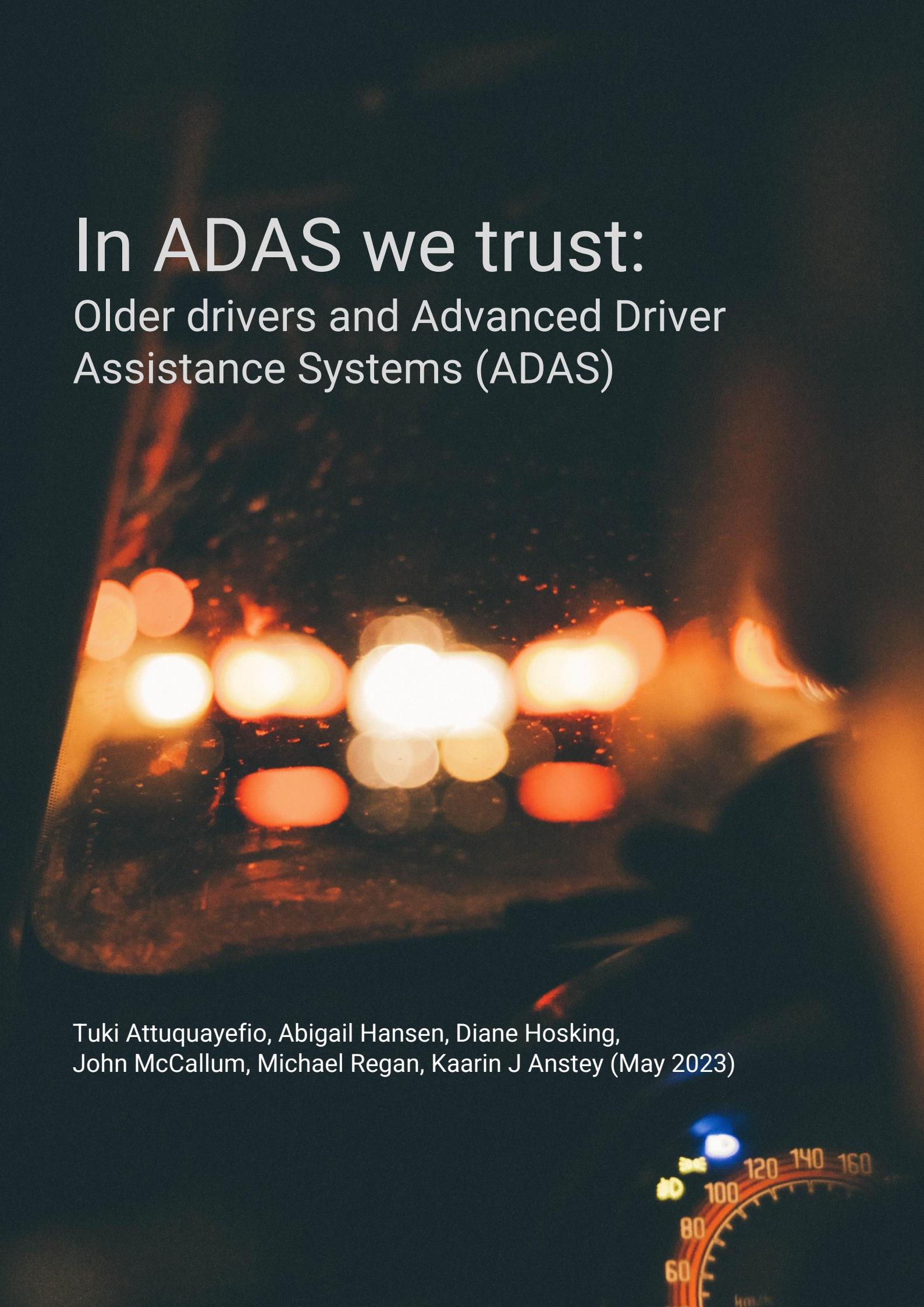
In ADAS we trust:

Older drivers and Advanced Driver Assistance Systems (ADAS)



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UNSW SYDNEY

National Seniors AUSTRALIA

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1. Abbreviations and definitions

Abbreviation	Meaning	Definition
ALA	Active Lane Assist	Helps the driver stay in the centre of the road lane
ACC	Adaptive Cruise Control	Helps the driver to maintain a constant speed and slows vehicle down to a safe distance from vehicles in front of other vehicles.
ADAS	Advanced Driver Assistance Systems	Advanced driver assistance systems, or ADAS, are in-built vehicle safety systems that support the driver to maintain safe driving. Most new vehicles on the market are equipped with ADAS which support drivers in following their chosen route, control their speed, stay safely within their lane, and in avoiding collisions.
ADH	Adaptive Headlights	Automatically change position when going around corners to increase visibility; dips automatically when there are approaching cars; turns on automatically when light levels are low.
AEB	Automatic Emergency Braking	Activates brakes automatically if collision with another vehicle or road user (e.g., pedestrian/cyclist) is imminent
BSM	Blind Spot Monitoring	Warns of vehicles in the blind spot as well as those approaching rapidly to the side
CCC	Conventional Cruise Control	Helps the driver to maintain a constant speed
CTA	Cross-Traffic Assist	Warns of oncoming traffic when reversing vehicle (e.g., out of a parking space or driveway)
FCW	Forward Collision Warning	Warns driver if a collision with another vehicle or road user (e.g., pedestrian/cyclist) ahead is imminent
HWYA	Highway Assist	Combines Active Lane Assist and Adaptive Cruise Control. Helps the driver to stay in their lane, maintain a constant speed and slow the vehicle down to a safe distance from vehicles in front if vehicles ahead are travelling more slowly.
LDW	Lane Departure Warning	Warns driver if they drift out of their lane
PA	Park Assist	Helps to steer vehicle automatically into a parking space
SL	Speed Limiter	Limits speed of vehicle to a top speed chosen by the driver

2. Executive Summary

Older drivers are over-represented in crash statistics. New partial automation technologies in cars such as Advanced Driver Assistance Systems (ADAS) offer an opportunity to improve driver safety, especially in older drivers. However, little is known about how older adults interact with, perceive and trust in ADAS in their cars. While some measures explore technology acceptance or trust in automation, none do so in the context of ADAS and older drivers. A total of 1330 National Seniors Australia (NSA) members and affiliates provided responses to a survey distributed through NSA's online 'Connect' newsletter and NSA's Facebook page. This survey sought to understand how drivers aged 60 years and older use and interact with ADAS features in their vehicle, including reasons to use/non-use, attitudes and perceptions, and trust towards ADAS. The sample comprised mostly males with an average age of 71.9 years. Conventional Cruise Control was by far the most used feature and Park Assist the least used. Drivers learned about these systems through dealerships or car manuals. Only a small number of drivers report any problems hearing or seeing the ADAS alerts. Older drivers reported concerns around trust and confidence, especially in self-driving cars. Older drivers generally agreed that ADAS features were easy to use, useful, aided in safety and the presence of ADAS features would impact their intention to buy a vehicle.

3. Background

Driving is important for the independence, and ongoing social and economic participation, of older Australians (Fonda, Wallace, & Herzog 2001). In 2017, 15.4% of the Australian population was aged 65 and over, a 3.3% increase from the previous year. By 2031 this figure will increase to 19.4% (between 5.7-5.8 million), with 4.5% aged 85+ (the group with the highest crash risk) (BITRE 2022). Approximately 92% of adults aged 70+ are licensed drivers (BITRE, 2014), and this demographic is over-represented in crashes per distance travelled (Pointer, Harrison, & Avefua 2019), have fatality rates equivalent to those of drivers aged 17-25, and their frailty increases their risk of serious injury (DeGrauw et al. 2016; Pointer, Harrison, & Avefua 2019). They also have the highest health care costs when involved in a crash (Braver 2004). In 2015, the estimated cost of fatal crashes involving at least one driver aged 65+ was $1.1 billion AUD and this will continue to increase with population ageing.

Older Australians are highly dependent on private vehicles as a preferred mode of transport (Australian Bureau of Statistics 2020), with 79% reporting travelling more than 50km per week (Anstey et al. 2017). Concurrently with an ageing population, we are undergoing a revolution in vehicle technology with the evolution of Automated Driver Assistance Systems (ADAS). Recent reviews identify vehicle automation as an opportunity to enhance mobility, safety and social participation of transport disadvantaged groups such as older adults but note that the usability of this technology is a potential critical barrier to achieving this (Millonig 2019; Young, Koppel, & Charlton 2017). A systematic review of existing evidence on the potential for ADAS to extend the period of safe driving for older adults concluded that most available systems showed high potential (Eby et al. 2016). Of the 271 studies reviewed, however, very few examined effects on real-world on-road safety, most only included older drivers within a larger sample, and rarely directly examined age-related effects (Eby et al. 2016). Thus, there is a need for data on real-world safety outcomes of automation for older drivers. Although prior studies have examined drivers' perceptions, use and attitudes toward ADAS, few have focused on older drivers (Eby et al. 2016).

