NSW Young Drivers Telematics Trial

Sept 2019

State Insurance Regulatory Authority

Findings, implications and lessons learnt

NSW GOVERNMENT

CONTENTS

1. Executive summary

The New South Wales State Insurance Regulatory Authority (SIRA), in collaboration with the New South Wales Data Analytics Centre (DAC) and the New South Wales Centre for Road Safety, launched the Young Drivers Telematics Trial (YDTT) in 2018. It is currently one of the most extensive studies in the world investigating the effectiveness of telematics use on young drivers.

The NSW Government has a State Priority target to reduce road fatalities by 30 per cent by 2021. In addition to the stated fatality reduction target, the NSW Government is also committed to reducing serious injuries on NSW roads by 30 per cent by 2021.

The primary trial objective was to investigate whether, and the extent to which, telematics use can positively influence young driver behaviour. Additionally, the YDTT sought to identify opportunities for, or, barriers to, broadening the use of telematics as a means for improving road safety. Finally, the YDTT also sought to better understand young driver behaviours through a comprehensive collection of real-time driving data.

This report documents the key findings of the YDTT, based on the analysis of over 1.8m km (out of a total 4.1m km) of driving data recorded by young drivers from across New South Wales.

1.1 Impact of telematics use on driver behaviour

The overall body evidence gathered from the Young Drivers Telematics Trial suggests that telematics use has an **overall positive impact** on young driver behaviour.

Results from the randomised control trial (RCT) component indicate that drivers who received driving feedback from an app and real-time LED light ray had a lower frequency and severity of speeding, harsh braking, rapid acceleration and harsh cornering behaviours. This includes:

- a 10.9 per cent lower rate of medium-range speeding (i.e. speeding at 10 to 20km/h over the limit) per 100 driving hours
- a 38.9 per cent lower rate of high range speeding (i.e. speeding at more than 20km/h above the limit)
- a lower overall positive delta speed (i.e. severity of speed limit exceedance), including a 1.56km/h reduction in 50km/h zones
- 42 per cent lower rates extreme harsh braking events per 1000km
- 24.9 per cent lower rates of very rapid acceleration per 1000km
- 24.1 per cent lower rates of harsh turning per 1000km.

Similar changes were also observed in a pre-post study, which occurred in parallel to the RCT.

Notwithstanding the overall conclusion that telematics use has a positive impact on young driver behaviour, the results also suggest that the extent of positive impact varied depending on the category of driving behaviour, traffic environment and driver socio-demographic characteristics.

For example:

- While there were substantial, sustained positive changes for harsh braking and harsh cornering behaviours, changes for speeding were comparably modest and varied throughout the trial.
- Treatment group drivers had lower travelling speeds and speeding frequency in urban and residential speed zones, but higher rates compared to the control group on freeways and rural roads.
- The most considerable treatment-control differences were observed amongst P1 male drivers, suggesting that telematics had a more substantial impact on drivers within this cohort. The differences between treatment-control groups were less substantial amongst female drivers.

Furthermore, the results are unclear as to whether the behavioural changes would be sustained over a longer period.

1.2 Potential to reduce casualty crash involvement by young drivers

The power relationship between mean speed and road safety

An extensive body of research suggests that there is a power relationship between mean travelling speeds and the frequency and severity of road casualty crashes.[1] By applying this relationship to model differences in average travelling speeds between treatment and control groups recorded in the trial, we estimate that telematics use could potentially prevent 159 casualty crashes involving young drivers each year.

This includes the prevention of:

- 2 fatal crashes
- 59 serious injury crashes
- 57 moderate injury crashes
- 41 minor injury crashes.

Telematics use would also help to prevent between 83 non-casualty crashes (i.e. crashes which do not cause injury) by young drivers.

From a road safety perspective, the estimated prevention of 2 fatal crashes and 59 serious casualty crashes is a more direct estimate of potential benefits associated with delivering on the NSW Government road safety targets for fatality and serious injury reduction. In NSW, serious injuries are considered to be all road-related injuries admitted to hospitals, based on hospital admissions records.

1 Cameron, MH (2008) Nilsson's Power Model connecting speed and road trauma: applicability by road type and alternative models for urban roads. Presentation at the Australasian Road Safety Conference 2008.

Limitations and assumptions of casualty crash estimates

Interpretation of crash prevention estimates (and policy decisions arising from this report) should take into account several key uncertainties.

These include:

- **Assumptions of sample representativeness –** the estimates assume that the sample is representative of all young drivers in the age group. However, there may be inherent selection biases in the sample given the voluntary nature of the trial.

- **Uncertainty of trial results –** the average speed differences are based on driving, which took place between July 2018 and March 2019. It is uncertain whether the same results would be replicated in other parts of the year, or over a more extended period.

- **Uncertainty within the power model –** the relationship between mean speeds and the severity and frequency of road trauma is widely accepted within the road safety literature. Notwithstanding, it is important to note the variability within these estimates. These are discussed more comprehensively in 9.1.1.

- **Assumptions that all young drivers are provided with similar telematics devices used in the trial –** Estimates assume that all P1, P2 and full licence holders aged 17-24 (approximately 490,000) and all future Provisional 1 licence holders (about 90,000 per year) are provided with telematics devices that would produce equivalent average speed reductions.

1.3 Potential to save the community between $38.2m and $59.9m per year

Applying existing NSW government methodologies for valuing the prevention of motor-vehicle crashes to the calculated crash reductions, this amounts to an annual community saving of:

- **$38.2m** if using the human capital approach or

- **$59.9m** if using the inclusive willingness to pay approach.[2]

The methods for estimating community savings is discussed more comprehensively in section 9.1.2.

1.4 Young driver perceptions of telematics use

Young drivers perceive multiple benefits of using a telematics device

75 per cent of drivers believed that the use of a telematics device had a positive impact on their driving, 74 per cent indicated they had reduced the risks they took as a driver. 67 per cent believed that telematics use had helped them drive more safely during the trial period.

Many had indicated that the telematics device had given them a higher level of awareness of their driving behaviour. Many also cited the fuel efficiency benefits associated with using the device.

2 Transport for NSW (2016). Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives. p292

The overall experience with using a telematics device was positive, but not without concerns

17 per cent of drivers said that they found the real-time feedback to be distracting, while 11 per cent cited issues relating to connectivity, device design and ergonomics, and the accuracy and validity of recorded data.

Majority of young drivers would like to see telematics used more broadly

Based on their trial experience, 70 per cent of participants surveyed (n=589) believed that more drivers should have a telematics device installed in their cars.

89 per cent also believe that the number of crashes on the roads would decrease if more drivers had telematics installed in their cars.

A surprisingly high percentage of participants (75 per cent) believed that telematics should be mandatory for ALL drivers and an even higher number supported the use of telematics for risky drivers (85 per cent).

1.5 Motivators and barriers to using a telematics device

While some had reservations about privacy risks associated with using a telematic device, the majority of young drivers were not too concerned

17 per cent of participants listed privacy, tracking and data disclosure as a concern they would have with using a telematics device. Some were also wary of the potential for being fined or charged for driving offences based on their recorded driving behaviour.

However, 90 per cent stated that they would not be concerned with government accessing their driving data if it was de-identified.

92 per cent also said they would not be concerned about an insurance company accessing their data if it meant they could get a discount on their insurance.

Cost of purchasing a telematics device is the most significant barrier to young drivers using a telematics device

53 per cent of participants said they would be unlikely to buy a telematics device. However, 77 per cent said that they would be likely to use one if it was provided to them by government or an insurance company.

Survey results also highlight various ways to encourage telematics use in young drivers

Almost universally, young drivers could be encouraged to use a telematics device through:

- Offers of discounts for insurance for good driving (96 per cent)
- Opportunities to win prizes (92 per cent)
- Focusing on fuel efficiency benefits (92 per cent)
- Focusing on the potential to improve driving behaviour (95 per cent) and reduce the likelihood of losing demerit points (93 per cent).

1.6 Limitations & lessons learnt

The findings from the trial suggest substantial scope for expanding the use of telematics as a means of promoting road safety amongst young drivers. However, like all research studies, there is a need to consider the limitations of the trial when interpreting the findings.

One key limitation is that the driving activity of participants may not be strictly representative of the driving activity of all NSW young drivers, and therefore findings cannot be generalised to the broader population.

Another limitation is the likely occurrence of selection bias given the research design for the trial. Although the sampling was targeted to populations of interest and participant selection criteria aligned to highest risk driver cohorts, drivers who chose to participate in the trial were generally more safety-conscious drivers, which might not be truly representative of the highest risk drivers amongst that cohort.

Moreover, there is insufficient evidence from this trial to comment on whether the positive behavioural changes observed within the six months can be sustained.

There are also a few critical issues that will need to be addressed to retain (or maximise) the benefits while minimising the risks of using telematics devices. These include:

- **Improving participant engagement over time and avoiding feedback fatigue** - this could be through integrating social gaming/gamification or rewards features into the telematics app

- **Managing the risk of distraction –** based on analysis of participant feedback around driver distraction, this could be further improved through improving device ergonomics (e.g. secure stowage and brightness of lights), as well as clearer and more upfront communication regarding potential risks

- **Minimising the effects of higher travelling speeds in high-speed zones for those drivers who received real-time feedback** – one strategy would be to re-calibrate the feedback in such a way that it is aligned to speedometer speed (as opposed to true vehicle speed under the configurations of this trial)

- **Optimising the use of push messaging to encourage further behavioural change** – the use of push messaging (post-trip speeding notifications) was only briefly explored in this trial. Further use of push messaging and other 'nudge' techniques could assist with extending and sustaining driving improvements, particularly in ingrained behaviours. Future use of push messaging could explore:

    - the effectiveness of different forms of messaging

    - messages with specific call-to-action (e.g. practical tips to reduce speeding)

    - varying the tone of messaging depending on the frequency and severity of individual risky driving behaviours

2. Introduction

2.1 Background

The New South Wales State Insurance Regulatory Authority (SIRA), in collaboration with the New South Wales Data Analytics Centre (DAC) and the New South Wales Centre for Road Safety (CRS), launched the Young Drivers Telematics Trial (YDTT) in 2018.

The NSW Government has a State Priority target to reduce road fatalities by 30 per cent by 2021 and has released its Road Safety Plan 2021 that will deliver actions to improve safety on NSW roads.

The primary trial objective was to investigate whether, and the extent to which, telematics use can positively influence young driver behaviour. Additionally, the YDTT sought to identify opportunities for, or barriers to, broadening the use of telematics as a means of improving road safety. Finally, the YDTT also sought to better understand young driver behaviours through an extensive collection of real-time driving data.

This report documents the key findings of the YDTT, based on the analysis of over 1.8m km (out of a total 4.1 million km) of driving data recorded by young drivers from across New South Wales.

2.1.1 What is telematics?

Telematics refers to a system capable of measuring and capturing data about real-time vehicle usage. Typically, telematics systems measure acceleration, turning, braking and speed, as well as locational information. High-frequency sampling of data produces granular, high-volume datasets, which can then be analysed to generate detailed insights about driver behaviour.

2.1.2 Growing rates of adoption

The proliferation of mobile connectivity has resulted in rapid growth in the use of telematics. The global telematics industry is projected to be worth $750 billion by 2030.[3]

The most significant growth is in the motor vehicle insurance industry, with many insurance companies offering usage-based insurance policies (UBI), which allow customers' insurance premiums to be determined by actual recorded driving behaviour. As of 2017, there were 17 million active usage-based insurance policies globally.[4]

2.1.3 Growing interest amongst government

In light of global trends, the NSW government has taken proactive steps to encourage the use of telematics.

For example, recent reforms to the State's Compulsory Third Party (CTP) insurance scheme saw the introduction of new legislative provisions to enable CTP policyholders to receive discounts from their insurers based on *"digital information recorded about the safe driving of the motor vehicle during [the policy] period"*.[5]

3 McKinsey 2018. 'Telematics poised for strong global growth.' McKinsey Centre for Future Mobility
4 ibidIbid
5 Motor Accident Injuries Act 2017 (NSW). s 2.19 (2) (g).

The NSW Road Safety Plan 2021 commits to improving the "safety provided by new and proven technology" and "to investigate with the insurance industry opportunities to reduce premiums for customers who adopt safer vehicle technology and telematics."

NSW is not alone in its encouragement of the use of telematics.

At a national level, the 2018 Inquiry into the National Road Safety Strategy, commissioned by the Australian Government, recommended the "acceleration of adoption of speed management initiatives that eliminate harm" including "innovation in speed management to be pursued as a high priority, noting best practice in the vehicle sector (e.g. Intelligent Speed Adaptation), private sector (fleet management incentives and workplace culture), and insurance reforms (e.g. telematics)."[6]

Internationally, governments are also actively considering, or have implemented policies to facilitate, the broader use of telematics.

- Telematics-based driver scores are used as a rating factor in personal injury protection (PIP) motor vehicle insurance in 50 states of the United States of America.[7]

- The European Union recently approved legislation requiring all cars built and registered in the EU after 31 March 2018 to install GPS enabled e-Call emergency technology to facilitate early crash detection to reduce 'golden hour' response times.[8]

2.2 Rationale for NSW Young Drivers Telematics Trial

2.2.1 Improving the existing body of knowledge

Various small-scale field studies support the idea that telematics can be effectively used to improve driver behaviour, but this proposition has not been evaluated at scale.

- A study by Klauer et al. (2017) found that the use of real-time audio/visual feedback, parental feedback, and monitoring led to a reduction in the frequency of driving errors among 92 novice drivers.[9]

- Farah's et al. (2013) randomised control study showed statistically significant improvements in driving performance amongst young drivers who received real-time driving feedback and parental coaching (n=53) compared to a control group (n=55) who received no feedback. However, this research was inconclusive regarding the contributions of the feedback and parental coaching to the improvement in driving performance.[10]

- NSW Centre for Road Safety (2010) trial of intelligent speed adaptation systems found that 89 per cent of vehicles (n=106) that had installed auditory alert systems for speeding had reduced the amount of time they spent speeding.[11]

The advantage of the Young Drivers Telematics Trial is that it provides a larger sample size (n=717 active drivers) to improve the generalisability of results. Data gathered by the trial also offers invaluable insights into young driver behaviour to inform future road safety policy development.

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6 Inquiry into the National Road Safety Strategy (2018) pg 58.
7 Karapiperis (2015). Usage-Based Insurance and Vehicle Telematics: Insurance Market and Regulatory Implications. Centre for Insurance and Policy Research.
8 European Commission (2018), The interoperable EU-wide e-Call.
9 Klauer et al (2017) "Using real time and post hoc feedback to improve driving safety for novice drivers" – Proceedings of the human factors and ergonomics society 2016 Annual Meeting.
10 Farah et al 2013 "The First Year of Driving – Can an in-vehicle data recorder and parental involvement make it safer?" Transportation Research Record Journal of the Transportation Research Board December 2013.
11 NSW Centre for Road Safety (2010). Results of the NSW Intelligent Speed Adaptation Trial. Effects on road safety attitudes, behaviours and speeding. OCTOBER 2010

2.2.2 Improving young driver safety

Although the incidence of motor vehicle collisions (MVC) in NSW has declined in recent years, drivers under the age of 25 continue to be overrepresented in MVC statistics.

NSW Centre for Road Safety data suggests that drivers under the age of 25 are still up to 4.5 times more likely to be involved in an MVC and up to 5 times more likely to be involved in an MVC resulting in death or serious injury.[12]

New car technologies, such as telematics potentially provide policymakers with additional tools for improving road safety.

12 Relativity rankings for motor vehicle controllers involved in casualty crashes, NSW 2014 to 2016 (unpublished). New South Wales Centre for Road Safety.

3. Objectives, design, methodology & data

3.1 Objectives

The main objectives of the trial were to:

- determine whether, and the extent to which, telematics-based feedback positively influences young driver behaviour
- improve understanding of young driver behaviour through the gathering of real-time data.

Depending on the results, the secondary objectives of the trial were to:

- consider the feasibility – including costs, benefits and associated challenges – of incorporating telematics into existing road safety initiatives
- work with insurers to explore the applicability of telematics to improve safety for motorists

3.2 Research questions

Guided by the above objectives, the key questions we sought to answer were:

- Does telematics use (particularly use of real-time feedback) improve driver behaviour and to what extent?
- What were some key insights into young driver behaviour, with regards to speeding, braking, turning and acceleration?
- Are there any limits or unintended consequences of using a telematics device?

Assuming that telematics use does lead to tangible, quantifiable improvements in driver behaviour:

- To what extent and under what circumstances can telematics use be encouraged?
- What are the potential social and economic benefits of broader telematics use?

3.3 Research Design

The Young Drivers Telematics Trial was a large study to evaluate the effectiveness of telematics on young driver behaviour.

There were three components to the Young Drivers Telematics Trial:

1. **a randomised control trial** comprising a control group of n=255 and a treatment group of n=362 drivers aged 17 to 24
2. **a pre- and post-intervention trial** involving n=100 drivers aged 17 to 24
3. **attitudinal research** on young driver perception and acceptance of telematics use.

3.3.1 Randomised controlled trial

A total of 717 participants, n=355 control (consisting of n=255 control group and n=100 (pre- and post-intervention group) and n=362 treatment participants, were invited to install and drive with a telematics device in their vehicle.

Group allocation determined the configuration of the telematics device they would receive, with only the treatment group receiving feedback from their telematics system.

Driving data was collected over six months.

Driving performance for the treatment and control group was compared after a six-month exposure period to determine if there were statistically significant improvements in safety, as measured by validated safety surrogate indicators for braking, acceleration, turning and speed.

3.3.2 Pre- and post-intervention study

n=100 young drivers from the control group were selected at random and "switched over" into the treatment group after the completion of 3 exposure months of driving.

Driving performance for exposure months 1-3 was compared to months 4-6 to determine whether there were statistically significant improvements across several literature-validated outcome measures for braking, acceleration, turning and speeding.

3.3.3 Attitudinal and behaviour research

Post-trial surveys were implemented to gather information relating to participant's experience of the trial, level of engagement, general attitudes towards the use of telematics, perception of impact and future use intentions. A smaller sample (n=50) of treatment and switchover group drivers were also invited to participate in semi-structured focus group and interviews to discuss their views in more detail.

3.4 Methodology

Participants were recruited through an open expression-of-interest page hosted on SIRA's website from April 2018 to July 2018.

The majority of participants were made aware of the trial through boosted Facebook advertising, which targeted users based on age and location requirements. A smaller number of participants were referred to the trial by a family member, friend or driving instructor.

3.4.1 Sampling criteria

To be included in the trial, participants had to:

- be aged 17-24
- reside in Regional NSW, Western Sydney or Outer Sydney
- hold a valid Provisional P1, Provisional P2 or Unrestricted licence
- provide consent for participation
- own, or have access to and permission to use, an OBDII compatible vehicle.[13]

13 OBDII" (on-board diagnostic II) is a standardised vehicle port, present in all vehicles with a manufacture year of 2006 and onwards.

The selection criteria were broadly aligned to NSW casualty crash prevalence statistics, which indicate that 9 of the top 10 cohorts most frequently involved in casualty crashes were drivers aged between 16 and 24 and residing in Western Sydney, Outer Ring of Sydney or Regional NSW (refer to A.1).

Notwithstanding the residential requirements of the selection criteria, a small number of participants living outside of these locations were permitted to participate at the discretion of the trial team. In all cases, these participants had either:

- relocated in the time between signing up for the trial and receiving their telematics device, or
- lived in a suburb immediately adjacent to the targeted geographic areas.[14]

Data for these participants were coded as "Other Sydney Metro" to differentiate between these participants and participants in the targeted geographical areas.

3.4.2 Trial promotion

Participants were recruited through an open expression of interest page, hosted on SIRA's website from April 2018 to July 2018. The majority of participants were made aware of the trial through boosted social media advertising, targeting users based on age and location requirements.

Social media advertising proved to be a cost-effective means of generating public awareness of the trial and directing traffic to the registration page. Of the 6,212 visits to the expression-of-interest page:

- 60 per cent came via social media
- 26 per cent came directly via the SIRA home page (which usually indicates referral by word of mouth)
- 6 per cent came via search engine search
- 5 per cent came via referral traffic from third party websites.

Examples of recruitment material are at A.2.

14 Several participants from Baulkham Hills were permitted to participate in the trial as it was immediately adjacent to Blacktown LGA which is considered Western Sydney for the purposes of the trial.

3.4.3 Recruitment

Recruitment to the trial took place over three stages:

1. Application/expression of interest
2. Completion of onboarding survey and consent process
3. Verification of OBDII compliant vehicle.[15]

The figure below overviews the process that each participant went through for onboarding.

3.4.4 Participant randomisation

Participants were randomised using the random number generator function in Microsoft Excel. Participants with even number assignments were allocated into the treatment group, and odd number assignments allocated into the control group.

The same methodology was applied when selecting switchover participants from within the control group.

For large sample sizes (n>30), this simple randomisation method provides a straightforward and reliable approach for allocating participants evenly into subject groups.[16]

Test of statistical significance was applied to assess equivalency between treatment and control groups. Results of these analyses found **no statistically significant differences** in terms of demographics (sex, gender, mean age, licence type), vehicle types (vehicle body type, mean engine size, mean recorded driving kilometres), and driving behaviour (self-reported traffic offences in previous 12 months, self-reported deviant driving behaviours), suggesting that baseline characteristics of treatment and control groups were similar.

Full results of these analyses are in Appendix A.3.

