average weekday. This could be due to the unavailability of family and friends during the week; thus support networks were unable to cater to the transport needs of older friends and relatives during this period. This hypothesis may be reinforced by the results shown in Table 4. Only 0.6 and 1.7 percent of all trips made within this trip chain for this age group were as car driver or as car passenger, respectively. This may indicate that public transport will be used by older people if there are no other transport alternatives. However, it cannot be simply stated that the lack of automobile transport will lead to increased public transport patronage.

For the average weekend day, Table 3 shows that the dominant trip chain undertaken by those aged 75 to 84 years was the simple non-work car driver chain (the proportion of this chain increased to 44.1 percent compared to that reported for the average weekday). The proportion of complex non-work public transport chains more than halved to 3.2 percent, compared to the weekday value. The proportion of simple non-work car passenger trip chains increased to 25 percent, complex non-work car passenger chains decreased to 9.9 percent for the average weekend day, whilst the proportion of complex non-work car driver chains remained relatively unchanged. It appears as though drivers in this age group preferred to drive or ride during weekend periods due possibly to the lack of frequent public transport services.

For those aged 85 years and over (the elderly), the dominant trip chains during the average weekday were simple non-work car driver (29.2 percent), simple non-work car passenger (24.5 percent), complex non-work car passenger (16.4 percent) and complex non-work public transport (16 percent). It is noteworthy that individuals in this age group conducted complex non-work public transport chains quite regularly. In addition, Table 4 shows that only 0.5 and 2.8 percent of trips made by individuals within the complex non-work public transport trip chain, were made as car driver and car passenger, respectively. Thus, people aged 85 years and over, who conducted this particular trip chain, almost solely used public transport to service their accessibility needs.

The most dominant trip chains for the elderly, for the average weekend day, were complex non-work public transport (25.1 percent), complex non-work car passenger (21.9 percent) simple non-work car driver (21.5 percent), and simple non-work car passenger (21.2 percent). It is surprising that the complex non-work public transport chain increased in significance compared to the average weekday, given that public transport services are not as frequent during the weekend period. In addition, the results reveal a reduction in the proportion of car passenger trips within the complex non-work public transport chains, possibly due to the lack of availability of support networks to cater to this particular transport need of the 85 and over age group, and the desirability of these older individuals to exert some independence. Thus, again we may hypothesise that older individuals may tend to use public transport if they have no other transport options. These issues require further investigation at a more micro and causal level.

Overall, car trip chains (driver) represented 68.6 percent, 55.5 percent, and 43.1 percent of all chains conducted by young seniors, old seniors and the elderly respectively, for the average weekday. This proportion increased to 60.3 percent for the old seniors, but decreased for the young seniors; 60.3 percent for the average weekend day. These results may suggest that old seniors (75 to 84 years) seem to place more emphasis on driving during the weekend period than the weekday period, possibly due to the lack of

frequent public transport services and the range of destinations they wish to travel to. These destinations may be "out of the way" for family and friends to provide rides to, and given that 51 percent of old seniors have a driver license, it was not surprising that they engaged in more driving during the weekend period (RTA, 2004). In addition, the proportion of car passenger trip chains for young and old seniors increased for the average weekend day compared to the average weekday; 32.3 percent and 34.9 percent respectively. This again was not surprising given that many of the people in these age groups may have participated in activities together thus travelled together. Further investigation is required to gain a more in depth understanding of the actual events leading to these results.

However, the proportion of car driver chains conducted by the elderly (those aged 85 years and over) during the weekend period decreased to 26.3 percent, from a high of 43.1 percent recorded for the average weekday. The very low license rates of the 85 and over population gives rise to an important question: are the mobility and accessibility needs of a high proportion of old seniors being met without these individuals having to physically move? This is discussed in more detail later in this paper. Table 4 shows the percentage of trips within the trip chain that were made by modes of travel other than the main mode indicated.

