MONASH University

MONASH UNIVERSITY ACCIDENT RESEARCH CENTRE

ROAD SAFETY COMMISSION

Safe vehicles and older adults: enhancing travel and mobility options

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1 Introduction

A major shift is occurring in the age distribution of Australia's population. By 2061, the proportion of Australian adults aged 65 years and over is expected to reach 22 percent and the proportion of adults aged 85 years and over is expected to reach five percent (ABS, 2013). Similar trends are occurring in Western Australia, with an increase in the proportion of older adults and subsequent increase in the median age forecast (ABS, 2013).

With the ageing of the population, it is anticipated that there will be an increase in the number of older adults using the transport system. Further, while it is expected that the private motor vehicle will remain a key mode of transport for the emerging cohorts of older drivers, there are rapid changes to transportation, with a reduction in private vehicle use and an increase in use of other travel modes such as self-drive, volunteer services and active travel (Marottoli & Coughlin, 2011). Notwithstanding the mode of travel, it is clear that future cohorts of older road users will be more mobile, travel more frequently, travel greater distances, and will have higher expectations with regard to maintaining personal mobility compared with earlier cohorts OECD, 2001).

While there is a strong emphasis around the world for older adults to maintain their mobility for as long as possible, their safety is also a serious community concern and one that requires innovative measures to reduce crash and injury risk (Langford & Koppel, 2006).

Casualty crashes amongst older Western Australians are clearly of concern. Of the 161 deaths on Western Australia's roads in 2017, 12 percent involved adults aged 80+ years (a fatality rate of 23.1 per 100,000 residents, substantially higher than the state-wide rate of 6.2) – this was a marked increase compared with the five-year average. Further, older adults aged 80+ years comprised one-third of all pedestrian fatalities in 2017 (Western Australia Road Safety Commission [WA RSC], 2018). Moreover, given the ageing of the population and associated increases in numbers of older adults using the road transport system, there is an urgent need to manage the safe mobility of current older drivers as well as plan effectively for future cohorts.

Within the Safe System approach, one of the most promising methods to address overall safety is through safer vehicles and technology. In particular, promoting the purchase of safer vehicles equipped with key safety features for current drivers, use of technology to enhance accessibility, and use of alternative transport modes for those planning their transition to retirement from driving. In addition, there is evidence that many current technologies, such as Advanced Driver Assist System (ADAS) technologies can potentially mitigate the occurrence of common older driver crash types (e.g., Intelligent Speed Assist [ISA], lane-keeping and forward and lateral collision technologies to reduce the incidence of various crash types).

The deployment of Intelligent Transport System (ITS) technologies has the potential to yield a new wave of road safety and other benefits for Australia and can play a key role in managing the safe mobility of older adults. It is critical for their success that these systems are tailored to the specific safety needs of road users and that human factors knowledge and principles are incorporated into the design, deployment and evaluation of these systems (Regan, Oxley, Godley & Tingvall, 2001; Logan, Young, Allen & Horberry, 2017).

While a recent survey (C-MARC Safe Vehicles project) examined the use of and adaption to ADAS, only a small proportion of respondents were older adults. Hence, there is little known about older Western Australians' use of safe vehicles and ADAS technologies, particularly in regard to their adaptation to new technologies in vehicles and other transport modes, and there is a pressing need to better understand these issues.

Notwithstanding the paucity of research on older people's attitudes and use of vehicle-specific technologies, there is good evidence that the use of technology is increasing amongst older populations, especially amongst younger cohorts (60-70 years) but also amongst older cohorts (75+ years), and that increased use of technology among these groups is beneficial, for instance, enabling them to access information, advice, goods and services with more ease (Langford & Mitchell, 2003; Age UK, 2016). It is suggested in-vehicle assistive technologies can address older drivers' functional decline and avoidable behaviours, assist older drivers with regular driving activities and increase safe mobility (Rakotonirainy & Steinhardt, 2009). It is also suggested that older adults are willing to accept in-vehicle technology that assists their driving (Musselwhite & Haddad, 2007; Bryden, Charlton, Oxley & Lowndes, 2013; Koppel & Charlton, 2013). Access to such assistive technologies may also improve the general awareness of older drivers in planning their transition to retirement from driving.

With the rapid propulsion into the technology age, it is appropriate and timely that this project provides an enhanced understanding of the uptake of safer vehicles and adaptation to in-vehicle technologies by older adults. Furthermore, there is a need to consider the way in which communication technologies can be leveraged to assist older people access safe and sustainable transport options beyond driving their private motor car.

1.1 Study Aims

The overall aim of this project is to enhance our understanding of the issues surrounding the use of safer vehicles and technologies that can promote or incentivise the use of other travel options that will enhance the mobility of older Western Australians. Specifically the aims of the project were to examine:

a) The extent of use of safer vehicles amongst older adults;

b) Awareness of, acceptance of and adaptation to new vehicle technologies;

c) Mobility needs, expectations for future mobility and intentions regarding uptake of alternative transport modes; and

d) Current resources, tools and programs aimed at encouraging mode shift from driving to other transport modes.

1.2 Structure of Report

In order to achieve the above aims, two discrete project tasks were undertaken, including a review of the literature and a survey of older Western Australian road users.

The methods undertaken for each project task are described in detail in the following sections, however a brief overview of the methods and the structure of the report are provided here.

Section Two presents the findings of the literature review. The review was conducted to understand a number of issues associated with technology and the mobility options for older adults including:

- The role of technology in transport safety and delivering transport information and education to older adults;
- Knowledge regarding safer vehicle choices amongst older adults;
- Understanding human factors issues and behaviours regarding in-vehicle technologies;
- Understanding current update of technologies including adaptation to use of technologies; and
- Identification of technological initiatives and incentive schemes to support the transition from driver to non-driver including methods to encourage travel mode shift and use of alternate modes of transport.

Section Three presents the findings of the survey that was conducted to further our understanding of the issues surrounding mobility and technology for older adults. First the methods for data collection are provided, including the development of the survey, recruitment, and telephone interview. This is followed by detailed reporting of the results of the survey.

Section 4 brings together the findings of the literature review and the survey responses to provide a summary and discussion of the findings. In addition, a suite of recommendations is provided for implementation of effective policies, resources and practices to assist older adults maintain safe driving and successful transition to alternative transport modes.

2 Literature Review

2.1 Methodology

To undertake the literature review, a comprehensive methodological approach was adopted. Details of the methodology are described below.

2.1.1 Search Terns

First, a set of keywords, phrases and search terms and their combinations were generated for searching the scientific literature and library databases.

The search terms included: “older drivers”, “older driver safe mobility”, “vehicle technology”, “acceptance of technology”, “willingness to pay”, “assistive technology”, “vehicle safety”.

2.1.2 Databases

Relevant published scientific literature was sourced using a range of search engines and databases, available through Monash University and other library services (with the assistance of a specialist transport/public health librarian). The main databases and search engines that were accessed included:

- International Transport databases: *Transport* Research International Documentation (TRID); Transportation Research Information Services (TRIS); International *Transport* Research Documentation (ITRD); Transport; and,
- Health, education, science and safety databases: ProQuest; Ovid (platform for Medline, Embase, Psychinfo, Transport); Web of Science; The Cochrane Library.

In addition, ‘in-house’ national and international literature and other grey literature was sourced by accessing selected national and international websites.

The literature search was restricted to resources published in English, post-2000.

2.1.3 Grey Literature

In addition to using the search terms for the published literature (described above), Google Scholar was used to source grey literature. Further, websites of each Australian jurisdiction were sourced for information, as well as selected international jurisdictions known for their exemplar road safety records (e.g., Canadian, United Kingdom, European, and US jurisdictions). Selected webpages, reports and papers were searched and accessed for relevant information.

2.2 Technology in Transport Safety

A wide range of in-vehicle and other technologies that have been developed to improve safety and efficiency of cars, commercial vehicles, public transport and trucks are already commercially available worldwide, and continue to be developed. Systems available vary from those that provide the driver with information, for example about congestion or obstacles on the road ahead to more complex systems that take over driving tasks in hazardous situations, or fully drive vehicles in all conditions. Given that many of these systems are relatively new, it is still not clear whether a given ITS application will, or will not, enhance safety. This is mainly due to the fact that many technologies have not yet been deployed in vehicles on a large enough scale and over along enough period of time in traffic for the crash numbers to be a reliable indicator of a change in safety (Regan et al., 2001; Logan et al., 2017; Newstead, Watson, Keall, Cameron & Rampollard, 2019).

A number of vehicle safety technologies were identified that have the potential to improve older driver safety. These technologies fall into three broad categories, namely Intelligent Transport Systems (ITS), Advanced Driver Assistance Systems (ADAS), and Autonomous Vehicles (AVs).

AVs refers to automated vehicles which are rated between levels 3 and 5 on the SAE's J3016 'levels of driving automation' standard (SAE, 2018). These vehicles have the ability to take control of the driving function (to varying levels) as illustrated in Figure 2.1 through the utility of multiple sensors and computer analytics that are capable of performing real-time detection, analysis and reactions to the road environment (Canadian Senate, 2018).

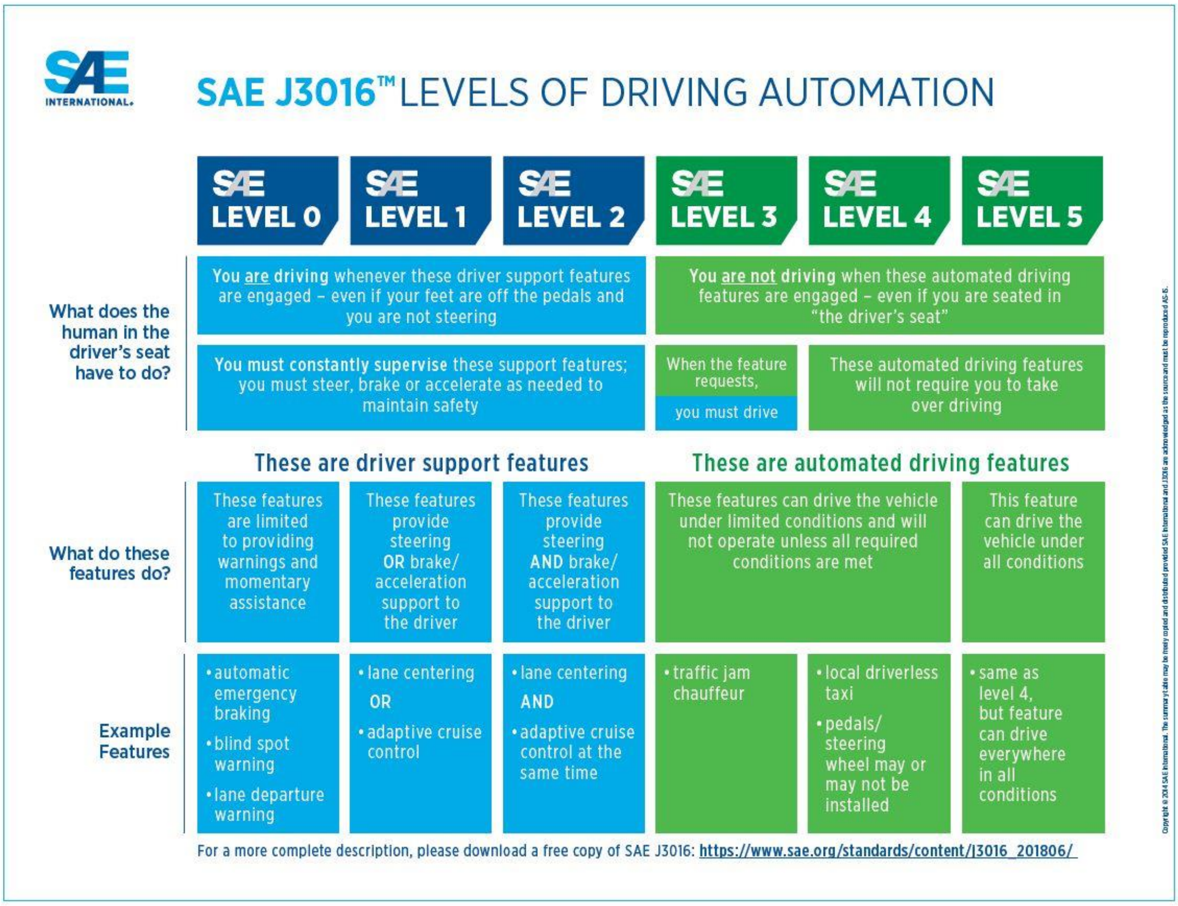

Figure 2.1: SAE's levels of driving automation (SAE, 2019)

The key features of each level are described below:

Level 1 — Driver Assistance: A driver is still the driver, and continues to be in charge of mostly every driving function. However, the car includes some functions that are designed to warn the driver of hazards and if action is not take the vehicle will intervene. Vehicles with ADAS features are considered to be Level 1.

Level 2 — Partial Automation: Vehicles are equipped with features that can take control of the vehicle if a driver does not react to warning systems. Many luxury vehicle manufacturers are now producing and selling Level 2 cars that can take control of the vehicle (e.g., control steering and speed simultaneously), without driver interaction for short periods of time (under 1 minute, and, in some cases, seconds). While the vehicle is able to react to warning systems, can steer, and can adjust the speed, the driver is still required to drive the vehicle and pay attention to the road.

Level 3 — Conditional Automation: In Level 3 vehicles, a driver is still needed, but can transfer safety-critical functions to the vehicle, depending on traffic and other conditions. The system manages most of the driving and assesses the traffic dynamics. The system will cues a driver to intervene when it encounters a scenario it can't navigate, at which time the driver must take over. The key point in moving from Level 2 to Level 3 autonomy is that Level 3 expects that the driver only has to intervene whenever the vehicle is not able to handle the driving task.

Level 4 — High Automation: Moving from Levels 3 to 4 is a significant leap. At this Level, vehicles do not require human intervention, but are limited to certain operational domains. Level 4 vehicles perform all safety-critical driving functions and monitor all roadway conditions for the duration of all trips. However, a driver still needs to be aware while travelling in the vehicle, as Level 4 does not fulfil every driving scenario. For example, a driver may have to take over driving if certain road types or geographic areas require it. A driver may alternate involvement between active engagement and system management, such as managing all driving duties on surface streets, then becoming a passenger as the vehicle enters a multiple lane highway. Compared with Level 3, Level 4 is able to handle 'fall-back' to manual driving and is therefore considered safer than Level 3.