15 Due to the technology that was selected for the trial, it was mandatory for participants to have access to an OBDII compliant vehicle. OBDII refers to the self-diagnostic port to enable mechanics to diagnose and generate reports on a vehicle's engine status and other vehicle systems. Generally, vehicles older than 2006 are OBDII compliant.

16 Suresh KP (2011). An overview of randomization techniques: An unbiased assessment of outcome in clinical research. Journal of Human Reproductive Sciences. 2011 Jan-Apr; 4(1): 8–11.

3.5 Vehicle instrumentation

3.5.1 Device selection

Following a competitive tender process that fielded 17 prospective telematics device vendors, GOFAR was selected as the preferred supplier for the trial. GOFAR is an Australian-based telematics company.

Vendor proposals were assessed based on:

- ability to meet the technical requirements of the trial:
    - including being able to capture data of interest
    - not requiring drivers to interact with their mobile phone while driving
    - Australian-based data storage; and
    - high standards of data security and privacy
- value for money
- ability to provide in-service support for trial participants.

Tender assessment panels consisted of a diverse range of expertise, including:

- a prominent academic in the field of human factors research
- a member of the NSW Centre for Road Safety's Safe Systems team
- an insurance actuary specialising in telematics
- a member of the State Insurance Regulatory Authority's Road Safety Partnership team
- a former chairman of an Australian-based telematics insurance company.

3.5.2 Installation

All participants were sent a GOFAR telematics system via mail.

The GOFAR telematics system is a "plug and play" device consisting of:

1. an OBDII-based gyroscope/accelerometer unit

2. an LED light ray which changes colours in response to risky driving behaviours

3. a mobile phone app

A visual of the GOFAR telematics is at A.3 of the appendices.

3.5.3 Technical support

Installation instructions were provided with the device.

The instructions provided information on how to locate the OBDII port, appropriate placement of the LED light ray and calibration of the gyroscope/accelerometer unit.

Participants were also able to seek further technical assistance via the GOFAR website or a specific email set up for the trial.

3.5.4 Recording and transmission of vehicle data

Recording and transfer of vehicle data occurred automatically when the ignition was engaged and the phone's Bluetooth was turned on.

The OBDII unit links to the user's mobile phone via Bluetooth, to facilitate real-time recording and transmission of driving data. Provided the Bluetooth was activated at the time of engine ignition, data recording occurred automatically, meaning that participants did not need to interact with their phone at any point while the vehicle was in motion.

3.6 Driver feedback from the telematics device

3.6.1 Different configurations for treatment and control

Group assignment determined the setting of a participant's telematics system.

The treatment group system featured:

- driving scores for driver acceleration and braking performance
- a leaderboard to provide performance ranking relative to other drivers in the trial
- trip detail summary maps to indicate locations where the driver was exceeding the speed limit or braking, turning or accelerating harshly
- post-trip push notifications informing the user if they spent more than 20 per cent of their driving time exceeding the posted speed limit
- an LED light ray situated above the driver dashboard that changed colour to alert the driver when speeding or making harsh manoeuvres.

The control group system featured:

- non-safety information (via an app) on driving distance, fuel economy and CO_2 emissions as a way of ensuring that participants would still be encouraged to activate and use the app
- an LED dashboard display which did not change colour, irrespective of driver behaviour. In the case of the control group, the purpose of the light ray was to indicate connectivity between their mobile phone and the recording device.

A more detailed description of the telematics system is at A.3.

3.6.2 Real-time feedback triggers for the treatment group

The LED light ray is positioned above the driver dashboard (above the steering column or centre) and changes colour when pre-set g-force and speed thresholds are exceeded.

For harsh braking, the LED feedback was configured to:

- Emit a purple light if longitudinal vehicle deceleration was ≤ -0.2g but > -0.3g
- Emit a purple/red light if longitudinal vehicle deceleration was ≤ -0.3g but > -0.4g
- Emit a bright red light if longitudinal vehicle deceleration was ≤ -0.4g.

For rapid acceleration, the LED feedback was configured to:

- Emit a purple light if longitudinal vehicle acceleration was ≥ 0.2g but <0.3g
- Emit a purple/red light if longitudinal vehicle acceleration was ≥ 0.3g but <0.4g
- Emit a bright red light if longitudinal vehicle deceleration was ≥0.4g.

For harsh cornering (turning), the LED feedback was configured to:

- Emit a purple light if lateral acceleration was ≥ |0.35g| in either direction
- Emit a bright red light if lateral acceleration exceeded ≥ |0.5g| in either direction.

For speeding, the LED feedback was configured to:

- Emit a purple light if **true vehicle speed**[17] was ≥1km/h but <3km/h above the posted speed limit
- Emit a purple/red light if true vehicle speed was ≥3km/h but<5km/h above the posted speed limit
- Emit a bright red light if longitudinal vehicle deceleration was ≥5km/h above the posted speed limit.

3.7 Data collection

Trial data was collected from numerous sources, including the telematics system, participant pre- and post-trial surveys and qualitative focus groups and interviews.

3.7.1 Telematics data

The following variables were recorded and transmitted every two seconds:

1. longitudinal acceleration (forwards and backwards movement)

2. lateral acceleration (sideways movement)

3. yaw (turning speed)

17 With respect to speeding feedback it is important to note that feedback threshold was set to true vehicle speed. **True vehicle speed** refers to the speed detected from a car's wheel sensors. This is different to the speedometer speed as observed by the driver. As required by Australian Design Rules, speedometers may not indicate a speed that is less than true vehicle speed. Consequently, **true vehicle speed may be 1km/h-5km/h lower** than what is actually being observed by the driver on the speedometer.

4. GPS coordinates

5. timestamp

6. vehicle speed

7. speed zone

8. revolutions per minute (RPM)

9. engine load

10. mass airflow intake

11. CO_2 intake

Numbers 8, 9, 10 and 11 were not explicitly analysed for this trial. The process for capturing and storing real-time driving data is depicted in A.3.

3.7.2 Survey data

All participants were required to complete pre- and post-trial surveys. Questions in the survey were designed to gather the following information about the participant:

- Geo-demographic characteristics (pre-trial)
- Driving history (pre-trial)
- Infringement history (pre-trial)
- Perception of driving skills (pre- and post-trial)
- Perception of driving risk (pre- and post-trial)
- Driving behaviour (pre- and post-trial)
- Crash occurrence and accident history (post-trial)
- Experience of the trial (post-trial)
- Policy support/acceptance (post-trial).

3.7.3 Qualitative interviews and focus groups

Post-trial focus groups and phone interviews were conducted with treatment group drivers and switchover drivers to discuss views on:

n=50 treatment group and switchover group drivers were invited to participate in focus groups or phone interview discussions.

The focus groups and interviews discussed participants':

- experience of using the telematics device
- perceived impact of the telematics device on driving behaviour

- motivators and influences for using the telematics device or joining the trial
- obstacles, barriers or concerns that might prevent young people from using telematics devices more widely.

3.8 Outcome measures

3.8.1 Telematics-detected surrogate safety indicators

The Australian Road Research Board (ARRB) was commissioned in 2018 to conduct a comprehensive literature review to identify and recommend suitable surrogate safety measures for use in this trial.

"Surrogate safety measures" is a measurement standard that has the properties of:

- being an observable non-crash event with a statistical and/or causal relationship to a crash;
- corresponding to crash frequency and/or severity in a predictable and reliable manner.

The use of surrogate safety measures has several advantages over official crash data for road safety analysis, including:

- greater frequency of occurrence, which provides a richer dataset for understanding individual driver behaviour
- the ability to identify less serious crashes or near-miss incidents which are not reported in official crash data.

Surrogate safety measures are widely used as alternatives, or complements, to official crash data for road safety research.[18]

ARRB's review identified numerous suitable measures relating to harsh braking, rapid acceleration, hard turning and speed. These included:

- Speeding frequency - time spent driving over the posted speed limit as a percentage of non-idle driving time.
- Positive delta speed – the speed difference to the posted speed limit when driving above the speed limit.
- Average free speed – average free speed when it was travelling at least 75 per cent of the posted speed limit.
- Frequency and magnitude of longitudinal deceleration (braking):
    - ≤ -0.3g per 1000 km driven
    - ≤ -0.45g per 1000 km driven
    - ≤ -0.5g per 1000 km driven
    - ≤ -0.75g per 1000 km driven.

18 Johnsson, Laureshyn and Ceunynck (2018). In search of surrogate safety indicators for vulnerable road users: a review of surrogate safety indicators. Transport Reviews Volume 38 Issue 6. https://doi.org/10.1080/01441647.2018.1442888

A comprehensive overview of safety surrogate indicators selected for this trial, and their reasons for inclusion, is at A.4.

3.8.2 Driver risk score

In addition to the surrogate safety measures mentioned above, the DAC was commissioned to create a composite risk score to measure and rank the relative riskiness of participant driving behaviour.

The risk score was created using a two-stage approach consisting of:

- supervised machine learning to identify individual risky trips and to identify the key features associated with those trips
- mapping individual trips back to the drivers responsible for making those trips and constructing a linear combination of variables to create to a composite risk score, where "1" is defined as least risky and "100" is defined as most risky.

An overview of the methodology for developing the driver risk scores is at A.5.

3.8.3 Survey-based measures

The survey questionnaire also sought to ascertain:

- participant motivations for using a telematics device and factors that influenced their decision
- participant beliefs about the usefulness of the telematics device and the feedback provided
- the types of feedback participants found most useful
- participant views on whether the device had caused them to alter their driving behaviour
- participant future use intentions and their willingness to purchase a telematics device for personal use
- views on potential product enhancements that would increase the likelihood of participants using telematics devices in future.

Survey questions were a mixture of Likert scale, multiple choice selection and free text questions.

3.9 Privacy

Several controls were in place to mitigate risks of misuse and/or unauthorised disclosure of participant information.

These included:

- **System controls –** the telematics recording device was incapable of recording geolocation data unless the trial participant activated Bluetooth on their mobile phone and was signed-in to the mobile app. The mobile phone also had to be within range of the vehicle for geolocation information to be recorded. Participants using shared vehicles for the purposes of the trial were also required, as terms and conditions of participation, to advise other users of their involvement in the trial.

- **De-identification and aggregation –** all personally identifiable information, names, phone numbers, email and home addresses were removed for analysis and each participant assigned a unique identifier. For example, a participant "John Smith, DOB: 01/01/2000, Male, Provisional 2 licence holder, 123 Church Street Blacktown" would only be identified as participant "B_754, Male, 18 years, P2, Parramatta". Geographic information was further aggregated for public reporting so that the participant would only be identified as"Male,18years,P2,Blacktown".

- **Controlled access to personal information –** Personal information of participants was retained only for the duration of the trial and for the purposes of administering the trial (for example, the shipping of telematics devices, processing of participant trial incentive payments and trial communications). Personal information was accessible only to two members of the SIRA project team; GOFAR, the supplier of the telematics device; and AMR, the research company contracted to manage the participant onboarding and offboarding process. Personal information was stored on encrypted files and saved on password-protected computer networks.

- **Deletion of personal information at the end of the trial –** all personal information was deleted by SIRA at the end of the trial. GOFAR and AMR were also required to delete all trial data, as per the conditions of their contract with SIRA. Driving information, such as geolocation, was retained and stored under strict access conditions on an Australian-based cloud server. Driving information does not contain personal information such as names, addresses, email or phone numbers.

The trial was subjected to a comprehensive privacy impact assessment, which was reviewed by the NSW Information and Privacy Commission, before implementation.

3.10 Minimising the risk of distraction

Conscious of the potential dangers of distraction posed by the real-time feedback, the project team, before the trial launch, commissioned a literature review[19] to address the following questions:

- To what extent do auditory/visual in-vehicle warnings pose a safety risk to novice drivers?

- Are they distracting?

- Does the distraction (if they are distracting) increase the risk of collision?

19 Australian Road Research Board (2018) Driver distraction from in-vehicle real-time feedback and warning systems: Literature review.

Relevant search terms were identified, and a literature search was undertaken using academic databases and search engines. Papers were selected for full review if they documented an investigation of the impact of driver distraction deriving from the use of an in-vehicle telematics system providing real-time feedback to a driver.

Six papers met the criteria for a full review. Two of the articles investigated distraction from devices providing feedback on the efficiency of fuel use (so-called eco-driving devices), one paper investigated distraction from a device providing both eco-driving and safety-related feedback, and two articles studied whether driver use of real-time feedback devices (crash warnings) encouraged driver engagement in distracting secondary activities. The final paper investigated young driver and parent perceptions of the distractibility of advanced driver assistance systems (ADAS) that provide safety-related warnings in real-time. No literature was found that attempted to investigate the relationship between in-vehicle feedback/warnings and crash risk, for any drivers. However, other relevant literature was found that demonstrated that long eye glances away from the forward roadway of 2 seconds or longer increase, by at least two times, the risk of a near-crash or crash.

Three of these studies investigated whether real-time feedback alerts can distract drivers from activities critical for safe driving. Findings from these studies were mixed. In the first, any form of distraction, other than visual distraction (for example, cognitive distraction), could not be ruled out. In the second study, it was concluded that the feedback system assessed was not likely to have a strong negative impact on drivers' visual attention to the forward roadway. Finally, in the third study, it was concluded that the feedback system was distracting.

The remaining three studies, two experimental and one involving focus groups, investigated whether the provision of real-time feedback alerts encourages drivers to compensate for the perceived safety benefit of the warnings by engaging in secondary distracting activities. It was found, in the two experimental studies, that the provision of these alerts did not encourage drivers to engage in secondary activities more frequently, regardless of age and driving experience.

Accordingly, it was concluded that in-vehicle devices that provide real-time feedback to drivers should only be selected if there was a minimal likelihood of drivers being induced to look away from the roadway for 2 seconds or longer. This finding consistent with recommendations contained in the in-vehicle electronic device distraction mitigation design guidelines issued by the US National Highway Traffic Safety Administration.

Advice from the NSW Centre for Road Safety's Safer People team further recommended the installation of the device at eye level and disabling of audio features (if any).

Finally, the project team conducted an informal assessment of the telematics system against technical guidelines for driver distraction prepared by the US Federal Motor Carrier Safety System Administration.[20]

20 Federal Motor Carrier Safety Administration (2009) Driver Distraction In Commercial Vehicle Operations.

4. Telematics data pre-processing

In total, the trial collected 138 million rows of raw data or approximately 80,000 driving hours.

Data profiling and cleansing was undertaken by the DAC before analysis to remove erroneous or missing values.

Example of an individual trip file (location data removed)

2018-07-05 05:56:47+00		26	2292	0.46	0.11	0.05	2.71	000f3350-	50
2018-07-05 05:56:49+00		27	1667	0.47	-0.03	0.03	2.76	000f3350-	50
2018-07-05 05:56:51+00		26	1120	0.49	-0.04	0	3.47	000f3350-	50
2018-07-05 05:56:57+00		26	1293	0.52	0.02	-0.07	-5.72	000f3350-	50
2018-07-05 05:57:20+00		31	1288	0.53	-0.07	-0.02	-5.5	000f3350-	50
2018-07-05 05:57:22+00		36	1854	0.65	0.08	0	-6.77	000f3350-	50
2018-07-05 05:57:24+00		40	1950	0.67	0.07	0.03	1.59	000f3350-	60
2018-07-05 05:57:26+00		40	1645	0.69	-0.03	0.05	2.15	000f3350-	60
2018-07-05 05:57:28+00		41	1535	0.72	-0.05	0.04	2	000f3350-	60
2018-07-05 05:57:30+00		40	1522	0.74	-0.06	0.01	1.62	000f3350-	60
2018-07-05 05:57:32+00		38	1522	0.77	-0.05	0	-0.76	000f3350-	60
2018-07-05 05:57:34+00		30	1483	0.78	-0.07	-0.01	-1.5	000f3350-	60
2018-07-05 05:58:41+00		26	1374	0.81	-0.16	-0.01	-2.77	000f3350-	60
2018-07-05 05:58:43+00		34	2427	0.87	0.12	0.01	-1.03	000f3350-	60
2018-07-05 05:58:45+00		40	2208	0.88	0.11	0.02	-2.12	000f3350-	60
2018-07-05 05:58:47+00		37	2418	0.91	0.1	-0.01	-1.66	000f3350-	60
2018-07-05 05:58:49+00		36	1931	0.96	-0.08	0.01	-1.58	000f3350-	60
2018-07-05 05:58:51+00		41	1835	0.97	-0.06	-0.02	-1.76	000f3350-	60
2018-07-05 05:58:53+00		43	1949	1	0.08	-0.01	-1.35	000f3350-	60

Information about vehicle motion is gathered every 2 seconds. Data includes:

- Unique tripid
- Geolocation
- True vehicle speed
- RPM
- Distance
- X and Y axis g-forces (forward-backwards motion/side to side motion)
- Z-axis (rotation speed degrees per second)
- Posted speed limit

4.1 Common data issues

Common issues within the dataset included:

- Missing GPS values, which were critical to identifying speed zones as well as driver location. Missing GPS values are attributable to:
    - the participant not activating Bluetooth on their mobile phone before driving
    - the participant not being in the car while it was being driven (in situations where the participant shared the car with a parent or sibling)
    - the participant being out of mobile phone range while driving.
- errors in speed zone mapping
- highly improbable g-forces being recorded as a result of miscalibration of the telematics device. Common causes of miscalibration include:
    - participants accidentally dislodging the recording device from the OBDII port
    - participants reinstalling the OBDII recording device into a different vehicle (although the device recalibrates automatically over ten trips).

4.2 Filtering and exclusion

Some trips were excluded from the analysis to ensure consistency and data quality. Trips were automatically excluded if:

- more than 50 per cent of GPS locations within a trip was missing OR
- more than 20 per cent of a trip is harsh braking OR
- more than 50 per cent of a trip is harsh acceleration OR
- more than 20 per cent of a trip is hard turning OR
- more than 50 per cent of a trip had a speed of 255.

Additional filtering rules were also applied to exclude data where there was little analytical value, including trips where:

- More than 80 per cent of a trip the vehicle is not moving (speed is 0) OR
- More than 80 per cent of a trip was made in less than 40km/h speed zones.

After applying exclusion and data cleansing filters, 44 per cent of the total raw data (80 million rows) remained available for analysis. This amounted to 1,848,651 of driving kilometres recorded over 33,279 driving hours.

5. Randomised control trial results

5.1 Summary

The results of the randomised control trial consisting of n=362 treatment group participants (15,932 recorded driving hours) and n=255 control group participants (10,485 recorded driving hours) suggests that the use of a telematics device-based feedback is associated with reductions in risky driving behaviours, based on a comparison of surrogate safety measures and the DAC's driver risk scores.

5.1.1 Comparison of surrogate safety measures

The treatment group out-performs the control group across nearly all of the surrogate safety measures selected as outcome measures for this trial.

Relative to the control group, the treatment group have:

- A lower frequency of speeding per 100 driving hours, including a 10.9 per cent and 38.9 per cent lower rate of speeding at 10-20km/h and 20km/h or more above the limit.
- A lower overall positive delta speed (that is, lower severity of speed limit exceedance), including a 1.56km/h reduction in 50km/h zones.
- Lower rates of harsh braking, rapid acceleration and harsh cornering events per 1,000km, including:

    - 42 per cent lower rates of extreme harsh braking events

    - 24.9 per cent lower rates of very rapid acceleration

    - 24.1 per cent lower rates of harsh turning.

The differences in treatment and control group results were most prominent and consistent amongst the P1 male driver cohort. Compared to their control group counterpart, treatment group P1 male participants recorded:

- 24.1 per cent lower frequency of speeding per 100 driving hours
- a lower overall positive delta speed (that is, the severity of speed limit exceedance), including a 1.2km/h reduction in 50km/h zones
- substantially lower rates of harsh braking, rapid acceleration and harsh cornering events per 1,000km, including:

    - 46 per cent lower rate of extreme harsh braking

    - 29 per cent lower rate of rapid acceleration

    - 47 per cent lower rate of harsh turning.

Comparison of treatment and control group in terms of average travelling speed provides mixed conclusions.

The treatment group recorded **lower** average travelling speeds for 40km/h, 50km/h and 60km/h zones (-0.34kmh, -1.13km/h and -0.26km/h respectively). Driving through these speed zones accounted for around 60 per cent of the driving recorded by all participants.

On the other hand, the treatment group recorded **higher** average travelling speeds in 70km/h, 80km/h, 90km/h, 100km/h and 110km/h zones (+0.04km/h, +0.42km/h, +0.17km/h, +0.4km/h and +0.8km/h respectively). Driving in these speed zones accounted for around 40 per cent of the driving recorded by all participants. The differences in mean travelling speed for 90km/h and 110km/h zones were not found to be statistically significant.

5.1.2 Comparison of DAC driver risk scores

Overall, the average risk score (the higher, the riskier) for the treatment group is lower than that of the control group (60 compared with 63), suggesting that the real-time feedback did have a positive influence in moderating driving behaviour.

The other dimensions that were evaluated to depict changes in driving behaviour based on average risk score are:

- residential location
- gender
- drivers' residential location
- licence type.

The drivers that are apparently most likely to moderate their driving behaviour, as reflected in the reduction in the average user risk score between the control and treatment groups, are:

- male participants
- residents of the Other Sydney Metro areas
- full licence holders.

Most notably, females show only a very slight improvement in average risk score as a result of using the telematics device. However, females had a lower baseline risk score (and were therefore classified as being less risky) from the outset.

5.2 Comparison of safety surrogate indicators

5.2.1 Speeding frequency (speeding per 100 hours)

For this trial, speeding frequency was operationally defined as the number of hours driving over the speed limit (speed hours) divided by the total hours of non-idle driving time (driving hours).