Vehicle automation is classified by the Society of Automotive Engineers (SAE) in levels from zero (no automation) to five (full automation, and several decades away from consumer use). Level 3 and 4 vehicles (which can automate all driving functions, most of the time, e.g., driverless shuttle buses) are still being trialled in Australia. Most new vehicles on the consumer market include Level 1 (e.g., Adaptive Cruise Control) and Level 2 (e.g., Highway pilot; automated acceleration, braking and steering) features. Insurance and market data suggest Australian consumers aged 65+ years are the fastest growing group intending to purchase a new vehicle (Roy Morgan 2018). As vehicles with

increasing levels of automation enter the market, insurers (Teoh 2020) and consumer advocacy groups (National Council on Disability 2015) are calling for evidence-based information on how drivers adapt to such vehicle changes, its impact on driver behaviour, mobility, and crash risk.

Analyses conducted in United States and Sweden show some systems like Forward Collision Warning (FCW) can reduce rear-end collisions by 18-27% (Cicchino 2017) and in combination with Automated Emergency Braking (AEB) systems reduce rates to 50-59%. However, data on Blind Spot Monitoring (BSM) systems suggest no decrease in crash rates (Isaksson-Hellman & Lindman 2018) and findings for Lane Departure Warnings (LDW) are unclear with lane-related crash reductions of 18%, and once driver demographics such as age and gender are considered in models, this reduces to around 11% (Cicchino 2018). Indeed, studies rarely control for driver characteristics, and none have examined effectiveness in older drivers (Cicchino 2017, 2018; Isaksson-Hellman & Lindman 2018).

3.1. Study Aims

A potential solution to the challenges older drivers face may be the use of ADAS. Therefore, the aim of this project is to understand how older drivers use, interact with and learn about ADAS features in vehicles. In addition, we aimed to better understand the attitudes and trust held towards ADAS by older drivers.

4. Survey

To meet the study aims, the research team at UNSW worked with NSA to create a survey of its members and affiliates across Australia. The methodology is described in detail below.

4.1. Participants

The targeted sample size was 1000 adults aged 60 years and above who are NSA members or affiliates, with a current driver's license. The survey comprised questions on demographics and driving experience; general health and wellbeing questions; ADAS experience, knowledge and use, as well as intention to use which included items on trust in, acceptance of and attitudes towards ADAS. The survey also included a separate module of cognitive tests, though these findings will not be reported here.

4.2. Measures

4.2.1. Demographics

For demographics, information was collected on the respondents' age, gender, education, occupation, living situation and accommodation type.

4.2.2. Driving Behaviour and Experience

For driving experience, information was collected on frequency and distance of driving, vehicle type, license status, use of in-vehicle technology, and crash history.

4.2.3. ADAS use and knowledge

For ADAS experience, knowledge and use questions were developed in consultation with experts in the field to assess the respondents' level of experience with 12 commonly employed ADAS features in Australian vehicles. These included: Active Lane Assist (ALA), Adaptive Cruise Control (ACC), Adaptive Headlights (ADH), Automatic Emergency Braking (AEB), Blindspot Monitoring (BSM), Conventional Cruise Control (CCC), Cross-Traffic Assist (CTA), Forward Collision Warning (FCW), Highway Assist (HWYA), Lane Departure Warning (LDW), Parking Assist (PA), Speed Limiter (SL). A detailed explanation of feature definitions is included in the *Abbreviations* section.

4.2.4. ADAS Attitudes

Questions measuring attitudes towards and trust of ADAS measured the following: Behavioural intention, Negative and Positive Attitudes, Perceived Risk, Trust and self-efficacy, Usefulness and Ease of Use. These items were measured using a 5-point Likert scale, from 1 (strongly disagree) to 5 (strongly agree).

4.3. Procedure

The research team at UNSW engaged with study partner, NSA, to recruit participants to take part in the survey and introduce the research via its mailing list. NSA advertised the survey in their weekly e-newsletter called '*Connect*' which is distributed to its members and affiliates who have opted in to receive the e-newsletter. In addition, NSA recruited through its social media page. Below is an overview of the recruitment and survey distribution:

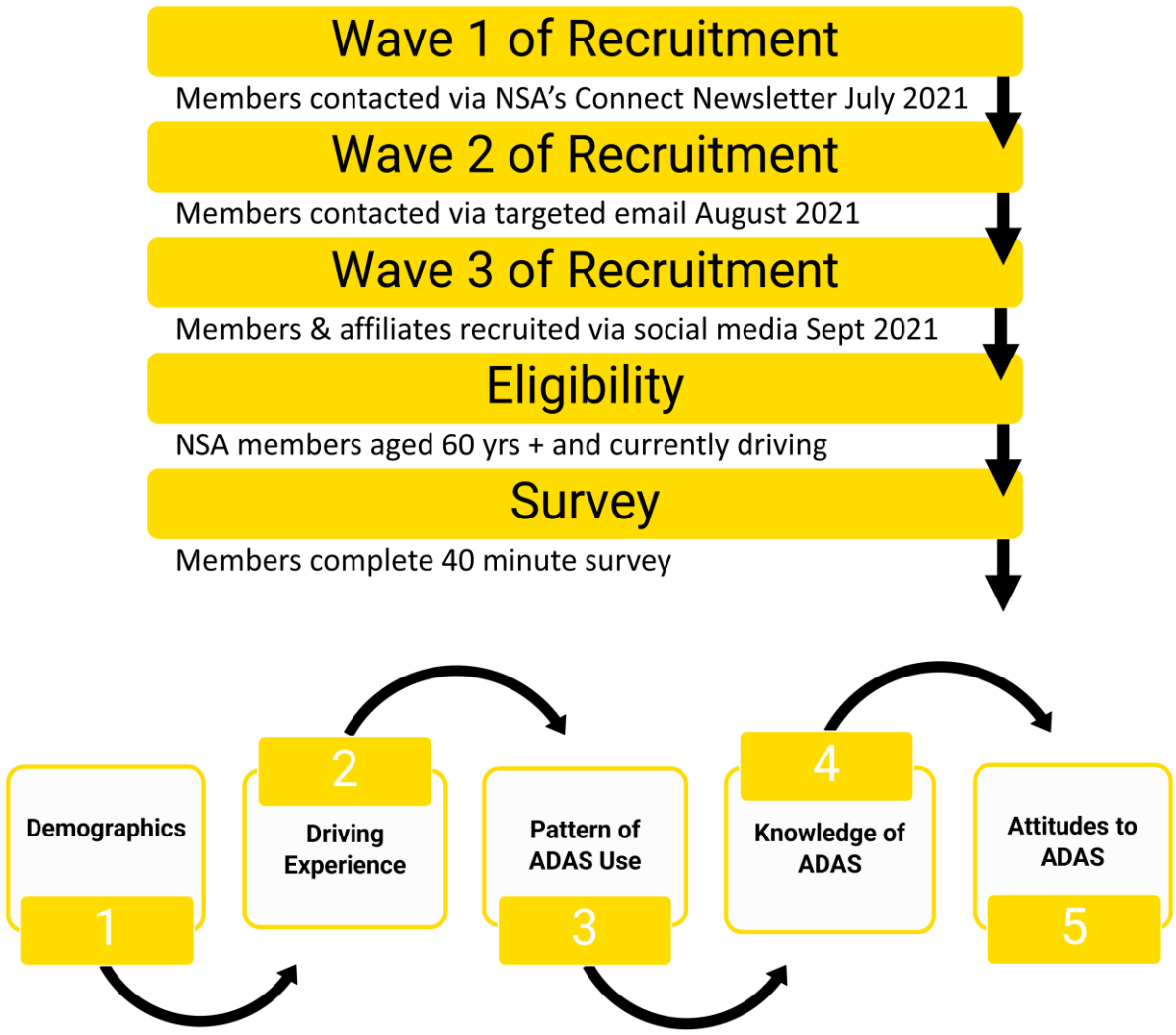


Figure 1. Flowchart showing Study Overview.

The recruitment process was three-fold:

Wave 1: A brief article published in the e-newsletter introducing the research project, the research team at UNSW, the definitions of ADAS technology and why it is important to understand how older adults engage with this type of technology. Information about the study was described, including inclusion criteria. Interested persons could click on a link to the information sheet and eligibility form, before going to the main survey. Survey responses were collected in an online survey platform, REDCap.