Table 4: Percentage of Trips Using the Indicated Mode of Travel, Within Trip Chains, Average Weekday and Weekend Day

Chain Type and Other Travel Mode	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85+	Total
Simple Work Car Driver: Public Transport	**0.0**	**0.3**	**0.2**	**0.2**	**0.2**	**0.4**	**2.0**	**0.0**	**0.0**	**0.3**
	0.0	0.0	0.8	0.0	1.3	0.0	0.0	0.0	0.0	0.6
Simple Work Car Passenger: Public Transport	**0.0**	**5.0**	**0.5**	**1.9**	**2.8**	**5.8**	**0.0**	**0.0**	**0.0**	**3.3**
	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Simple Work Public Transport: Car Driver	**0.0**	**0.0**	**0.0**	**0.0**	**2.8**	**0.0**	**0.0**	**0.0**	**0.0**	**1.1**
Simple Work Public Transport: Car Passenger	**0.0**	**8.3**	**0.0**	**0.0**	**3.2**	**0.0**	**0.0**	**10.0**	**0.0**	**4.4**
Complex to Work Public Transport: Car Driver	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Complex to Work Public Transport: Car Passenger	**0.0**	**2.5**	**0.8**	**2.2**	**1.4**	**2.1**	**0.0**	**0.0**	**0.0**	**1.7**
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Complex to Work Car Driver: Public Transport	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Complex to Work Car Passenger: Public Transport	**0.0**	**20.4**	**0.0**	**3.0**	**11.4**	**0.0**	**0.0**	**0.0**	**0.0**	**11.6**
	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.1
Complex to from Work Car Driver: Public Transport	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Complex to from Work Car Passenger: Public Transport	**0.0**	**26.1**	**24.9**	**21.9**	**29.4**	**0.0**	**0.0**	**0.0**	**0.0**	**25.5**
	0.0	0.0	0.0	28.6	0.0	0.0	0.0	0.0	0.0	4.5
Complex at Work Car Driver: Public Transport	**0.0**	**0.0**	**0.0**	**0.0**	**0.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Complex at Work Car Passenger: Public Transport	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Complex from Work Car Driver: Public Transport	**0.0**	**0.0**	**0.2**	**0.3**	**0.0**	**0.0**	**0.0**	**2.3**	**0.0**	**0.2**
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Complex from Work Car Passenger: Public Transport	**0.0**	**5.1**	**2.3**	**1.7**	**6.4**	**0.0**	**0.0**	**33.3**	**0.0**	**3.4**
	0.0	4.1	1.4	0.0	10.0	7.4	0.0	0.0	0.0	2.7
Simple Non-work Public Transport: Car Driver	**0.0**	**0.6**	**1.9**	**0.6**	**2.0**	**3.1**	**0.6**	**2.1**	**0.0**	**1.0**
	0.0	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.4
Simple Non-work Public Transport: Car Passenger	**0.0**	**4.3**	**0.0**	**0.0**	**5.0**	**0.7**	**4.3**	**0.0**	**0.0**	**3.0**
	4.2	0.0	1.0	0.0	0.0	0.9	0.0	0.0	0.0	1.1
Simple Non-work Car Driver: Public Transport	**0.0**	**1.1**	**0.7**	**0.5**	**0.6**	**0.6**	**0.7**	**0.3**	**0.0**	**0.6**
	0.0	1.1	0.5	0.3	0.0	0.0	1.0	0.7	0.0	0.4
Simple Non-work Car Passenger: Public Transport	**2.9**	**7.7**	**4.9**	**4.3**	**1.0**	**1.2**	**3.7**	**0.3**	**0.0**	**3.6**
	0.0	3.1	0.8	0.8	1.1	0.5	0.3	0.2	0.0	0.7
Complex Non-work Public Transport: Car Driver:	**0.0**	**0.4**	**0.4**	**0.9**	**1.5**	**1.5**	**0.3**	**0.6**	**0.0**	**0.5**
	0.0	0.0	1.1	0.0	0.0	1.1	0.0	0.0	0.0	0.4
Complex Non-work Public Transport: Car Passenger	**6.0**	**4.0**	**0.4**	**1.4**	**0.8**	**0.7**	**1.4**	**1.7**	**0.0**	**2.8**
	3.8	0.8	0.8	1.2	1.6	1.2	2.1	1.8	0.0	1.4
Complex Non-work Car Driver: Public Transport	**0.0**	**0.6**	**0.8**	**0.4**	**0.3**	**0.3**	**0.8**	**1.0**	**0.0**	**0.5**
	0.0	0.5	0.1	0.3	0.1	0.1	0.0	0.0	0.0	0.2
Complex Non-work Car Passenger: Public Transport	**6.4**	**12.4**	**7.1**	**2.4**	**4.6**	**3.4**	**4.7**	**2.8**	**2.0**	**6.7**
	0.8	4.7	2.4	2.6	1.6	1.8	1.0	7.8	0.0	2.0

Results in bold are for the average weekday

For people aged 25 to 64 years, the most interesting results are for the car passenger trip chains, work and non-work. The complex to and from work car passenger chains showed that 25.5 percent of all trips within this chain are made by public transport; complex to work car passenger chains show that 11.6 percent of all trips made within this chain are by public transport; and complex non-work car passenger chains show that 6.7 percent of all trips are made by public transport. These proportions decreased significantly during the weekend period.