Data was adjusted to obtain a normalised rate of speeding hours per 100 driving hours. This was necessary to account for the differences in total speeding hours and total driving hours recorded by the treatment and control group.

(1) Speeding frequency – overall comparison

There were modest differences between treatment and control groups in terms of overall rates of speeding. The treatment group, however, had substantially lower rates of high and medium-range speeding (that is, speeding at 10-20km/h and 20km/h+ over the limit).

Compared to the control group, the treatment group had a:

- 3.4 per cent lower rate of speeding overall (17.01 vs 17.6 speeding hours per 100 driving hours)
- 0.4 per cent higher rate of speeding at less than 10km/h over the limit (14.01 vs 13.85 speeding hours per 100 driving hours)
- 10.9 per cent lower rate of speeding at 10-20km/h over the limit (2.45 vs 2.75 speeding hours per 100 driving hours)
- 38.9 per cent lower rate of speeding at more than 20km/h over the limit (0.55 vs 0.9 speeding hours per 100 driving hours).

A.6 provides a more detailed comparison of treatment and control group speeding frequency outcomes over the entire trial period.

(2) Speeding frequency over six months

The descriptive analyses at A.7 of the appendix provide a month to month comparison of speeding frequency between treatment and control groups.

The treatment group had consistently lower rates of speeding at medium range (10-20km/h over the limit) and high range (>20km/h over the limit).

The most considerable treatment-control group difference was observed in month 1, with the treatment recording a 57 per cent lower rate of high-range speeding and a 26 per cent lower rate of medium-range speeding in that period.

Treatment-control group differences in the lower-speeding range (<10km/h over the limit) were less discernible and varied month to month, such that treatment group recorded higher rates of low-range speeding in months 1, 4 and 6, but higher rates of low-range speeding in months 2, 3 and 5.

Moreover, the differences also became smaller as the trial progressed, partially as a result of the control group decreasing their speeding frequency and partly due to the treatment group increasing speeding frequency over the trial period.

The results suggest that:

- telematics use appears to have the greatest impact on reducing the frequency of medium and high range speeding behaviours
- telematics use had limited impact on reducing the frequency of low-range speeding
- the impact of telematics use on speeding attenuates over time.

(3) Speeding frequency by speed zones

An analysis of speeding by speed zones (refer to A.8) was conducted to understand how speeding frequency was distributed across speed zones.

Speeding frequency varied depending on the speed zone, but participants had a greater tendency to speed in high-speed zones.

The frequency of speeding was 16.0 speeding hours per 100 hours in 40km/h to 70km/h zones. This increased to 21.0 speeding hours per 100 hours in 80km/h to 110km/h zones.

Compared to the control group, the treatment group recorded:

- **Lower** rates of speeding for:

  - 40km/h zones (13.0 vs 13.4 speeding hours per 100 driving hours)

  - 50km/h zones (14.9 vs 17.4 speeding hours per 100 driving hours)

  - 60km/h zones (15.7 vs 16.7 speeding hours per 100 driving hours),

  - 70km/h zones (11.9 vs 12.8 speeding hours per 100 driving hours), and

  - 100km/h zones (21.3 vs 21.9 speeding hours per 100 driving hours).

- **Higher** rates of speeding in 80km/h zones (20.6 vs 18.5 hours per 100 driving hours).
- The treatment group also had higher rates of speeding at 90km/h (29.2 vs 23.8 speeding hours per 100 driving hours) and 110km/h (22.9 vs 19.1 hours per 100 speeding hours).

5.2.2 Speeding severity (positive delta speed)

Positive delta speed (that is, the average speed over the posted speed limit) is used as an indicator for the severity of speeding performed by the individual driver. The advantage of positive delta speed is that it provides an insight into the degree to which a driver exceeds the speed limit.

Jun, Guensler and Ogle (2011) and Jun (2006) found that drivers involved in crashes tended to drive at positive delta speed compared to drivers who were not involved in crashes and showed a higher tendency of non-compliance with posted speed limits.

Positive delta speed is calculated by subtracting the recorded vehicle speed from the posted speed limit. For example, a driver travelling at 55km/h in a 50km/h zone will have a positive delta speed of 5km/h. Vehicle speed and the speed limit was logged every two seconds, enabling a highly detailed view of speeding tendency.

Analysis of positive delta speed (refer to A.9) recorded by participants indicates:

- an inverse relationship between average positive delta speed and speed zones, meaning that drivers exceeded the speed limit by more in lower speed zones compared to higher speed zones

- that compared to the control group, the treatment group had:

- **lower** average positive delta speeds for:

    - 50km/h zones (-1.56km/h)

    - 60km/h zones (-1.0 km/h)

    - 70km/h zones (-0.1 km/h)

    - 80km/h zones (-0.1km/h), and

    - 100km/h zones (-0.1 km/h)

- **higher** average positive delta speeds for:

    - 40km/h zones (+0.5km/h)

    - 90km/h zones (+0.3km/h)

    - 110km/h zones (+0.1km/h).

5.2.3 Mean travelling speeds

Mean speed is an important road safety metric, given the substantial body of research linking increases in mean travel speed with increased severity and frequency of motor vehicle crashes.[21]

For the purposes of this analysis, comparisons were based on free-speed to account for potentially confounding effects of idling time and traffic. Free-speed was defined as vehicle speed greater than or equal to 75 per cent of the posted speed limit.

The treatment group recorded lower mean free speeds in 40km/h, 50km/h and 60km/h zones (accounting for around 60 per cent of all recorded driving hours).

However, the treatment group's mean free speeds were higher than the control for 70km/h+ speed zones.

With the exception of 90km/h zones and 110km/h zones, the differences in mean free speeds between the treatment and control groups are statistically significant ($p<0.01$).

21 Elvik R (2009). The Power Model of the relationship between speed and road safety: Update and new analyses. Report 1034/2009 (The Institute of Transport Economics. Norway).

Differences in average mean speed and speeding time per 100 driving hours by speed zones.[22]

KM/H	40	50	60	70	80	90	100	110
Mean free speed[23]								
Treatment	39.88	48.22	56.84	64.91	75.56	85.67*	93.40	100.70*
Control	40.22	49.35	57.1	64.87	75.14	85.50*	93.00	99.90*
T-C	-0.34	-1.13	-0.26	0.04	0.42	0.17	0.4	0.8
Hours speeding per 100 driving hours								
Treatment[24]	13.02	14.86	15.66	11.88	20.62	29.18*	21.3	22.94*
Control	13.4	17.4	16.68	12.78	18.52	23.84*	21.85	19.08*
Total driving hours								
Treatment	275	4,572	4,324	1,669	1,960	335	1,526	1,271
Control	175	3,245	2,719	920	1,403	209	1,083	731

(1) Explanation of average free speed results

The comparatively higher mean speeds recorded by the treatment group for 70km/h+ may be attributed to the configuration for feedback receiving real-time feedback.

As previously outlined, feedback is triggered when the true vehicle speed is ≥ 1km/h above the posted speed limit. This is different from the speedometer speed as observed by the driver. As required by Australian Design Rules, vehicle speedometers may not indicate a speed less than the true vehicle speed, and consequently, speedometers (depending on the manufacturer) will display a speed that is 1km/h to 5km/h higher than the true vehicle speed.

For example, a driver who is driving through a 100km/h speed zone and observing 100km/h on their speedometer would have an actual vehicle speed of 95km/h to 99km/h (depending on make and model of vehicle). However, the same driver using the telematics device would not receive any real-time feedback to alert them of speeding until the speedometer reaches 102km/h to 106km/h – although they may be travelling at a true vehicle speed of 101km/h.

Control group drivers who do not receive any feedback are therefore reliant on the speedometer as their reference point for speed. These drivers would select a travelling speed that is lower than a treatment group driver who is reliant on the real-time feedback as a reference point, to ensure compliance with the posted speed limit.

5.2.4 Frequency and severity of harsh braking

Analysis at A.10 shows that the treatment group had substantially lower rates of extreme, very harsh and harsh braking events per 1,000km.

Notably, the treatment group had a 42 per cent lower rate of extreme braking (0.36 events vs 0.63 per 1,000km) compared to the control group for the entire trial period.

The differences appear to be sustained across the trial duration, suggesting that changes in harsh braking behaviours may be more sustained, compared to other behaviours.

By way of reference, a deceleration of less than -0.75g would be the equivalent of travelling at 27 km/h and coming to a dead stop in the space of 1 second. Although not necessarily a crash, deceleration of less than -0.75g may be indicative of an emergency braking event. Simons-

22 Final YDTT data over 6 months of driving (T=362, C=255), 26,417 driving hours (T=15,932, C=10,485), 1,451,156 km (T=890,597km, C=560,559km). Driving hours is based on analysable data after pre-processing and may not reflect the sum total driving hours by participants. KMs are based on sum total kilometres.
23 Freespeed refers to the speed at a which a vehicle is travelling unimpeded by traffic. Freespeed is defined as when vehicle speed is ≥0.75 of posted speed limit.
24 * indicates that results are not statistically significant. All other results are statistically significant at $p<0.01$.

Morton's (2011) study suggests a strong positive correlation (r=0.76) between the frequency of harsh braking events per 100 miles and crash and near-crash events per 10,000 miles.[25]

5.2.5 Frequency and severity of rapid acceleration

Compared to the control group, the treatment group had a 19 per cent lower rate of rapid acceleration (82.3 vs 102.6 events per 1,000km) at 0.35g≤ x <0.58g at the end of six months. Acceleration of 0.35g is equivalent of going from 0-100km/h in 8 seconds. Acceleration of 0.58g is the equivalent of going from 0-100km/h in 5 seconds, respectively.

Analysis at A.11 shows that the overall rate of rapid acceleration at x≥0.58g was 24.6 per cent lower for the treatment group (4.9 vs 6.5 events per 1,000km) however, the month to month differences are inconsistent, with the control group having lower rates in some months of the trial.

Qualitative focus group discussions suggest that some in the treatment group were influenced by peer passengers to "turn the ray red" out of amusement. One female participant from Western Sydney reported:

- *"...they are like 'make it go red, make it go red' ... They want to see it happen, and they will encourage you and say just go over for a second so I can see it and they get excited by it."*

A similar experience was reported by a male participant from Regional NSW:

- *"Sometimes they say 'put it in red. Make it go red'."*

The Spearman's correlation between individual rates of rapid starts and crash/near-crash rates for teenage participants was r=0.75. This indicates a strong positive relationship between a higher crash and near-crash rates and more frequent rapid starts.[26]

5.2.6 Frequency and severity of hard turning

Analysis of harsh turning events at A.12 shows that the treatment group had lower rates of harsh turning events per 1,000km (215.4 vs 283.8 per 1,000km). This result is consistent across the whole trial period.

Simons-Morton (2011) found that Spearman's correlation between individual rates of harsh turning and crash/near-crash rates for teenage participants was r=0.53 for hard left turns and ρ=0.62 for hard-right turns. This suggests a moderate positive relationship between a frequency of harsh turns and crashes and near-crashes.[27]

5.2.7 Substantial improvements observed amongst P1 male drivers

Given the over-representation of young male drivers in casualty trauma, it is noteworthy that the most considerable and consistent differences in treatment-control speeding, harsh braking, harsh acceleration and turning behaviours were observed amongst young P1 male drivers.

Differences between treatment and control group speeding rates were most pronounced amongst P1 male drivers. Analysis at A.13 shows that, compared to the control group of P1 males, the treatment group of P1 males drivers had a:

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25 [Simons-Morton, B. G., Ouimet, M. C., Zhang, Z., Klauer, S. E., Lee, S. E., Wang, J., ... & Dingus, T. A. (2011). The effect of passengers and risk-taking friends on risky driving and crashes/near crashes among novice teenagers. Journal of Adolescent Health, 49(6), 587-593.
26 [Simons-Morton, B. G., Ouimet, M. C., Zhang, Z., Klauer, S. E., Lee, S. E., Wang, J., ... & Dingus, T. A. (2011). The effect of passengers and risk-taking friends on risky driving and crashes/near crashes among novice teenagers. Journal of Adolescent Health, 49(6), 587-593.
27 [Simons-Morton, B. G., Ouimet, M. C., Zhang, Z., Klauer, S. E., Lee, S. E., Wang, J., ... & Dingus, T. A. (2011). The effect of passengers and risk-taking friends on risky driving and crashes/near crashes among novice teenagers. Journal of Adolescent Health, 49(6), 587-593.

- 24.0 per cent lower rate of speeding overall (14.6 vs 19.2 speeding hours per 100 driving hours)
- 21.6 per cent lower rate of speeding by less than 10km/h over the limit (12 vs 15.3 speeding hours per 100 driving hours)
- 31.8 per cent lower rate of speeding by 10-20km/h over the limit (2.0 vs 2.9 speeding hours per 100 driving hours)
- 37.5 per cent lower rate of speeding by more than 20km/h over the limit (0.65 vs 1.04 speeding hours per 100 driving hours).

The P1 Male treatment group appears to have increased their speeding frequency relative to the control group by month six. However, this is likely to be an artefact of the substantially lower driving hours recorded in month six.

Analysis at A.14 shows that P1 male treatment group participants also have substantially lower rates of harsh braking, rapid acceleration and harsh cornering compared to control group counterparts. Notable differences include:

- 46 per cent lower rate of extreme harsh braking per 1,000km (0.55 vs 1.02)
- 29 per cent lower rate of rapid acceleration per 1,000km (96.2 vs 135.6)
- 47 per cent lower rate of harsh turning per 1,000km (23.1 vs 44.1).

5.2.8 The treatment group had slightly higher rates of very rapid acceleration ($x \geq 0.58g$) per 1,000km (8.4 vs 8.7 per 1,000km). Multivariate analysis of safety surrogate indicators

In addition to the descriptive analyses above, multiple linear regression (MLR) analysis was applied to assess differences between treatment and control groups in terms of safety surrogate indicators.

The purpose of the multiple regression analysis was to adjust for covariates – such as gender, age, participant zone of residence, licence type, months of exposure, driving hours and speed limits – which could influence driving performance.

Statistical results for speeding frequency, speeding severity, average speed, harsh braking, harsh turning and rapid acceleration are discussed below.

(1) Speeding frequency (speeding per 100 hours)

Being in treatment or control groups was not statistically significantly associated with rates of speeding per 100 driving hours ($p=0.22$); however, it was also found that:

- membership of the treatment group was significantly associated with lower rates of medium-range speeding (speeding at 10km/h-20km/h over the posted speed limit) per 100 driving hours ($\beta=-0.20$, $p<0.01$)
- membership of the treatment group was significantly associated with lower rates of high range speeding (speeding at more than 20km/h over the posted speed limit) per 100 driving hours ($\beta=-0.16$, $p<0.01$).

These results suggest that driving feedback had a limited effect on the overall rate of speeding per 100 driving hours. However, it did significantly reduce rates of medium and high range speeding.

(2) Speeding severity (positive delta speed)

Membership of the treatment group was associated with a lower positive delta speed ($\beta=-0.29$, $p<0.01$), suggesting that driving feedback had the effect of lowering the severity of speeding.

(3) Mean travelling speed

Membership of the treatment group was significantly associated with lower average free speeds ($\beta=-0.43$, $p<0.01$) for urban and residential zones (i.e. 40km/h to 70km/h speed zones).

(4) Harsh braking

Membership of the treatment group was significantly associated with:

- lower rates of harsh braking events ($-0.5g< x \leq -0.45g$) per 1000km ($\beta=-5.58$, $p<0.01$)
- lower rates very harsh braking events ($-0.75g< x \leq -0.5g$) per 1000km ($\beta=-4.31$, $p<0.01$).

(5) Rapid acceleration

Membership of the treatment group was significantly associated with lower rates of rapid acceleration ($x \geq 0.35g$) per 1000 km ($\beta=-22.68$, $p<0.01$).

(6) Hard turning

Membership of the treatment group was significantly associated with lower rates of hard turning events ($y \geq |0.5|g$) per 1000km ($\beta=-10.5$, $p<0.01$).

5.3 Comparison of DAC risk scores

Male control group participants had a notably higher average risk score than female control group participants, but show the most substantial reduction in risk score as a result of membership in the treatment group.

The use of a telematics device appeared to have a negligible impact on driving behaviour/risk score of the female participants. However, female participants generally had a lower baseline risk score.

Participants from the Other Sydney Metro area had the lowest average risk score in the control group and also showed the largest reduction in average risk score as a result of being in the treatment group.

Residents in the Outer Ring of Sydney have the highest average risk score in the control group and show the second-highest impact from the trial. The changes for Regional NSW and Western Sydney residents were similar and smaller than the changes for other areas.

Full licence holders have the highest average risk scores in the control group and the highest reduction in average risk score arising from participation in the trial. P1 and P2 licence holders showed a smaller (and almost identical) reduction.

5.3 Comparison of DAC risk scores

Average driver risk score by geo-demographic characteristics			
	Control	**Treatment**	**Change in risk score**
Gender			
Male	67.8 (n = 134)	58.9 (n = 130)	-8.9
Female	58.1 (n = 172)	57.9 (n = 176)	-0.2
Residential location			
Outer Ring of Sydney	67.1(n = 50)	61.3(n = 44)	-5.8
Regional NSW	64.6(n = 144)	60.6 (n = 126)	-4.0
Western Sydney	58.5(n = 85)	55.5(n = 119)	-3.0
Other Sydney Metro	57.5(n = 27)	50.4(n = 20)	-7.1
Licence type			
Full	66.8 (n = 119)	61.1 (n = 132)	-5.7
P2	61.6 (n = 107)	57.4 (n = 99)	-4.2
P1	58.1 (n = 80)	54.1 (n = 75)	-4.0

6. Pre/post-intervention comparison

Results of the pre- and post-intervention analysis (n=100 participants, n=4,105 pre-intervention driving hours, n=2,846 post-intervention driving) accord with findings of the treatment versus control RCT analysis, with participants driving in a less risky manner in the period when they were receiving feedback compared to the period when they were not receiving feedback.

The table provides a summary of the differences in performance during pre- and post-intervention periods.

Surrogate safety indicator	Pre-intervention (4,105 driving hours)	Post-intervention (2,846 driving hours)	Pre/Post change
Speeding hours per 100 driving hours	17.08	15.12	-11.4 per cent
Average free speed	68.05 km/h	67.83 km/h	-0.22 km/h
Average positive delta speed	5.87km/h	5.23km/h	-0.64km/h
Extreme harsh braking events per 1000 km	0.29	0.26	-10.3 per cent
Very rapid acceleration events per 1000 km	2.31	1.44	-37.6 per cent
Harsh turning events per 1000km/h	21.28	14.14	-33.5 per cent

7. Other insights from the telematics dataset

This section provides general insights about young driver behaviour based on the 33,279 hours of driving data recorded over six months.

7.1 Distribution of driving time by speed-zone

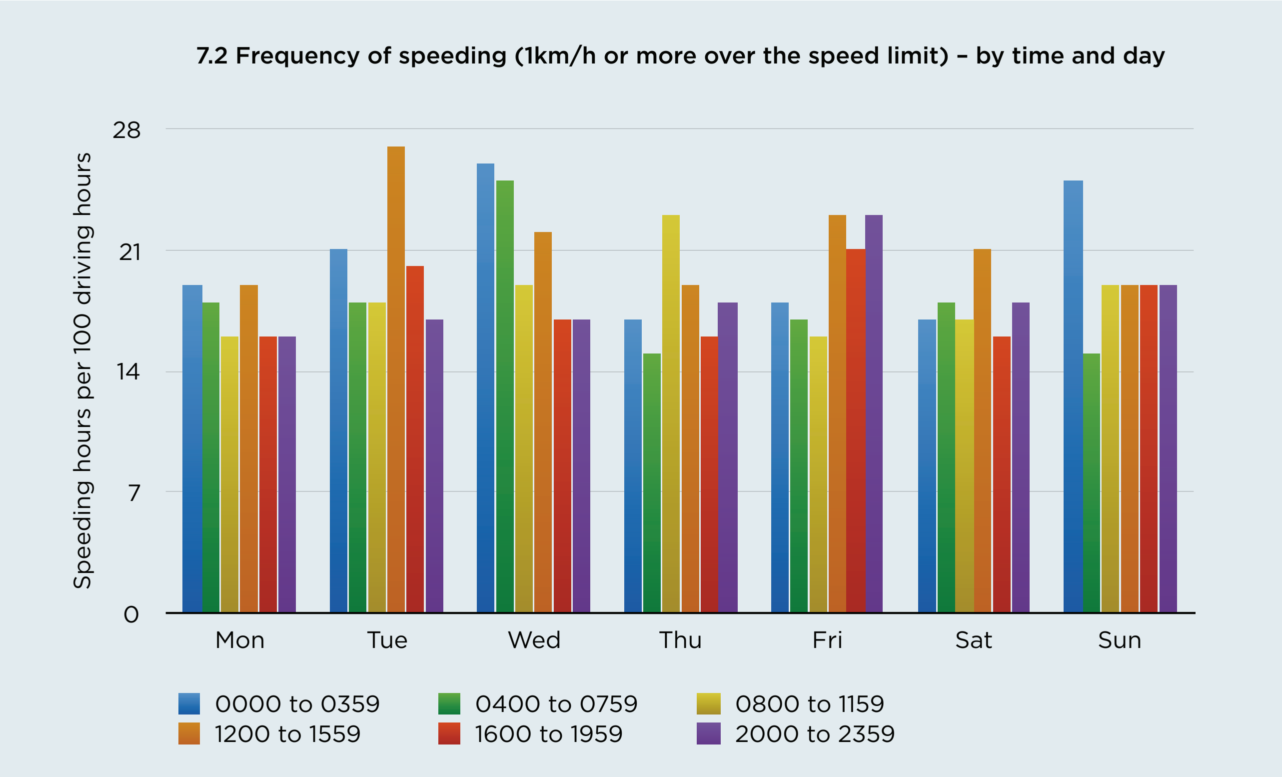
Of all recorded driving hours in the trial, around 60 per cent took place within 40km/h, 50km/h, and 60km/h speed ranges. The distribution of recorded driving hours in the trial appears to have a strong relationship to the distribution of casualty crashes involving young drivers from 2013 to 2017 (r=0.98).