Wave 2: The following week, the flyer and survey link were published again in the e-newsletter with the secure survey link. To boost response rate, members and affiliates who had opted into receiving online communication were sent an email with the flyer and link attached reminding them about the opportunity to do the survey.

Wave 3: Facebook advertising: a directed social media marketing campaign was run on Facebook via NSA to reach its members and any other persons on Facebook that met the eligibility criteria.

To account for varying digital proficiency levels amongst this older population, the online survey aimed to be simple and intuitive, with the option to save and return later to complete the survey in multiple sittings if needed. Respondents who did not wish to answer a question could select the 'Prefer not to answer' option. The online survey took up to 40 minutes to complete.

Below is a breakdown of the number of people that were reached, clicked the ad, and subsequently completed the survey. This is also split by the recruitment source (i.e., Facebook and the NSA Connect Newsletter)

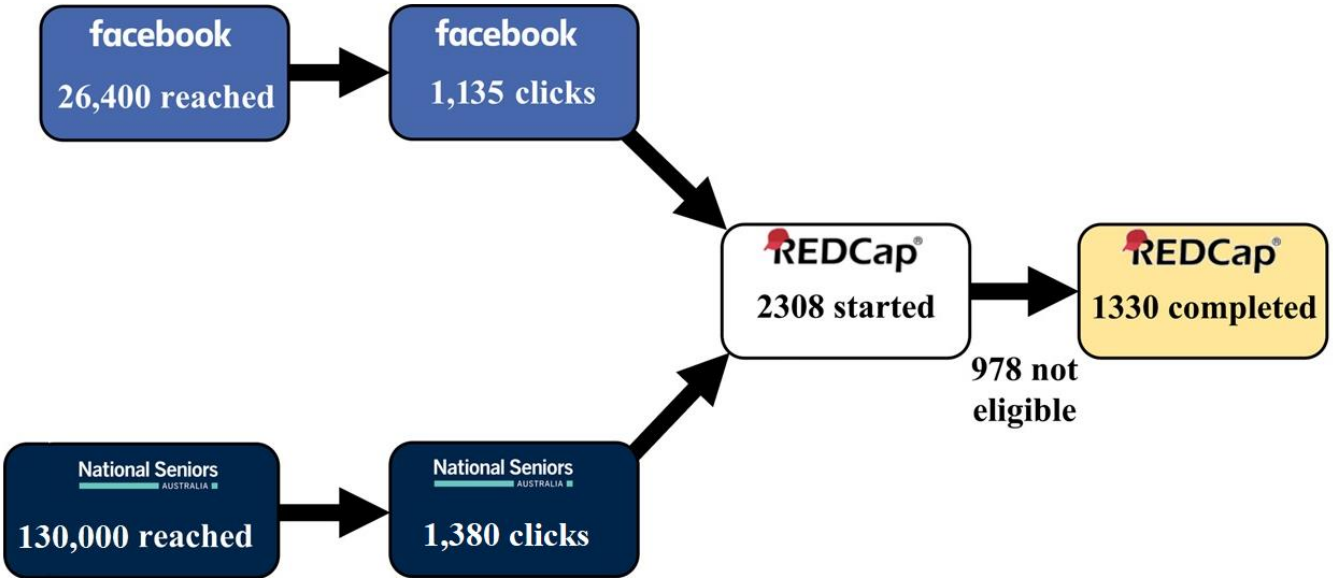


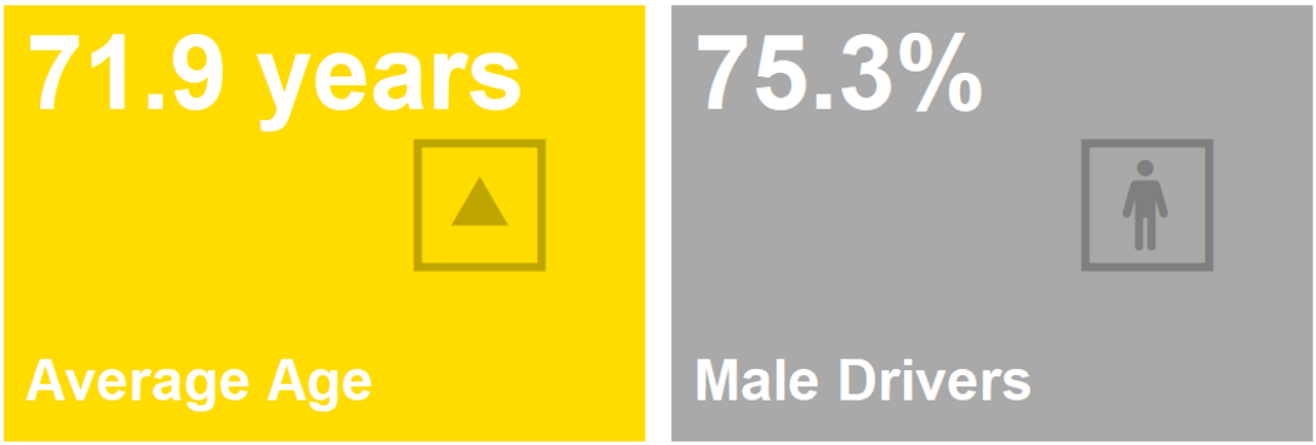
Figure 2. Breakdown of Reach, Clicks and Survey Completions by Recruitment Source.

4.4. Analysis Methods

All analyses and data visualisations were generated in RStudio (2022). Respondents younger than 60 years were removed and partial and completed responses were retained.

5. Results

5.1. Survey Respondents



The online survey was completed by 1330 Australian licensed drivers ranging in age from 60 to 98 years. All states were represented, however the majority lived in NSW (37%) or Queensland (23%). Seventy-five percent identified as male, 23% identified as female, along with 0.15% identifying as non-binary, and 0.07% as other. Most respondents lived with at least one other person - 72% with their spouse and 2% lived with family - while 21% lived alone, and only 0.07% lived in residential aged care. Overall, the older drivers that responded had completed some form of education after high school (79%), with 8% not finishing high school. Unsurprisingly, the majority were retired (77%), however, 8% reported engaging in full-time and 10% in part-time paid employment. The most frequently reported medical condition among drivers was hypertension (30%), followed by visual impairment (16%) and arthritis (14%). More than 16% of drivers reported having none of the listed medical conditions.

5.2. Top 10 Vehicle Brands

Below are the top ten most reported vehicle brands driven by the survey respondents with Toyota being by the far the most common.