Level 5 — Full Automation: At Level 5, the self-driving system is equal to the driver in all vehicle functions, traffic, environmental decision-making, and emergency situations. The vehicle can operate on any road and in any conditions in which a human driver could negotiate. The vehicle must be capable of assuming control under all conditions, with no intervention required by the human driver at any time.

AVs are a rapidly advancing technology, with claims that some vehicles may be introduced within the very near future). These technologies are increasingly being incorporated into ride-share services (e.g. Uber), taxis (e.g. nuTonomy) and public transport (e.g. Olli and Intellibus). It is predicted that level 5 technology may be ready for deployment by the year 2030 (International Transport Forum, 2015).

While fully AVs are likely to be some years away from creating an impact on older drivers' safe mobility, many current vehicles are equipped with features within the SAE standard levels 0 to 2 (SAE, 2018). Many of these features fall under within the ADAS category which refers to driver support technologies that can sense and predict potential dangers to vehicle occupants and other road users, with or without active intervention. ADAS generally fall under levels 0 to 2 of driving automation on the SAE standard (SAE, 2018). ADAS are capable of enhancing driver safety while undertaking a variety of complex driving tasks, thus helping prolong the safe mobility of older drivers. There are many technologies that fall under the umbrella of ADAS, with some being more passive systems that are designed to provide visual, auditory and / or tactile warnings, while others are more active systems that are capable of actively intervening to rectify or mitigate potentially harmful situations (e.g., applying brakes, correcting lane position). ADAS can be grouped by function. These functionalities include forward vision and safe distance maintenance (e.g. Forward Collision Warning, Automatic Emergency Braking, Adaptive Cruise Control and Night Vision Enhancement), lane management (e.g. Blind Spot Monitoring, Lane Departure Warning and Lane Keeping Assist), rear vision and parking (e.g., Parking Assist and Rear Cross Traffic Alert) and negotiating turns and intersections (e.g. Cross Traffic Detection and Adaptive Headlights) (MRCagney, 2017; Eby et al., 2018). Other ADAS have been developed to monitor and enforce driver behaviours (e.g. Fatigue Warning System, Alcohol Interlock and Seatbelt Interlock) (Searson, Ponte, Hutchinson, Anderson & Lydon, 2014) or provide emergency notification (i.e. Automatic Collision Notification). Brief descriptions of common ADAS are provided below.

Forward Collision Warning (FCW) systems rely on sensors to detect slower moving or stationary vehicles or other obstacles in the path ahead, and alert the driver of an impending collision with so that a driver can brake or swerve to avoid a collision. Some versions will take control of the vehicle if there is no human response and independently complete the avoidance manoeuvre.

Automatic Emergency Braking (AEB) is a feature that brakes the vehicle automatically if it detects a slow-moving or stationary vehicle in front if the situation becomes critical and no human response is made. Some vehicles can detect pedestrians and cyclists and brake automatically for these road users too. Often used in conjunction with Forward Collision Warning.

Adaptive Cruise Control (ACC) is a system that automatically adjusts the vehicle speed and adapting to changing traffic conditions, slowing down or speeding up with traffic as needed. While this feature provides a different functionality than FCW and AEB (comfort vs safety), it still relies on the same technology and principles to variably adjust a vehicle's speed in order to maintain a safe distance from vehicles ahead at highway speeds. Other variants of ACC are the stop-and-go ACC (or traffic jam assist), which allow for the same functionality in stop-and-go traffic on inner city roads (MRCagney, 2017).

Intelligent Speed Assist (ISA) detects the speed limit on roads and alerts drivers if they exceed the speed limit. In some vehicles the system will intervene and independently slow the vehicle to the posted speed limit.

Electronic Stability Control (ESC) helps drivers to avoid crashes by reducing the danger of skidding, or losing control as a result of over-steering. ESC becomes active when a driver loses control of their car. It reduces engine power and applies individual brakes to help the driver maintain control of the car.

Night Vision Enhancement utilises a forward facing infrared camera to display an enhanced view of forward vision in very dark conditions. This system assists drivers to clearly see road hazards (vehicles, pedestrians, animals, etc.) and alert a driver to these hazards while driving at night.

Blind Spot Monitoring (BSM) monitors vehicles traveling in blind spots, and provides the driver with a warning to avoid changing lanes until that vehicle has moved out of the blind spot.

Lane Departure Warning (LDW) has the ability to detect change of lanes and warn the drivers to intervene. Lane Keeping Assist (LKA) relies on the same principles as LDW, but has the ability to actively intervene to bring the vehicle back into the lane.

The right turn assist (or left turn assist) function can issue a warning to the driver or can automatically apply the brakes in order to avoid a collision with oncoming vehicles when turning across opposing traffic.

The lane change assist system makes changing lanes safer by detecting the presence of vehicles in a driver's blind spot and alerting the driver and/or independently steering to avoid collision.

In terms of parking and rear-vision ADAS, Rear Cross Traffic Alert (RCTA) is comparable in functionality to FCW, but provides a warning to the driver and can brake automatically when a vehicle or obstacle is detected in the rear path while reversing (MRCagney, 2017). Parking Assist allows drivers to detect obstacles when reversing by employing rear sensors that provide audible warnings in reference to obstacle proximity, and/or through the use of a rear-view camera to allow for better visibility. Further advancement in parking assist technologies have seen the introduction of semi-autonomous parking assist, where the vehicle can assume control of driving in order to park into a parking space (Eby, Molnar, Zakrajsek et al., 2018).

Cross Traffic Detection (CTD) detects oncoming traffic from both the right and left sides, and provides a warning to the driver. More advanced systems can intervene to stop the vehicle. Adaptive Headlights use "steerable" headlights to adjust light beams in the direction the vehicle is being steered.

Fatigue Warning Systems (FWS) utilise either eye-lid detection to monitor driver drowsiness or loss of concentration by monitoring driver actions to detect degradation of driver performance. Once this is detected, the driver is alerted to prompt them to take a break. The system will alert a driver through visual and/or auditory warnings that increase in intensity until action is taken. In some vehicles, the vehicle will intervene with braking and steering to avoid collision.

Finally, Automatic Collision Notification (ACN) detects a vehicle's involvement in a crash and notifies emergency personnel of it.

The last of the three broad categories is ITS. While ITS can refer to a whole suite of traffic engineering innovations in management of traffic, the primary technologies of concern to driver safety are Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication systems (Canadian Senate, 2018). V2V allows for nearby vehicles to establish a short-range communication system based on speed and positioning to alert drivers/vehicles to potential crashes (Searson et al., 2014; Dutschke, Searson, Ponte, Ryan & Anderson, 2017), while V2I allows for road infrastructure to communicate with nearby vehicles regarding road and traffic information (Searson et al., 2014, 2014; Governers Highway Safety Association [GHSA], 2018). Both technologies are still in their infancy, with experts predicting them to be 20 to 30 years away from mainstream deployment. It is likely that V2X systems are likely to be applied to enhance the operation of self-driving vehicles.

2.3 Benefits of Vehicle Safety Technologies

Perhaps the most promising of all vehicle safety technologies, AVs are believed to be safer, more economical, and more environmentally friendly than vehicles equipped with ITS or ADAS. Australian and international experts widely regard AVs to be of the greatest potential in mitigating crash fatalities and injuries on the road (RACV, 2014). In Canada, it is estimated that AVs will result in an estimated potential savings of CAD65 billion per year, and could prevent up to 80 percent of all collisions and road casualties (Canadian Senate, 2018). In addition to this, it is argued that automated driving can help improve older people's mobility while decreasing traffic congestions (Anderson et al., 2014; Schoettle and Sivak, 2014). Moreover, there is some evidence that older drivers believe that AVs can help mitigate the effects of ageing on their driving performance, and help them safely manoeuvre through high risk driving situations they may encounter on a daily basis (Gish, Vrkljan, Grenier & Van Mittenburg, 2017).

Commonly regarded as the most effective of all ADAS, AEB is predicted to bring about significant improvements in road safety in Australia in the coming years (Searson, Ponte, Hutchinson, Anderson & Lydon, 2015). A meta-analysis of crash data in six countries found a 38 percent total reduction in rear-end crashes for vehicles equipped with AEB technology (Fildes, Keall, Bos, et al., 2015). This result compares well with other international literature that investigated the effects of AEB, where generally a 20-45 percent reduction in road crashes was concluded (Sugimoto & Sauer, 2005; Grover, Knight, Okoro, Simmons et al., 2008; HLDI, 2011; Hummel, Kühn, Bende & Lang, 2011; Döcke, Anderson, McKenzie & Ponte, 2012). Other studies have predicted that an aggressive introduction strategy of AEB would bring about reductions of 20 percent and 25 percent in fatalities and injuries due to crashes, respectively (Searson et al., 2014; Dutschke et al., 2017). In comparison, a slow introduction scenario are estimated to be limited to 12-14 percent reductions in fatalities and 15-17 percent reductions in injuries. It is roughly estimated that AEB alone could potentially save the Australian economy AUD5 billion per year that would, otherwise, be associated with crash costs (Searson et al., 2014).

Yue, Abdel-Aty, Wuc and Wang (2018) evaluated a number of ADAS technologies and their combinations against crash records, and estimated that ADAS could lead to reductions of 33 percent and 41 percent in total crashes for light vehicles and heavy vehicle's, respectively. They also estimated that ADAS could lead to a 47 percent reduction in rear-end crashes for both vehicle categories. This means that while ADAS have demonstrable benefits in many different crash scenarios, they tend to have the most benefits in rear-end crashes and in heavy vehicles. Furthermore, their results suggest that ADAS technologies generally fare better when used in a combined format (i.e., multiple ADAS technologies in a single vehicle). Other studies that evaluated non-intrusive ADAS technologies such as FCW and LDW found them to significantly improve driver behaviours (Ben-Yaakov, Maltz, & Shinar, 2002; Birrell, Fowkes, & Jennings, 2014; Blaschke, Breyer, Färber, Freyer, & Limbacher, 2009).

With regard to older drivers, Classen, Jeghers, Morgan-Daniel, et al. (2019) reviewed 28 studies on the impacts of ADAS on this group. They found that ADAS, particularly FCW and AEB, improved older drivers' performance and compensated for deteriorations of age in dealing with complex situations.

A summary of study findings on the effectiveness of several ADAS technologies is provided in Table 2.1.

Table 2.1: Summary of research findings on the effectiveness of ADAS technologies

Name of technology	Findings
Forward collision warning	• Might lead to a trauma reduction of 2% (Paine, Healy, Passmore, Truong & Faulks, 2008) • Could address 38% of crashes in the US (study did not distinguish between vehicles with standalone FCW and those equipped with FCW+AEB) (Farmer, 2008)
Autonomous emergency braking	• Could address 38% of crashes in the US (study did not distinguish between vehicles with standalone FCW and those equipped with FCW+AEB) (Farmer, 2008) • Could address 20% of crashes in the US (Jermakian, 2011) • Could reduce crash fatalities by 36% in striking vehicles, and 28% in struck vehicles (Kusano & Gabler, 2011) • Could lead to 22% reduction crashes and 20% reduction in crashes involving vehicles (HLDI, 2011) • Could lead to 44% reduction in pedestrian fatalities and 33% in serious injuries (with a 180-degree field of view) (Rosen et al., 2010) • Estimated saving of 5-10% in fatalities and serious injuries over the period of 2010-20 (Budd et al., 2015) • Could lead to a 38% overall reduction in rear-end crashes for vehicles fitted with AEB compared to a comparison sample of similar vehicles (Fildes et al., 2015)
Adaptive cruise control	• Might lead to a trauma reduction of 1.5% (Paine et al., 2008)
Night vision enhancement	• Might lead to a trauma reduction of 0.4% (Paine et al., 2008)
Blind spot monitoring	• Might lead to a trauma reduction of 0.5% (Paine et al., 2008) • Estimated saving of 0.6-1.2% in fatalities and serious injuries over the period of 2010-20 (Budd et al., 2015) • Relevant in 1% of crashes (Gottselig, Eis, Wey& Sferco, 2008) • Might lead to 1% reduction in fatalities (Anderson et al., 2011)
Lane departure warning	• May be relevant in as many as 8% of crashes (Farmer, 2008) • May be relevant in as many as 4% of crashes (Gottseliget al., 2008) • Might lead to a trauma reduction of 2% (Paine et al., 2008)

Name of technology	Findings
	• Might lead to an estimated reduction of 7% in road fatalities (Anderson et al., 2011) • Might lead to an estimated reduction of 3% in road crashes (Jermakian, 2011) • Estimated saving of 0.2-0.5% in fatalities and serious injuries over the period of 2010-20 (Budd et al., 2015) • Lane Keep Assist was estimated to yield a 30% reduction for all head-on and single vehicle run-off-road crashes in Sweden (excepting snow-covered roads), (Sternlund et al., 2017). • Logan et al (2017) estimated an advanced LKA system would have an effectiveness of 26-41% in an Australian environment.
Right turn assist	• Logan et al (2017) estimated a warning-only version of this technology could prevent 27-42% of this crash type in Australia.
Intersection Movement Assist	• IMA was estimated to prevent 33-51% of serious injury intersection crashes (Logan et al., 2017)
Parking assist (i.e. reversing visibility systems)	• Has the potential to reduce back-over or reversing collisions with vulnerable road users, particularly children in driveways (Henderson, 2000) • Could potentially reduce fatalities resulting from back-over crashes involving light vehicles by 28-33% (NHTSA, 2014b)
Fatigue warning system	• Might lead to a 10% reduction in crashes (COWI, 2006) • Might lead to a trauma reduction of 2% (Paine et al., 2008) • Estimated saving of 1.5-3.2% in fatalities and serious injuries over the period of 2010-20 (Budd et al., 2015)
Seat belt interlocks	• May result in a reduction in all fatalities of around 2% and a reduction of 7% for serious injuries in South Australia by 2030 if made mandatory by 2015 (Searson & Anderson, 2013)
Automatic collision notification	• Estimated fatality reductions in the US of between 1.5% and 6% (Clarke and Cushing, 2002) • Estimated fatality reductions in the US of 1.8% (Wu, Subramanian, Craig, Starnes & Longthorne, 2013) • May have resulted in a reduction in all fatalities of around 3.6% or a reduction of 4.4% for vehicle occupant fatalities in Finland (Sihvola Luoma, Schirokoff, Salo& Karkola,., 2009) • May have resulted in a reduction in all fatalities of around 2.8% in France (Chauvel & Haviotte, 2011) • May have resulted in a reduction in all fatalities of around 2.2% or a reduction of 2.8% for passenger vehicle occupant fatalities in South Australia for the period of 2008/9 (Ponte, Ryan & Anderson, 2013)

While no large-scale studies have been conducted to date to investigate the real-world benefits of V2V and V2I communication, smaller field trials conducted on V2I have shown marked improvements in traffic light and stop sign recognition by drivers (Brewer, Koopmann & Najm, 2011; Fukushima, 2011). It is estimated that in a world where V2I is available in half of all roads, almost all relevant crashes will be accounted for (Luedeke, Schindhelm, Francano, Levizzani, et al., 2010). There is also some evidence suggesting that V2V and V2I technologies can improve coordination of traffic, reduce congestion, and improve anticipation of emergencies and other changes in traffic conditions (GHSA, 2018). In a report published by Searson et al., (2014), the authors estimated that an aggressive introduction scenario of V2V (i.e., mandatory in all new vehicles from 2020 onwards) will result in around an 8 percent reduction in road fatalities by 2045, compared to around a 4 percent reduction with a slow introduction scenario (i.e., no policy changes to encourage V2V adoption). However, it is proposed that ITS technologies, in particular V2V communications, will be most effective when combined with other driver safety technologies such as AVs and ADAS (Dutschke et al., 2017). One such example that has been investigated is the combination of V2V communications with AEB, which is anticipated to bring about 21-23 percent reduction in road fatalities with an aggressive introduction scenario, and 13-14 percent reduction in a slow introduction scenario (Searson et al., 2014; Dutschke et al. 2017). Finally, Luedeke et al. (2010) estimated that, for V2V communications to have any real-world benefit, at least 4.2 percent of vehicles on the road must be equipped with this feature.