7.2 Speeding frequency by time and day

The rate of speeding (as measured by the number of speeding hours per 100 driving hours) appears to be highest between midday and 4pm on Tuesdays, peaking at approximately 27.0 speeding hours per 100 driving hours. Other periods where the rate of speeding is notably higher include:

- 12am to 4am on Sunday (25 hours per 100 driving hours)
- 12am to 8am on Wednesday morning (25-26 hours per 100 driving hours).

It should be noted that the chart refers to the frequency of speeding as a proportion of all driving hours completed within a specific time period, as opposed to the distribution of all speeding hours across the time and day.

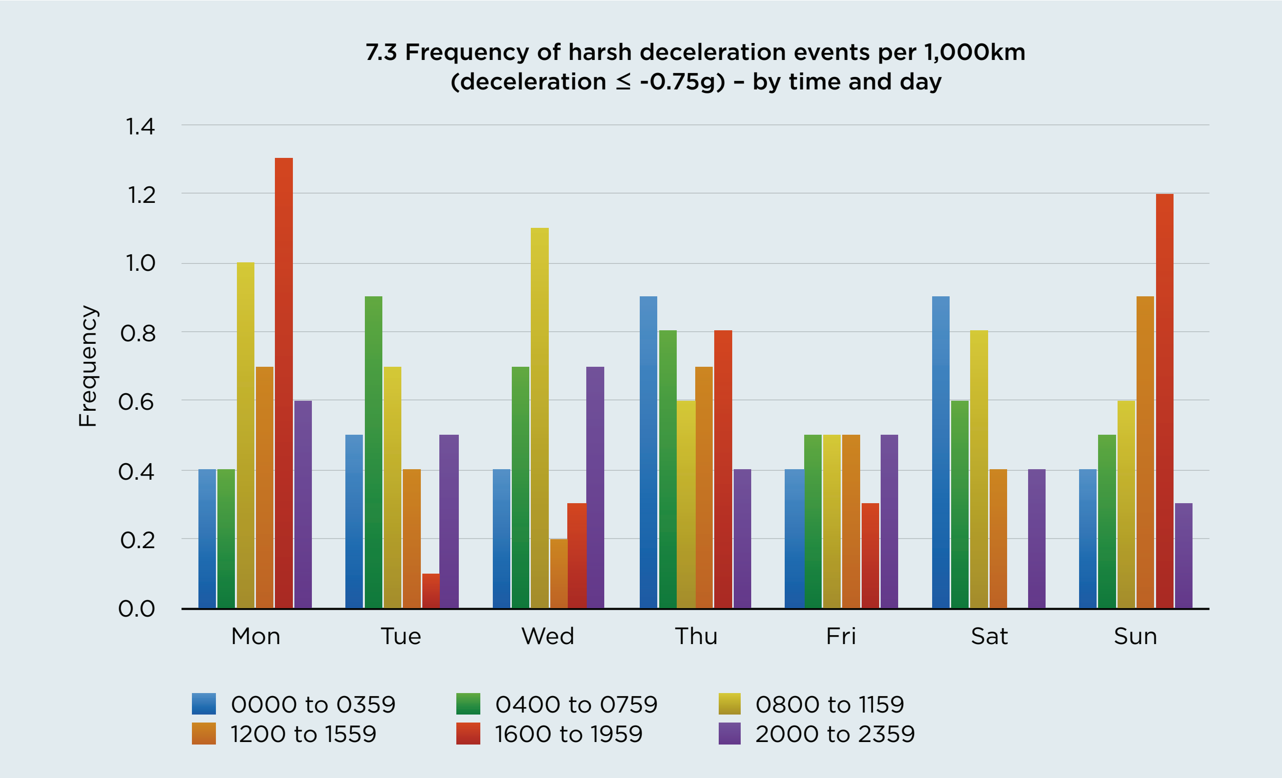


7.3 Frequency of extreme harsh braking events by time and day

There appears to be a higher occurrence of extreme braking events (deceleration ≤ -0.75g) on Monday from 4 pm to 8 pm, as well as Sunday from 4pm to 8pm.

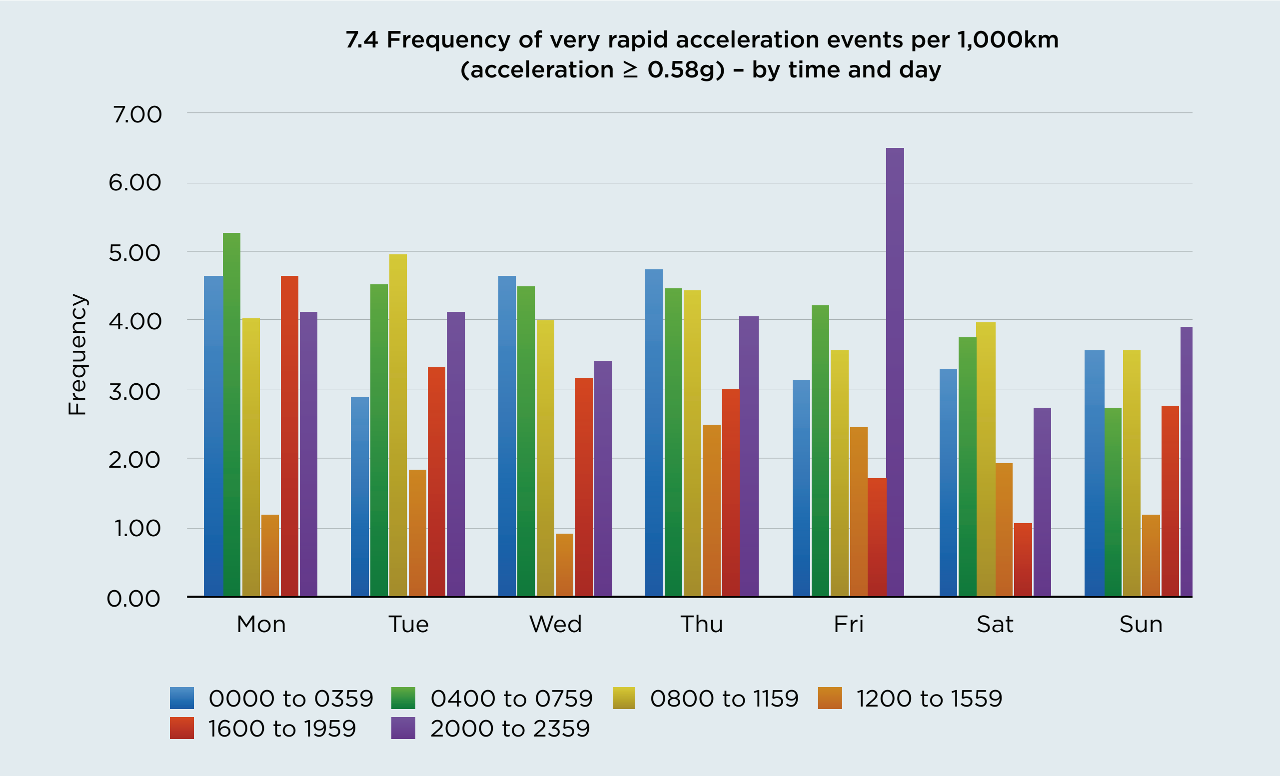
For reference, a deceleration of ≤ -0.75g is experienced if a vehicle reduces speed by 27km/h in the space of 1 second.

However, it should be noted that this trial did not collect any video footage to enable positive confirmation of a crash or near-crash event.



7.4 Frequency of very rapid acceleration by time and day

Rates of very rapid acceleration (acceleration ≥ 0.58g) are notably higher on Friday between 8pm and midnight. This may be the consequence of lower traffic impedance at those times. For reference, acceleration of ≥ 0.58g is equivalent to going from 0km/h to 100km/h in the space of 5 seconds.



7.5 Geographic distribution of high range speeding events

8 out of 10 trips recorded for the trial had at least one instance of speeding (exceeding the speed limit by at least 1km/h).

Each coloured dot indicates one 1 instance of speeding within a 2 second period.

A single dot suggests an isolated incident of speeding, whereas continuous dots indicate greater frequency. Yellow dots indicate speeding by 1-10km/h, orange dots indicate speeding by 11-20km/h and red dots suggest speeding by more than 20km/h.

The majority of speeding observed in the trial is low range speeding.

Speeding at above 10km/h and above 20km/h accounts for less than 3 per cent of all recorded driving time but is highly concentrated in rural and major arterial roads.

8. Results of focus group and surveys

8.1 Summary

The majority of participants believe that the telematics device was positive in changing their behaviour.

63 per cent of all participants indicated that the telematics device had some positive impact on their driving. The treatment group were more likely to rate that their use of telematics had a positive impact on driver behaviour (74 per cent treatment, 44 per cent control).

Participants in the trial reported improved self-awareness and fuel efficiency as a result of using the telematics device.

Participants agreed that they altered their driving style to avoid receiving feedback. About three quarters agreed that the feedback had been effective in getting their attention and reduced the risks taken as a driver.

Overall, females and provisional licence holders reported that feedback from the telematics device helped them drive in a safer way – this is less so among male participants.

How the device changed driver behaviour

Participants interacted and responded to the feedback in different ways, and there were numerous factors for changing behaviour. Analysis of survey post-trial and focus group results identifies the following key motivators for behavioural change:

- better self-awareness of driving behaviour
- desire to adopt a more fuel-efficient driving style
- competition with other trial participants
- passenger monitoring and critique of driver behaviour based on real-time feedback.

Participants rated the telematics device positively and were engaged with its use

Overall, 8 out of 10 participants indicated that they would be likely to continue to use the telematics device even after the trial. There were small differences across licence classes and control vs treatment groups in likelihood to recommend the device.

Over half (54 per cent) claimed that they had activated the telematics device for over 80 per cent of their driving trips – over a quarter claimed they did this for all trips. Higher engagement rates were seen amongst those in the treatment group – with a significantly higher proportion reporting activating the device in over 80 per cent of the trips.

Trip details were considered to be the most helpful aspect of the telematics feedback, followed by speeding push messages. In contrast, participants did not find the Leaderboard particularly helpful.

While some aspects of the telematics device rated positively, some participants (25 per cent) found the feedback annoying – especially amongst those with P1 licence. Females were also more likely to report that the “feedback stressed me out” (19 per cent vs 9 per cent).

Young drivers supportive of broader use of telematics

3 out of 4 participants agreed that it should be mandatory for risky drivers to use a telematics device. A similar proportion indicated that they would not be concerned about the government accessing their data if it was de-identified.

Two thirds (67 per cent) agreed that more drivers should have a telematics device installed in their car. 24 per cent were undecided, and only 9 per cent were not in favour.

Those in the treatment group felt that more drivers should have a telematics device installed in their car, with 71 per cent in agreement that more drivers should have a telematics device installed.

Young drivers unlikely to pay for their own telematics device but would be willing to use one provided by government or an insurance company

Over half of the participants stated that they are unlikely to buy a telematics device for personal use, but 3 out of 4 said they would be likely to use one if provided by the government or insurance company.

Young drivers could be encouraged to use a telematics device through discounts on insurance or by being offered opportunities to win prizes. Others could also be encouraged through other vehicle-related discounts such as registration or fuel vouchers.

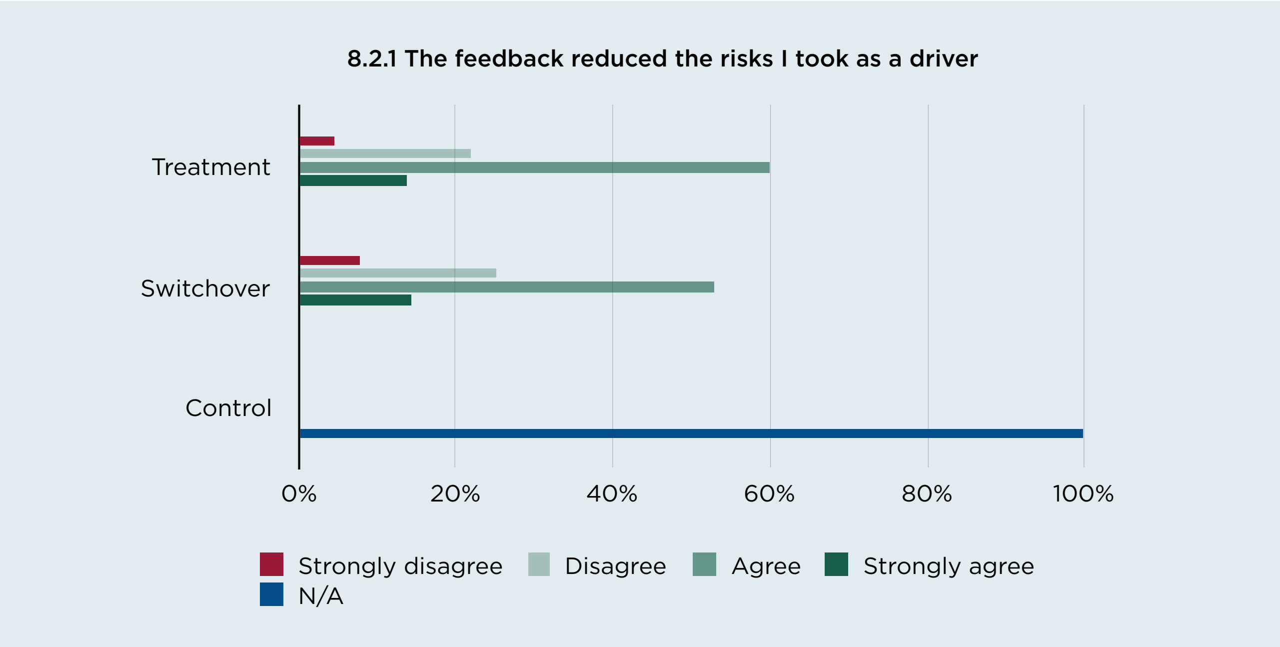
Key concerns with using a telematics device

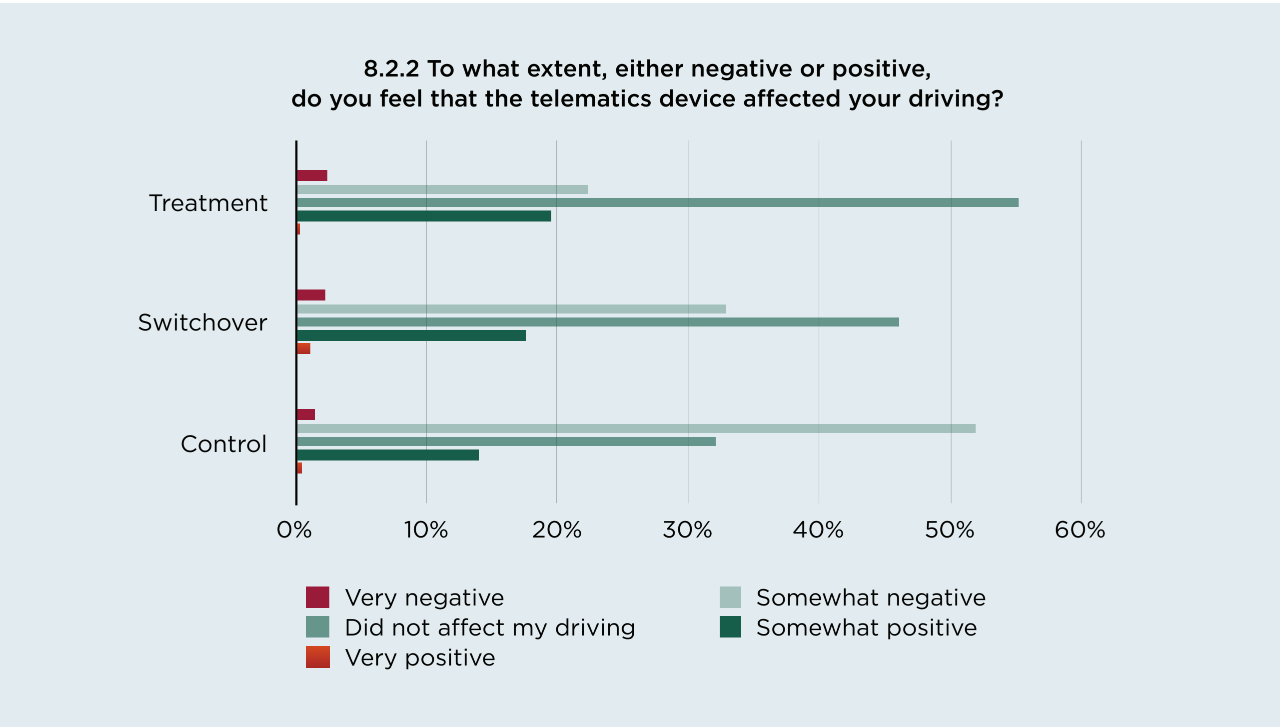
Privacy, device connectivity/accuracy and device ergonomics were the main areas of concern cited by participants. 17 per cent of participants cited privacy concerns; however, 90 per cent also stated that they would not be concerned with government accessing their driving data if it was de-identified. 92 per cent also stated they would not be concerned about an insurance company accessing their data if it meant they would get a discount on their insurance.

8.2 Perceived impact on driving behaviour

Overall, the use of the telematics device was seen to have a positive impact on behaviour.

- 74 per cent of drivers who received driving feedback[28] believed that they had reduced the risks they took as a driver
- 67 per cent of drivers who received feedback thought that the feedback helped them drive in a safer way
- 75 per cent of drivers who received feedback found that the telematics device had affected their driving in a positive manner.





28 Refers to treatment group and switchover group drivers

Curiously 46 per cent of control group drivers, who did not receive driving feedback, believed that the telematics device had affected driving behaviour in a positive way. Analysis of free-text comments provided by control group drivers suggests that even though they didn't receive safety feedback, control drivers were self-regulating behaviours due to the knowledge that they were being monitored and being made more aware of their fuel consumption:

- *"The trial made me concentrate on my speed"*
  – Regional NSW, P1, Female

- *"Made me think more about what I was doing"*
  – Outer Ring of Sydney, P2, Female

- *"Having the statistics of my fuel usage, kilometres, emissions etc. boosted my awareness of how I drive and how often. It helped me to become more passive in my driving style, e.g. not feeling the need to accelerate hard from traffic lights, becoming more aware of other people's driving styles then using that awareness to gauge my driving. An example is someone drifting out of their lane, speeding up and slowing down in front of me – I often keep a safe distance, but I created even more. It made me rethink my driving styles. My main point is that it drastically heightened my awareness."*
  – Regional NSW P2 licence

- *"Made me think about my actions more, i.e. Acceleration and braking"*
  – Western Sydney P2 Male

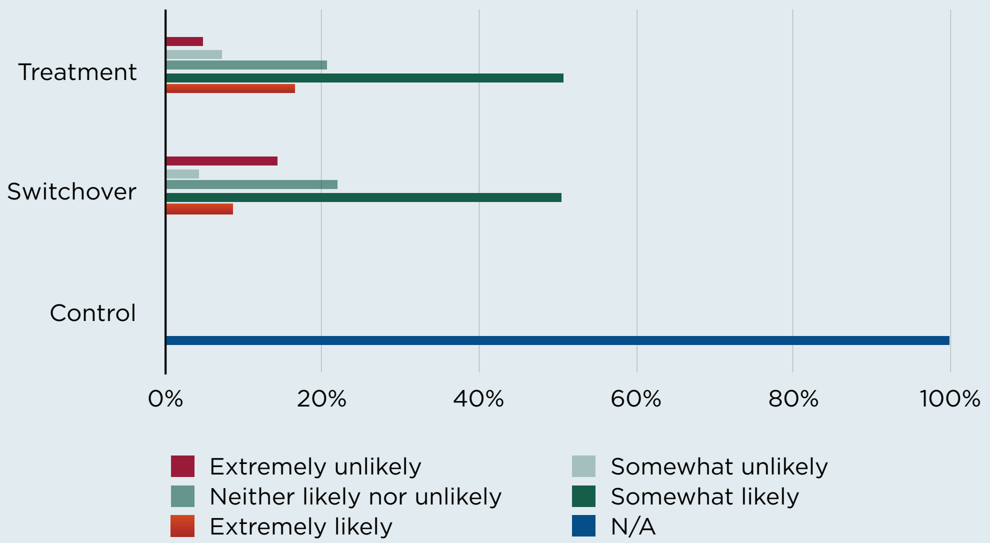
- *"It meant that I was more fuel-conscious, and drove differently, safer because I knew my trips were recorded"*
  – Outer Ring of Sydney P1 licence

- *"The device stayed blue 99 per cent of the time, so it did not particularly affect my driving however it was helpful in being conscious about my fuel efficiency"*
  – Regional NSW P1 licence Male

- *"Kept me conscious of fuel usage and the kilometres I drove every week."*
  – Regional NSW Full licence Male

However, drivers who did receive the feedback (75 per cent treatment and 72 per cent switchover group vs 44 per cent control) were much more likely to report that the telematics device had influenced their driving behaviour in a positive manner.