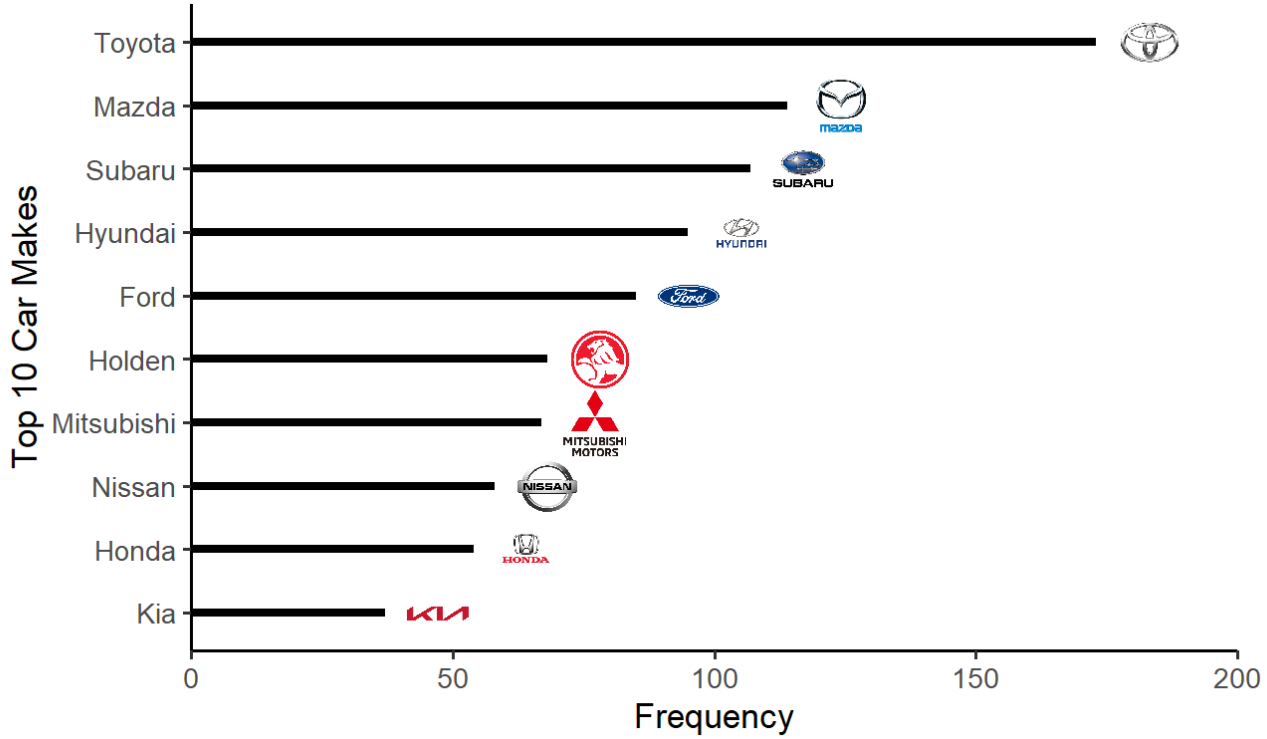
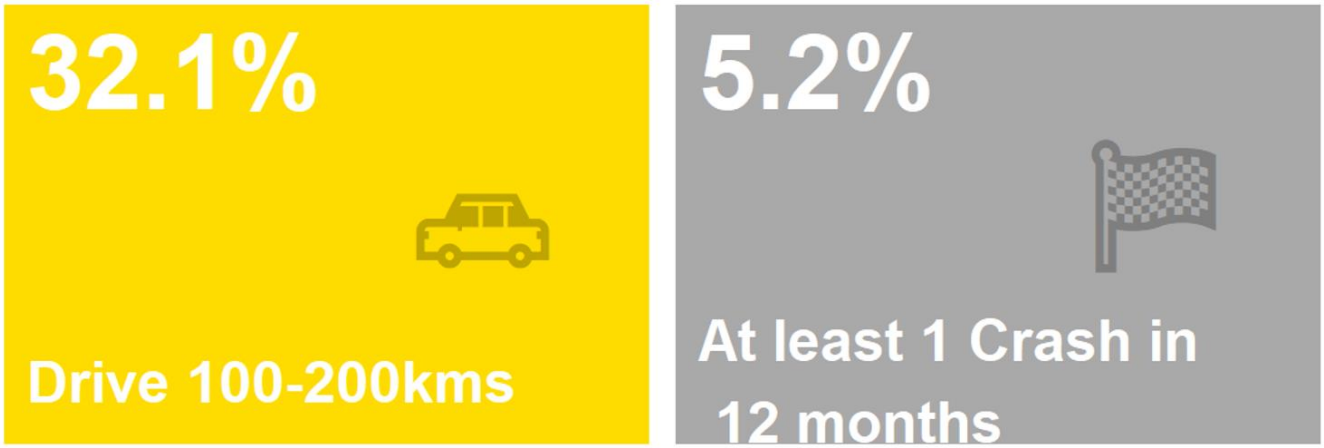


Figure 3. Top 10 vehicles owned by survey respondents.

5.3. Driving Behaviours and Experience

All respondents had a current license, with only 1% having a modified license. The primary mode of transport was a private vehicle (87%) and 98% owned their own car. The average age people started driving was 17.1 years for males and 19.7 years for females. Most seniors rated their driving quality as Good (53%) or Excellent (37%). Respondents mostly drove 100-200kms per week (32%), with 77% of driving undertaken in familiar areas. Fortunately, self-reported crashes were not common, with ~5% of drivers reporting a crash in the past 12 months.



5.4. Experience with ADAS

To better understand how older drivers use and interact with ADAS features, we asked seniors which features they use, how often, and how they learned to use the feature. If they reported not using them often, we asked why. Findings are reported below.

The most used ADAS feature was Conventional Cruise Control, which often comes standard in many vehicles and drivers report using it regularly. The least used ADAS feature was Park Assist.

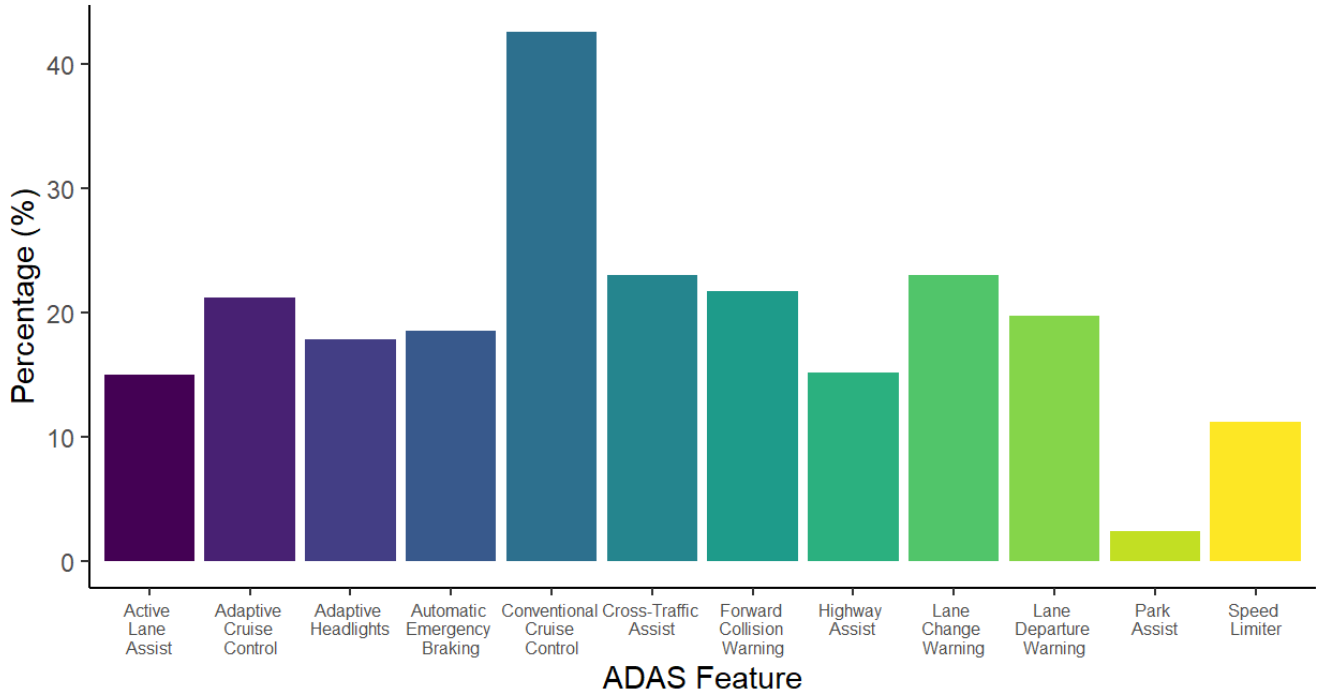


Figure 4. Frequency of ADAS features regularly used by older drivers.

Differences in ADAS use between the most and least used features are interesting to observe. Despite much lower rates of use, drivers were still aware of Park Assist. More older drivers reported having it in their car and rarely or never using compared to regularly using it. Drivers may therefore opt to *not* use Park Assist.

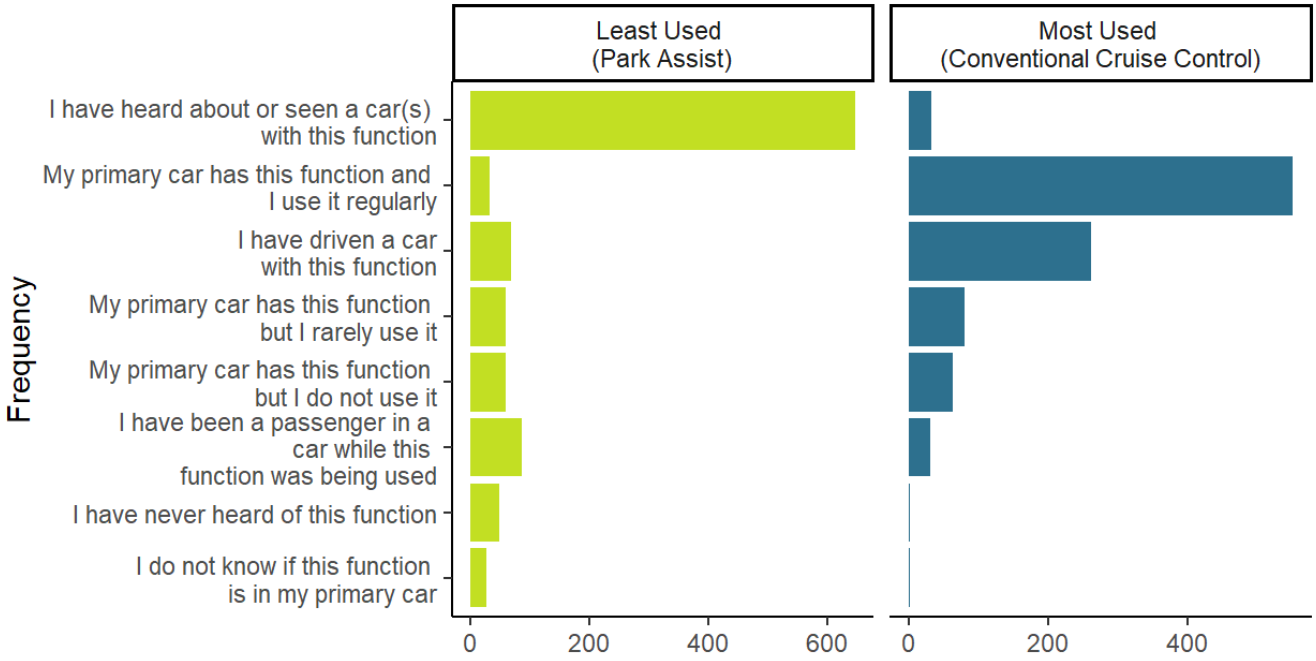


Figure 5. Comparison of ADAS use and knowledge between least and most used ADAS.