2.4 Awareness, acceptance, uptake and Willingness to Pay (WTP) for vehicle safety technologies

While there is evidence of the benefits of the introduction of new technologies in vehicles, the success of ITS and ADAS features as a safety countermeasure depends not only on their effectiveness in reducing driving errors, improving driver performance, or taking control in the event of no driver response, but also on the extent to which the target group is aware of the technology and whether it is adopted by the target group (Vlassenroot, Brookhuis, Marchau, & Witlox, 2010). Indeed, it is argued that the successful rollout of driver technologies in common vehicles is very much dependent on public acceptance of their usefulness and effectiveness (Najm, Stearns, Howarth, Koopman & Hitz, 2006). Moreover, it is suggested that actual usage of technology is the ultimate measure of acceptance. Arguably, ongoing, regular use of a technology implies that the user finds the performance of the system satisfactory and they are able to use the system, at least at a basic level. More importantly, it is only through actual use that a technology has the capacity to lead to road safety change (be that positive or negative; Adell, 2007).

2.4.1 Models of acceptance of technology

Many acceptance models have been used to explain acceptance of in-vehicle technologies, including the motivational model, Technology Acceptance Model (TAM), Theory of Reasoned Action (TRA), and the Theory of Planned Behaviour (TPB) (Venkatesh, Morris, Davis & Davis, 2003). The TAM was one of the first theories to explain the relationship between attitudes towards technology and usage (Davis, Bagozzi & Warshaw, 1989) and proposes that attitudes about "perceived usefulness" and "perceived ease of use" predict intention to use, and in turn, actual use of a technology (see parts A, B and C of Figure 4.1). "Perceived usefulness" is defined as attitudes about whether the technology will assist the user to achieve their tasks, while "perceived ease of use" is defined as attitudes about how effortful the technology will be to use (Davis et al., 1989). The TAM has been used extensively across different technologies and task settings (Morris & Turner, 2001).

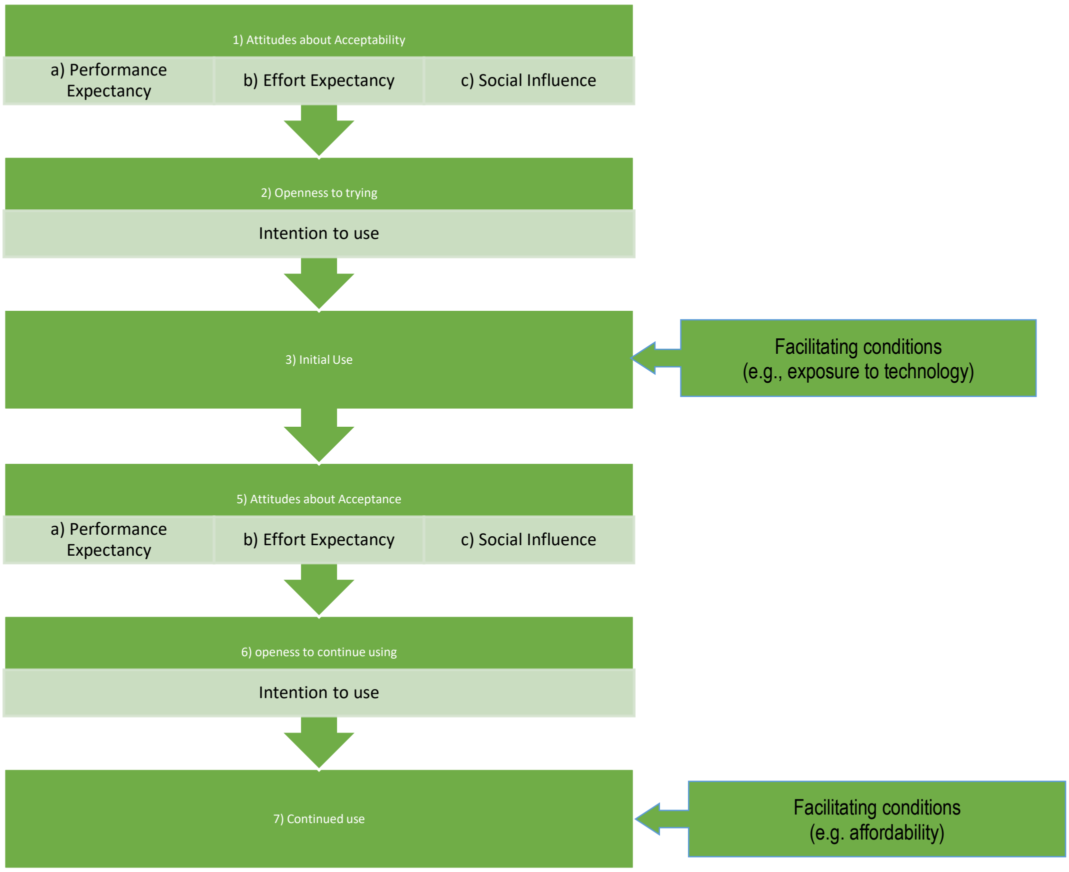

Figure 4.1. Models of acceptance. The TAM comprises elements 1a, 1b, 2 and 3. The UTAUT comprises elements 1 (a, b and c) to 4. Elements 1-4 refer to acceptability and elements 5-8 refer to acceptance. (Adapted from Venkatesh et al, 2003).

The United Theory of Acceptance and Use of Technology (UTAUT) is an extension of the TAM and is based on elements of the TAM and seven other acceptability models (Venkatesh et al., 2003). Like the TAM, the model proposes that beliefs about the technology predict intention to use a system, which predicts technology usage. However, the UTAUT makes numerous additions to the model. Predictors of intention to use a system include three factors: performance expectancy, effort expectancy and social influence. Performance expectancy is analogous to TAM's perceived usefulness and can be described as beliefs about whether the technology is useful to and enhances the performance of the task being performed. Effort expectancy is based on the TAM's perceived ease of use, and also involves beliefs about learnability and complexity of the technology. Social influence is based on the concept of subjective norms used in other models, and is defined as the extent to which the individual thinks that others believe they should use the system. Similarly to the TAM, intention to use predicts actual use, however the UTAUT also adds facilitating conditions as other factors which influence use. Facilitating conditions are based on the concept of behavioural control and include provision of support to learn or use the technology and having access to the technology.

2.4.2 Acceptance and use of technology

This section describes recent research about acceptance of adoption technology generally and in-vehicle technologies.

Government surveys in Australia and the US have found that adults aged 65 years and older were around half as likely as the rest of the population to use the internet (ABS, 2011; US Census Bureau, 2010). However, the proportion of adults using the internet in this age group is increasing, with one Australian survey demonstrating that rates of internet use doubled from 2003 to 2009 (ABS, 2011).

More recent reports suggest there has been an increase in internet access among all older age subgroups in Australia over the past five years to June 2015 (Australian Communications and Media Authority, 2016). Specifically, it was reported that internet access has risen from 75-89 percent (65-69 age group), 65-81 percent (70-74 age group), 58-73 percent (75-79 age group) and 48-58 percent (80 and above age group) between the period of July 2010-June 2011 and July 2014-June 2015. A review of the evidence on technology and older people in the UK found that increased use of technology among older populations has shown many benefits, for instance, enabling them to access information, advice, goods and services with more ease (Age UK, 2016). These findings suggests a generational shift that may also apply to other forms of technology.

With regard to in-vehicle technologies, there are similar reports of increases in use of technologies and willingness to accept in-vehicle technology that assists their driving by older adults (Musselwhite & Haddad, 2007; Bryden et al., 2013).

One ITS technology that has received substantial attention in the literature is the use of navigation systems (unlike most ADAS, navigation systems require active use). A survey found that 28 percent of US drivers aged 65 years and older owned portable navigation systems and 12 percent owned built-in navigation systems (Tison, Chaudhary, & Cosgrove, 2011). Older drivers were just as likely or more likely to own built-in navigation systems as other age groups, possibly because they were more likely to buy cars which had navigation systems as standard. However, two-thirds of those who owned a navigation system reported using it whilst driving ‘Rarely’ or ‘Never’. This may indicate that these drivers did not find the technology useful after purchase, or that they did not drive to unfamiliar places.

Another study used focus group discussions to investigate older drivers’ (aged 66-92 years) attitudes towards navigation systems (Owsley, McGwin & Seder, 2011). The results revealed that the majority of comments about navigation systems were positive. However, around one third of comments indicated the absence of a need for a navigation system and experiencing frustration in using these systems. No further details about the difficulties experienced by users were reported. The major limitations in interpreting the results of this study are that it was unclear how much information participants were given about navigation systems, and the experience that drivers had with them (if any). Therefore, it is difficult to determine whether this study reflected participant’s perceptions or personal experiences, and whether frustrations were about contemporary or older systems.

Vrkljan and Miller-Polgar (2007) investigated acceptability of navigation systems in married older couples aged 60 years and older who had not previously used navigations systems and found that participants with more experience with technology, considered the unit as more convenient than other navigation strategies, other participants expressed a willingness to try a navigation device if one was available to them (e.g., in a rental vehicle whilst on holidays), and some participants stated that they had little use for the device as they did not drive in unfamiliar areas. A concern expressed by participants who were less familiar with technology in general was that it might be difficult to learn. This study provided valuable insights into willingness to use and concerns related to acceptability, however investigation of participant concerns were limited to perceptions and not actual driving experience.

Other studies of ADAS acceptance can also give insights into the use of new in-vehicle technology. One study used focus groups to explore participants’ acceptance of technologies including crash avoidance systems, adaptive cruise control and drowsy driver detection systems (Charles River Associates, 1998). The findings showed that the participants aged 65 years and older were receptive to the new technologies, particularly with respect to how the technologies could improve their driving safety. Simplicity and functional reliability were identified as the most important factors associated with acceptability of in-vehicle technology.

Another acceptance study by Regan, Mitsopoulos, Haworth and Young (2002) led focus groups about the acceptability of Lane Departure Warning systems with participants aged 65 years and over and participants aged

18-24 years. Regan and colleagues found that older drivers rated 'usefulness' as the main factor for willingness to purchase the technology, whereas the younger group rated 'cost' higher. Older drivers were also concerned about the performance of the technology, particularly whether it would give them enough warning.

Recent surveys conducted in Australia showed that most drivers have basic awareness of AVs and ADAS technologies, but only a minority had experienced them firsthand (Schoettle and Sivak, 2014; Regan at al., 2016; Cunningham, Ledger & Regan, 2018). Regan et al. (2016) also noted that older drivers were less aware of AV technologies in comparison with their younger counterparts (Regan at al., 2016). This is a reasonable finding as younger people are more technologically-oriented and are perhaps more likely to have heard of these new technologies. Contrasting findings were made by Bellet, Paris & Marin-Lamellet (2018), where a majority of male older participants in France had knowledge, and were users, of speed-related ADAS assessed in the study. Despite Australian drivers being less aware of AV technologies than their counterparts in the US and France, Davern, Spiteri & Glivar (2015) found that Australians had more favourable views towards it. This is an encouraging finding, as research suggests that direct experience is a key factor in people's knowledge and perceptions of driver technologies (Davern et al., 2015). Hence, it is expected that people will have far more favourable views towards AVs and ADAS once they develop more awareness of these technologies and gain firsthand experience in their functions (GHSA, 2018).

In general, international findings, primarily based on self-report survey techniques, reveal that people have positive perceptions towards AVs, albeit with some reservations (Schoettle and Sivak, 2014; Kyriakidis, Happee & de Winter, 2015;). People believe that AVs will help benefit them personally by cutting down on travel time and helping lower insurance premiums (Schoettle and Sivak, 2014; Cunningham et al., 2018). Notwithstanding, there is evidence to suggest that people are still cautious about AVs. Surveys show that while drivers did not perceive AVs to be less risky than human operated ones, pedestrians felt safer interacting with AVs compared to human operated vehicles (Regan, Cunningham, Dixit, et al., 2016; Hulse, Xie & Galea, 2018). Judging by activities that drivers will carry out while being driven in an AV, it appears that there is still a lack of trust for human drivers in AV technologies, as the majority of respondents were more likely to engage in active driver-like activities rather than more passive passenger-like ones while riding in AVs (Basal et al., 2016b; Cunningham et al., 2018). Furthermore, drivers did not find riding in AVs to be enjoyable and were far more comfortable in regaining control of driving than giving it up in different scenarios assessed (Kyriakidis et al., 2015; Regan et al., 2016; Cunningham et al., 2018). However, more than half of those surveyed in Germany and the US had belief in the capabilities of AVs in handling stressful driving situations and, ultimately, in reducing crashes (Continental, 2015).

There is some evidence that older adults are less interested and less likely to accept AVs in comparison with younger drivers (Schoettle and Sivak, 2014; Kyriakidis et al., 2015; Owens, Antin, Doerzaph & Willis, 2015; Hulse et al., 2018), and this has been attributed to concerns with learning new technology, perceived distractions and loss of driving enjoyment (Owens et al., 2015; Bansal, Kockelman & Singh, 2016). In an Australian study, older drivers did not preference safety when choosing a vehicle, and only considered safety when it became a choice between certain vehicles. Moreover, their perceptions of a vehicle's safety were heavily influenced by visual appearance, where they perceived vehicles that look 'bigger' and 'stronger' as safer rather than relying on more objective evaluations such as crash ratings (Davern et al., 2015).