8.2.3 How likely is it that the feedback helped you drive in a safer way?



8.3 How the device changed driver behaviour

Participants interacted and responded to the feedback in different ways and there were numerous factors for changing behaviour. Analysis of survey post-trial and focus group results identifies the following key motivators for behavioural change:

- better self-awareness of driving behaviour
- desire to adopt a more fuel-efficient driving style
- competition with other trial participants
- passenger monitoring and critique of driver behaviour based on real-time feedback.

Improved self-awareness

The telematics device, particularly the real-time feedback, made participants more aware of driving behaviours which they were not necessarily conscious of or that they had not previously considered to be “unsafe”.

Participants reported feeling surprised to see the extent to which their driving behaviours had caused the feedback device to turn red. For example, there was a significant gap in what participant’s perceived as a safe cornering speed, compared to the feedback being given by the telematics device.

Of the participants who received the real-time feedback (treatment and switchover group), 56 per cent reported changing their driving style to avoid triggering the behavioural feedback.

Participants also mentioned that they were continually learning and responding to the feedback to challenge themselves to improve. For some participants, this led to lasting changes in behaviour, while others reported that their behaviours had reverted back to pre-trial behaviours as the trial progressed.

- *“I’m surprised I sped so much…”*
  – Male, Newcastle
- *“My dad he always tells me that I brake really hard because my brakes wear out really quickly and I didn’t believe him, but I didn’t realise until I was in the car and I was braking, and it was flashing red, and I was like ‘oh I do brake really hard’”*
  – Female, Parramatta
- *“When I first installed it I was so disappointed to see how easy it went into the red.”*
  – Male, Wollongong
- *“I was like I’m a great driver. And then one day it just kept going red, and I was like sh#t what?”*
  – Female, Regional NSW
- *“It helps you improve as an individual, you can see exactly what you are doing wrong, and some things you don’t realise are a dangerous behaviour that you are doing you think it is normal, and then that thing blows red.”*
  – Female, Western Sydney

- *"I think my driving improved from it … I didn't drive overly recklessly before I had it. But, I probably think about my driving a bit more now."*
  – Male, Regional NSW

- *"I definitely improved the way I drive with accelerating and braking … But certainly having the brake feedback that's changed, I brake smoother, I take corners less hard now."*
  – Male, Regional NSW

Desire to adopt a more fuel-efficient driving style

Enabling drivers to monitor their fuel efficiency allows participants to link their driving behaviour to something more tangible – money spent at the fuel pump. Fuel usage and efficiency were tracked by the telematics device, with this information being easily accessible by the participants through the app.

Participants who recognised a link between their driving style and fuel consumption were motivated to change their driving behaviours (for example, excessive acceleration) as a way to avoid excessive fuel consumption.

Having access to information such as routes and time of day travelled also enabled some of the more budget-conscious participants to optimise their travelling habits such as choosing to drive at certain times of the day to avoid traffic.

- *"When I read into it more I was intrigued by the device just because I was spending a lot of fuel at the time so when I read that I could see how much I was spending on fuel that sounds interesting."*
  – Male, Western Sydney

- *"I thought if I drove better that would be more economical and I wouldn't have to spend so much on petrol."*
  – Female, Other Sydney Metro

- *"More just having the device and being able to look at the different things like acceleration and braking, just knowing that stuff I guess. I liked the whole fuel economy thing."*
  – Female Regional NSW

- *"I didn't really care about the money [the incentives]; money is not an issue for me. More so I just wanted to see how good my fuel economy was."*
  – Male Regional NSW

- *"Wanting to see how much my fuel efficiency and when I want to enter in what I have spent on fuel and general me being organised."*
  – Female, Western Sydney

- *"I was looking at fuel consumption and when I was driving intentionally a bit harsher and see what the differences are."*
  – Male, Parramatta

- *"It gives you a reading for your trip … if I'm going between certain points like…from work and home I know ok I'm more efficient this time of the day. This time of the day, I'm a bit less efficient."*
  – Male, Regional NSW

Competition with other trial participants

The leaderboard, a feature of the telematics device app, resonated well and was initially very engaging for some participants.

Participants reported feeling motivated to drive more cautiously to improve their driver rankings and reported a sense of satisfaction when they could see that they were climbing up the leaderboard.

Those participants reported checking the leaderboard frequently to see whether they had improved their driving ranking.

However, many participants also noted that their level of conscientiousness and caution had declined once it became clear that they had dropped out of the top 10 rankings. Once lost, the motivation to continue to improve their driving was difficult to recover.

- *"The main feature for me was the leader board believe it or not … with the leader board I didn't get any gamifying (sic) component or rewarding people for driving well by bumping them up is a great thing and I think that works really well for people generally, and so I did pay attention, and I even checked it before coming today."*
  – Male, Western Sydney

- *"I guess that made you want to drive better cause you wanted to move up above other people"*
  – Male, Regional NSW

- *"You snail drove for the first four weeks and then went I can't do this anymore … For the first few months, I was a lot more cautious, and then I definitely got a bit more lapse after that."*
  – Female, Western Sydney

- *"I found that I was obsessed with the leader board at the beginning. I would be so annoyed if I'm breaking all my accelerating scores it was lower, so I try to get up the top I was focusing hard and trying to brake really well and accelerate really well to try and be at the top. But in the last few months, I haven't really cared about it."*
  - Female, Regional NSW

- *"I just gave up on worrying about my score and things like that. I mainly checked it for fuel consumption and things like that."*
  – Female, Western Sydney

- *"Where am I on this leader board? Until a month ago I was like I am nowhere near the top, so I am never going to look at it."*
  – Female, Western Sydney

- *"At the start, I wanted to get higher up the leader board with acceleration and braking. I wanted to see how high I could get if I did well."*
  – Male, Other Sydney Metro

Presence of real-time feedback enabled passengers to critique driver behaviour

Participants reported that the presence of the real-time feedback ray enabled other passengers to monitor the driver's performance, highlighting to them when the device was turning red and warning them to drive more safely.

- *"Sometimes when other people were in the car because the ray is saying if it is red so I'd try to avoid that so they don't see it."*
  – Female Regional NSW

- *"My mates were like 'oh what's that?' I just tell them bluntly 'it's my d#ckhead meter to tell me if I'm driving like a d#ckhead'."*
  – Male Regional NSW

However, the extent to which this caused drivers to improve behaviour is unclear, as some drivers reported that this additional passenger feedback was unwelcome or unhelpful.

- *"My friend started off annoying and saying 'it is red, it is red', I thought shut up, and they all drive autos, so they don't understand the concept that your car sometimes does go to higher revs when you are changing gears, so they were annoying about that at first."*
  – Male, Other Sydney Metro

- *"Yes, some people made a couple of comments when it turned red saying you are not driving well and commentary on your driving."*
  – Female, Western Sydney

8.4 User experience of the real-time feedback

Overall, the real-time feedback was well received by participants and, in the main, had served its intended purpose of alerting drivers to risky driving behaviours and encouraging them to reflect and change.

Drivers, however, were not necessarily reliant on the feedback to guide their driving.

The feedback itself was considered by participants to be un-obtrusive but simultaneously effective at grabbing their attention. Survey results indicate that:

- 75 per cent of drivers stated that the feedback was effective at getting their attention.

- 57 per cent of drivers indicated that they'd changed their driving style to avoid triggering the real-time feedback

- 72 per cent of drivers believed that they had reduced the risks they took as a driver

- only 41 per cent of drivers stated they were reliant on the feedback to guide their driving.

The ray was intuitive and easy to understand, although initially distracting and not very descriptive. The concept of the colour gradient on the ray, indicating a continuum of safe to unsafe driving behaviour, was intuitively understood.

Some also felt that having such an overt display of driving behaviour in the car could result in more careful driving behaviour when passengers were in the car.

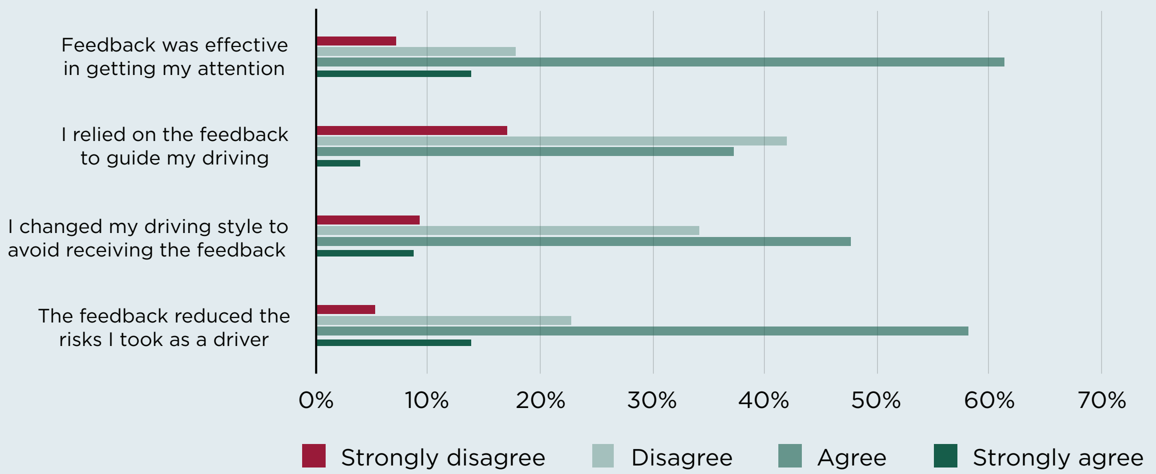
- *“It helps you improve as an individual, you can see exactly what you are doing wrong, and some things you don’t realise are a dangerous behaviour that you are doing you think it is normal, and then that thing blows red.”*
  – Female, Western Sydney

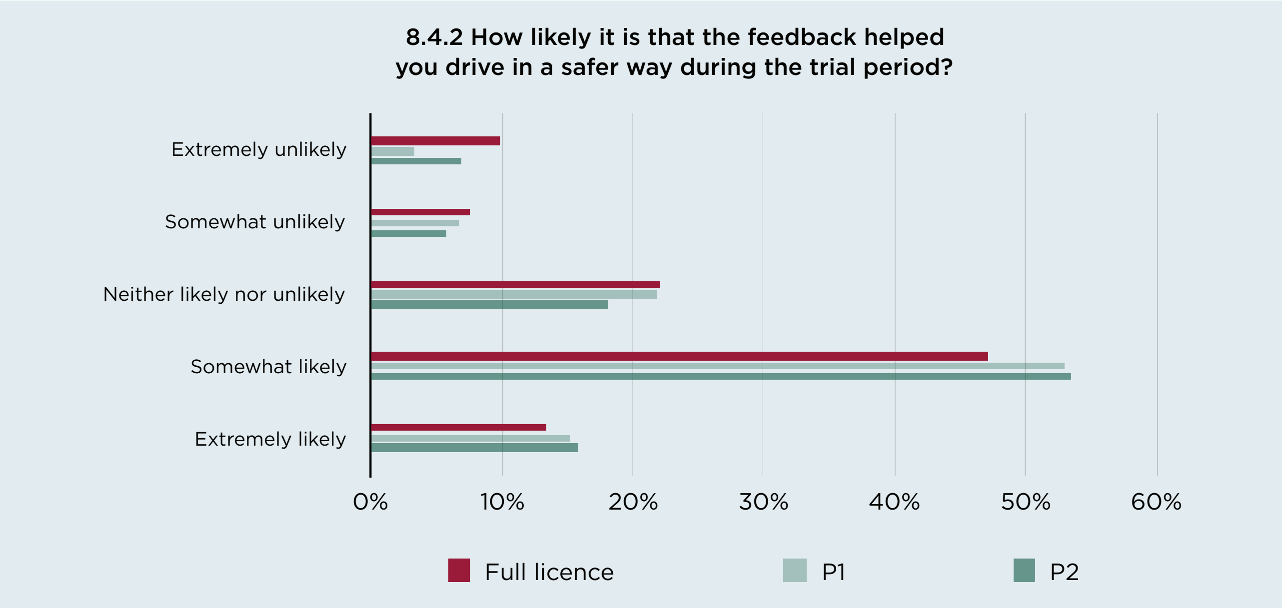
- *“[It] let me know sorta my driving style, I see myself as a fairly good driver. So I liked it and to get a bit of feedback on your driving, from someone other than a mother that screams at you and stuff.”*
  – Male, Regional NSW

Females were also more likely than males to report that the feedback helped them drive in a safer way (70 per cent vs 59 per cent).

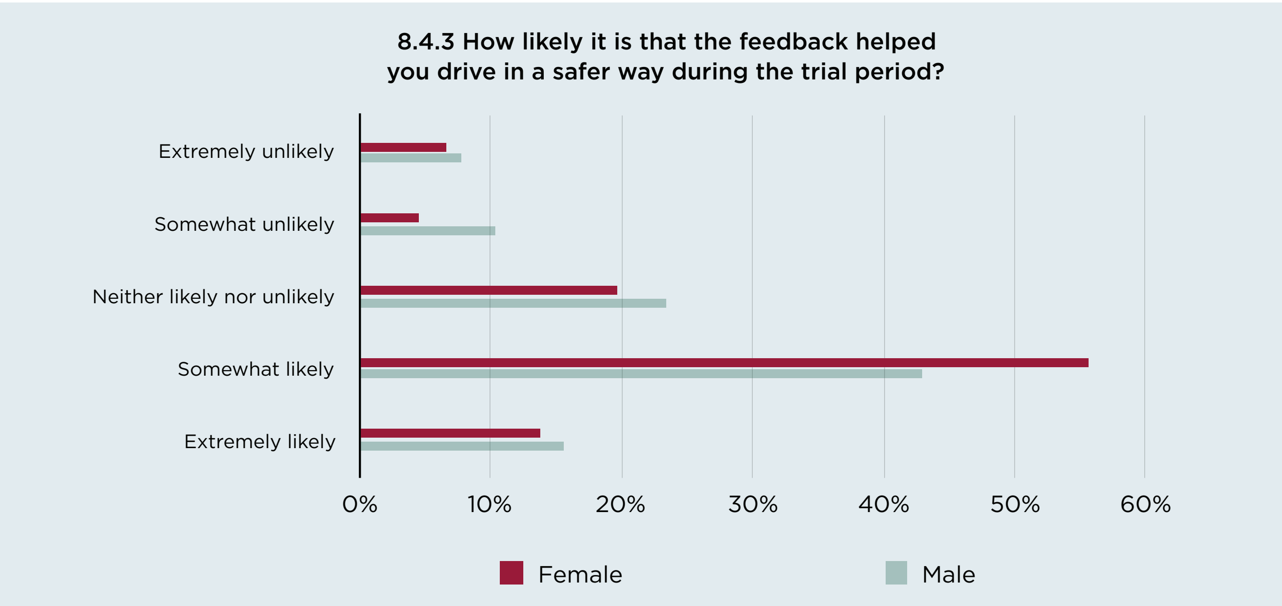
Provisional licence holders were more likely than full licence holders to report that the feedback helped them drive in a safer way (68 per cent P1 and 69 per cent P2 vs 60 per cent full licence).

8.4.1 To what extent do you agree or disagree with the following?





8.4.2 How likely it is that the feedback helped you drive in a safer way during the trial period?
Extremely unlikely
Somewhat unlikely
Neither likely nor unlikely
Somewhat likely
Extremely likely
0%
10%
20%
30%
40%
50%
60%
Full licence
P1
P2



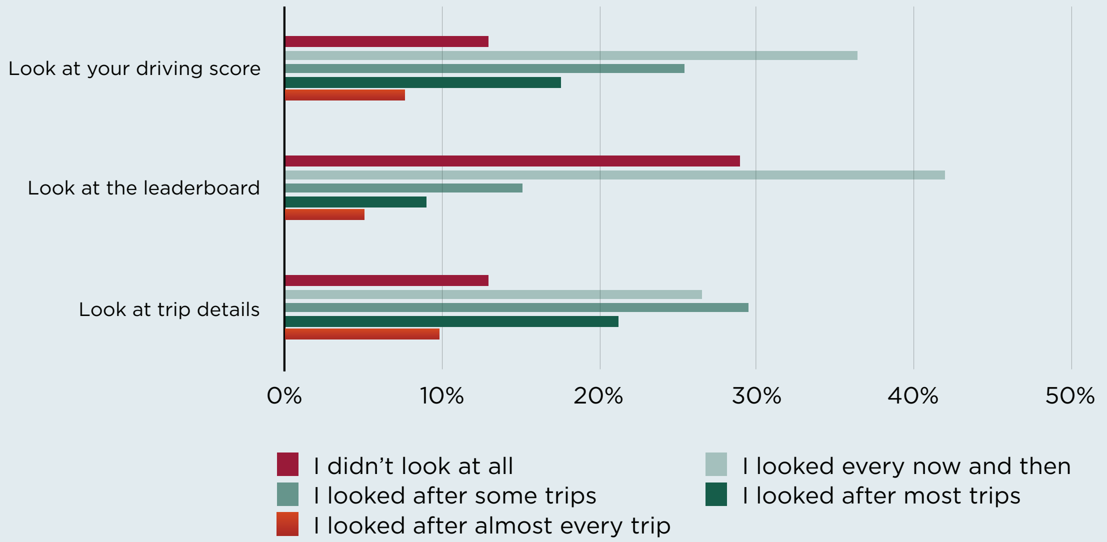
8.4.3 How likely it is that the feedback helped you drive in a safer way during the trial period?
Extremely unlikely
Somewhat unlikely
Neither likely nor unlikely
Somewhat likely
Extremely likely
0%
10%
20%
30%
40%
50%
60%
Female
Male

8.5 User experience with other app features

Other than the real-time feedback, participants most frequently interacted with the trip details feature available on the app. Participants also reported reviewing their driving scores.

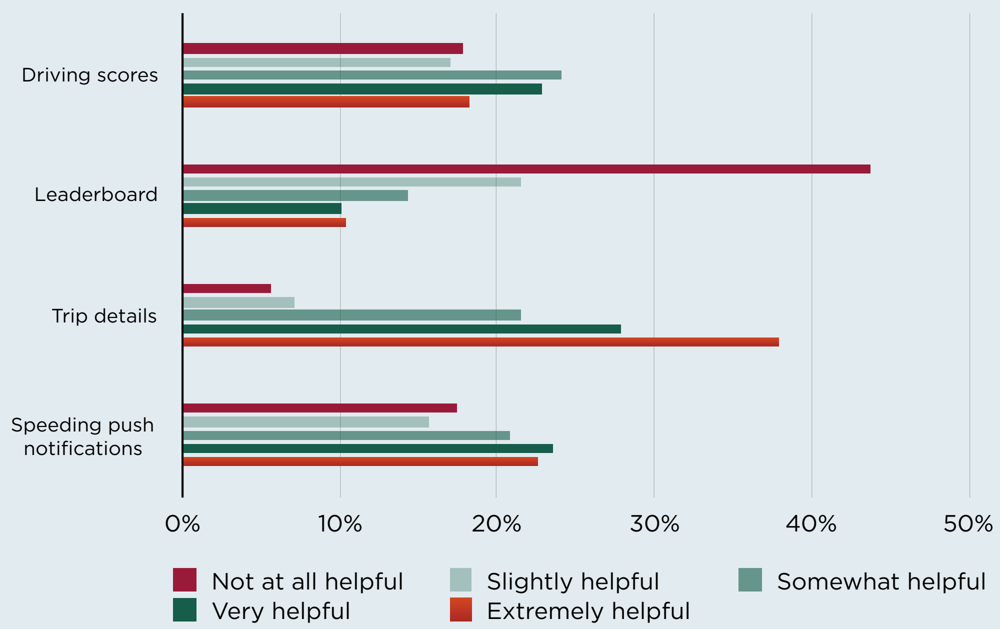
The "leaderboard" however was considered the least helpful and the least used feature, with nearly a third of participants stating that they did not refer to this feature at all.

8.5.1 On average, how often did you do the following?



Participants considered the trip details to be the most helpful feature (94 per cent found this useful in some way), followed by speeding push notifications (83 per cent) and driving scores (82 per cent). The leaderboard was considered the least helpful feature for providing feedback for driving, with 44 per cent finding this feature not helpful at all.

8.5.2 How helpful were the following in providing feedback about your driving?



Beyond the safety benefits, participants also valued the business tracking, fuel economy and maintenance scheduling capability offered by the telematics system.

Service reminders and engine status alerts were helpful for participants with older cars that did not have these styles of alert systems built-in to the car's interface.

One participant reported receiving an engine status alert and claimed that this helped save time and money in taking the car to the mechanic.

Fuel efficiency tracking was highly valued by participants as this assisted with managing budgets amid surging petrol prices.

Participants who also used their vehicle for work purposes also made use of the business tracking function offered by the app to track work trips and calculate fuel usage for tax reporting purposes.

- *"I did find intriguing it's like a pilot as well, and the monetary incentive is quite appealing well as for sure. But other main reason like I thought it'd be cool to see how well I drive and stuff."*
  – Male, Regional NSW

- *"I drive a lot for work and I never really claimed anything on tax, but then they had the little business thing where I would just literally put in my trips, and it would calculate how much everything was, so that was a lot easier at tax time."*
  – Female, Western Sydney

- *"My biggest one of why I did it I am a very organised person and part of that is keeping track of my odo and when I need to pump my tyres and when I need to do my oil and when I need to do my rego so when I was reading through all the information, and it kept track of this."*
  – Female, Other Sydney Metro

- *"It shows you what's wrong instead of spits out numbers or having to go to a mechanic it's excellent."*
  – Male, Regional NSW

- *"You can track like business stuff as well so in the mornings before work sometimes I have to pick up the newspaper so it is that little bit I can claim back on tax."*
  – Female, Newcastle

8.6 Limits and unintended consequences of use

Although the overall user experience was a positive one, there were some limitations and unintended consequences of using the device.