Unsurprisingly, a large majority of respondents reported using CCC for more than 24 months. However, most respondents reported using all other ADAS features for a similar time, suggesting older drivers would be familiar with these ADAS features.

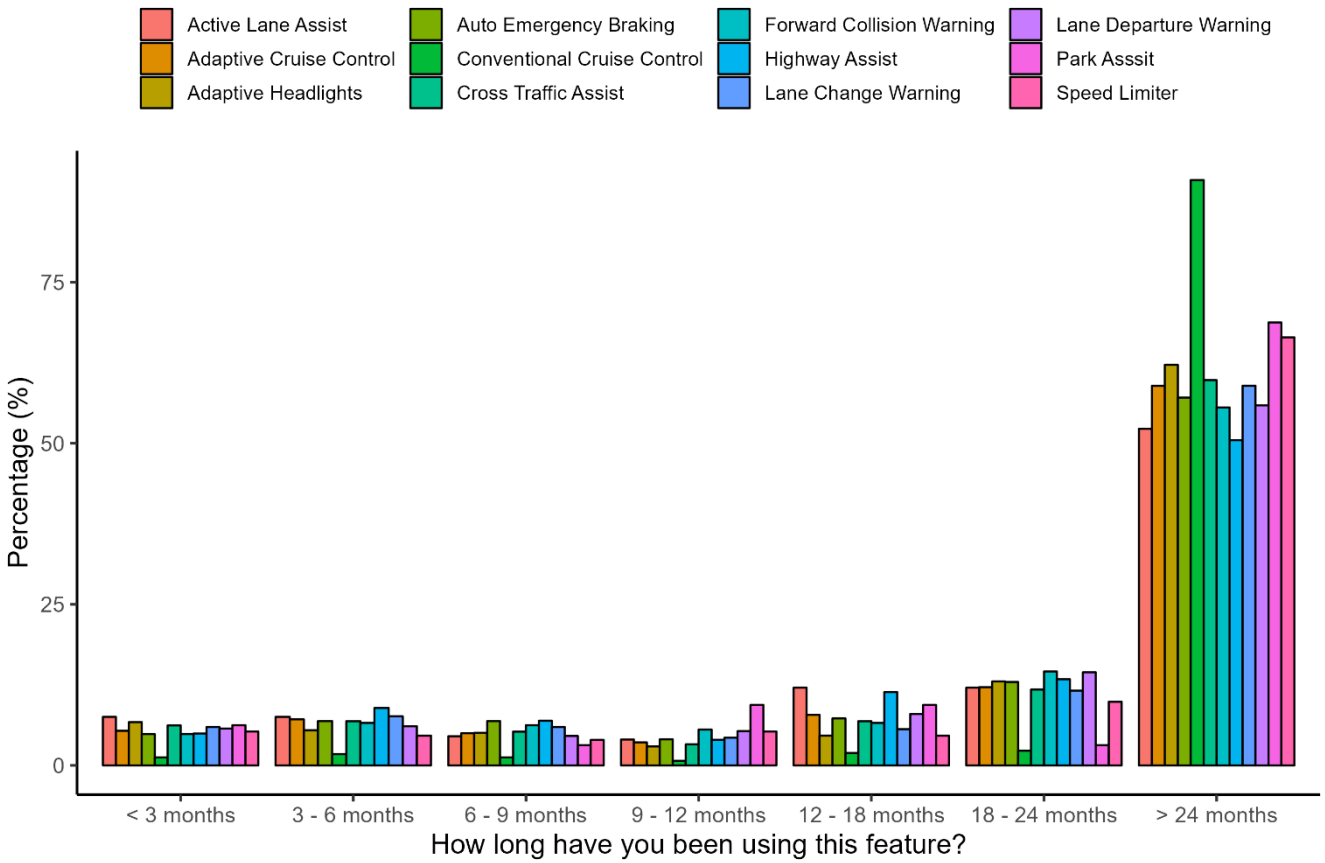


Figure 6. Length of use for each ADAS feature.

5.5. Learning to Use ADAS

Survey respondents were asked how they typically learn to use ADAS in their vehicles. Respondents could select more than one option if they learn to use the systems through multiple means. Responses are shown below.

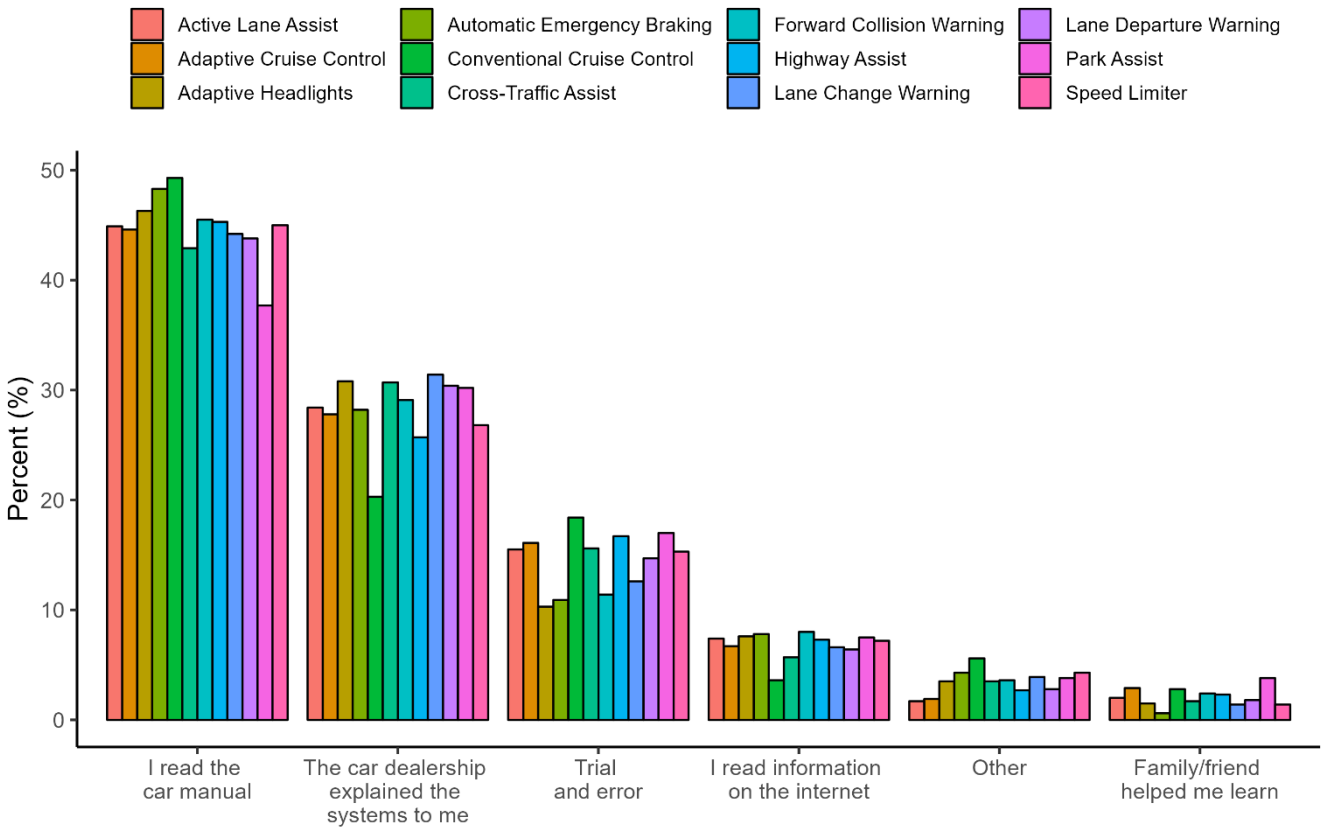


Figure 7. How older drivers learn to use each ADAS feature.