These results suggest that the mobility and accessibility needs of individuals undertaking complex travel were assisted by using public transport. However, these individuals were car passengers and therefore did not have access to an automobile at all times. In addition, because these individuals are accustomed to using public transport to partially meet their mobility needs, they *may* adopt similar behaviour during retirement. Therefore, they may be willing to use public transport if they do not have access to an automobile in future years, once they enter their senior years.

For individuals aged 75 to 84 years, within the complex from work car passenger chains, 33 percent of trips were recorded as public transport trips. This is quite a high proportion; 10 percent of trips were recorded as public transport trips within all complex from work car passenger chains. This could be due to a lack of network support availability during the weekday period and also the result of these particular individuals wishing to exert some independence. Overall, the evidence suggests that older persons may be willing to use public transport especially if there are no other transport alternatives.

Tables 5 and 6 present average travel times for each trip chain for each age group, weekdays and weekend respectively. The average travel times for the simple non-work car driver chains for people aged 65 to 74 years and people aged 75 to 84 years was 28 minutes during the average weekday. However, the average travel time recorded for those aged over 85 years who undertook this trip chain was lower than that recorded for the young and old senior age groups; 20 minutes respectively. Given that this particular trip chain was the most dominant trip chain conducted by the elderly during the average weekday, the results may indicate that elderly drivers exercise caution and moderate their driving given acknowledgement of their reduced driving ability. Further, because travel times are relatively low, if we use travel time as a proxy for distance and assume that elderly drivers drive at a much slower speed than younger drivers, then this supports the position that elderly drivers moderate their driving. This pattern is also evident for the trip chains during the weekend period. Table 6 shows the average travel time for the simple non-work trip chains conducted by the elderly to be lower than the average travel times recorded for the young and old seniors; 24 minutes opposed to 31 and 32 minutes respectively. Thus the results may show that elderly drivers exert driver modification behaviour during all days of the week.

The average travel times for the simple non-work car passenger trip chains undertaken by the young and seniors old were quite similar; 32 minutes and 28 minutes respectively. The weekend trip chains, shown in Table 6, show the same trend for this particular trip chain for the respective age groups. However, for the elderly, the average travel time for simple non-work car passenger chains was 56 minutes. This is somewhat expected, if friends and family are providing the transport. Further investigation is required to confirm this hypothesis.

Table 5: Average Trip Chain Times for Each Age Group (Weekday)