Lack of descriptiveness of the real-time feedback

The most common criticism amongst drivers was that the feedback did not enable them to differentiate which behaviours were problematic. 38 per cent of participants stated it was hard to tell if they were receiving feedback due to the acceleration, braking or speeding.

- *"I found that there were a few things that could make it go red and you didn't always know which one it was complaining about ... but I don't think it is very well explained as in how the driving score is made up for that particular trip of what you could have done differently to alter it."*
  – Female, Other Sydney Metro

Inability to customise feedback to specific vehicles

Participants driving manual cars also felt that the continuous change in light from blue to red with each gear shift was annoying.

- *"I actually got annoyed with the ray so I did that for about two weeks and that was it... I drive at night a lot, and you are changing gears it goes from blue to red and blue to red every gear so when you are going down a gear, it just comes up red instantly."*
  – Female, Other Sydney Metro

Participants with car modifications were frustrated; they could not adjust their car profiles, so the feedback was more reflective of their specific situations.

- *"I found as well with I think my issue with the ray was that it only would allow you to put in the engine capacity of the car, it wouldn't let you choose to have forced induction and so with my car having that it just registered that it has always been driven hard."*
  – Male, Regional NSW

Distraction from the real-time feedback

17 per cent of participants also stated that the telematics device had distracted them from other driving tasks. Although reported to be initially distracting for some participants, having the ray on the dashboard meant that it could be noticed without taking attention from the roadway. In many cases, the distraction was due to the brightness of the LED light ray, which was a greater issue at night, the LED light ray being dislodged from the dashboard while driving or being preoccupied with trying to improve driving scores rather than focusing on the road.

- *"Initially (first two days only), the brightness and colours of the device could sometimes be distracting while driving – the distracting aspect wore off after two days – from then onwards it greatly helped"*
  – Regional NSW Full licence Male

- *"The light can be distracting, and trying to improve its status takes your focus from the road"*
  – Regional NSW Provisional P1 licence Female

- *"...some drivers could be distracted, but the ray brightness can be changed, and the device isn't big"*
  – Western Sydney Provisional P1 licence Male

- *"The lights on the display are distracting while driving at night"*
  – Western Sydney Provisional P2 licence Male

Finding the feedback stressful, confusing, or annoying, or ignoring the feedback

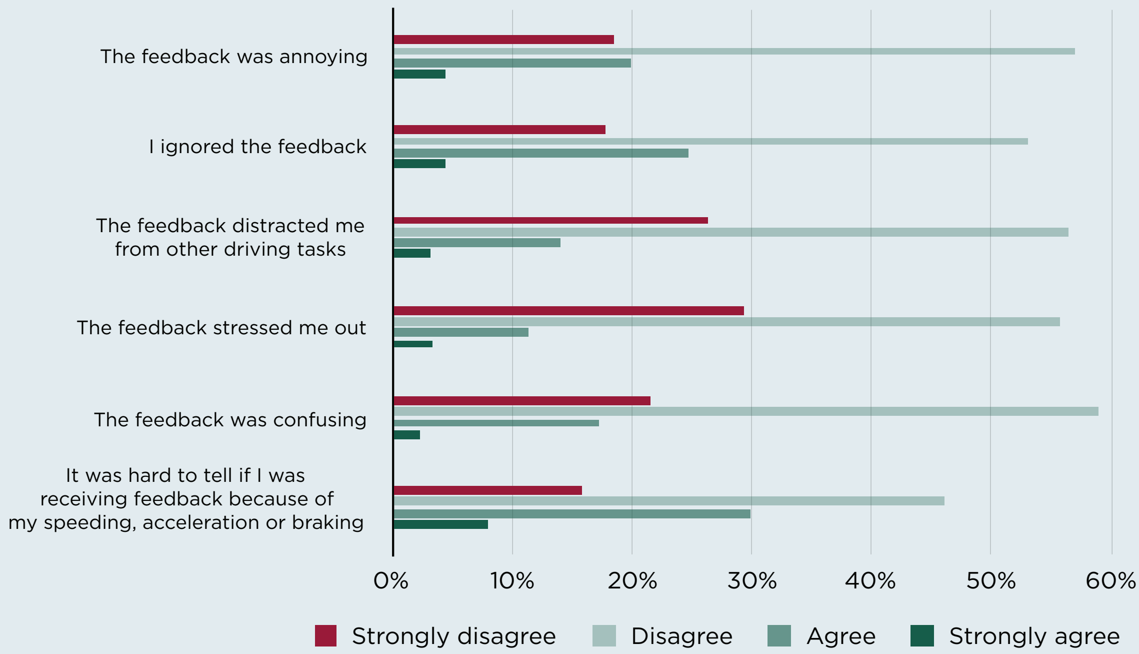
Around 25 per cent of participants also found the feedback annoying. P1 drivers were slightly more likely (30 per cent) to report finding the feedback annoying. 13 per cent reported finding the feedback stressful, with a higher proportion of females (19 per cent) than males (9 per cent).

- *"In a negative sense, the colour was very distracting. It made me stress whenever my eye caught a bit of blue or red as I thought it was emergency services. Positively, I became a better driver by driving slower."*
  – Other Sydney Metro Provisional P2 licence Female

- *"...I found it annoying that it would go red when accelerating hard up a hill to maintain speed. There's nothing wrong with that except that it isn't very fuel-efficient."*
  – Regional NSW Full licence Female

- *"It made me a little annoyed as it was very sensitive to my driving style which in turn made me angry when driving"*
  – Regional NSW Provisional P1 licence Female

8.6.1 To what extent do you agree or disagree with the following?



Encouraging bad behaviour out of amusement

Other participants also reported that they were also encouraged by passengers to engage in bad behaviours to make the ray turn red out of amusement.

- *"Then they are like make it go red, make it go red ... They want to see it happen, and they will encourage you and say just go over for a second so I can see it and they get excited by it."*
  – Female, Western Sydney

- *"Sometimes they say 'put it in red. Make it go red'."*
  – Male, Regional NSW

Initial set-up was difficult for some participants

Although the set-up and use of the telematics device was smooth for most participants, and the ongoing use required little maintenance and effort, some participants reported difficulties with the setup process.

Common issues included:

- difficulties in locating the OBDII port of the vehicle

- finding relevant vehicle information, such as the VIN and engine capacity, to set up the app

- calibrating the device, which required participants to perform multiple vehicle stop/starts.

The majority of participants were able to resolve these issues by referring to the setup guide and instructional videos provided on the supplier's website.

Securing the feedback ray on the dashboard was problematic for some

Finding a way to secure the cable which connected the feedback ray to the OBDII recording device was challenging for some participants. They reported trying a few techniques to hook it out of the way and sometimes unintentionally unplugging it when hooking the cable while getting in or out of their cars. Others felt that securing the ray was tricky, reporting it fell from their dashboards several times throughout the trial.

Loss of connection between ray and app was commonly experienced

Loss of connection between the ray and app caused some frustrations amongst participants. Key issues included:

- intermittent loss of Bluetooth connectivity between the app and ray

- the app reportedly crashing during a trip

- data not being transmitted to the app.

The loss of connection also had an impact on the volume and quality of data that could be analysed. Of the 140 million rows of data that was recorded, representing nearly 80,000 driving hours, only 79 million rows were available for analysis after pre-processing.

Inaccuracies with GPS and feedback

Participants identified GPS location errors, which consequently led to the wrong speed limits being referenced, and drivers being provided with incorrect feedback about speeding. In some cases, this caused participants to question the accuracy of the device and become dismissive of the data. Other common feedback-related complaints were of incorrect feedback when changing gears in a manual car, going up or down an incline or over speed bumps. Claims of the wrong road, and consequently the incorrect speed limit, being referenced by the device were made which were attributed to GPS location errors.

Feedback about poor braking and cornering also felt inaccurate to some participants.

Push notifications were helpful, but sometimes annoying

Push notifications for speeding, braking and acceleration, particularly those providing positive reinforcement for good behaviour, were appreciated by some participants. However, the high frequency of push notifications experienced by some participants was found to be annoying and caused a level of "feedback fatigue".

8.7 Participant Engagement

Survey results indicate that participants were highly engaged with using the telematics device. Over half (54 per cent) claimed that they had activated the telematics device for over 80 per cent of their driving trips – over a quarter claimed they did this for all trips. There was a higher engagement rate amongst those who had received feedback – with a significantly higher proportion reporting activating the device in over 80 per cent of the trips.

On the one hand, telematics data shows that only 50 per cent of users were still logging analysable data by month six of the trial. While this is not a definitive indicator of user engagement – as the lack of trip data may also be due to connectivity issues from the device or the participant's mobile phone; participant sharing cars with other drivers; or less frequent car usage – it certainly highlights the challenges in sustaining engagement with the device over a long period of time.

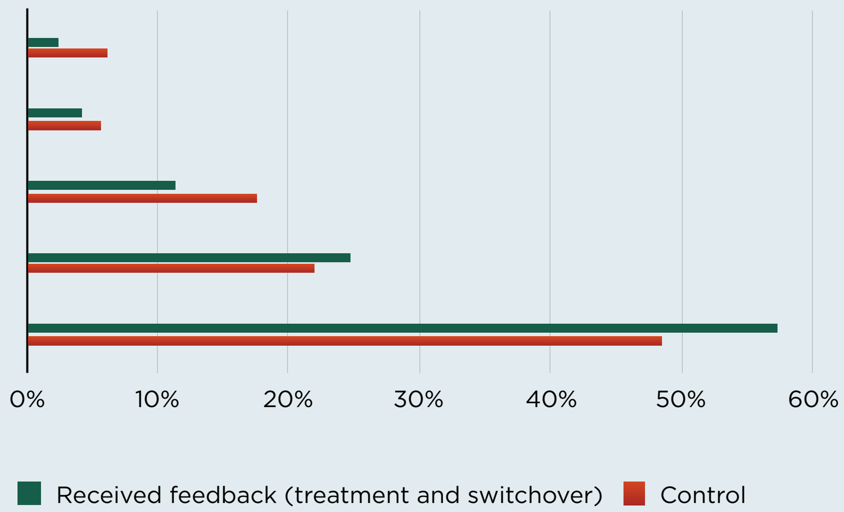
During focus group discussions, there appeared to be widespread interest in continued use, but the degree of enthusiasm varied.

Some participants were quite nonchalant about their decision, explaining that as there is no subscription fee and not much effort to maintain the system is required, they 'might as well let it sit there and look cool.'

For those actively choosing to continue with the device, the features which were claimed to motivate usage included the real-time feedback through the ray, trip data, service reminders and fuel costs for taxation/business records.

Those who said they would not continue with the device reported few benefits to their trial involvement and were frustrated by the inconvenience of the cable.

8.7.1 As a percentage of all the trips you made during the trial, how often did you activate the device when driving?



8.8 Future-Use Intentions

Around 80 per cent of trial participants stated that they would be likely to continue using the telematics device after the trial, although less than half of the participants said they would be willing to pay for it.

Barriers to purchase among younger drivers varied and included:

- perception of being a high upfront cost for a non-essential item
- the newness of an unproven device
- fears about the likelihood of individuals being directly penalised for poor driving behaviour if this information was shared with law enforcement
- concern about data privacy and the ability of the system to track their habits and for the data to be hacked
- a lack of perceived need as some young people consider themselves to be good drivers currently.

However, 77 per cent of participants said they would be likely to use a telematics device if it was provided to them by government or insurance company.

Participants also considered the idea of rewarding use and subsequent behaviour improvement by reducing premiums on car insurance and registration costs as being a potentially attractive incentive for young drivers on a budget who were faced with high insurance premiums.

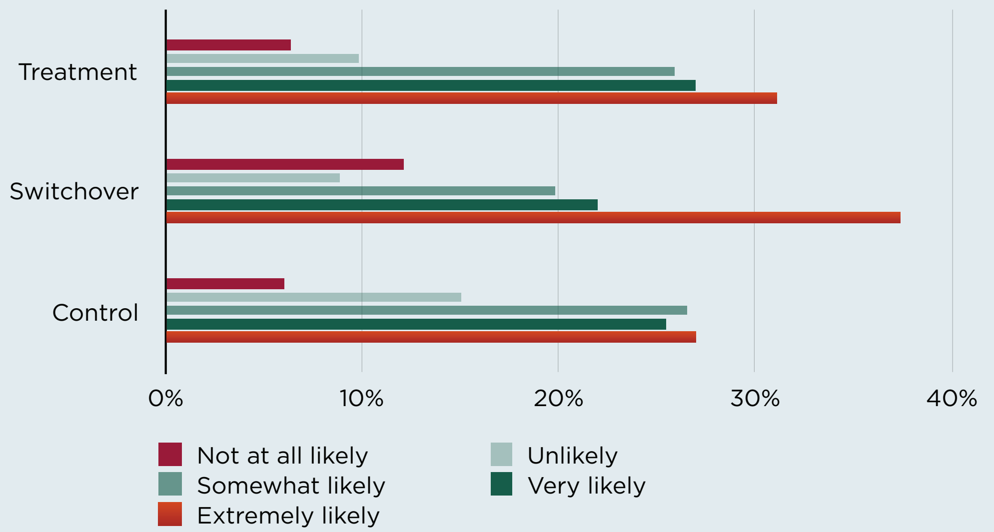
Feedback from participants suggests that offering a discount on the telematics device purchase cost for young drivers would help address concerns about a significant upfront investment. Participants also believed that raising awareness of the telematics through advertising would help encourage adoption.

Participant feedback from survey results and focus group interviews was that the use of telematics devices could be encouraged by:

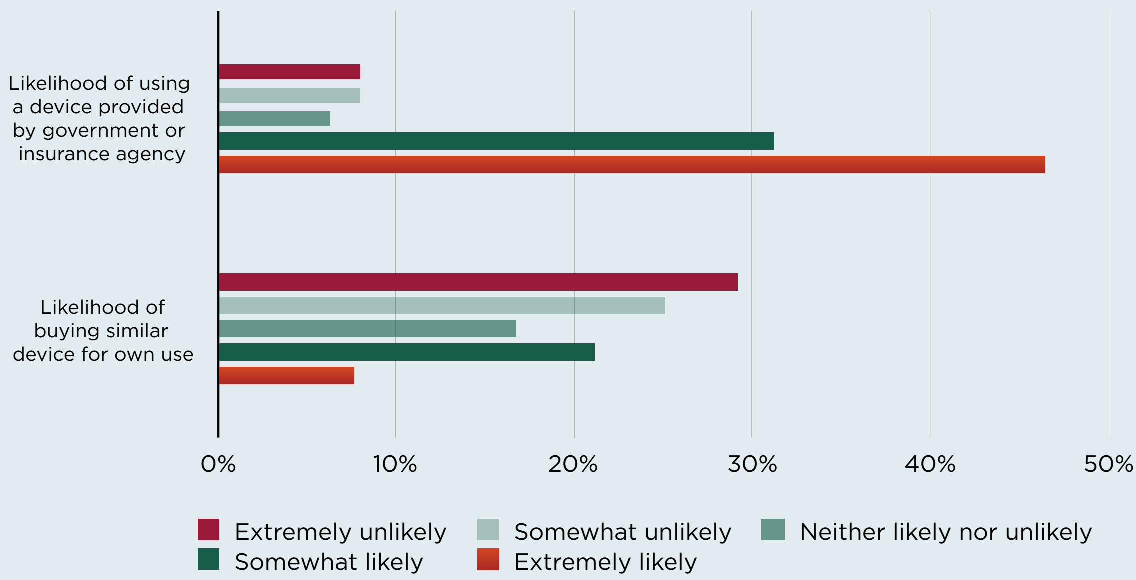
- offers of discounts for insurance or prizes for good driving
- opportunities to win prizes
- focusing on fuel efficiency benefits
- highlighting its ability to improve driving behaviour and reduce the likelihood of losing demerit points.

Some participants also suggested discounts on registration or fuel during focus group discussions. In addition to tangible rewards and benefits, altruistic factors such as reducing the chance of harming themselves or others as a result of a motor vehicle accident could also be used to motivate telematics use. Motivators are important to keep in mind for recruitment and messaging for future programs/products involving telematics devices.

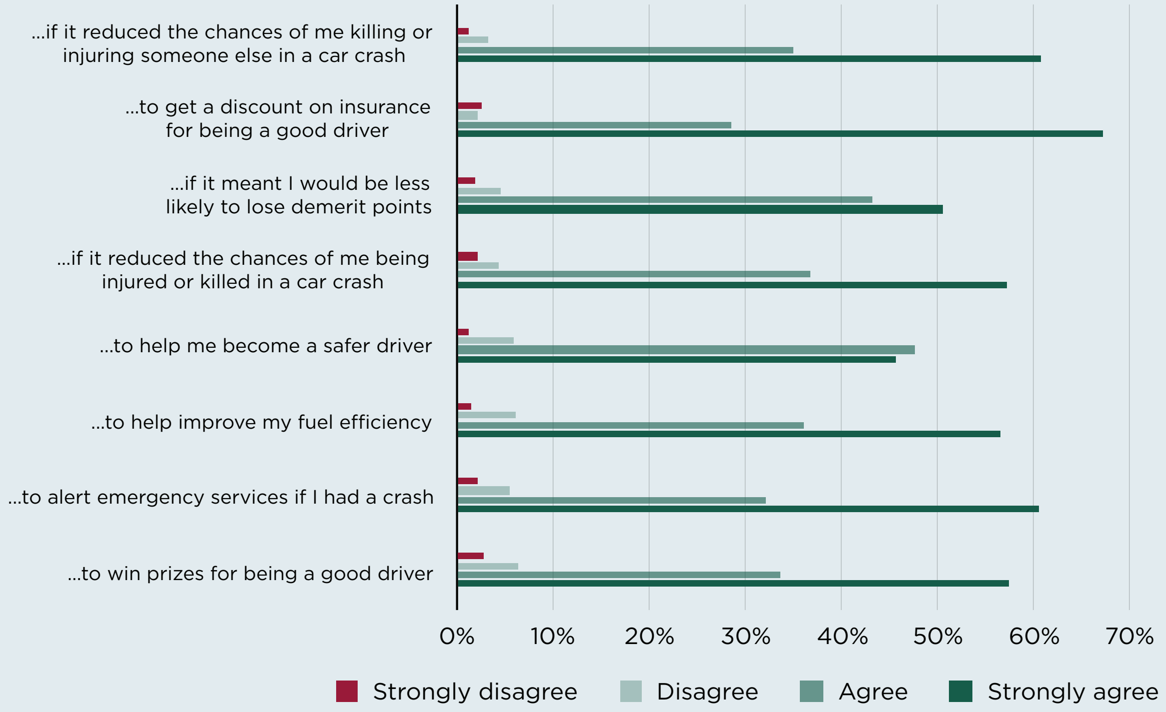
8.8.1 How likely are you to continue using the telematics device provided to you for this trial?



8.8.2 How likely are you to continue using the telematics device provided to you for this trial?



8.8.3 I would use a telematics device...



8.9 Participant Concerns

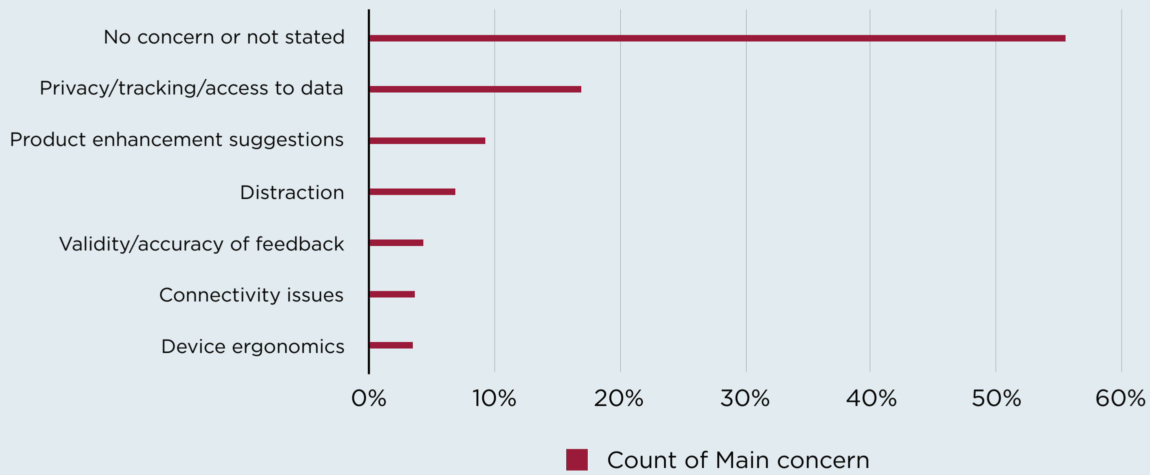
Most participants did not raise concerns about using a telematics device:

- 55 percent of participants did not state any specific concerns about using a telematics device.
- Of the 45 per cent who did raise concerns:
  - 17 per cent related to privacy/tracking/access to data
  - 9 per cent were product improvement suggestions
  - 7 per cent were related to distraction
  - 4 per cent were related to the validity/accuracy of feedback
  - 4 per cent were related to connectivity issues
  - 3 per cent were related to the design and ergonomics of the particular device used in the trial.

While participants cited privacy and data disclosure as areas of concern, they did not appear to be pre-occupied by it.