Gender also appears to play a key role, where male drivers tend to have more positive views of AVs (Alessandrini, Campagna, Delle Site, et al., 2015; Schoettle and Sivak, 2014; Hulse et al., 2018; Liljamo et al. 2018). These gender differences were further explored by Hohenberger, Spörrle & Welpe (2016), where female drivers reported feeling less pleasure and more anxiety with using AVs than male drivers did.

With regard to acceptance of ADAS, the evidence suggests that there is higher awareness and acceptance of these vehicle features compared with AVs. A large US study, using self-reported data from close to 3000 older respondents indicated that a high proportion of adults perceived that ADAS technologies helped them become safer drivers (Eby et al., 2018). Older respondents indicated that the ADAS they used the most were BSM, FWS and FCW (all warning systems), while automated ADAS such as semi-autonomous parking assist and ACC were amongst the least used technologies. Furthermore, the technologies that most older respondents believed helped them most in becoming safer drivers were CTD, BSM, LDW, FCW, parking assist, while semi-autonomous parking assist, ACC and FWS were considered the least effective (Eby et al., 2018). Other research support these findings. Pradhan and colleagues (Pradhan, Pulver, Zakrajsek, Bao & Molnar, 2018) also noted that drivers whose vehicles are equipped with ADAS reported that they considered safety of ADAS to be a great asset, and that these technologies helped improve their driving performance. In another study, vehicle owners reported that BSM and RCTA were the technologies they most appreciated, and FCW, AEB, LKA, and LDW were also regarded positively, and many respondents indicated that they would want them when they purchase their next vehicle (McDonald, Carney & McGehee, 2018).

In a French study, Bellet et al. (2018), compared attitudes towards technologies that provided warnings with more advanced systems in which a vehicle takes control of some driving manoeuvres, and noted that, despite older drivers generally having a positive attitude towards ADAS and other future driving aids, they still had a preference for informative or warning type systems over more advanced automated systems that could force them to relinquish driving control. These findings are consistent with other studies using public opinion surveys, where people showed preference for non-intrusive ADAS over automated ones, such as ACC, and were less enthused about handing over vehicle control (Kamalanathsharma, Rakha & Zohdy, 2015; König & Neumayr, 2017; Viktorova & Sucha, 2018). Addressing specific warning systems, Son, Park & Park (2015) noted that FCW were widely considered useful amongst older drivers. Another warning system, BSM, was rated as the most acceptable out of six ADAS investigated in a survey of 250 older drivers in the US (Motamedi, Wang & Chan, 2018). On the other hand, ACC (an automated ADAS) was viewed as irritating and aggravating by older drivers (Gish et al., 2017), with most drivers who had access to it in their vehicles reporting not to have used it and not needing it in the first place (McDonald et al., 2018). More so, seatbelt interlocks, which despite their effectiveness in enforcing safe behaviours, have not been widely adopted due to lack of public acceptance. These findings suggest that older drivers are perhaps less willing to adopt technologies that require them to adapt or change their driving behaviours.

Given that advanced ITSs such as V2V and V2I are still in its infancy, there is a lack of research with regards to the public's awareness and acceptance of these technologies. However, the evidence from a small number of studies shows that the general perception is positive amongst the public. In a study by Lukuc (2012), the majority participants expressed desire in owning V2V communications on their personal vehicle, with the highest percentage recorded amongst participants in the oldest age group (i.e. 60 to 70 year olds). Furthermore, over half of participants were willing to pay over US$250 for this type of technology. These findings on the high acceptance of V2V, as well as V2I, communications are further supported by Francano, Levizzani, Damiani, Manfredi, et al. (2010), Kompfner (2010) and Green (2012). No studies were identified that addressed older drivers' awareness and acceptance of these technologies.

2.4.3 Uptake and WTP

Adoption rates of ADAS in Australia appear to be slightly lower than in other comparable countries, where only five percent of all new vehicles were sold with collision-related ADAS in 2013 (Searson et al., 2014). A recent survey conducted in five high-income countries indicate that approximately 5-10 percent of new vehicle owners had purchased ADAS-equipped vehicles, despite over half of them being aware of these technologies and around a quarter had first-hand experience with at least one of the technologies (Choi, Thalmayr, Wee & Weig, 2016). In contrast, however, there is evidence of substantially higher uptake of ADAS, in the order of 50 percent in countries such as Japan and Sweden (Searson et al., 2014). Furthermore, it is predicted that uptake will improve in the coming years as ADAS become more common, more affordable, and make their way into vehicle fleets, even to basic trim levels of vehicles (McDonald et al., 2018).

Willingness to pay (WTP) is another good indicator for uptake of driver technologies (Cunningham et al., 2018). The WTP method was first applied in the health area in the seminal study of WTP to avoid heart attacks, by Acton (1973). The term usually refers to individuals' willingness to spend money personally, i.e., ‘out of pocket,’ to obtain health gains for themselves or to avoid health losses or reduce health risks for themselves, and in the field of transport safety and vehicle choice, it refers to individuals’ willingness to spend money to obtain a vehicle that is likely to provide high protection in the event of a collision.

Regarding WTP for AVs, there remains considerable debate around consumer acceptance and willingness to pay for a fully ‘automated’ driverless car, mostly due to the fact that these vehicles are not yet commercially available (despite the fact that the development of driverless car technology is occurring at a rapid pace). However, it is noted in the literature that the rate at which AVs cars will penetrate the market depends primarily on whether consumers are willing to use and pay for the new technology and therefore some exploratory research has addressed this issue. In a US study by Bansal et al. (2016), average WTP figures obtained were US$3,300 for Level 3 AVs, and US$7,300 for level 4 AVs. A similar figure of US$6,900 was obtained by Ellis, Douglas and Frost (2016). In Australia and New Zealand, drivers were also willing to pay more for full automation in vehicles with reported average WTP figures between AU$9,000 and AU$13,800 (Regan et al., 2016; Cunningham et al., 2018). These studies also investigated effects of age on WTP and found that older drivers, in particular, were less willing to pay for AV technologies compared to younger drivers (Bansal et al., 2016; Ellis et al., 2016). Furthermore, similar to gender patterns already established in previous sections, females were less willing to pay for AV technologies than males (Kyriakidis et al., 2015; Ellis et al., 2016).

Although average WTP figures are good indicators of potential uptake of in-vehicle technologies, they do not account for the full picture. Most studies on WTP figures reported between 22-59 percent of surveyed drivers who did not wish to pay more at all for a fully automated vehicle than they would for a traditional vehicle (Kyriakidis et al., 2015; Ellis et al., 2016; Cunningham et al., 2018).

One of the most effective ways of incentivising the uptake of AVs and ADAS is through government regulation (Searson et al., 2014). Other effective incentives include reduced insurance premiums and dedicated AV lanes on roads to reduce commute times (KPMG, 2013; Searson et al., 2014).

2.4.4 Human factors and adaptability

Some of the key concerns regarding the introduction and use of in-vehicle technologies are human factors (including driver performance) and drivers’ adaptability (this includes ability to use technologies as well as trust and reliance on technologies and potential tampering).

In a study of older drivers who owned vehicles with ADAS, Eby and colleagues (2018) found that between 25 to 75 percent of older drivers had learnt to use specific ADAS by themselves, averaging 49 percent over the 12 technologies investigated. The second most common source of education was the dealer, followed by the owner’s manual and family and friends. The internet was the least likely source, with an average of 0.1 percent indicating to have used it to learn about ADAS. Moreover, around 13 percent indicated that they never learned to use these technologies. Surveys from more general audiences also indicate that beyond learning on one’s own, from the owner’s manual or from the dealer, very few people were willing to use the internet to learn how to use ADAS (McDonald et al., 2018). Hence, it is important that older drivers are trained on specific ADAS through more structured educational methods, whether that be through dealers, informational campaigns or other appropriate training materials (Young, Koppel & Charlton, 2017; Viktorova & Sucha, 2018).

It is noted in the literature that the development and promotion of in-vehicle technology needs to take into consideration human factors (Regan et al., 2004) and especially regarding older drivers' performance (Classen et al., 2019), however, it is also noted that there is currently a lack in our understanding of studies to examine benefits of ADAS on older driver's performance), particularly in-depth naturalistic driving research (Classen et al., 2019. Older drivers, in particular, may be overwhelmed or distracted when using multiple ADAS and navigating complex interfaces, which could adversely affect their safety (Bruyas & Simões, 2010; Strayer, Cooper, Turrill, Coleman & Hopman, 2016). Current driver technologies and Human Machine Interaction (HMI) guidelines are mostly designed for an average younger driver, and rarely account for cognitive, sensory and physical limitations of the older driver (Young et al., 2017). Several examples of such limitations are highlighted by Young et al. (2017), such as the need to examine visual warnings, where size and length of warning text should account for the effects of ageing on vision. A second example is auditory warnings, where the tone and volume of the warnings should account for hearing difficulties experienced by most older adults. Third, as people grow older they experience a range of cognitive declines and a general slowing of processing speed (Eby & Molnar, 2012; Yang & Coughlin, 2014). In-vehicle technologies often require drivers to divide their attention between information provided by the device and the driving task which can lead to cognitive overload and/or distraction (Koppel, Charlton & Fildes, 2009). Other human factors issues to consider include slower reaction times by older drivers and how future generations of older drivers will be able to adapt and interact with the rapidly evolving pace of driving-related technologies (Owens et al., 2015; Yang & Coughlin, 2014).

One of the main human factors issues with level partial automation (in particular AV Levels 2 and 3) is potential complacency by drivers, where they could fail to react when automatic driving mode disengages (Bansal et al., 2016; Kyriakidis, de Winter, Stanton, Bellet, et al., 2017; Van Brummelen, O'Brien, Gruyer & Najjaran, 2018). Such has been the case with several fatal crashes recorded over the past few years in Tesla and Uber self-driving vehicles. In a survey of drivers who owned vehicles with ADAS, McDonald et al. (2018) found that around half of drivers of vehicles equipped with BSM had performed lane changes without completing a visual check, while some others with RCTA-equipped vehicles admitted to having reversed in the past without performing a visual check. Other drivers with LDW or ACC systems also indicated that they were more comfortable in looking away from the road. Apart from complacency, overreliance on vehicle safety technologies could potentially affect natural driver performance (Pradhan et al., 2018).

2.5 Identification of technological initiatives to support the transition from driver to non-driver / Role of technology in transport safety and delivering transport information and education to older adults

Beyond the role of in-vehicle technologies in enhancing older drivers' safety and prolonging their safe driving mobility, there are technologies and other resources that can deliver important transport information and education to older adults that can assist with transitioning from driving to non-driving and uptake of alternative transport modes. These can be classified as trip planning, traveller information, reservation and dispatching systems, journey substitution (e-services), or training on public transport.

For the purpose of delivering transport information, as well as aiding in trip planning, there are a number of websites and/or smartphone applications that provide a range of features and accessibility options for users, that could be of particular help to older adults. Some of the features included in these websites and/or applications are real-time departure / arrival / service alerts and updates / current location information for public transport, customised door-to-door trip-planning (including people with limited mobility), displaying and announcing stops for people with vision and hearing impairment, and other nearby transport options. Other technologies included taxi, ride-share, car-share and carpool booking applications. These applications allow the users to request location-based transport.

Other technological means are journey substitution services which replace the need for making shopping, banking or other trips. One of the best practices in Australia is the CTABS project (currently being developed in NSW), which will eventually allow users to book trips online with their local community transport organisations (https://future.transport.nsw.gov.au/plans/regional-nsw-services-and-infrastructure-plan/customer-outcomes-for-regional-nsw).

Internationally, a number of good practices have been identified. First is the GoLA app in Los Angeles, California. GoLA is an integrated mobility app which combines public and private transport options (including ride-share and car-share), a “one-stop” application for all transport needs. The success of GoLA is being replicated in Denver, Colorado. Another similar example is Connect San Mateo (California). A second good practice is the Rhein-Main Transport Authority website and application, which provides a door-to-door accessibility service for getting to a destination with particular attention to passengers with limited mobility. Some of the accessibility information provided includes walking distance, stairs (number, size), mechanic stairs, ramps and toilets. A third good practice is GoGoGrandparent, which is a concierge service that allows older people to book ride-share services over the phone. GoGoGrandparent conducts checks on the suitability of the car and the driver in delivering the required trip, taking into consideration the mobility requirements of the user. Finally, Singapore’s “Green Man +” is a card activated system that allows older people and people with limited mobility longer pedestrian crossing times.

The delivery of transport education for older people in WA is provided by TransPerth’s ‘Using TransPerth’ webpage and TransWA’s educational videos. Some of the best practices internationally include Germany’s “fit & mobil” campaign, which promotes the uptake of sustainable modes of transport by older people. Furthermore, the mobility day in Salzburg, Austria allows older people to walk around public transport buses and obtain hands-on information and training from drivers in order to familiarise them with the use of the services in a more relaxed environment.

2.6 Identification of incentive schemes to support the transition from driver to non-driver including methods to encourage travel mode shift and use of alternative modes of transport

A number of schemes that are aimed at encouraging older people to use transport modes other than driving a private motor vehicle were also identified, primarily through a desktop review. These schemes are briefly described below within the broad categories of public transport, community transport, taxi, ride-share, patient transport, other vehicle transport, mobility devices, and walking and cycling.

2.6.1 Public transport

In terms of public transport, the current concessions provided to older residents within WA (free off-peak travel and 50% off regular fare) are in line with the most generous offerings available in other Australian States and Territories. Of note, free seniors off-peak public transport is implemented in the Australian Capital Territory, South Australia (Adelaide Metro) and Queensland (Brisbane and Gold Coast). A recent study conducted by the University of Adelaide identified that the free off-peak travel scheme in South Australia resulted in increased uptake of public transportation among older residents (University of Adelaide, 2016).

Internationally, there are free seniors off-peak public transport schemes in place in the UK, New Zealand and the Czech Republic. Several evaluations have been carried out for the older person’s bus pass in the UK, which showed significant uptake of public transport by older residents and mode-shift from car use as well as an increase in usage of public transport by older residents who were making new and additional trips than previously (Baker & White, 2010).

2.6.2 Community transport

Community transport is another alternative means of transport, where older persons' transport services are provided through local councils or third-party operators. The nature of the schemes as well as the eligibility criteria can vary amongst the different operators. While this is certainly one of the most affordable transport options, many providers are dependent on volunteer drivers and are limited to trips for daily activities that are booked in advance and carried out during the daytime on weekdays.