Chain Type/ Age group	0-14 yrs	15-24 yrs	25-34 yrs	35-44 yrs	45-54 yrs	55-64 yrs	65-74 yrs	75-84 yrs	85+ yrs	Overall
Simple Work Car Driver	0	60	70	62	64	61	50	47	0	63
	0	**43**	**66**	**54**	**55**	**51**	**44**	**30**	**0**	**55**
Simple Work Car passenger	0	45	58	51	42	41	27	71	0	47
	0	**36**	**51**	**29**	**51**	**32**	**8**	**31**	**0**	**43**
Simple Work Public Transport	0	107	70	37	110	34	0	15	0	82
	0	**99**	**80**	**33**	**60**	**0**	**0**	**0**	**0**	**78**
Complex to Work Public Transport	0	91	101	102	85	88	65	0	0	96
	0	**36**	**47**	**46**	**30**	**19**	**18**	**0**	**0**	**42**
Complex to Work Car Driver	0	91	69	60	55	69	58	32	0	62
	0	**62**	**38**	**40**	**36**	**40**	**4**	**5**	**0**	**40**
Complex to Work Car Passenger	0	45	67	46	85	0	42	0	0	56
	0	**18**	**66**	**23**	**34**	**0**	**0**	**0**	**0**	**37**
Complex to from Work Car Driver	0	92	116	72	117	118	72	0	0	97
	0	**34**	**60**	**39**	**89**	**101**	**32**	**0**	**0**	**67**
Complex to from Work Car Passenger	0	110	120	106	120	89	0	0	0	113
	0	**56**	**37**	**39**	**45**	**17**	**0**	**0**	**0**	**44**
Complex at Work Car Driver	0	79	79	79	69	84	34	0	0	77
	0	**42**	**37**	**46**	**36**	**40**	**0**	**0**	**0**	**40**
Complex at Work Car Passenger	0	37	69	87	31	64	0	0	0	64
	0	**11**	**18**	**30**	**5**	**44**	**0**	**0**	**0**	**34**
Complex from Work Car Driver	0	80	77	70	73	81	54	37	0	73
	0	**43**	**54**	**55**	**55**	**67**	**35**	**12**	**0**	**55**
Complex from Work Car Passenger	0	46	63	72	48	49	0	21	0	55
	0	**22**	**32**	**35**	**20**	**32**	**0**	**0**	**0**	**30**
Simple Non-work Public Transport	35	27	25	23	30	23	22	37	0	29
	29	**16**	**21**	**19**	**19**	**15**	**13**	**24**	**0**	**22**
Simple Non-work Car Driver	0	33	26	24	26	28	28	28	20	27
	0	**30**	**23**	**22**	**21**	**24**	**28**	**27**	**16**	**24**
Simple Non-work Car Passenger	26	31	39	30	35	37	29	33	43	28
	24	**24**	**48**	**23**	**28**	**29**	**32**	**28**	**56**	**27**
Complex Non-work Public Transport	76	98	105	94	106	142	101	111	69	97
	49	**51**	**55**	**51**	**73**	**112**	**71**	**84**	**16**	**65**
Complex Non-work Car Driver	0	66	52	49	53	59	52	43	49	53
	0	**41**	**40**	**39**	**41**	**39**	**37**	**26**	**24**	**40**
Complex Non-work Car Passenger	52	67	82	82	76	69	69	77	48	60
	41	**41**	**87**	**67**	**67**	**39**	**69**	**63**	**27**	**50**
Weighted Average	38	56	53	45	48	50	45	49	50	n/a

Results in bold show standard deviations

Table 6: Average Trip Chain Times for Each Age Group (Weekend)

Chain Type/ Age group	0-14 yrs	15-24 yrs	25-34 yrs	35-44 yrs	45-54 yrs	55-64 yrs	65-74 yrs	75-84 yrs	85+ yrs	Total
Simple Work Car Driver	0	38	68	61	57	53	31	0	120	56
	0	**35**	**71**	**48**	**40**	**31**	**19**	**0**	**0**	**50**
Simple Work Car passenger	0	28	44	62	41	48	0	27	0	37
	0	**19**	**22**	**34**	**34**	**40**	**0**	**0**	**0**	**28**
Simple Work Public Transport	0	0	0	0	0	0	0	0	0	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Complex to Work Public Transport	0	60	85	0	128	15	0	0	0	88
	0	**0**	**7**	**0**	**12**	**0**	**0**	**0**	**0**	**40**
Complex to Work Car Driver	0	68	78	67	46	77	0	0	0	67
	0	**13**	**77**	**25**	**22**	**101**	**0**	**0**	**0**	**59**
Complex to Work Car Passenger	0	85	135	0	0	0	44	0	0	89
	0	**50**	**82**	**0**	**0**	**0**	**0**	**0**	**0**	**65**
Complex to from Work Car Driver	0	131	158	59	89	134	0	0	0	109
	0	**81**	**0**	**30**	**60**	**0**	**0**	**0**	**0**	**64**
Complex to from Work Car Passenger	0	74	104	0	0	0	0	0	0	79
	0	**20**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**22**
Complex at Work Car Driver	0	130	47	128	71	60	0	0	0	83
	0	**0**	**7**	**64**	**10**	**0**	**0**	**0**	**0**	**50**
Complex at Work Car Passenger	0	44	100	0	60	0	0	0	0	80
	0	**11**	**64**	**0**	**0**	**0**	**0**	**0**	**0**	**55**
Complex from Work Car Driver	0	67	90	69	71	84	69	35	0	74
	0	**38**	**78**	**50**	**61**	**64**	**63**	**0**	**0**	**60**
Complex from Work Car Passenger	0	55	57	80	71	47	0	0	0	59
	0	**22**	**36**	**16**	**13**	**17**	**0**	**0**	**0**	**31**
Simple Non-work Public Transport	25	28	51	15	89	37	10	19	0	43
	10	**25**	**25**	**15**	**89**	**38**	**0**	**14**	**0**	**50**
Simple Non-work Car Driver	0	37	31	32	29	32	31	32	24	32
	0	**37**	**32**	**33**	**31**	**26**	**33**	**36**	**15**	**32**
Simple Non-work Car Passenger	33	36	50	37	41	41	34	35	52	36
	32	**41**	**81**	**43**	**55**	**42**	**30**	**33**	**40**	**44**
Complex Non-work Public Transport	98	85	112	110	110	117	115	98	124	106
	54	**57**	**62**	**60**	**56**	**76**	**61**	**34**	**64**	**62**
Complex Non-work Car Driver	0	71	74	64	68	64	68	65	45	68
	0	**47**	**66**	**49**	**59**	**54**	**48**	**65**	**0**	**56**
Complex Non-work Car Passenger	68	78	72	76	100	77	63	83	54	74
	51	**68**	**46**	**68**	**140**	**59**	**51**	**68**	**56**	**68**
Weighted Average	45	58	53	46	49	48	45	45	72	n/a