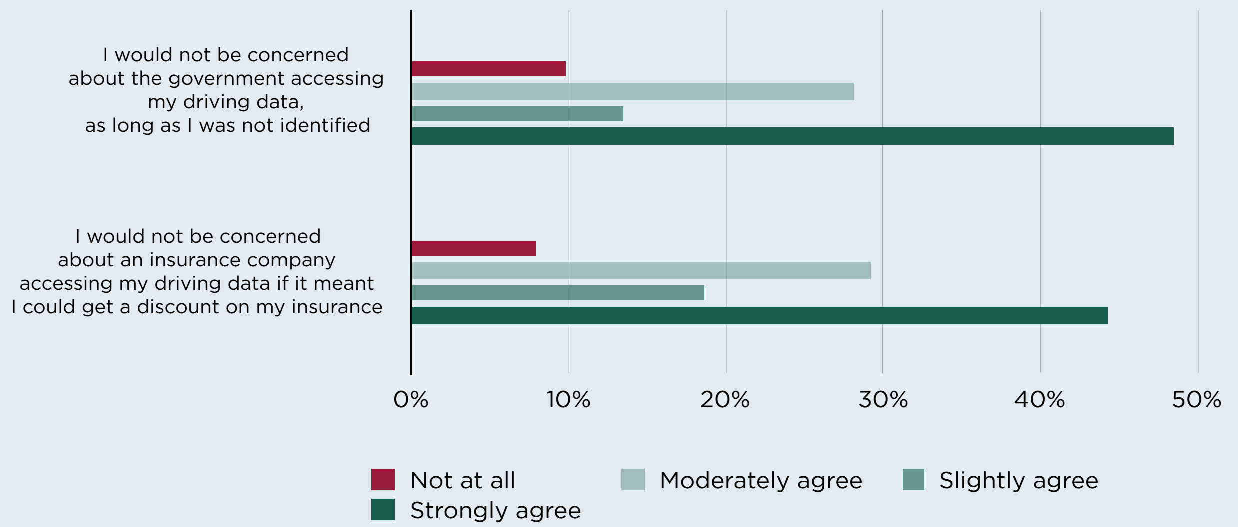
- 90 per cent indicated that they would not be concerned if the government accessed their driving data, as long as it was de-identified.
- 92 per cent reported that they would not be concerned if their insurance company could access their data if it meant they could get a discount on their car insurance.

8.9.1 Do you have concerns about using a telematics device?



Theme	Examples of comments
Privacy/tracking/ access to data	"The only concern I had was whether the government/law enforcement could use it to prosecute me." "Security of the data and it being used against me, eg. Speeding" "Obvious concerns about privacy and use of data, especially if government or insurance agencies become involved. For example, if they were installed in every car, a driver with a poor driving record is crashed into by a driver with a good telemetric driving record, the assessment of the accident is biased already rather than being assessed for what has actually happened on the scene."
Product enhancement suggestions	"I don't have any concerns; however, I would like more detail. Perhaps more detail can be found on the other app, but I've read that the device and read faults in your car such as the engine etc. you can then take it to a mechanic and specifically request to fix that problem without them trying to say the problem is much worse and charging extra. I don't know, being female, uneducated on cars without father figure etc. it's easy to be pushed over. Id like for a little device like that to have my back." "My device got very hot very quickly and left a mark on my car (burnt the rubber)" "The location to the device on my dash looked good, but I often forgot to put it away when leaving my car on a hot day."
Distraction	"The light can become very bright, especially at night, which can be very distracting." "The light can be distracting, and trying to improve its status takes your focus from the road." "The consistent changing of the lights (from blue to red, or vice versa) was very distracting – especially at night time."
Validity/accuracy of feedback	"Some of the feedback, i.e. turning speed, is annoying and seems overly conservative." "Just improving sensitivity and maybe get it to recognise speed limits cause it would be telling me I was speeding in a 70 zone when I was doing 60-65." "Acceleration and braking feedback was bullsh#t. You could barely accelerate without it giving negative feedback, same with braking. If everybody drove how the telematics device wanted us to drive traffic would be disgraceful and trip times would increase."
Connectivity issues	"There were some issues with connection through Bluetooth and sometimes it didn't record my trips properly." "The only issue I had was that it would sometimes disconnect and my trip would not be recorded." "The only main issue was the amount of space the app that connected took up on my phone."
Device ergonomics	"While using the device, the end of the cord was tearing, which may lead to a short-circuit and flames." "The wire from the port to the device located on top of the steering wheel is quite far and may get tangled while driving." "The chord was a bit of a hazard because of how long it was and where I would need to place the device on the dashboard."

8.9.2 To what extent do you agree with the following statements?



8.10 Support for expanding the use of telematics

The majority of participants believed that more drivers should have telematics devices installed in their cars.

There was stronger support amongst the treatment group (72 per cent support) and switchover group users (69 per cent support), who had the benefit of receiving feedback about their driving, compared to the control group (59 per cent support).

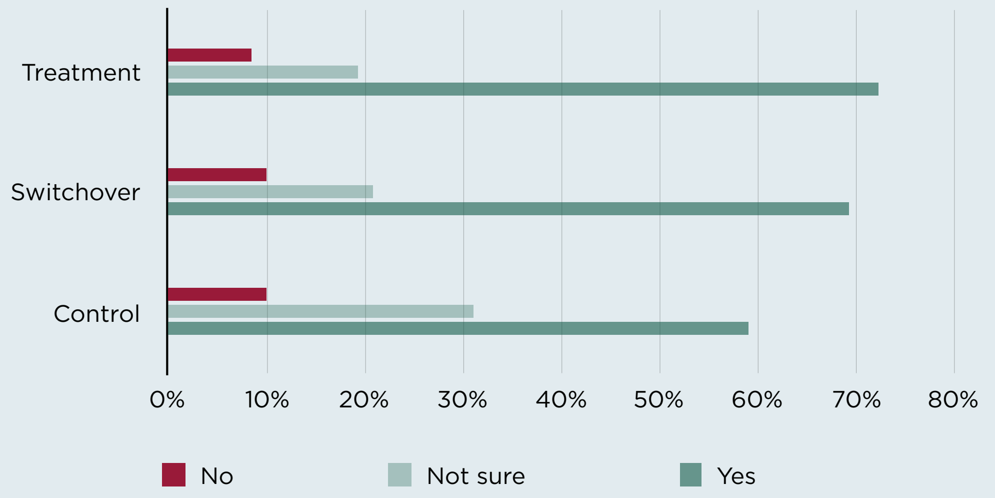
89 per cent of young drivers agreed with the notion that there would be reduced crashes on the road if telematics devices were used by all drivers.

There was also support for the idea that it should be mandatory for risky drivers to install telematics devices in their cars (85 per cent agree).

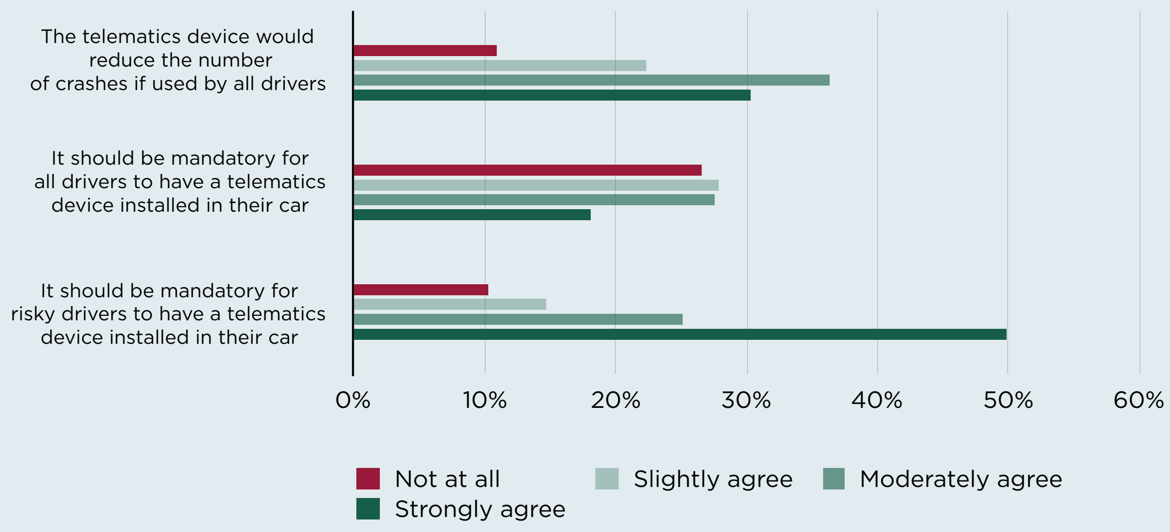
However, participants were less likely to support making telematics use mandatory for all drivers (75 per cent agree).

Some participants suggested that the device could be given to drivers who lost their license so they could prove their good behaviour before returning to a full licence.

8.10.1 Based on your experience of the trial, do you think more drivers should have a telematics device installed in their car?



8.10.2 To what extent do you agree or disagree with the following?



9. Implications for road safety

The results of the randomised control trial and pre- and post-intervention studies provide strong evidence of the effectiveness of telematics use in improving young driver behaviour.

Relative to those who did not receive safety feedback, drivers who received safety feedback have:

- a lower frequency of speeding per 100 driving hours, including a 10.9 per cent and 38.9 per cent lower rate of speeding at 10-20km/h and 20km/h or more above the limit
- a lower overall positive delta speed (that is, the severity of speed limit exceedance), including a 1.56km/h reduction in 50km/h zones
- lower rates of harsh braking, rapid acceleration and harsh cornering events per 1,000km, including:
    - 42 per cent lower rates extreme harsh braking events
    - 24.9 per cent lower rates of very rapid acceleration
    - 24.1 per cent lower rates of harsh turning.

These differences are even more pronounced, and consistent when comparing P1 treatment male participants to P1 control group participants.

9.1 Estimating casualty reductions

Using widely established speed and crash-risk models, we can estimate changes in the frequency and severity of crashes, based on differences in average speed observed between the treatment and control groups.

The randomised control trial results show that the treatment group recorded **lower** average travelling speeds for 40km/h, 50km/h and 60km/h zones (-0.34kmh, -1.13km/h and -0.26km/h respectively).

At the same time, the treatment group also recorded **higher** average travelling speeds in 70km/h, 80km/h, 90km/h, 100km/h and 110km/h zones (+0.04km/h, +0.42km/h, +0.17km/h, +0.4km/h and +0.8km/h respectively).

9.1.1 The power model of the relationship between speed and road safety

The relationship between travelling speed and frequency and severity of casualties was first derived by Goran Nilsson based on speed changes resulting from a number of rural speed limit changes in Sweden from 1967 to 1972.

This relationship is now widely used in OECD countries to estimate road trauma reductions resulting from expected speed reductions.[29]

29 Cameron, MH (2008) Nilsson's Power Model connecting speed and road trauma: applicability by road type and alternative models for urban roads. Presentation at the Australasian Road Safety Conference 2008.

Also known as the "power model", the relationship between changes in average driving speeds and changes in road fatalities and injuries can be summarised in the following equation:

$$Y_1 = \left(\frac{V_1}{V_0}\right)^n Y_0$$

whereby:

Y_0 = *number of crashes before*

Y_1 = *number of crashes after*

V_0 = *average speed before*

V_1 = *average speed after*

"n" refers to the power (exponent), which varies depending on the road environment, and severity of the injury. Results of Elvik's (2009) meta-regression analysis provides a set of power estimates for victims and crashes to account for various road environments and crash types.[30] These are provided at A.15.

By applying the power model and using Elvik's "Best estimate" exponents for different traffic environments, we obtain the estimated percentage reductions in casualties by different speed zones and severity type overviewed in A.16.[31]

By applying these percentage reductions to the annual average number of crashes involving motor vehicle controllers aged 17-25 for 2013 – 2017[32] (A.17), it can be estimated that there would be 159 less casualty crashes involving young drivers each year. This number comprises:

- 2 less fatal crashes
- 59 less serious injury crashes
- 57 less moderate injury crashes
- 41 less minor injury crashes.

Telematics use would also help to prevent 83 non-casualty crashes (that is, property- damage-only crashes) where young drivers are involved.

30 Elvik R (2009). The Power Relationship between speed and road safety. "Institute of Transport Economics, Norwegian Centre for Road Safety". 2009.
31 Estimated reductions rely on Elvik's power model estimates "best estimate" exponents and makes distinctions for different road environments. For the purposes of Elvik's power model estimates, it is assumed that: speedzones 70km/h or less is the equivalent of "Urban/ residential" under Elvik's power model; speedzones of 80km/h or more is the equivalent of "Rural roads/ freeways". It should also be noted that Elvik's categorisation of crash severity differs from NSW Centre for Road Safety classifications. For the purposes of this analysis it is assumed that: Fatal crashes is the equivalent of "Fatal accidents"; Serious injury crashes areis the equivalent of "Serious injury crashes";", Moderate injury accidents are the equivalent of "Slight injury accidents";", Slight injury accidents are the equivalent of "Slight injury accidents";", Non-casualty (towaway) crashes are the equivalent of "Property damage only" accidents.
32 NSW Centre for Road Safety 2018

Estimated annual casualty reductions based on observed average speed differences							
Speedzone	Differences in mean travelling speed (treatment - control)	Fatal crashes	Serious Injury crashes	Moderate Injury crashes	Minor/ Other Injury crashes	Non-casualty (towaway) crashes	All crashes
40km/h	-0.34kmh	0**	-1	-1	-1	-1	-4
50km/h	-1.13km/h	-3	-63	-57	-38	-84	-245
60km/h	-0.26km/h	0	-7	-6	-5	-8	-26
70km/h	+0.04km/h	0	0	0	0	0	0
80km/h	+0.42km/h	0	5	3	2	4	14
90km/h	+0.17km/h*	0	0	0	0	0	0
100km/h	+0.4km/h	1	5	3	1	3	13
110km/h	+0.8km/h*	0	2	1	0	3	6
Net accident reduction		-2	-59	-57	-41	-83	-242
*Differences not statistically significant (p<0.01). **Numbers rounded down							

The estimated saving of 59 serious casualty crashes (those resulting in death or serious injury) is a more direct estimate of potential benefits associated with delivering on the NSW Government road safety targets for fatality and serious injury reduction. In NSW, serious injuries are considered to be all road-related injuries admitted to hospitals, based on hospital admissions records.

Notwithstanding the fact there were increases in the percentage of casualty crashes modelled for higher speed zones under the power model, these were offset by a more substantial reduction in casualty crashes in lower speed zones. This is a function of the:

- relatively greater decreases in average speeds (1.13km/h) reductions recorded in the 50km/h zone
- relatively smaller increases in recorded in 100km/h zone (0.4km/h), and
- the relatively lower historical rate of crashes recorded in high-speed zones compared to low-speed zones (refer to A.17).

9.1.2 Assumptions

It should be noted that these estimates assume that:

- the sample participant drivers and recorded driving behaviour are representative of the broader population of NSW young drivers
- all young drivers currently holding P1, P2 and full licences (approximately 490,000) and all future Provisional 1 licence holders (~90,000 per year) are provided with telematics devices that would produce equivalent average speed reductions.[33]

33 Roads and Maritime Services (2019). Table 2.1.6 Licence class by licence type by licence holders age group as at 31 Dec 2018.

9.2 Social/economic benefits of estimated casualty reductions

The social and economic impact of young drivers using telematics devices can be estimated by multiplying the abovementioned reductions by the estimated casualty crash values provided under Transport for NSW's Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives. There are two approaches for placing a financial value on crash prevention:

- **The Human Capital Approach** captures the ex-post sum of various identifiable costs, such as loss of work income, medical expenses, long term care, insurance cost, vehicle repair, property damage, travel delays and policing. The value of a statistical life or a fatality is the discounted present value of income or output over a period up to 40 years.

- **Willingness to Pay Approach** (WTP) uses an ex-ante measure of the amount that individuals are willing to pay for crash prevention. Values are derived from Stated Preference surveys where respondents are asked to choose hypothetical scenarios systematically varied in safety, travel time and cost. Econometric models are specified and developed to statistically estimate the monetised valuation of safety.

Transport for NSW requires the use of the Inclusive Willingness to Pay Approach to *"valuing road trauma in economic appraisal projects, programs and initiatives, policies and regulations."*[34] This is a policy position agreed between Transport for NSW and NSW Treasury.

Under this approach, estimated community savings are valued at:[35]

- $8,416,164 for each fatal crash prevented

- $562,779 for each serious injury crash prevented

- $95,395 for each moderate injury crash prevented

- $87,374 for minor injury crash prevented

- $10,139 for each property damage crash prevented.

Under more conservative estimates based on the human capital approach, estimated community savings are valued at:[36]

- $3,063,038 for each fatal crash prevented

- $594,153 for all other crashes prevented.

Based on a net annual reduction of 2 fatal crashes, 59 serious injury crashes, 57 moderate injury crashes, 41 minor injury crashes, 83 non-casualty towaway crashes, the estimated yearly community saving would be between **$38.2m to $59.9m,** depending on whether human capital or WTP estimates are used (A.18).

It should be noted that the values are calculated based on an average value of statistical life (VSL), which may be higher for persons aged between 17 and 25.

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34 Transport for NSW (2016). Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives. pg 288.
35 Transport for NSW (2016). "Section 4.3 Casualty and crash costs - Inclusive Willingness to Pay Approach pg pp289-292. Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives.
36 Transport for NSW (2016). "Section 4.4 Human Capital approach pp 279-280. Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives.

9.2.1 Uncertainty of crash prevention estimates

Interpretation of these crash prevention estimates (and policy decisions arising from this report) should take into account several key uncertainties. These include:

- **Assumptions of sample representativeness –** the estimates assume that the sample is representative of all young drivers in the age group. However, there may be inherent selection biases in the sample given the voluntary nature of the trial (that is, there may be differences in the driving behaviours of people who chose to volunteer for such trials). Issues of sample representativeness are further discussed in "Strengths, Limitations and Lessons Learnt".

- **Uncertainty of trial results –** the average speed differences are based on driving which took place between July 2018 and March 2019 – it is uncertain whether the same results would be replicated in other parts of the year, or over a longer period.

- **Uncertainty within the Nilsson power model and Elvik's exponent estimates –** the relationship between mean speeds and the severity and frequency of road trauma is widely accepted within the road safety literature. Notwithstanding, it is also important to note the variability within Elvik's exponents (as noted within Elvik's research) which would contribute to a wide margin of error in the estimated casualty reductions. The casualty prevention estimates in 9.1.1 use Elvik's "Best Estimate" exponents (for rural roads/freeways and urban/residential roads) to obtain a total of 242 crashes prevented. However, this number would change to 373[37] if using upper bound values, or 105[38] if using lower bound values.

37 2 fatal, 82 serious injury, 80 moderate injury, 55 minor injury, 154 non-casualty
38 0 fatal, 36 serious injury, 33 moderate injury, 25 minor injury, 11 non-casualty

10. Strengths, limitations & lessons learnt

An implicit goal of all trial evaluations is to provide readers with sufficient information to make an informed decision regarding future programs and applications. This section provides a transparent critique of the strengths and limits of trial and documentation of lessons learnt, which would factor into considerations for future programs.

10.1 Trial strengths

Trial findings are based on the analysis of 33,279 driving hours (contributed by n=717 trial participants over a six-month driving period), survey responses (n=589), as well as qualitative data from semi-structured interviews and focus groups (n=50).

The validity of trial findings is strengthened by:

- the well-controlled nature of the study which employed best-practice, evidence-based methodologies, and
- the granularity of data and high-frequency sampling of the telematics collection device.

Randomised control trial

One of the strengths of the trial is in the deployment of the randomised control trial (RCT) methodology. Participants were randomly allocated into control (n=255) and treatment groups (n=362), which determined the type of intervention they received (safety feedback vs no safety feedback). Driving data for both groups was analysed after six-months against validated safety surrogate indicators to assess differences in speeding, braking, acceleration and harsh turning. As on average the groups are identical apart from the intervention from the differing feedback, any differences in outcome are, in theory, attributable to that intervention. RCTs are generally considered to provide the highest level of evidence in primary research.[39]

Pre- and post-intervention analysis

In addition to the RCT, the trial consisted of a pre- and post-intervention study. A pre-/post- study measures the occurrence of outcomes before and after an intervention is applied. In this instance, the trial compared the frequency and severity of speeding, braking, acceleration and harsh turning of n=100 participants in a pre-intervention period (consisting of 4,105 driving hours) to post-intervention period (consisting of 2,486 driving hours). While pre-/post- studies are not considered to have the same level of rigour as an RCT, the benefit of a pre-/post- study in this instance was to provide secondary validation of the results observed within the RCT.

Attitudinal research

Finally, the trial also made use of participant surveys (n=589 respondents) and focus group/interview discussions (n=50) to gather qualitative data regarding participant trial experience. In addition to assisting in the interpretation of quantitative results, the qualitative data also provided rich insights about participant motivations, perceptions and concerns with using a telematics device, which would have otherwise been imperceptible from the telematics data alone.

39 Akobeng AK (2005). Understanding randomised controlled trials. Archives of Disease in Childhood 2005;90:840-844.

10.2 Trial limitations

Participant attrition

An important factor in the interpretation of RCT results is the rate of attrition. Attrition (also known as 'loss to follow up') can introduce bias in RCT results, which in turn could undermine the strength of the trial findings.

For this trial, the attrition rate for the overall sample of treatment and control groups after six exposure months was around 50 per cent, meaning that only half of the participants who recorded driving kilometres in month one were still recording driving data in month six.