A particularly noteworthy international best practice is the Independent Transportation Network of America (ITNAmerica) which operates as a non-profit transportation network for seniors and people with vision impairment. ITNAmerica adopts a self-sustainable model of transport that attempts to move away from external support. The network provides door-to-door transport at approximately half the fare of a taxi for an equivalent trip. ITNAmerica provides several programs that allow users to accumulate credits into their personal transport account. One such program is the car trade-in program, which allows users to trade-in their personal vehicles for credits added to their personal transport account.

2.6.3 Taxi

In terms of taxi transport, one of the subsidies available to assist people with severe and permanent disabilities is the 'Taxi Users' Subsidy Scheme,' which offers a 50% fare concession for eligible users. One of the best practices in Australia is 'Council Cabs', which runs in several councils across Queensland (e.g., Brisbane, Logan, Gold Coast). Council Cabs provide once-a-week shared shopping trips to older residents at heavily subsidised fares (between $1 and $3 each way). Other best practices include taxi vouchers offered by transport organisations (usually in the range of $5-$10 in value) to older residents to provide them with added freedom of taking trips outside of designated community transport routes or outside of their working hours, a scheme which is also present in the United States (Schaumberg, Illinois and Fresno County, California).

2.6.4 Ride-share

The past decade has seen a significant increase and success in ride-share services. While the availability of these ride-share services (e.g., Uber, GoCatch, Shebah, HiOscar) are incentives in themselves due to the lower fares they offer over taxis, no specific incentives for older residents have been identified in Australia apart from Uber's $20 off the first ride discount for Seniors Card holders. In contrast, in the United States, ride-share services have been integrated into a number of schemes targeted at older adults. The first of its kind, the Freedom in Motion initiative was launched as a collaboration between Uber and the City of Gainesville, Florida. The scheme allows for older residents to utilise Uber as a form of transport at heavily subsidised rates (starting from $1 to a maximum of $5). The success of this program brought about similar collaborations in other parts of Florida, Pennsylvania, Massachusetts and California. Recent start-ups (e.g., Lift Hero, SilverRide) have targeted ride-share services for older people (categorised as "specialised for profit services" in this report). While these services tend to be more expensive than their traditional ride-share counterparts, they offer the advantage of providing more convenient door-to-door or door-through-door transport service for older people.

2.6.5 Patient transport

Specialist patient transport schemes designed for adults requiring medical transport are also available in WA and other Australian states and territories. These schemes offer reimbursement of travel costs for patients in regional and remote areas that have been referred to a medical provider far away from their place of residence. Furthermore, non-emergency patient travel is available in several States, providing free transport to older residents who would otherwise be unable to commute via public transport to a medical facility. Some of the best practices internationally in this category include the Red Cross in New Zealand, which operates a free non-emergency medical transport service. In the United States, another form of ride-share integration has been implemented in the non-emergency transportation of patients. A collaboration between National Medtrans Network in New York City and Lyft has proven to be successful with over 2,500 rides carried out each week.

2.6.6 Other means of transport

Other means of transport include vehicle transport options such as car-sharing, carpooling, and car-hires, or other modes of transport such as mobility devices, cycling and walking. Several car-share services operate in NSW and other Australian states and territories. Of these, GoGet and GreenShareCar provide incentives for Seniors Card holders in the form of free annual membership and discounted rates. While car-share and car-hire do not eliminate driving by older drivers, they may be seen as incentives for older drivers to give up their cars and utilise these services on an as-need basis.

Currently, Queensland is the only Australian state or territory that registers mobility devices; this is for the purpose of providing third party insurance. While these devices may increase the mobility of older residents, lack of adherence to existing regulations as well as the lack of dedicated infrastructure is a matter of concern (see Johnson , Rose & Oxley, 2013).

Last, resources and schemes for cycling and walking modes of transport were identified. Two bike share schemes for older people were identified (Melbourne, Australia; West Hollywood, California). These schemes provide discounted annual membership for Seniors Card holders. One older people walking initiative was identified in the United States (New Haven, Connecticut), where free wellness checks were offered and the top ten walkers for each month were awarded gift cards.

3 Survey of awareness of ADAS, use of safer vehicles, and technology for travel mode shift

To further develop an understanding of the issues surrounding the use of safer vehicles, particularly those fitted with ADAS and technologies that can promote the use of other travel options to enhance mobility of older adults, a survey was developed and conducted amongst a sample of Western Australians. The survey considered three specific research objectives of the project:

- The extent of use of safer vehicles amongst older adults (including those in urban, regional and remote areas);
- Awareness of, acceptance of and adaptation to new vehicle technologies; and
- Mobility needs, expectations for future mobility and intentions regarding uptake of alternative transport modes.

The following sections provides a description of the development of the questionnaire, the recruitment phase and the results of the survey.

3.1 Method

The research was conducted using a phone survey with participants recruited using a panel held by a Perth-based market research group Edith Cowan Research Centre. To be eligible to participate in the survey, respondents were required to: be residents of Western Australia, hold a valid driver's licence, be an 'Active' driver (that is drive on average once a week), and be aged 65 years or older.

The survey was developed with six sections:

1. Participant information and demographics: including age, gender, marital status, education, employment and living situation.
2. Driving patterns and exposure: including annual distance driven, crash history and infringement history.
3. Current vehicle: details on their current vehicle including make, model, year of manufacture, factors that were considered when purchasing the vehicle and their perception of the safety of the vehicle.
4. Advanced Driver Assistance technologies: included questions regarding how aware they were of vehicle technologies particularly those that are considered safety features.
5. Mobility: included questions about their ability to travel and their mobility, including access to adequate transportation any difficulties they experience when travelling.
6. Intent to transition from driver to non-drivers and the use of technologies to assist mode change: included the Assessment of Readiness for Mobility Transition (ARMT) (Meuser et al. 2013) a 24-item scale measuring emotional and attitudinal readiness for mobility transition and a range of questions regarding participants use and access to of technologies.

The survey was approved for distribution by Monash University Human Research Ethics Committee.

Data collected was examined using descriptive analysis techniques as well as bivariate techniques to examine associations between variables of interest. Mean item and sub-scales scores were calculated for the ARMT.

3.2 Findings

3.2.1 Participant information and demographic characteristics

In total 501 completed survey responses were included in the analysis. Table 3.1 presents a summary of participants' demographic characteristics.

Table 3.1: Summary of participants' demographic characteristics

Demographics	Frequency	Percentage (%)
Age Group:		
65-74	285	56.9
75-84	203	40.5
85+	13	2.6
Gender:		
Female	267	53.3
Male	234	46.7
Marital status:		
Never Married	31	6.2
Married/ Defacto/ Common-law	374	74.7
Divorced/Separated	30	6.0
Widowed	63	12.6
No response	3	0.6
Location of residence:		
Metropolitan	351	70.1
Rural	150	29.9
Living Arrangements:		
House	454	90.6
Unit/Apartment	23	4.6
Independent Living Unit	13	2.6
Villa/ Town House	10	2.0
No response	1	0.2
Education:		
Primary School	14	2.8
Secondary School	211	42.1
Trade/ technical certificate	76	15.2
Diploma	65	13.0
University undergraduate degree	89	17.8
University postgraduate degree	40	8.0
No response	6	1.2
Employment:		
Full time employment	20	4.0
Part time employment	40	8.0
Retired	414	82.6
Volunteer	20	4.0
Other	6	1.2
No response	1	0.2

The majority of participants reported being Australian citizens (n = 489), two respondents chose not to answer, while the remaining respondents were citizens of New Zealand (5), United Kingdom (3) or were European (2). Across the sample, there was a relatively even split of gender with 267 female responses (53.3%). Participants were given the option to provide their exact age or report their age group. All participants provided their exact age, with participants ranging in age from 65 to 92 years with a median age of 73 years. The majority of participants stated they were in a married, de-facto or common law relationship (74.7%), while a further 12.6 percent stated they were widowed (Table 3.1).

When asked about their highest level of education completed, 42.1 percent reported having completed secondary school, while 38.7 percent of respondents had completed some form of tertiary education. As expected the majority of respondents reported that they were retired from the workforce (82.6%), with only 60 respondents still employed in either a full-time (4.0%) or part-time (8.0%) position.

Participants were asked to provide their postcode. Based on this information they were classified as living in either Metropolitan or Rural locations. The majority of participants were from Metropolitan regions (70.1%) of Perth and a diagrammatic representation of participants' postcodes are provided in Figure 3.1. From the diagram it can be seen that respondents tended to live in the Perth area. There were also clusters of responses from Albany and Busselton.

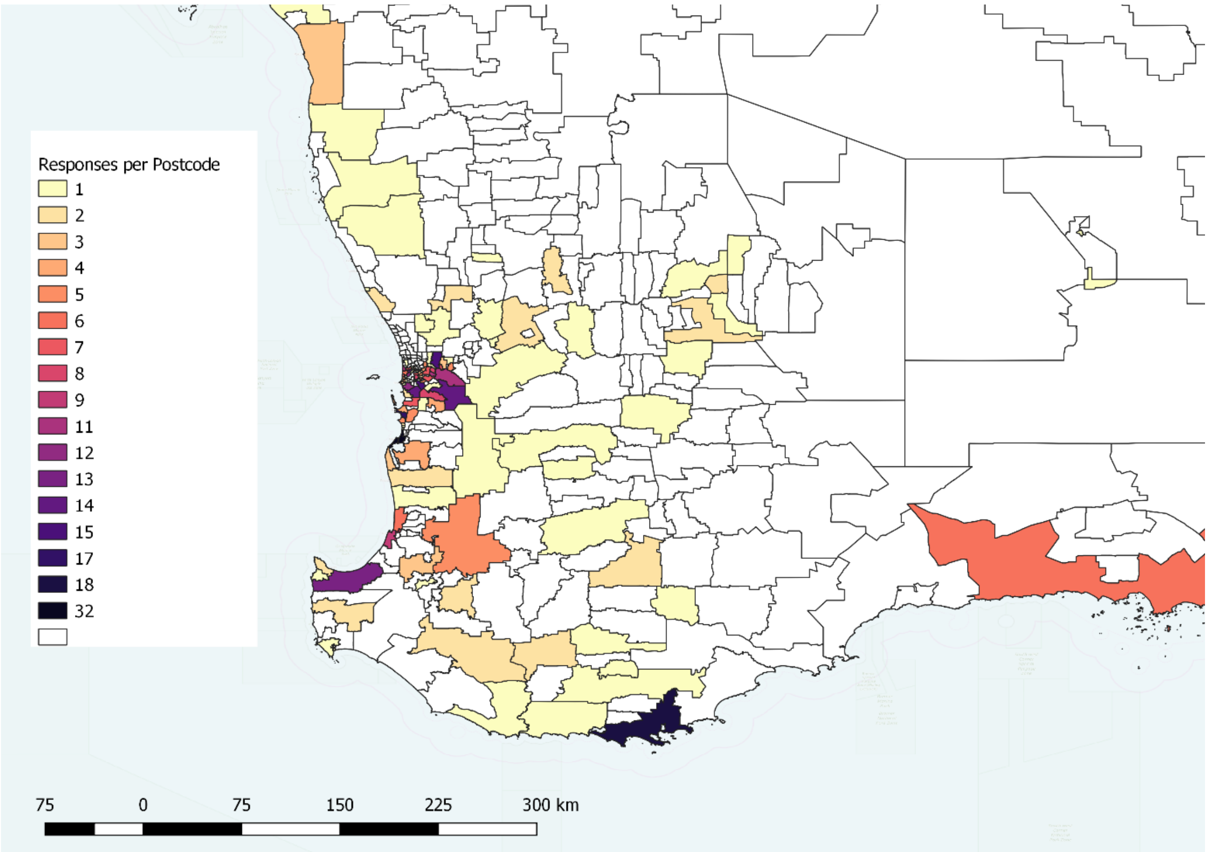

Figure 3.1: Responses by Postcode

3.2.2 Driving patterns and exposure

The second section of the survey was designed to investigate the driving history of participants including crash involvement and infringements. First, participants were asked how old they were when they first gained their driving licence. The majority of participants reported being 17 years of age when they first started driving, with a range of 14 to 42 years (see Figure 3.2).

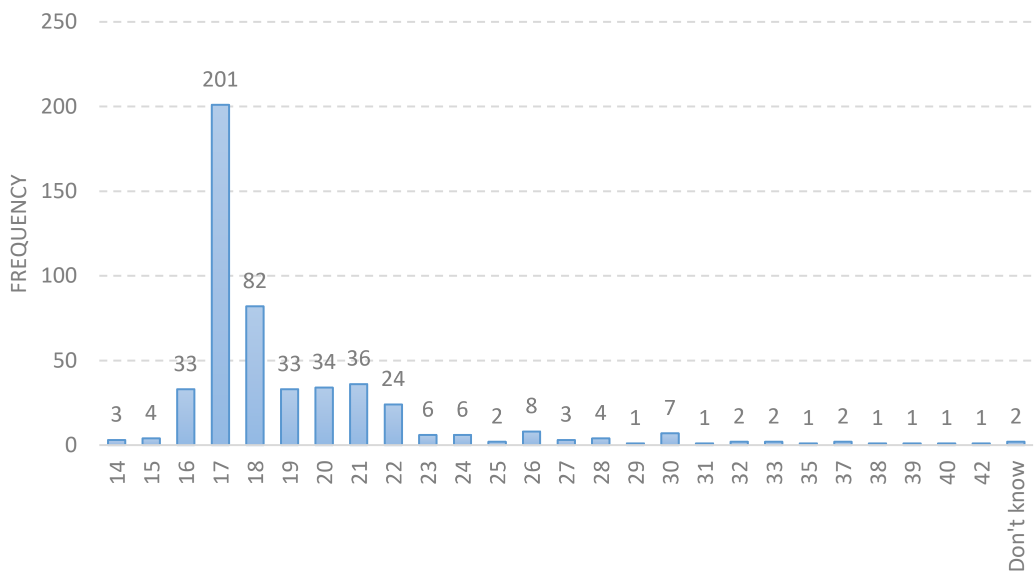

Figure 3.2: Age when licence was obtained

When asked about their current driving patterns, the majority of participants (61.3%) reported driving daily, this was followed by 24.4 percent of participants reporting that they drive 4 to 6 times per week (Table 3.2). However, this was somewhat expected given the inclusion criteria of being an 'active' driver who drove at least once per week.