The vast majority of older drivers report either reading the manual or learning through explanation by the car dealership. This pattern of results was similar across all 12 ADAS, with the exception of Conventional Cruise Control (CCC). This has lower rates of explanation through a dealership and higher rates of trial and error. This is likely due to the fact that CCC has been available in Australian vehicles since the 1970's. More recent ADAS systems likely take priority when car dealers are explaining the suite of vehicle features available.

5.6. Reasons for Rare ADAS Use

Respondents that reported not or rarely using ADAS were asked to provide reasons for its rare use. Respondents could select more than one option if there were multiple reasons. 2.2% and 3.1% of drivers reported not using or rarely using ADAS features, respectively. Not triggering the ADAS in the vehicle was the main reason for non-use. Relatively few drivers reported problems interacting with the vehicle ADAS such as not hearing, seeing, or being distracted by the ADAS. Figure 8 shows the proportions of non-users who selected each reason.

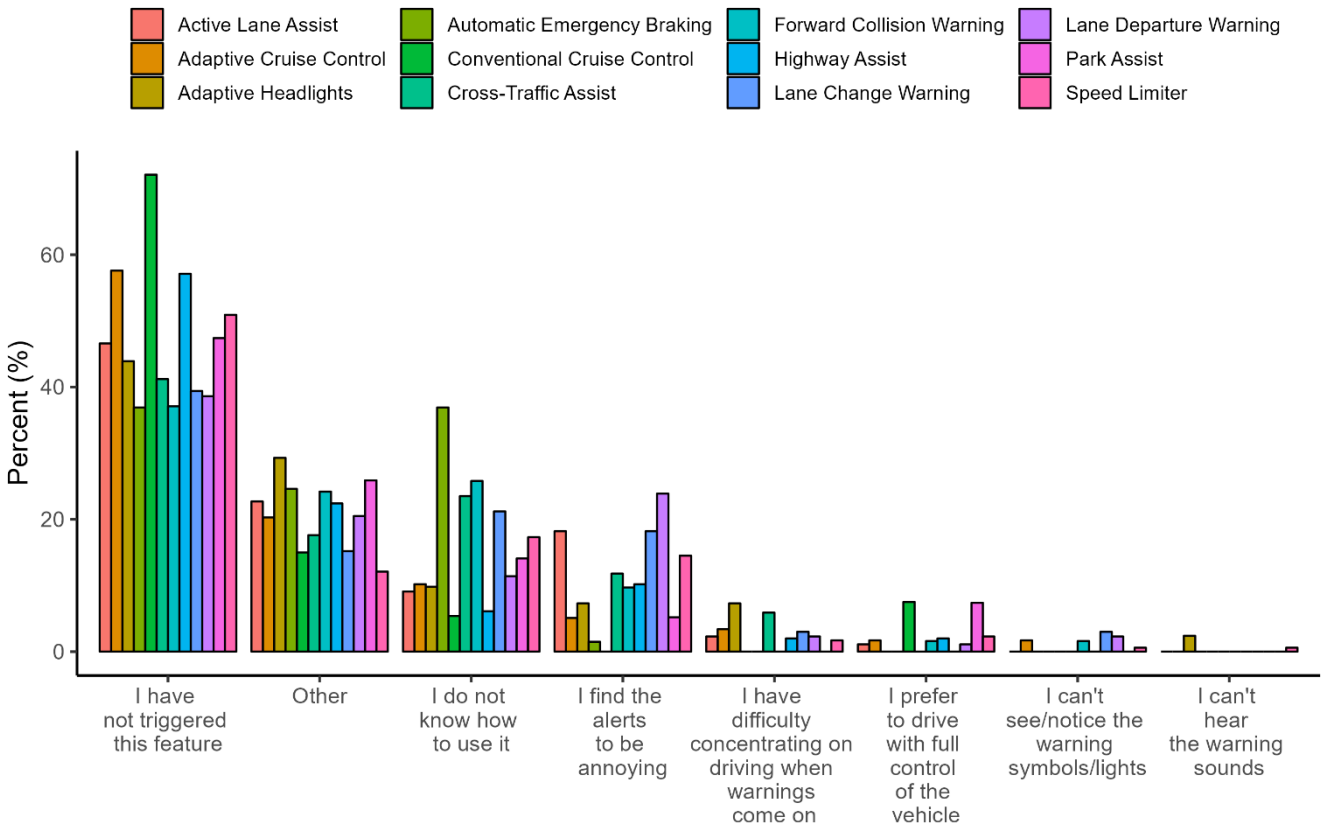


Figure 8. Frequency of reasons for not using ADAS features.

5.7. ADAS Attitudes and Trust

Attitudes, opinions, feelings and trust in ADAS are outlined below and fall into the following categories: (1) Behavioural Intention to purchase a car based on ADAS features; (2) Attitudes (positive and negative) towards ADAS; (3) Perceived usefulness and ease of use of ADAS; and (4) Perceived risk and trust in ADAS.

5.7.1. Behavioural Intention for ADAS

Generally, most respondents had positive behavioural intentions for ADAS, suggesting that the presence of ADAS features would influence their vehicle purchase decisions. Only a small percentage of respondents disagreed with statements about the impact of ADAS on buying intent, while 14-20% of respondents had neutral sentiments to these statements.

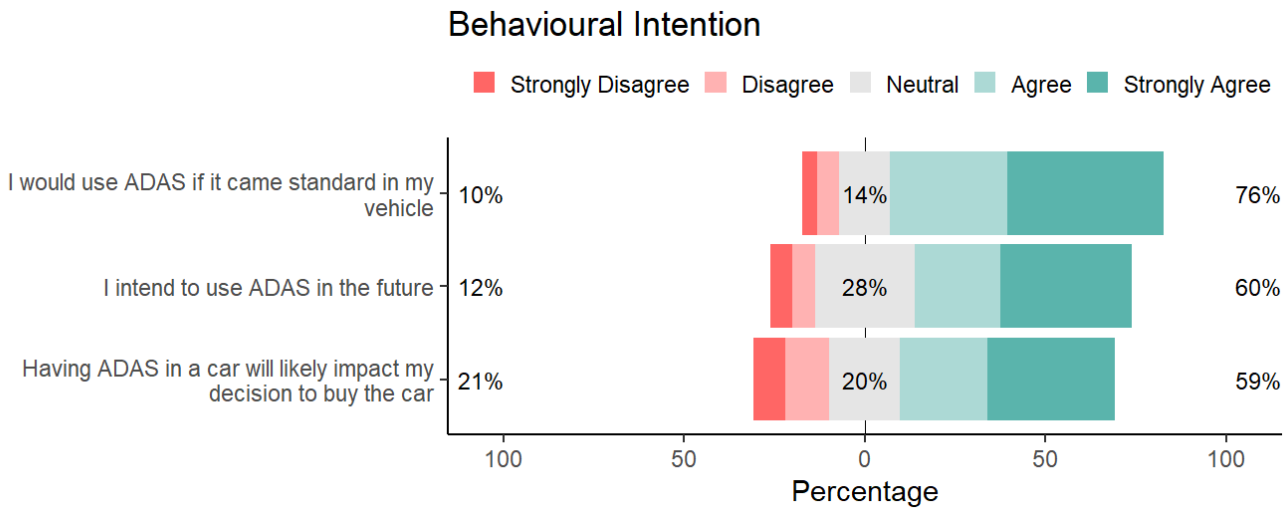


Figure 9. Plot of Behavioural Intention questions.

5.7.2. Attitudes to ADAS

Respondents mostly disagreed with the negative attitude statements for ADAS, suggesting that they held positive attitudes towards ADAS. Indeed, statements on positive attitudes were strongly agreed with, indicating ADAS features are positively viewed with few negative attitudes. Again, we see a range of responses to statements that fall into neutral sentiment.