Results in bold show standard deviations

Looking at the complex non-work public transport trip chain, it was not surprising to find that as age increased, average travel time decreased, given that physical and cognitive disabilities become more apparent as one ages. The elderly recorded the lowest average travel time, 69 minutes. However, when looking at the information presented in Table 6, the average travel time for the complex non-work public transport trip chain, by those aged 85 years and over, was greater than that recorded for the 75 to 84 age group. The average travel times were 124 minutes and 98 minutes respectively. This is a surprising result because one would not expect the average travel time associated with this travel behaviour to exceed that recorded for the old seniors, given the increased onset of disability. These results may also depict that support networks were unable to satisfy all of the accessibility needs of the elderly and it may also be possible that these individuals felt a need to exert some independence.

The weighted average travel times for the trip chains reinforce the trends observed. The weekday results show that the average travel time for the senior and elderly cohorts were quite similar. The weekend result confirms the trend discussed earlier; average travel time for the elderly exceeded that for the senior age groups. Further in-depth investigation is required to gain a better understanding of the underlying issues that result in particular travel behaviours, especially in relation to the travel patterns of the elderly.

5. Discussion

The expected increase in the non-work trip chains in the future will see further temporal dispersion of travel demand rather than the traditional travel demand peaks, given that the results of the trip chain analyses show that the majority of non-work trip chains were conducted by car, as driver or passenger, over the entire week. This may represent a better utilisation of underused road capacity. However, it is also likely to result in increased road congestion. This has specific implications for transport planners and policy makers, given the increase in use and the corresponding increase in safety concerns. This could be presented as one reason to improve public transport services now.

In addition, people aged 25 to 64 years are most likely to use to the automobile, as either driver or passenger, for most of their travel. This poses a challenge for policy makers; as these individuals age and enter retirement, an increasing number will, by choice, be automobile dependent. This suggests a greater focus on policy to cater for the mobility and accessibility needs of future elderly cohorts, whilst also maintaining driver and pedestrian safety. Clearly, safety issues surrounding older drivers and the impacts of in-vehicle technology and advances in medicine need to be investigated to develop improved older driver assessment procedures. For example, should we be continuing with mandatory annual driving licence tests for individuals over 84 years old, who in large adopt risk minimising behaviours to ensure they drive safely and do not lose the accessibility benefits of the car? Such behaviours include only driving during good weather and during the day on roads they are familiar with. This is part of ongoing research at the Institute of Transport and Logistics Studies.

For individuals aged 65 to 74 years, almost 88 percent of all trip chains were by car, either as driver or passenger, during the average weekday. During the average weekend day, this proportion increased to 96 percent. For those aged 75 to 84 years, over 84 percent of chains conducted during the average weekday, were by car, either as driver or passenger. This proportion increased to 96 percent for the average weekend day. In summary, these results show that the automobile was the most dominant mode of transport used by young and old seniors and confirms findings in the literature (Gantz, 2002; Rosenbloom, 2001; Donaghy *et al.*, 2004; Tacken, 1998; TPDC, 2004).