Table 3.2: Driving Patterns

Driving Patterns	Frequency	Percentage (%)
How regularly do you currently drive?		
Daily	307	61.3
4 – 6 times per week	122	24.4
3 – 3 times per week	65	13.0
Once a week	6	1.2
Once every two weeks	1	0.2
Kilometres		
Under 1,000kms	14	2.8
1,000 – 3,000kms	49	9.8
3,000 – 5,000kms	57	11.4
5,000 – 10,000kms	126	25.1
10,000 – 15,000kms	114	22.8
15,000 – 20,000kms	30	6.0
20,000 – 25,000kms	28	5.6
Over 25,000kms	41	8.2
Don't know/No response	42	8.4
Crash involvement		
No	468	93.4
Yes – One	29	5.8
Yes – Two	4	0.8
Infringements		
No	379	75.6
Yes	118	23.6
Don't know/No response	4	0.8

As shown in Table 3.2, estimates of annual kilometres travelled indicated that the sample generally drove substantial distances. Most participants reported that they drove between 5,000 and 10,000 kilometres per annum (25.1%), with a similar proportion reporting driving between 10,000 and 15,000 kilometres per annum (22.8%).

Participants were also asked whether they had been involved in a motor vehicle crash or received an infringement (other than a parking fine) in the last three years. The majority of participants had not been involved in a collision (93.4%), while 29 participants (5.8%) reported being involved in one collision and 4 participants (0.8%) reported being involved in two collisions over that time period. Almost a quarter of respondents had received an infringement (23.6%) over the three year period.

The most commonly reported offence was speeding up to 10km/h over the limit (n=100) and this was followed by 19 respondents speeding more than 10km/h over the limit. Other offences included 4 reports of red light running, 3 cases of not wearing a seat beat and one report each of holding a mobile phone and rolling through a stop sign.

3.2.3 Current vehicle

The next section of the survey focused on eliciting information on participants' current vehicle. Participants were first asked about the make and model of their current car. The most common vehicle make were Toyotas (19.0%), followed by Hyundai (12.8%) and Ford (10.6%) vehicles, a full summary of vehicle make is provided in Table 3.3.

Table 3.3: Vehicle Make

VEHICLE MAKE	Frequency	Percentage (%)
Audi	2	0.4
BMW	8	1.6
Chrysler	2	0.4
Ford	53	10.6
Holden	40	8.0
Honda	27	5.4
Hyundai	64	12.8
Isuzu	3	0.6
Jaguar	3	0.6
Jeep	8	1.6
Kia	13	2.6
Landrover	3	0.6
Lexus	4	0.8
Maserati	1	0.2
Mazda	39	7.8
Mercedes	13	2.6
MG	1	0.2
Mitsubishi	33	6.6
Nissan	33	6.6
Peugeot	4	0.8
Renault	3	0.6
Skoda	1	0.2
Subaru	18	3.6
Suzuki	10	2.0
Tesla	1	0.2
Toyota	95	19.0
Volvo	4	0.8
VW	14	2.8
Unknown	1	0.2

The age of vehicles was fairly diverse with the age of vehicle manufacture ranging from 1978 to 2018. Figure 3.3 presents a summary of vehicle year of manufacture – within the sample, the average vehicle age was 8.2 years (SD= 6.3 years).

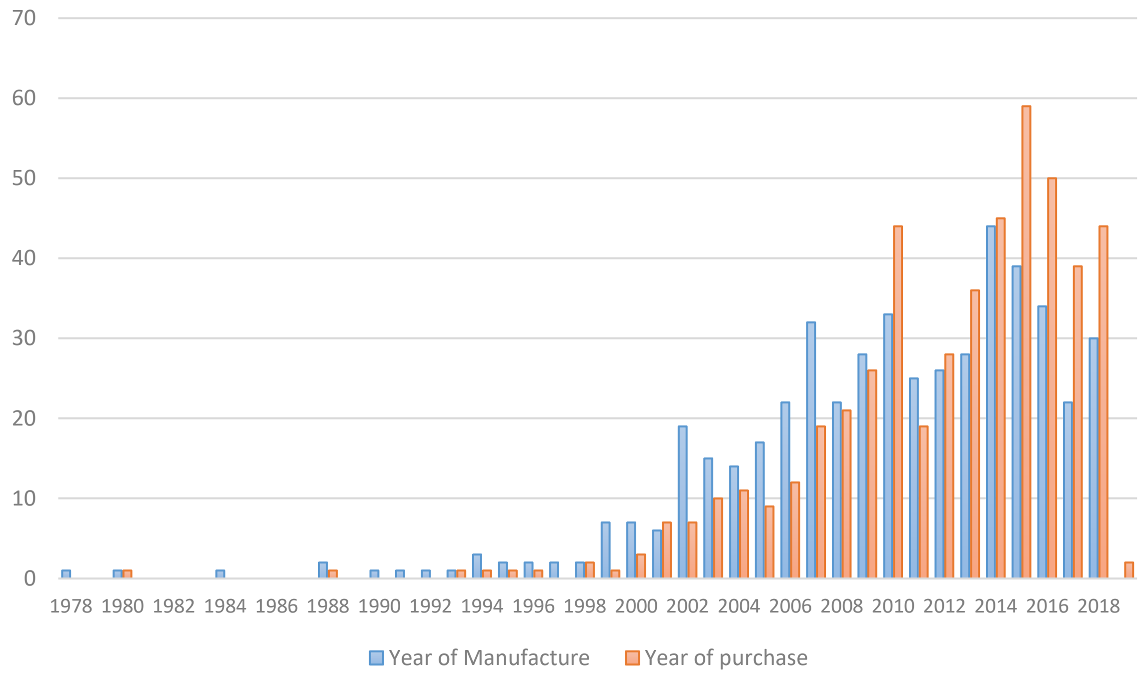

Figure 3.3: Vehicle year of manufacture

Over half of vehicles driven by participants were purchased new (57.9%) with the remaining 42.1 percent purchased as used vehicles. This was reflected in the question asking the year of purchase of vehicles with a range of 1980 to 2019 and an average length of ownership of 7.1 years (SD = 5.1 years). When asked if and when they expect to replace the vehicle, the most common response was that they did not intend to replace the vehicle (48.1%), followed by between 2 and 5 years (17.4%) and between 5 and 10 years (10%), with 12.8 percent of respondents stating that they would replace the vehicle within the next two years (Table 3.4).

Table 3.4: Expected time to replace vehicle

Time period	Frequency	Percentage (%)
Within the next 12 months	29	5.8
Between 12 months and 2 years	35	7.0
Between 2 years and 5 years	87	17.4
Between 5 years and 10 years	50	10.0
Not for at least 10 years	28	5.6
I don’t intend on replacing this vehicle	241	48.1
Don’t know	31	6.2

Next participants were asked to rate a range of factors for purchasing their current vehicle and whether they considered them a priority (Table 3.5). The most important were the reliability of the vehicle and the reputation of the make and model. Safety was also considered important by a substantial proportion of participants (66.7% of respondents rated safety as a high priority).

Table 3.5: Vehicle purchase factors

Factor	High (%)	Medium (%)	Low (%)	Don't remember (%)
Reliability	87.4	8.6	3.0	1.0
Reputation of make/model	72.3	15.6	11.4	0.8
Safety (Star) ratings / other safety reports	66.7	18.0	13.8	1.6
Vehicle size	65.3	27.3	7.0	0.4
Vehicle type	64.1	25.9	9.4	0.6
Performance (incl power & handling)	62.9	26.9	9.6	0.6
Comfort	57.1	32.9	9.0	1.0
Fuel economy	52.3	35.7	11.0	1.0
Make/model	51.5	25.9	21.0	1.6
Country of manufacturer	24.0	25.7	48.7	1.6
Warranty and service plans	47.1	26.5	25.3	1.0
Purchase price	44.7	41.9	11.4	2.0
Running costs	43.9	40.7	14.4	1.0
Style / look / colour	38.1	32.5	28.7	0.6
Re-sale value	17.6	33.3	47.5	1.6

When asked if there were any additional features they considered, 22 respondents stated that the seat height, ease of entry/ exit and accessibility into the vehicle were important. Eighteen respondents identified the ability to tow, 6 respondents stated 4 Wheel Drive or All Wheel Drive features were important, and 6 respondents stated the transmission (automatic transmission) was an important priority in their vehicle choice.

Finally, participants were asked about the safety of their current vehicles. The majority of participants thought their vehicles was either very safe (63.1%) or safe (32.7%), while only 11 respondents thought their vehicle was unsafe (2.0%) or very unsafe (0.2%).

3.2.4 Awareness and use of ADAS

The fourth section of the questionnaire was designed to gauge awareness of vehicles technologies, particularly those that are considered safety features. Participants were asked if they were aware of thirteen different vehicles technologies, if it was fitted to their current vehicles and if the technologies would be a priority when purchasing their next vehicles (Table 3.6).

Table 3.6: Awareness and use of ADAS

Vehicle technologies	Do you know what XX is?			If yes, is your current vehicle fitted with this?	If yes, will this be a priority for your next vehicle?
	Yes (%)	No (%)	Don't know (%)	Yes (%)	Yes (%)
Lane departure warning/assist	51.1	47.9	1.0	19.9	50.4
Automated Emergency Braking	49.3	49.1	1.6	36.8	57.5
Forward collision warning	46.7	52.7	0.6	19.2	54.7
Blind spot/obstacle detection	46.5	52.5	1.0	21.0	70.4
Lane change warning/assist	43.1	56.3	0.6	19.9	60.7
Driver fatigue monitoring	39.9	59.3	0.8	12.0	45.0
Electronic stability control	34.1	64.9	1.0	57.3	62.0
Adaptive cruise control	28.5	71.1	0.4	44.1	64.3
Pedestrian/cyclist AEB	23.8	74.5	1.8	14.3	60.0
Night vision enhancement	20.8	77.8	1.4	20.2	58.7
Intelligent speed assist	11.8	87.2	1.0	22.0	50.8
Rear cross-traffic warning assist	9.5	89.8	0.8	21.3	61.7
Right-turn assist	8.8	90.8	0.4	15.9	50.0
Driverless Vehicles*					
Level 1	1.0	99.0	0		
Level 2	1.0	99.0	0		
Level 3	0.5	99.5	0		
Levels 4 & 5	0.5	99.5	0		

*not all participants were asked this question (n= 199)

Overall there was fairly low awareness of the different vehicle technologies. The highest awareness was reported for lane departure warning systems with 51.1 percent of participants indicating they were aware of the technology. The lowest levels of awareness were for rear cross-traffic warning (9.4%) and right turn assist (8.8%) technologies.

For each technology that participants were aware of, they were asked if it was fitted to their current vehicle. Across the technologies Electronic Stability Control (ESC) (n=98), Adaptive cruise control (n=63) and Automated Emergency Braking (AEB) (n=91) were the most common technologies.

When asked which technologies would be a priority when purchasing a new vehicle, it was interesting to find that relatively high proportions of participants thought technologies would be a priority. The highest responses were for Blind Spot detection (70.4% or respondents), Adaptive cruise control (64.3%), AEB (60%) and lane change warnings (60.7%).

Participants were asked if they were aware of the different levels of vehicle autonomy associated with driverless vehicles in line with the Society of Automotive Engineers (SAE) automation levels. The questions regarding automation were only administered to a subset of the total sample. Of the 199 respondents who were asked the question only 2 were aware of the SAE levels. However, it is interesting to note that in the final section of the questionnaire which addressed assessment of readiness for mobility transition, participants were asked if they were aware of driverless or autonomous vehicles. For that question 489 of the 501 respondents indicated that they were aware of the technology, indicating that they were aware of the general concept of autonomous vehicles, but not the subtleties associated with the levels of automation.

Finally, participants were asked how much extra they would be prepared to pay for a vehicle with added safety technologies or driverless features (Table 3.7). When considering driverless features the majority of participants (78.2%) stated that they would not pay any additional amount for the inclusion of driverless features. Participants were more receptive to the inclusion of added safety features, with 27.1 percent willing to pay an additional $5,000 for the features, 18.4 percent would pay an additional $5,000 to $10,000 and a further 10 percent would pay over $10,000.

Table 3.7: Willingness to pay for safety and driverless features

	Added Safety Technology		Driverless Features	
	Frequency	Percentage (%)	Frequency	Percentage (%)
I would not pay any more for a vehicles with these features	179	35.7	392	78.2
Up to $5,000	136	27.1	23	4.6
Between $5,000 and $10,000	92	18.4	16	3.2
Over $10,000	50	10.0	26	5.2
Don't know	44	8.8	44	8.8

3.2.5 Mobility needs

Section five of the questionnaire focused on the participant's mobility and whether their mobility needs were being met. First, participants were asked to what extent they have adequate means of transportation (Figure 3.4), and the vast majority of participants stated that their needs were completely met (90.2%). Similarly, when asked if difficulties with transportation restricted their life, the majority stated not at all (83.6%) and the majority also stated that they did not have problems with transportation (95.6%). Not surprisingly, participants were generally very satisfied (80.0%) or satisfied (18.6%) with their transportation and this was reflected with the majority (92.0%) stating they were very able to get to the places they want to go and when they want to go, with the remaining 8.0 percent stating they were somewhat able.

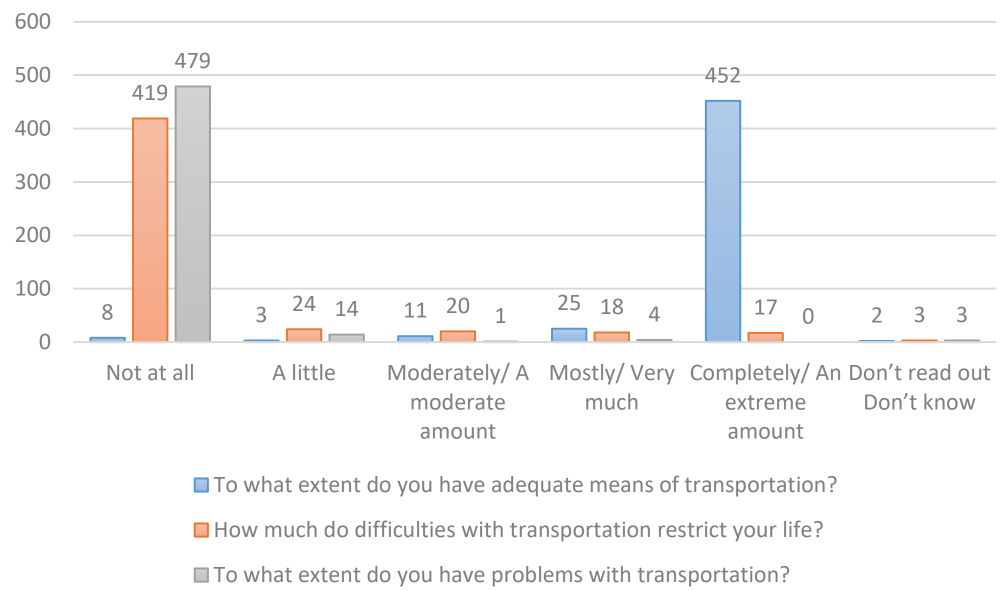

Figure 3.4: Adequacy of mobility

Participants were next asked to:

- report on the modes of transportation available to them in their community,
- if they use that mode of transportation in a typical month,
- if they do not use the mode, could they if they wanted, and
- if they do use the mode how many trips do they make in a month.