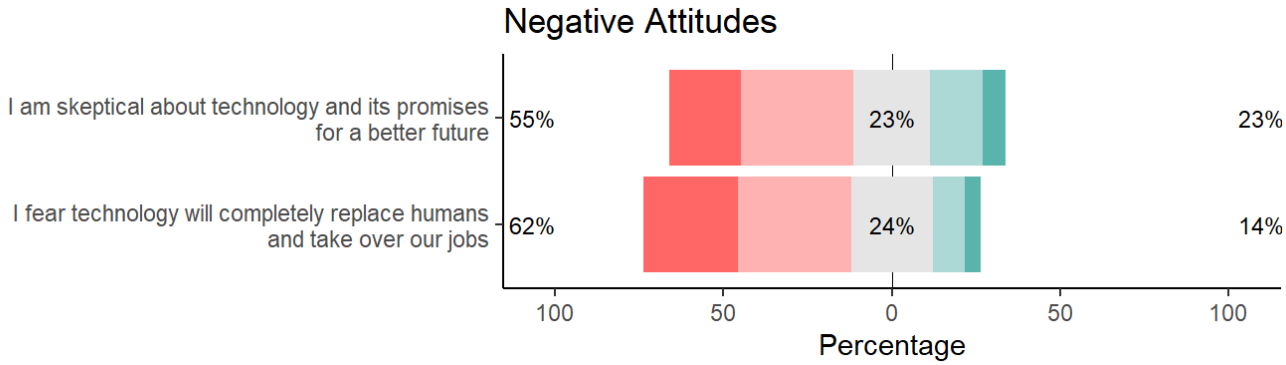


Figure 10. Plot of Negative Attitudes to ADAS.

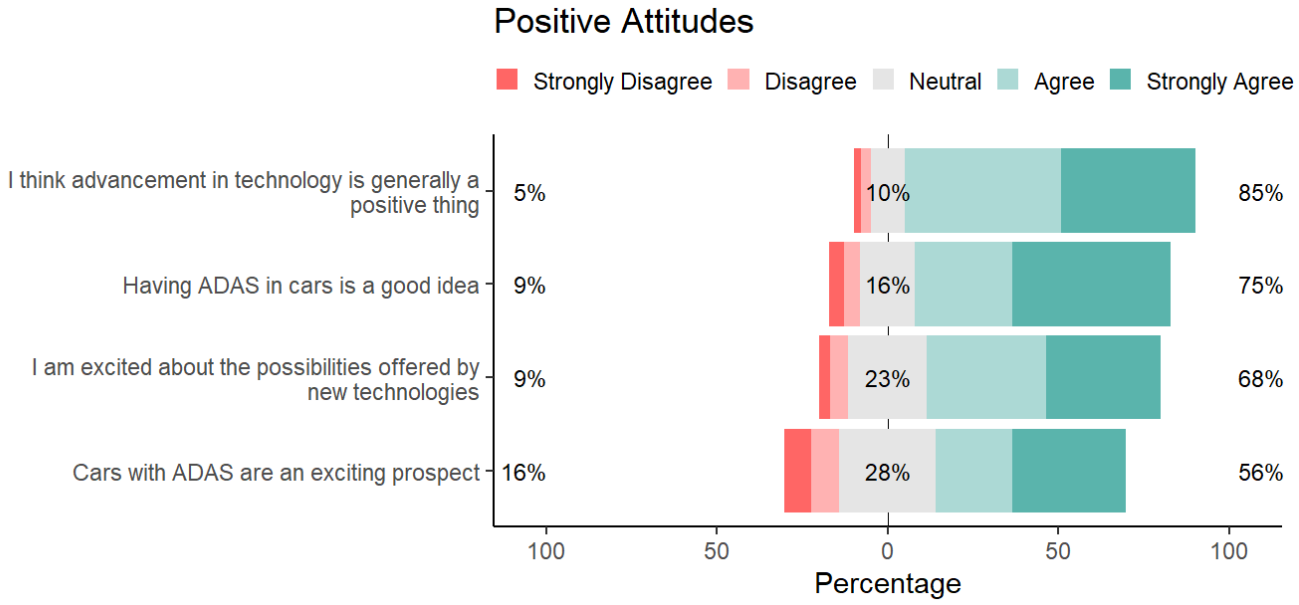


Figure 11. Plot of Positive Attitudes to ADAS.

5.7.3. Perceived Usefulness and Ease of Use

Respondents agreed strongly that ADAS features are useful and easy to use. This is great news as it indicates the utility of ADAS features to improve driver safety for older drivers, without major challenges associated with advancing technology - a common challenge that older adults are particularly vulnerable to. Despite these clear trends for positive sentiments about usefulness and ease of use, approximately 25% of respondents held neutral sentiment. It would be interesting to explore in future work why these respondents responded neutrally. It may suggest that ADAS design is not problematic, but drivers may not perceive its usefulness. Alternatively, the infrequent use of ADAS may mean that respondents may not see its usefulness.

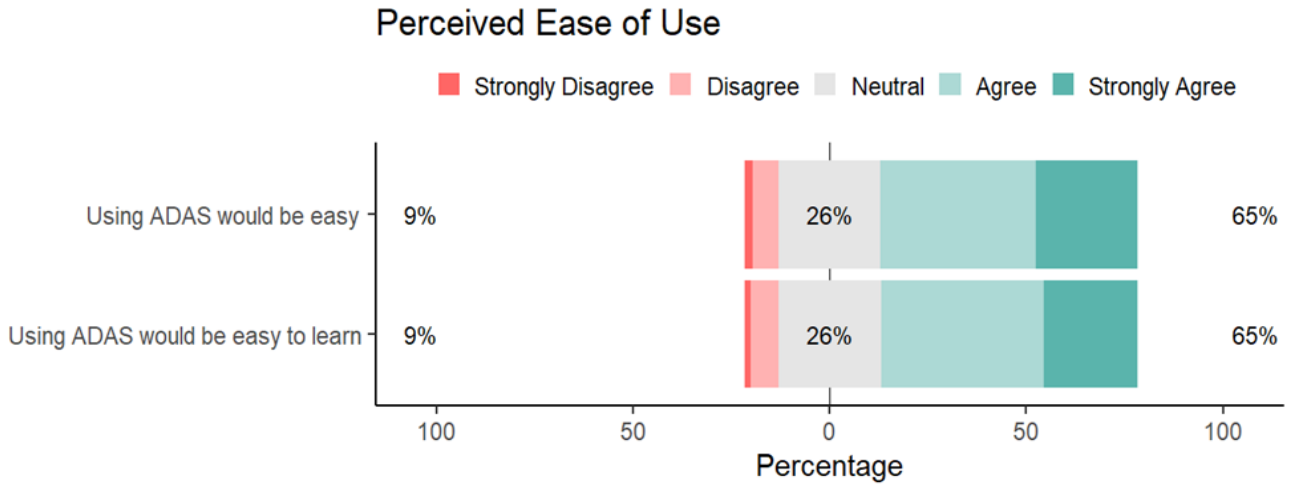


Figure 12. Plot of Perceived Ease of Use of ADAS.

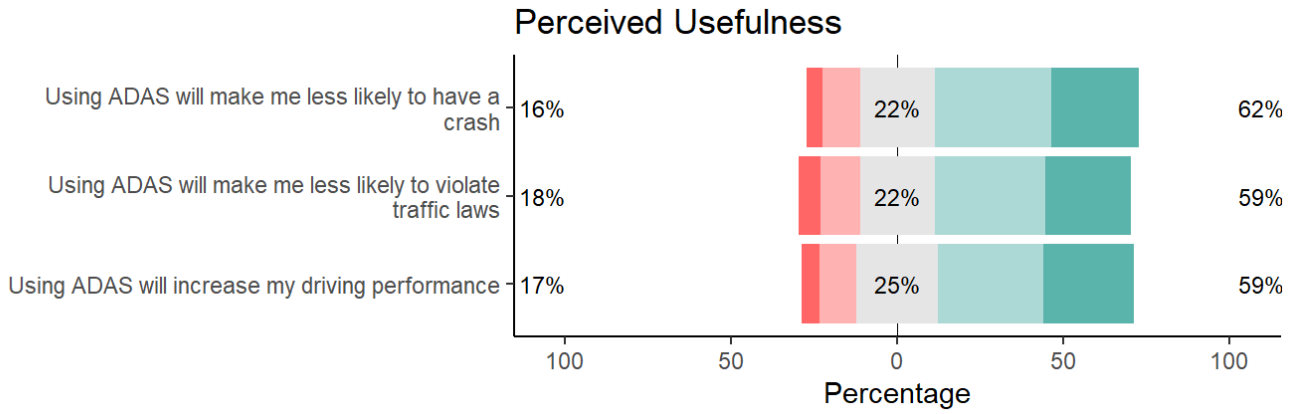


Figure 13. Plot of Perceived Usefulness of ADAS.

5.7.4. Perceived risk and Trust in ADAS

Drivers reported feeling comfortable using ADAS. This is not surprising given long-term exposure to features such as Conventional Cruise Control, though many ADAS features are much more recent. Drivers were split on opinions about how trustworthy, and dependable and reliable ADAS systems are in their vehicles, with similar numbers across the 2 statements on trust and reliability.