However, the real interest in the future is the expected increase in the population aged over 84 years and their modal preferences and activity. Currently, of the individuals over 84 who undertook a mandatory driving examination in New South Wales, an average of 61 percent of females and 71 percent of males passed this examination in 2004. It is not known how these pass rates will change in the future, as more people enter this stage in their lives. However, people aged 85 years and over with a driver's license only represented 16 percent of the total population in this age group (RTA, 2004). Thus, how are the majority of people within this age group meeting their mobility and accessibility needs?

The trip chain findings show that public transport *may* have a role to play in relation to catering to the older populations' transport needs. It was quite surprising to find that the complex non-work public transport trip chains were amongst the most dominant trip chains conducted by old seniors and the elderly. This suggests that public transport may satisfy some of the mobility and accessibility needs of future generations of older persons (Bonham *et al*., 2004; Davey, 2004; Straight, 2003). There is an important caveat: driving license rates amongst old seniors and the elderly are expected to increase in the future, increasing the likelihood of car travel, as drivers. The likelihood of public transport use declining in the older cohorts is very real, especially if radical improvements to public transport are not made now.

An improved public transport system, which better links all services, reduces transit times and travel times, offers better levels of service, and better access to public transport, in terms of rest benches and shelters from the pedestrian's perspective, could better serve the needs of older people. There is a need to move away from rigid public transport systems and develop more universally friendly public transport systems, such as flexible bus systems. Improvements to the public transport system now will allow more people to become familiar with the public transport system before they enter retirement, removing the sense of unfamiliarity (ECMT, 2002). This may increase the likelihood of public transport use in older age as well potentially increase public transport patronage of the general population. The task however is massive and says nothing about the continuing benefits of a door-to-door travel mode.

It cannot be simply claimed that the loss of driving ability will lead to an increase in public transport use; there are too many physical and psychological barriers at present to allow this to occur. In addition, despite the numerous citations about the consequential reduction in mobility and accessibility due to the cessation of driving (Okola and Walton, 2003; Ritter *et al*., 2003; Rosenbloom, 2004; Rosenbloom, 2003), not all the perceived loss in mobility, usually measured by the reduction in trips, may be a negative repercussion of the loss of one's driving license. The future may see an increase in the ability of older people to satisfy their accessibility needs without having to move

beyond their armchairs – they become the destination. Technology, such as the Internet, enables people to conduct shopping activities without having to physically leave their homes. Older generations of the future are expected to be more technically savvy, thus may make more use of this technology for shopping, banking and other personal business activities. In addition, family and friends may increasingly visit older friends and relatives; satisfying a social activity and reducing the need for older persons to physically leave their homes. We refer to this as reverse isolation.

The traditional household travel survey may be shown to be deficient in providing the necessary data to measure accessibility for the elderly. Although there is data about the incidence of social visits, there is no detail to identify who was visited: no information is captured relating to the incidence where older people's mobility and accessibility needs are being satisfied by others visiting them. In other words, traditional household travel surveys do not recognise the full supply chain of agency support for the elderly in which the so called loss of mobility, reported in much of the literature consulted, may indeed be false, given that other agents provide the benefits of mobility through visiting the elderly (Okala and Walton, 2003; Ritter *et al*., 2003; Gantz, 2002; Donaghy *et al*., 2004; Rosenbloom, 2004; Rosenbloom, 2004). There is the need to recognise the packaging of service provision in establishing the levels of accessibility, which is what matters, and not the amount of mobility associated with the elderly member of the agency set.

6. Conclusion

This paper has reported the results of trip chain analyses which specifically looked at the travel behaviour of older individuals. The empirical findings provide an insight into the travel behaviour of this increasingly important segment of the population.

The future will pose many challenges for an aging population, especially in relation to transport service provision, urban planning and management. One challenge is to establish the role that new technology, changing government policy and the changing socioeconomic characteristics of the future young and old seniors and how these affect travel behaviour and hence the mobility and accessibility responses of the elderly.

In ongoing research, the Institute of Transport and Logistics Studies is investigating (i) the role of service agents in meeting the accessibility and mobility needs of the future generations of older people, (ii) the ability in real conditions, of older drivers to maintain safe driving behaviours so as to preserve their ability to drive a car, and (iii) the potential role of public transport in contributing to meeting the travel needs of seniors in an aging population.

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