A summary of the results is presented in Table 3.8. For the first three questions the frequency of "Yes" responses is reported, for the fourth question the mean and standard deviation of the number of trips using that mode is reported.

Interestingly, while all participants were active drivers, only 81.2 percent reported having the option of being a passenger in a vehicle and only 80.2 percent had viable walking options. Ride share services (20%) and handi-transit (2.6%) were the least available transport modes.

Participants who stated they had access to alternative travel modes were asked if they use the modes in a typical month. The highest response rate was for passenger vehicles, with 71 percent of respondents who had access to this mode using it, while the lowest rates were for taxi (9.3%), ride-share (9.0%) and volunteer drivers (1.6%).

Participants who had access, but chose not to use the mode, were asked if they could use the mode. Typically most respondents stated that they could use the mode if they wanted to, with positive responses of over 90 percent for all motorised modes. Interestingly, fewer positive responses were recorded for walking and cycling. This may indicate a lack of bicycle ownership amongst older road users, that these respondents had impaired mobility that restricted their ability to utilise active modes of transportation, or could also be an indication of the lack of infrastructure to facilitate walking and cycling.

Table 3.8: Availability and use of alternative modes of transportation

	Is this mode of transportation available in your community?	If available, Do you use it in a typical month?	If available but you DO NOT use it, could you use it if you wanted to?	If you DO use this mode of transportation in a typical month, please indicate the number of uses per month
	Frequency: Yes	**Frequency: Yes**	**Frequency: Yes**	**Mean (SD)**
Passenger vehicle (as a passenger)	407	289	109	15.9 (19.8)
Walk	405	214	154	13.8 (15.2)
Bicycle	325	43	196	12.2 (15.3)
Public Bus	401	97	297	4.6 (10.3)
Train	308	145	158	4.0 (8.4)
Taxi & Uber	439	41	388	2.0 (2.4)
Ride-share	100	9	84	3.2 (1.8)
Volunteer Drivers	244	4	220	1.8 (0.5)
Handi-Transit	13	2	10	2.0 (-)

Finally, for participants who utilised each mode (other than as a driver) in the past month, they were asked to estimate the number of trips made using each mode. Not surprisingly, the highest number of trips were made as passengers in private cars with an average of 15.9 trips per person and a standard deviation of 19.8. The next most frequently used modes were walking and cycling, while very few trips were made using taxi, ride share, volunteer drivers or handi-transit services.

3.2.6 Transition from driver to non-driver

The next section of the survey was designed to gauge participant's thoughts on reducing or stopping driving and using other forms of transportation. Participants were asked to complete the Assessment of Readiness for Mobility Transition (ARMT) questionnaire (Meuser et al. 2013). The ARMT is a 24-item scale measuring emotional and attitudinal readiness for mobility transition (Meuser et al. 2013).

One item was removed from the scale as it states that "Other people simply don't understand what it's like to have limited mobility" and was not relevant to the cohort as they all currently considered themselves to be 'Active' drivers without mobility issues.

Each item required a response on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). A sixth response "not applicable" was included in the questionnaire. Participants who responded "not applicable" to any questions were not considered in the analysis of this questions. This left 345 responses included in the analysis. Complete responses were grouped into four subscales: anticipatory anxiety, perceived burden, avoidance and adverse situations. A summary of the mean and standard deviation scores for each item and subscale are presented in Table 3.9.

Table 3.9: Assessment of Readiness for Mobility Transition

Items	Mean	SD
Mobility loss can be sudden or progressive, but it is always devastating.	4.59	0.77
Asking others for help with mobility means that I am losing my independence.	4.16	1.10
I am a burden if I ask others for help with transportation.	3.28	1.42
I avoid thinking about losing my mobility.	3.24	1.46
I wish others would stop talking to me about my mobility.	2.32	1.34
Asking for a ride creates an inconvenience for others.	3.17	1.44
It is devastating for older people to have someone take away their car keys.	4.48	0.92
I do not like to ask others for a ride.	3.31	1.42
I feel depressed at the thought of being limited in my mobility.	3.07	1.52
Moving to a retirement community is too restrictive for my desired mobility.	3.48	1.46
When I see older people with significant limitations in mobility, I fear that I will end up like that too.	3.03	1.49
There is no way to plan for loss of mobility in ageing.	2.99	1.48
A big loss of mobility would really hurt my self-esteem.	3.61	1.39
Loss of mobility is very isolating and depressing.	3.84	1.27
I shudder to think of a time when I am less mobile than I am now.	3.57	1.38
I refuse to accept that I might lose my mobility in the future.	2.68	1.42
My future independence hinges on my ability to get myself around.	3.82	1.30
I have not thought much about my future mobility before today.	3.03	1.59
I've seen others become frail and immobile in older age, and I am determined to avoid this fate at whatever cost.	3.82	1.27
It really frustrates me when I have difficulty getting around.	3.23	1.43
I feel angry when I think about losing my mobility.	2.44	1.38
I feel self-conscious when my mobility needs become a concern for others.	3.26	1.39
It is not easy for me to ask for help with transportation when I need it.	2.90	1.47
Total Score (α =0.87)	3.36	0.69
Subscales		
Anticipatory Anxiety (α = 0.81)	3.42	0.86
Perceived Burden (α = 0.75)	3.18	1.05
Avoidance (α = 0.49)	2.89	0.92
Adverse Situation (α = 0.47)	3.81	0.68

On average, subscale scores were below the thresholds suggested by Meuser et al. (2013). This indicates that, on average, participants in our sample were less anxious and more prepared for mobility transition compared with US samples. Independent ANOVAs were undertaken to test the main effects of independent variables: age, gender and location, with the average subscale scores and total scores from the ARMT, however no significant main effects were identified in any of the models indicating that there were no significant relationships between age, gender and location and the subscale scores or total score for this sample of participants.

Following the ARMT survey, participants were asked a further series of questions relating to their intent to transition from driver to non-driver and the use of technologies to assist mode change. First, participants were asked if there was someone in their own house or outside their house who could drive them places and how available that person was. Approximately one-quarter of participants did not have someone in their household who could drive them places if needed (26.7%), while almost three-quarters of the sample did have someone available (73.3%). For those who did have an available driver within the household, most respondents stated that this person was always available (51.3%). For those who indicated that a driver was available outside the household, 35.9 percent of respondents indicated that these drivers were available 'quite often' (see Table 3.10).

Table 3.10: Availability of a driver (within and outside of household)

.	Person available to drive in your household		Person available to drive outside your household	
	Frequency	**Percentage (%)**	**Frequency**	**Percentage (%)**
No	134	26.7	64	12.8
Yes	367	73.3	437	87.2
Never	3	0.6	1	0.2
Seldom	10	2.0	55	11.0
Quite Often	33	6.6	180	35.9
Very Often	64	12.8	104	20.8
Always	257	51.3	85	17.0
Don't know	-	-	12	2.4

Next participants were asked about their ability to use different types of technology, such as computers/laptops, smart phones, home technologies, etc. Overall, the majority of participants stated that they do consider themselves able to use technology (85.8%). Participants, who responded "No" were asked if there were reasons why they do not use technology, while participants who responded "Yes" were asked if there were reasons why they do not use technology more often (Table 3.11).

For participants who were able to use technology, the most common barrier to increased use was the right experience or knowledge using the technology. This was also the most common reason given for those who were unable to use technology.

Table 3.11: Use of technology

	Able to use technology		Unable to use technology	
	No	**Yes**	**No**	**Yes**
You don't own one	422	8	58	10
You have a medical condition or impairment that affects your ability to use it	428	2	67	1
You can't afford it	427	3	66	2
You year using it	427	3	63	5
You don't have the right experience/ knowledge in using it	354	76	16	52
No Barriers	122	308	64	4
Other	422	8	63	5

The next set of questions were only asked to the 85.8% of respondents who stated that they considered themselves able to use technology. The questions asked about their awareness of a range of transport-related resources, schemes, and technology and if they had experience using each. Table 3.12 provides a summary of the responses to these questions.

When discussing available resources, there appears to have been some ambiguity with the question as only a small proportion of respondents were aware of the four resources mentioned. This was unusual as many participants stated they were not aware of technology such as trip planners, however this did not align with the responses regarding their awareness of technology.

When asked about different transport schemes, most participants were aware of discounted public transport fares for older adults and a high proportion of respondents took advantage of the scheme. Few respondents were aware of door-to-door or ride share schemes.

When asked about various trip planning technologies, there was a roughly even split for each of the categories, however participants were more aware of services provided by non-transport authorities, such as Google Maps. For each of the technologies, the majority of participants who were aware of the technology also had experience using the technology.

Table 3.12: Knowledge and experience in using transport-related resources, schemes and technology

	Knowledge			Experience		
	Yes	No	Don't know	Yes	No	Don't Know
Resources:						
Focus workshop	10.0	89.3	0.7	39.5	60.5	-
Booklets or brochures	17.9	81.6	0.5	48.1	50.6	1.3
Support groups	23.3	75.6	1.2	48.0	52.0	-
Technologies (e.g. online travel planner)	39.1	60.5	0.5	71.4	28.6	-
Schemes:						
Public transport fare discounts for older adults	80.5	18.6	0.1	83.2	16.7	-
Door-to-door services with credit point systems	6.0	93.0	0.1	42.3	57.5	-
Ride-share with discounts for older adults	10.7	88.4	0.1	41.3	58.7	-
Technology:						
Trip planners from transport authorities available through the Internet on a personal computer	45.8	53.5	0.7	77.7	21.8	0.5
Trip planners from transport authorities available through the Internet on a mobile device	36.9	62.6	0.5	73.6	26.4	-
Trip planners from non-transport authorities available through the Internet on a personal computer	64.8	34.7	0.5	73.6	26.4	-
Trip planners from non-transport authorities available through the Internet on a mobile device	60.0	39.8	0.2	81.7	18.3	-

Next participants were asked whether a range of technologies would improve the task of planning regular trips (see Table 3.13). Generally, participants agreed that trip planning and trip booking services would improve the planning task. There were mixed feelings to whether online shopping would improve trip planning, while there were positive views towards online banking and other online essential services.

Table 3.13: Ratings for improving planning tasks

	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree	Not applicable
Trip planners through the Internet on a personal computer	11.2	10.5	10.9	28.4	36.0	3.0
Trip planners through a mobile phone app.	16.7	12.6	8.8	21.9	35.8	4.2
Booking transport services through the Internet on a personal computer	13.7	14.9	11.2	25.8	27.2	7.2
Booking transport services Using a mobile device (e.g., iPad, Tablet, mobile phone)	18.6	11.4	9.8	24.7	28.6	7.0
Online shopping (e.g., groceries, medications, etc.)	26.0	14.9	7.9	20.9	23.3	7.0
Online banking and other essential services	16.7	7.4	4.7	20.2	48.4	2.6

The final set of questions related to driverless vehicles and participants willingness to privately own or use them for ride-sharing. First, participants were asked if they had heard of AVs, as previously mentioned the majority of respondents (489) were aware of driverless vehicles. Next participants were asked if they would consider privately owning a driverless vehicle. That majority of participants disagreed (62.2%) and would not use a driverless vehicle with only 21.8% agreeing and the remaining 16% unsure. The response proportions were similar when asked if they would use a driverless ride-share vehicle with 65.9% disagreeing, 21.7% agreeing and the remainder unsure (12.5%).

Common reasons given for not using a driverless ride-share vehicle included, not trusting them to arrive on time (13.6%), the service being too expensive (6.0%), concerns for safety (38.7%), and not knowing how to use them (11.4%).

The last question was designed to gauge participant's willingness to pay for, taxi, ride-share and community transport services. Participants were asked to state how much they would be willing to pay for a 10 kilometre trip using each travel option (Figure 3.5). Overall participants were most willing to pay for taxi's and least willing to pay for ride share services. The majority of participants (68%) would be willing to pay over $10 for a 10 kilometre taxi trip, compared to 34% for ride share services and 33% for community transportation.

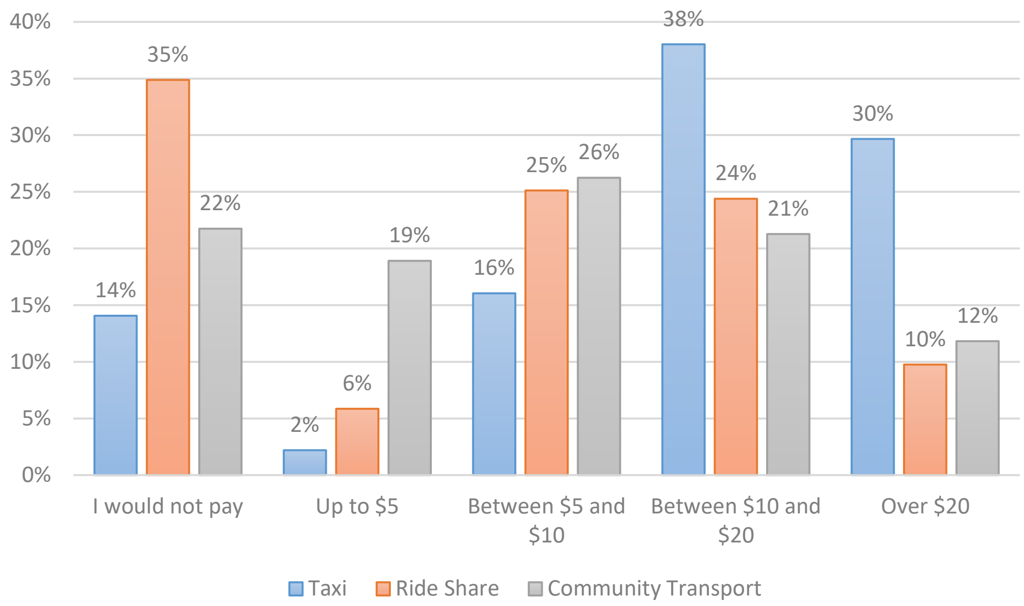

Figure 3.5: Willingness to pay for transport modes

4 Discussion

The deployment of new vehicle technologies has the potential to yield a new wave of road safety and other benefits and can play a key role in managing the safe mobility of older adults. It is suggested in-vehicle assistive technologies can address older drivers' functional decline and avoidable behaviours, assist older drivers with regular driving activities and increase safe mobility (Guo, 2010; Classen et al., 2019). It is also suggested that older adults are willing to accept in-vehicle technology that assists their driving (Musselwhite & Haddad, 2007; Bryden et al.; Koppel & Charlton, 2013).