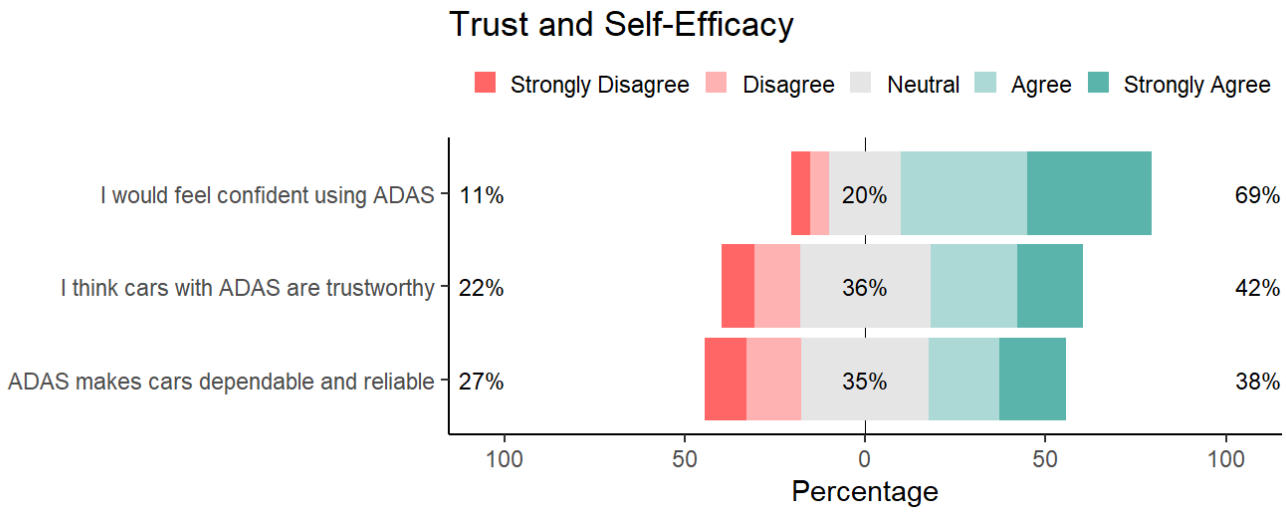


Figure 14. Plot of Trust in ADAS.

Despite overall positive attitudes shown earlier, older drivers report concerns about privacy, safety and failure of the systems. Of all the questions, respondents were most polarised on the question relating to data privacy. Generally, respondents reported not feeling comfortable with self-driving cars.

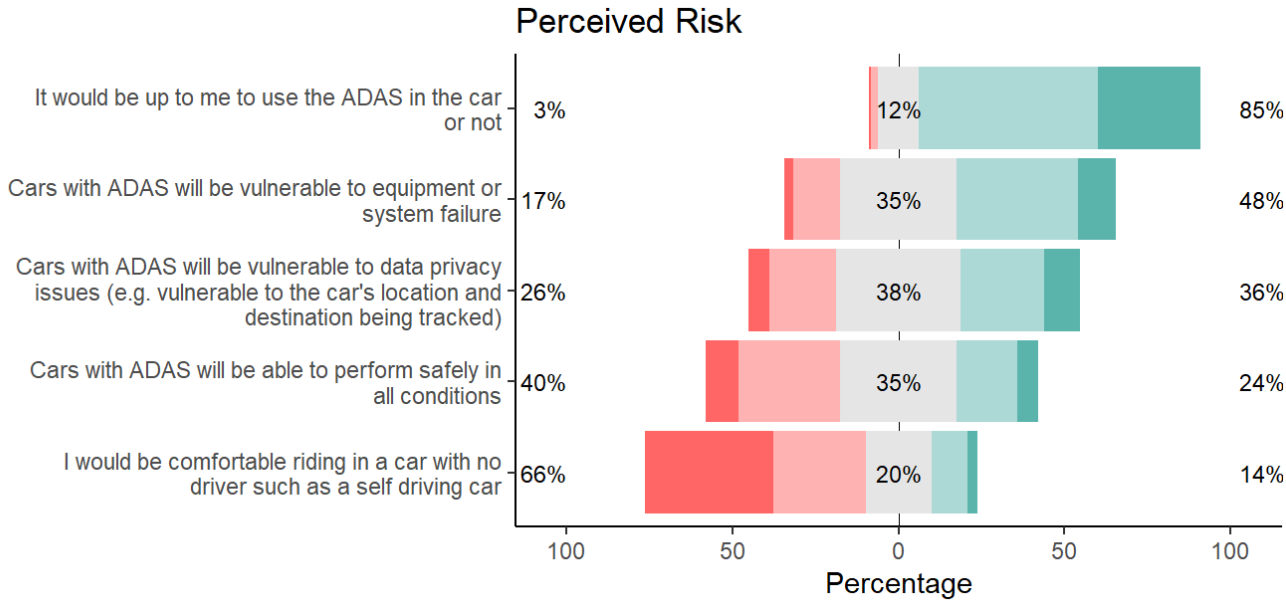


Figure 15. Plot of Perceived Risk of ADAS.

6. Summary

6.1. Key Findings

The sample of older drivers here were mostly males aged in their 70's. Respondents commonly drove 100-200kms and in familiar areas. Self-reported crashes were quite rare, with approximately 5% of drivers being involved in a crash in the past 12 months. In terms of ADAS use, CCC was by far the most used and familiar ADAS feature. This is unsurprising given that CCC has been widely available for many decades now. Interestingly, older drivers report learning to use the ADAS features by either reading the car manual or through the car dealership.

Drivers who reported not using specific ADAS features most commonly reported not triggering the feature. Indeed, some features (e.g., AEB) will only activate in the presence of danger and cannot be turned off. For ADAS features that have manual controls (i.e., can be turned on and off), drivers report not using the ADAS feature as they do not know how to use it or find the alerts annoying, with few reporting being unable to hear/see the alerts.

For the most part, the presence of ADAS impacts the intention to buy a vehicle. Older drivers overwhelmingly had positive attitudes towards ADAS, with few sceptical about the technology itself. Respondents agreed ADAS features are easy to use and useful when driving. Despite these positive attitudes and confidence in ADAS, respondents were more polarised on whether ADAS features are reliable and trustworthy. Indeed, respondents were hesitant to agree that ADAS would perform safely in all conditions and would not be vulnerable to failure or privacy concerns. Unsurprisingly then, older drivers reported not feeling comfortable riding in a self-driving car.

6.2. Significance

This survey reveals the attitudes and perceptions of ADAS technologies in older Australian drivers. There are two key findings from this survey. First, very few drivers report not being able to hear or see the ADAS alerts, suggesting the design features may be suitable for older drivers. Indeed, ADAS technology will benefit older drivers if its design is congruent with the complex needs and diverse abilities of this driving cohort (Young, Koppel, and Charlton 2017). Second, the attitudes and perceptions of ADAS technologies in this sample of older drivers was generally positive. Most agree ADAS technologies are safe, improve driving, and would (at least in part) base their decision to purchase a vehicle on what ADAS features were present.

6.3. Recommendations and Future Research

There is an opportunity for future research to explore which ADAS features are most useful to older drivers and the complex cognitive, health and age-related changes present in this driving cohort. For instance, between 10% and 37% of older drivers reported not knowing how to use ADAS. This is even the case for CCC - the most common and oldest ADAS feature. One possibility is that older drivers may be overwhelmed by the large number of ADAS technologies available and may have difficulty remembering how to use each feature. Future research could explore if a specific selection of ADAS features is effective for improving driver safety without overloading the driver.

Although older drivers' attitudes to ADAS were overall positive, there were approximately 20-30% of people who nominated the neutral response to questions about ADAS perceptions and attitudes. Characterising these neutral responders through demographic or health-related information could direct future studies that focus on expanding awareness of or exposure to ADAS features.

Given that crashes were uncommon, we were unable to determine whether ADAS use was or was not related to self-reported crashes. Future studies could determine in a larger number of older drivers that have recently been involved in a crash the role and use of ADAS systems in their driving.

The sample is large and captures data from all around Australia, however most respondents were male. In addition, older adults already interested or knowledgeable on ADAS may have been more likely to respond to recruitment call-outs. This concern could be tackled in a future survey by drawing on more female voices.

7. Conclusions

Use of ADAS varied substantially, though older drivers typically learned to use ADAS using a manual or in speaking with a car dealership. Non-use typically related to not triggering the ADAS feature, and older drivers report some concerns related to confidence and trust in assistive technology, especially with respect to self-driving cars. Overall, older drivers hold positive attitudes towards ADAS features and the presence of ADAS features increases the intention to purchase a vehicle.

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