The current study aimed to enhance our enhanced understanding of older adults' awareness, acceptance and use of safer vehicles and technologies that may assist safe mobility as drivers and users of other modes of transport. In particular, it investigated: i) the extent of use of safer vehicles amongst older Western Australians; acceptance of and adaptation to new vehicle technologies; mobility needs and use alternative transport modes and current tools and programs to encourage and assist mode shift.

The study comprised a comprehensive review of the relevant literature and a survey of older Western Australian drivers. The findings of the literature review showed that there is a small but substantial body of literature addressing the impacts of ADAS on older drivers and that a number of technologies, particularly forward collision warning and advanced emergency braking systems, that can assist older drivers' performance and compensate for potential deteriorations of age in dealing with complex driving situations. On the other hand, it was noted that there is a lack of understanding regarding the benefits/disbenefits of technologies on older drivers' performance that can affect their safety (e.g., distraction, limited attention and information processing resources to navigate complex interfaces, etc.) (Bruyas & Simões, 2010; Strayer et al., 2016).

The review also identified that there was a significant body of literature addressing the awareness, acceptance and adaptability to in-vehicle technologies (Classen et al., 2019; Eby et al., 2018; Musselwhite & Hadden, 2017). Generally, the evidence suggests that, while there is some awareness and acceptance of new technologies, older adults (particularly older women) are less aware and accepting of new technologies compared with younger adults.

It was noted that actual usage of technology is the ultimate measure of acceptance, and that more effort should be made to promote purchase and use of safer vehicles and provision of more experience using technologies. Evidence suggests that, even though many older adults are receptive to new technologies, particularly with respect to how the technologies could improve their driving safety, there are factors that can influence adoption of technologies including simplicity, usefulness, and functional reliability of features (Charles River Associates, 1998; Regan et al., 2002), as well as provision of enough time by warning signals, and direct experience in using technologies (Davern et al., 2015; GHSA, 2018).

With regard to the use of other technologies and resources to assist in the transition from driver to non-driver and use of alternative transport modes, there was very little published literature, however, the review identified a number of technological advances in resources providing information that could assist the use of alternative transport options by older adults including trip planning, traveller information, reservation and dispatching systems, journey substitution (e-services), or training on public transport. The review identified a number of incentives and schemes to encourage use of alternative travel modes including public transport, community transport, taxi, ride-share, patient transport, other vehicle transport, mobility devices, and walking and cycling. In addition, best practice principles in implementing effective initiatives were identified. Examples included: free travel on public transport during times that older adults are most likely to use public transport; establishment and co-ordination of community transport networks for older adults (such as the ITNAmerica initiative); establishment of taxi/ride-share services and schemes to encourage use; provision of accessible travel information; etc.

The findings of the survey of older Western Australian older drivers confirmed previous literature regarding awareness and acceptance of vehicle technologies and willingness to purchase safer vehicles. Overall, the sample was representative of older metropolitan and rural drivers ranging in age from 65 to 92 years, mainly residing in Perth and surrounding areas, and comprised active drivers who drove frequently and substantial distances. They were experienced and safe drivers, having few crashes or infringements.

In response to questions on their current vehicle, the majority of respondents owned vehicles with some safety features (albeit, an older fleet of vehicles being on average 8 years old), and safety featured as a relatively high priority factor in selecting their vehicle (although other factors such as reliability and reputation of the make and model of the vehicle were more important than safety).

While there was some awareness by the sample of some important in-vehicle technologies, such as AEB, ACC and FCW systems, overall awareness was generally low, and this was particularly so amongst older participants. Moreover, there was little knowledge of the presence of safety features in current vehicles. It was encouraging to find that, for those who were aware of features, a high proportion of this group indicated that they would consider these features as priorities when purchasing a new vehicle. However, most participants were not planning on replacing their vehicle in the short term, and many had no intention to ever purchase a new vehicle. The lack of intention to change vehicles, was reflected in knowledge of new vehicle technology, and suggests that any initiative to raise awareness of safer vehicle purchases should occur at an early stage.

It was interesting to note that, while participants were generally aware of AVs/driverless vehicles, most of the participants were not aware of the specific Levels of autonomy. Moreover, there was poor acceptance of AVs, with only one-quarter of participants willing to pay any additional amount for the including of driverless features. This is a new finding. In contrast and consistent with previous findings, participants were more receptive to the inclusion of added ADAS safety features, with over half of participants willing to pay additional amounts for features.

It was not surprising to find that younger participants were more aware of technologies, more likely to use safety technologies, and indicated higher willingness to pay for technologies. This supports previous evidence that the use of technology is increasing amongst older populations, especially amongst younger cohorts (60-70 years) (Langford & Mitchell, 2003; Age UK, 2016).

With regard to the transition from driver to non-driver, there is a large body of literature addressing this process. There is strong evidence that, to continue to be active participants in their communities, to reach services, and to maintain social connectedness, older adults require good access to adequate and appropriate transport and mobility options (WHO, 2015). However, older people's transport and mobility needs are diverse, and tend to change over time and, it is important to acknowledge that, at some point, most older adults will need to consider transitioning from driver to non-driver. Decisions about driving cessation are difficult and complicated by the numerous adverse psychosocial and health consequences association with driving cessation.

Much of the research attests to the fact that the transition from active driver to former driver, for many older adults, is accompanied with a sense of lost independence and personal identity, social isolation, decline in overall quality of life and well-being, loss of self-esteem, depression, reduced satisfaction with the ability to go places, and increased stress of family and carers (e.g., Marottoli et al., 2000; Mezuk & Rebok, 2008). In contrast, there is emerging evidence that, with the aid of resources, planning, appropriate timing and decision making, some older adults can and do make a successful transition from driving to non-driving (e.g., Oxley & Charlton, 2009). There is also evidence that older adults are increasingly engaging in walking and cycling (Garrard, 2009), and other active modes of transport such as motorised mobility scooters (Johnson et al., 2013; Coxon & Oxley, 2019).

The current findings demonstrate that our sample of older Western Australian drivers were generally satisfied with their transport mobility and ability to reach services and social engagements when they required, and less anxious and more prepared for mobility transition compared with US samples (Meuser et al., 2013), regardless of age, gender and location of residence. While participants also indicated that a range of transport options were available to them and access was not an issue, there was little use of transport modes alternative to the private vehicle (as driver or passenger), particularly taxis, ride-share and community transport with a volunteer driver

The current findings also suggested that our sample was 'tech-savvy' with over 85 percent of participants considering themselves able to use technology, consistent with previous research indicating increased use of technology amongst older adults (ABS, 2011; Australian Communications and Media Authority, 2016). For those not able to use technology, experience and knowledge were common reasons for non-use.

With regard to use of technologies to assist with use of alternative transport modes, there was some awareness of some technologies and resources, but little awareness of others. Moreover, few participants used technologies or took advantage of incentive schemes, views towards AVs/driverless vehicles were fairly negative with substantial resistance to using driverless vehicles, and there were mixed responses regarding online resources, despite acknowledging that some technologies would improve access to services and general mobility. Common barriers included mistrust, cost, inexperience and safety concerns.

4.1 Recommendations

The viability, affordability, accessibility and sustainability of safer vehicles and alternative transport modes are critical to maintaining mobility, and the implications for transport utilisation by older road users will be significant. This section provides a suite of recommendations that will inform the development of effective strategies and initiatives to promote uptake of safer vehicles, awareness and acceptance of in-vehicle technologies and effective technologies that can assist transport mode change and ultimately enhance safe mobility of older Western Australians.

It is expected that the recommendations will inform considerations for the WA Road Safety Commission in the short, medium and longer term, to implement effective policies, resources and practices that assist older drivers maintain safe driving and successful transition to retirement from driving.

4.1.1 Uptake and use of safer vehicles and awareness/acceptance of vehicle technologies:

Given the evidence of the benefits of safer vehicles and vehicles equipped with safety technologies including ADAS and driverless features, and the survey findings that i) current vehicles are relatively old, ii) safety is not the highest priority for vehicle purchase, iii) there is currently little awareness of vehicle safety features, and iii) few participants intend on future vehicle purchase, there is a clear need promote the purchase and use of safer vehicles and to improve understanding of the benefits of in-vehicle technologies.

Programs and initiatives that may be considered to address improved uptake and awareness of safer vehicles include:

- Incorporate safer vehicle purchase into broader programs and activities addressing safe mobility of older drivers;
- Develop and implement a targeted education campaign on safe vehicle purchase and use. A targeted education campaign could include the following components:
    - Community and public service announcements using a range of media appropriate for the target audience and with appropriate messaging. TV and/or newspaper advertisements appropriately designed for the target audience can provide an efficient way to impart information when there is wide community lack of understanding.

- Publicise key safety issues: increase awareness of the evidence surrounding the benefits of safer vehicles and vehicle technologies, correct use of vehicle technologies, increase trust in using technologies, etc.

- Enhance existing information and resources available on the RSC website, such as www.howsafeisyourcar.com.au, www.ancap.com.au, used car safety rating guides, with targeted messages for older drivers.

- Develop and implement training programs and resources to increase knowledge and experience with using technologies:

  - Training programs providing practical experience in using vehicle technologies

  - Incorporation of programs with existing education initiatives offered by road safety advocacy and community groups such as those offered by RACWA (e.g., 'Your Driving Future'). Consideration of implementing successful programs such as CarFit, enhanced with safer vehicle purchase information is also recommended.

- Wide promotion of resources and services available through the RSC website and other appropriate organisations such as RACWA, WALGA, Community Services, U3A, seniors clubs and community groups, etc.

- Engagement with car dealers to enhance information dissemination at time of vehicle purchase.

- Engagement with insurance agencies/organisation to develop subsidy schemes for purchase of safer vehicles. Consider the promotion of safer mobility for older drivers through:

  - Providing insurance subsidies for safer cars (i.e., 5-star ANCAP safety rating), and

  - Providing insurance subsidies for completing refresher training courses

4.1.2 Resources and technologies to assist transition from driver to non-driver and use of other travel modes:

There are rapid changes worldwide regarding future transport options and utilisation, including use of the private car and the emergence of viable, affordable and sustainable alternatives. Moreover, it is important for the successful transition from driving to non-driving that older road users are aware of alternatives to driving, familiarise themselves with other modal choices at an early age, and be encouraged to use these modes. To mitigate potential negative outcomes of driving reduction/cessation, it is critical for the RSC and other government agencies and community organisations to recognise i) the need to support older Western Australians to live full and active lives and remain healthy and vital members of the community, and ii) the benefits of providing better access to viable transport options as a key method to achieving a positive impact on healthy ageing.

Programs and initiatives that may be considered to address improved utilisation and awareness of, availability and access to enhanced alternative travel modes include:

- Consider options to encourage use of public transport by:

  - Further incentivising local public transport trips in metropolitan, regional and remote areas and exploring the feasibility of free off-peak travel on public transport for older Western Australians;

  - Reviewing the eligibility criteria for seniors' concessionary public transport travel to consider lowering the age and/or work requirements to allow older adults to transition to public transport before retirement from work;

- Maintaining the support and funding to public transport providers;
- Working with public transport operators to analyse state coverage to ensure most communities are within public transport coverage;
- Exploring the feasibility of conducting open mobility days for older adults and people with limited mobility to obtain information and hands-on training on public transport use, allow older adults become acquainted with public transport services and their accessible use

- Consider options to encourage use of safe community transport options by:
  - Exploring the opportunity for integrating the community transport network to ensure resources are well-allocated and utilised;
  - Considering the use of a unified call centre number to book local community transport trips;
  - Exploring the integration of community transport with public transport in local communities (e.g., drop-off and pick-up at public transport stations;
  - Considering the unification of the eligibility criteria, fee structure and nature of services provided by all community transport providers within WA;
  - Ensuring driving record checks are in place for volunteer community transport drivers including medical fitness to drive, and offer regular refresher training; and,
  - Conducting detailed analysis of state coverage to ensure most communities are within reach of community transport coverage.
- Consider options to encourage the use of taxi and ride-share services by:
  - Extend provision of existing WA taxi voucher scheme to extend eligibility to include older residents in metropolitan, regional, rural and remote communities with limited access to public transport; and
  - Providing specialised taxi services for older residents in regional and rural communities with limited access to public transport to commute to essential services (e.g., similar to the schemes in Gold Coast, Logan and Brisbane councils in Queensland).
- Consider options to encourage use of active/alternative travel modes by:
  - Enhancing educational materials such as a handbook for promoting alternative transport options and mode shift schemes for older road users, and
  - Exploring modifications to road design and urban planning to accommodate increased walking and cycling.
- Consider options to provide accessible travel information by:
  - Providing an integrated website (with supporting smartphone application) providing detailed accessibility information for older adults to plan multi-modal trips (similar to the GoLA smartphone application or Connect San Mateo website).

These recommendations will pave the way for the next phase of translation and implementation of programs which will require engagement between the WA RSC with community groups, ageing peak bodies, health and transport groups and road safety research organisations to provide information and messages to older adults on safer vehicles, and access to alternative transport modes. Implementation of any program will require evidence-based research for development, trial and evaluation to ensure sustainability and effectiveness.

4.2 Conclusions

This study employed a multi-method approach to understand the issues surrounding use, awareness and acceptance of vehicle technologies as well as other technologies that can enhance the safe mobility of older Western Australians. The findings from a comprehensive review of the relevant literature, as well as the findings of a survey of older Western Australian adults, have been synthesised to identify a range of evidence-based opportunities for initiatives to enhance the safe mobility of older adults through the uptake of safer vehicles and initiatives to assist use of alternative transport modes for non-drivers. The opportunities identified are centred around promotion of safer vehicle purchase, awareness and acceptance of current and emerging in-vehicle technologies, and initiatives, incentives and subsidy technologies to promote use of alternative transport options. Recommendations are provided to inform policies, programs and resources that will effectively assist older adult maintain safe mobility which, in turn, will achieve targets of more Western Australians with better health and wellbeing, to be resilient and connected, and to create healthier choices and healthier environments.

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