Attrition was 46 per cent after month six (54 per cent of control group participants continued to record data) and 53 per cent for the treatment group (47 per cent of treatment group participants continued to record data), meaning that the differential rate of attrition between the control and the treatment group was 7 per cent.

Attrition, in some form, is a nearly universal reality in longitudinal research with human participants.[40]

Although the total rate of attrition (50 per cent) in this trial is high by conventional standards for clinical studies, it should also be noted that:

- the intention of this study was to investigate the effects of telematics use under real-world, rather than strict clinically controlled, conditions
- attrition bias only becomes an issue if there are substantial differences in attrition rates between treatment and control groups which might affect randomisation[41] – in this case a differential rate of attrition of 7% and an overall attrition of around 50% would be considered tolerable by some standards[42]
- a given rate of attrition in and of itself does not equate to bias, nor does it confer methodological flaws or, conversely, integrity[43]

Sample representativeness

Notwithstanding the large sample size and extensive driving hours recorded compared to other studies, the driving activity of participants may not be strictly representative of the driving activity of all NSW young drivers. This assertion is supported by the fact that:

- the data collection was conducted over a period between July 2018 and March 2019, and therefore the behaviours observed within the data may not be generalisable across the whole calendar year
- the average recorded driving time per trip amongst participants was 22 minutes, and it is not clear the extent to which this accords with the broader population of young drivers
- the composition of trial participants was skewed towards female drivers and drivers from Regional NSW.

40 Amico K. R. (2009). Percent total attrition: a poor metric for study rigor in hosted intervention designs. American journal of public health, 99(9), 1567–1575. doi:10.2105/AJPH.2008.134767
41 ibid
42 Office of Planning, Research and Evaluation (2015) Addressing Attrition Bias in Randomized Controlled Trials: Considerations for Systematic Evidence Reviews. US Department of Health and Human Services.
43 Nigg JT, Quamma JP, Greenberg MT, Kusche CA (1999) Journal of Abnormal Child Psychology. 1999 Feb;27(1):51-63.

Selection bias

Although the sampling was targeted to populations of interest and participant selection criteria aligned to highest risk driver cohorts, the occurrence of selection bias cannot be ruled out and is likely given the research design for the trial (based on previous studies with a similar design).

One indicator of potential selection bias can be found in the participants' stated motivations for joining the trial:

- 41 per cent of participants were motivated by a belief that the trial would improve the safety of themselves or others
- 34 per cent were motivated by a curiosity to learn more about their driving
- 25 per cent stated a general interest in research and to know the results of the study
- 12 per cent stated they were motivated to disprove the notion that young people are "bad drivers."
- 10 per cent indicated a desire to improve their driving
- 7 per cent indicated that they were motivated by the monetary incentive ($100).

This may suggest that the drivers who chose to participate in the trial were generally more safety-conscious drivers, which might not be truly representative of the highest risk drivers amongst that cohort.

Data limitations

While the analysable dataset gathered for the trial is substantial (1.8 million kilometres and 33,000+ driving hours), this represented only 44 per cent of the entire dataset collected for the trial.

The data loss is attributable to the strict filtering rules to account for issues in the data collection, which led to:

- missing GPS values, which were critical to identifying speed zones as well as driver location
- errors in speed zone mapping, particularly where certain roads had undergone recent upgrades
- miscalibration of the accelerometer within the telematics device which resulted in highly improbable g-forces being recorded.

There were various contributing factors to data loss, including:

- connectivity issues from the telematics device
- failure by the participant to activate Bluetooth on their phone (intentionally or unintentionally)
- instances where the vehicle was being driven by someone other than the participant
- removal and installation of the telematics device causing temporary miscalibration.

Accordingly, to improve data quality and consistency, filtering rules were applied to exclude trips where:

- more than 50 per cent of GPS locations within a trip were missing OR
- more than 20 per cent of a trip was harsh braking OR
- more than 50 per cent of a trip was harsh acceleration OR
- more than 20 per cent of a trip was hard turning OR
- more than 50 per cent of a trip had a speed limit of 255.

Additional filtering rules were also applied to exclude data from trips that were considered of little analytical value, including trips where:

- more than 80 per cent of a trip the vehicle is not moving (speed is 0) OR
- more than 80 per cent of a trip was made in less than 40km/h speed zones.

10.3 Lessons learnt

In addition to findings of positive behavioural change amongst young drivers, the trial has also identified several areas that require greater emphasis and consideration, if any future telematics-based programs are contemplated. These include the need to:

- improve participant engagement over prolonged periods and to avoid feedback fatigue
- manage the risks of distraction associated with real-time feedback
- minimise the effects of higher travelling speeds in high-speed zones for those drivers who received real-time feedback

Improving participant engagement over time and avoiding feedback fatigue

Other than follow up emails and push notifications reminding participants to ensure that their device was activated, there were limited strategies for encouraging and maintaining user engagement.

Future implementations of telematics-based programs, whether under the auspices of a government road safety program or part of an insurance product, could consider the use of gamification and game-based learning where users can set and complete driving tasks in return for micro-rewards, or compete with other drivers, as a way to improve engagement.

For example, some treatment group participants reported that the concept of the leaderboard (within the app) was initially engaging. However, their interest waned as leader rankings dropped, particularly in the absence of any immediate reward.

In focus groups, participants spontaneously suggested the use of prizes to reward improved driving behaviour through the device, such as:

- discounts, cash or rebates
- car-related rewards, such as discounts on insurance or petrol, or
- entertainment-related rewards, such as movie tickets or restaurant vouchers.

- *“A weekly thing or a monthly thing if you get in the top ten you would win a voucher for something.”*
  – Female, Western Sydney

- *“A competition to competition to pitch each other on the leader board and have rewards for people who come first or second that would be a good idea. Using the app.”*
  – Male, Other Sydney Metro

- *“Even just a small petrol, a card or something that you scan at petrol things and it gives you even just two cents off or three cents off or something per litre. It would still add up … I would use that. I’m guessing other people would use it.”*
  – Female, Regional NSW

Evidence from the focus group also suggests that attrition could be minimised by minimising the user frustrations associated with using a device, such as loss of connectivity and the need for recalibration. This frustration contributed to disengagement by otherwise enthusiastic participants and was noticeably more of an issue amongst users of Android phones.

- *“I have an android, and there was a problem with the App android, and it’s been bumpy quite a bit.”*
  – Male, Regional NSW

- *“There were little faults here and there like I would have to constantly turn my Bluetooth on and off to reconnect it and things like that.”*
  – Female, Western Sydney

- *“I have Bluetooth on my phone all the time although a lot of the time it won’t connect to the gofar so I’m driving without Bluetooth on because I have just given up on trying to get it all adjusted.”*
  – Male, Regional NSW

- *“The first couple of months was smooth driving, pretty good, in December mine just broke … It is hooked up to my car, but it won’t connect to my phone … my app updated and then ever since then it won’t connect to the device.”*
  – Female, Western Sydney

Complaints amongst treatment group members of feedback accuracy – including incorrect speed indications, feedback being triggered when shifting gears while driving a manual car, going up or down an incline, and driving over speed bumps – also called into question the accuracy of the device, which arguably contributed to the rate of disengagement.

- *“…one time when I had a speeding notification, but it wasn’t me. Sometimes I would get a random red light, and I am not sure why … Because it is how vague it is I stopped checking, it wasn’t really telling me how to improve my driving and what affected my scores so I couldn’t care less afterwards.”*
  – Male, Other Sydney Metro

- *“I have a few speed bumps, and every time I would go past a speed bump, it will flash, and I don’t know why it does that.”*
  – Male, Western Sydney

- *“… accelerating up to 80 I always go on the red on second and third gear.”*
  – Male, Regional NSW

- *“They have a little bit of lag to them … you go into a new speed limit zone, and it takes half a kilometre sometimes for it to change.”*
  – Male, Newcastle

Managing the risk of distraction

Notwithstanding the steps taken before the trial launch, there appears to be some scope for improvement in managing the risk of distraction associated with using a telematics device.

17 per cent of participants had stated that the telematics device had distracted them from other driving tasks. Similar rates of distraction were reported by P1, P2 and full licence holders, as was the case with males and females (16-18 per cent), although participants from Outer Sydney (21 per cent) and Regional NSW (22.4 per cent) were more likely to report distraction than those from Western Sydney (9.32 per cent).

The distraction was due to the brightness of the LED light ray, which was a greater issue at night. For some, the distraction from the LED light was a passing issue and the annoyance and distraction caused by light diminished over time. Other participants adjusted the brightness through the app.

Other than the light, participants also cited distraction from the device being dislodged from the car dashboard while driving or being preoccupied with trying to improve driving scores rather than focusing on the road (cognitive distraction).

Further exploration of distraction from the real-time, and consequences of this distraction, will need to be explored more thoroughly; however, immediate steps that could assist in rectifying distraction issues could include:

- clearer communication about how the LED lights can be adjusted to minimise brightness and contrast

- providing participants with more secure stowage options or more explicit advice on how to secure the light ray and cord.

Minimising the effects of higher travelling speeds in high-speed zones for those drivers who received real-time feedback

As discussed previously in section 5.2.3, the comparatively higher mean speeds recorded by the treatment group for 70km/h+ zones can be attributed to the configuration for receiving real-time feedback, which meant that treatment group users would not be alerted to speeding behaviours until they were travelling at 1-5km/h above the posted speed limit.

Given the relationship between average travelling speed and crash risk, even marginal increases in higher speed zones are intolerable from a road safety perspective and the unintended effect of the delay in being alerted needs to be addressed in future trials.

One evident approach is to recalibrate the feedback triggers so that it is aligned to speedometer speed, which by Australian Design Rules, should always be lower than true vehicle speed (if the vehicle is manufactured after 2007). This would ensure that the real-time feedback would be triggered at a lower speed threshold and cause the driver to react sooner.

However, this seemingly straightforward solution could be complicated by the fact that the differences between true speed and speedometer speed vary between manufacturers. In practice, manufacturers display a speedometer speed at 1-5km/h below true speed and algorithms for triggering speeding feedback may need to account for these differences to avoid false-positive feedback, which may in turn cause driver frustration and disengagement.

11. Conclusion

The overall body of evidence gathered from the YDTT suggests that telematics use has an **overall positive impact** on young driver behaviour.

The extent to which telematics use can positively impact young driver behaviour can depend on certain variables, such as the traffic environment and the driver's socio-demographic characteristics and it is unclear as to whether the behavioural changes would be sustained over a longer period.

Young drivers who participated in the trial perceived multiple benefits from using a telematics device, with most believing it had a positive impact on their driving, reduced the risks they took, and increased their level of awareness about their own driving behaviour. While a minority reported finding the telematics device to be distracting and questioned the device design, function and reliability, the majority of participants want to see telematics used more broadly, believing it would reduce the number of crashes on NSW roads.

Results also suggest that telematics could have a positive impact on road safety – estimates, facilitated by modelling based on the trial results, indicate that telematics use could potentially prevent 159 casualty crashes and 83 non-casualty crashes each year if telematics devices were used by all NSW young drivers. By applying existing NSW government methodologies for valuing the prevention of motor vehicle crashes to the calculated crash reductions, this would amount to an annual community saving of between **$38.2m** to **$59.9m**.

Notwithstanding these overall positive perceptions, the trial identified some barriers to telematics use that should be taken into account in any future rollouts:

- The cost of telematics devices is a key barrier to adoption, with around half the participants indicating they would be unlikely to purchase one due to the cost.
- Privacy, tracking and data disclosure issues associated with telematics use concerned a minority of participants, although most were favourable about the potential for telematics to improve road safety.
- Finding strategies to motivate drivers to use a telematics device on ongoing basis was also identified as an area for further exploration.
- Where real-time feedback is used, a focus on product design is required to minimise distraction to drivers.

Appendices

A.1 NSW Centre for Road Safety casualty crash involvement rates

Table 1 – Casualty crashes 2014-2016. Source: NSW Centre for Road Safety 2018.

Age	Sex	Zone of residence*	Licence	Involvement per 10,000 licence holders*	Relative risk ratio
16 – 19	M	Western Sydney	P1	207.1	4.5x
16 – 19	M	Western Sydney	P2	158.9	3.4x
16 – 19	M	Outer Ring of Sydney	P1	151.5	3.3x
16 – 19	M	Rest of NSW	P1	146.0	3.2x
16 – 19	F	Western Sydney	P1	139.6	3.0x
20 – 24	M	Western Sydney	Full	139.5	3.0x
20 – 24	M	Western Sydney	P2	136.0	2.9x
16 – 19	F	Rest of NSW	P1	130.0	2.8x
25 – 29	M	Western Sydney	Full	117.5	2.5x
20 – 24	F	Western Sydney	P2	102.9	2.2x
Average involvement rate is 46.4 per 10,000 licence holders					

Table 2 – Casualty crashes resulting in serious injury or fatality 2014-2016. Source: NSW Centre for Road Safety 2018.

Age	Sex	Zone of residence	Licence	Involvement per 10,000* licence holders	Relative risk ratio
16 – 19	M	Western Sydney	P1	68.2	5.0x
16 – 19	M	Western Sydney	P2	50.5	3.7x
16 – 19	M	Rest of NSW*	P1	40.8	3.0x
20 – 24	M	Western Sydney	Full	37.6	2.8x
20 – 24	M	Western Sydney	P2	35.4	2.6x
16 – 19	F	Rest of NSW	P1	30.9	2.3x
30 – 39	M	Western Sydney	Full Rider	29.8	2.2x
25 – 24	M	Western Sydney	Full	28.3	2.1x
20 – 24	M	Western Sydney	P2	27.3	2.0x
40 – 49	M	Western Sydney	Full	24.7	1.8x
*Average involvement rate is 14.0 per 10,000 licence holders					

A.2 – Examples of recruitment material

State Insurance Regulatory Authority
24 May 2018 ·

SIRA needs drivers aged 17-24 to take part in an exciting project that will make NSW roads safer.

SIRA.NSW.GOV.AU

Young drivers needed for paid trial

If you live in Western Sydney or regional NSW, SIRA would like to know more...

State Insurance Regulatory Authority
1 May 2018 ·

Think you're a safe driver? Register now to participate in our paid road safety driver awareness trial. We're looking for drivers who are under 25 and live in Western Sydney or regional NSW.

SIRA.NSW.GOV.AU

Register now for our telematics road safety pilot

Learn More

A.3 – Participant randomisation

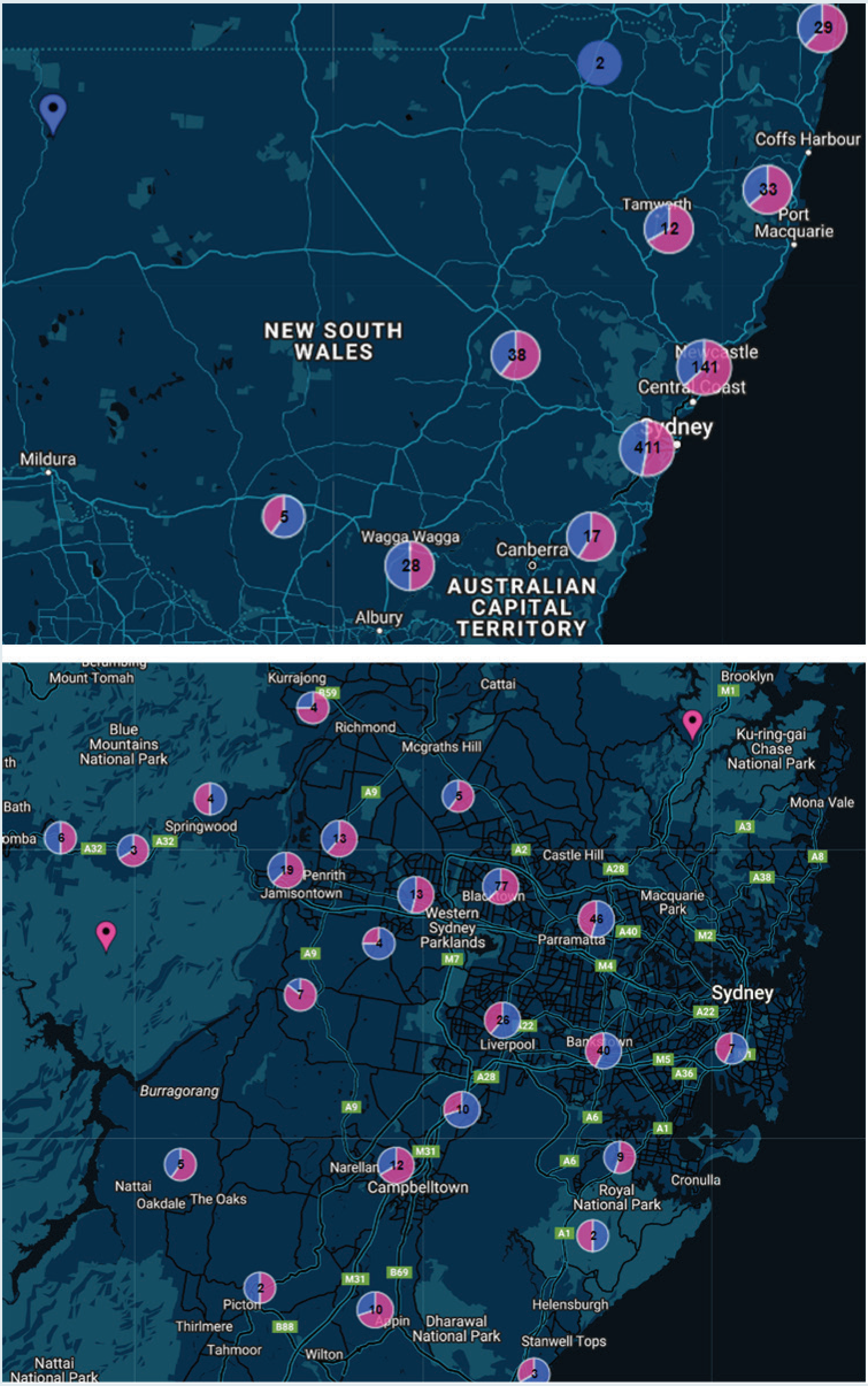
Distribution of female participants by control, switchover and treatment groups

Geo-demographic characteristics (Female)	Control	Switchover	Treatment
Female-Full licence-Other Sydney Metro	2	-	2
Female-Full licence-Outer Ring of Sydney	6	7	10
Female-Full licence-Regional NSW	26	15	42
Female-Full licence-Western Sydney	7	5	28
Female-Provisional P1 licence-Other Sydney Metro	8	2	5
Female-Provisional P1 licence-Outer Ring of Sydney	4	3	7
Female-Provisional P1 licence-Regional NSW	16	4	19
Female-Provisional P1 licence-Western Sydney	12	7	20
Female-Provisional P2 licence-Other Sydney Metro	5	-	3
Female-Provisional P2 licence-Outer Ring of Sydney	15	1	11
Female-Provisional P2 licence-Regional NSW	21	12	31
Female-Provisional P2 licence-Western Sydney	13	4	25
Total	**135**	**60**	**203**

Distribution of male participants by control, switchover and treatment groups

Geo-demographic characteristics (Male)	Control	Switchover	Treatment
Male-Full licence-Other Sydney Metro	7	-	8
Male-Full licence-Outer Ring of Sydney	7	4	13
Male-Full licence-Regional NSW	22	8	27
Male-Full licence-Western Sydney	17	5	27
Male-Provisional P1 licence-Other Sydney Metro	-	2	1
Male-Provisional P1 licence-Outer Ring of Sydney	4	-	7
Male-Provisional P1 licence-Regional NSW	16	7	16
Male-Provisional P1 licence-Western Sydney	5	3	12
Male-Provisional P2 licence-Other Sydney Metro	4	-	6
Male-Provisional P2 licence-Outer Ring of Sydney	3	3	6
Male-Provisional P2 licence-Regional NSW	16	6	18
Male-Provisional P2 licence-Western Sydney	19	2	18
Total	**120**	**40**	**159**

Distribution of participants by gender and postcode



Female Male

Assessment of baseline equivalency

Demographic characteristics

Zone of residence			
	Control	**Pre-Post**	**Treatment**
Other Sydney Metro	26	4	25
Outer Ring of Sydney	39	18	54
Regional NSW	117	52	153
Western Sydney	73	26	130
P value	$\chi 2$	**DF**	
0.12	10.15	6	

Gender			
	Control	**Switchover**	**Treatment**
Female	135	60	203
Male	120	40	159
P value	$\chi 2$	**DF**	
0.46	1.54	2	

Licence type			
	Control	**Switchover**	**Treatment**
Full licence	94	44	157
Provisional P1 Licence	65	28	87
Provisional P2 Licence	96	28	118
P value	$\chi 2$	**DF**	
0.34	4.55	4	

Two sample t-test (mean participant age)		
Age	**Control**	**Treatment**
Mean	20.6	20.7
Variance	5.4	5.3
SD	2.31	2.3
Observations	255	362
Pooled Variance	5.34	
Hypothesized Mean Difference	0	
df	615	
t Stat	-0.76	
P(T<=t) one-tail	0.22	
t Critical one-tail	1.64	
P(T<=t) two-tail	**0.45**	
t Critical two-tail	1.96	

Vehicle characteristics

Vehicle Types			
	Control	**Switchover**	**Treatment**
Hatch	88	35	142
Sedan	117	45	153
SUV	33	12	42
Utility	15	8	23
Van	2	0	2
P value	χ^2	**DF**	
0.93	3.02	8	

Two sample t-test (mean vehicle age)		
Vehicle age	**Control vehicle age**	**Treatment vehicle age**
Mean	6.7	6.6
Variance	13.2	12.7
SD	3.6	3.6
Observations	255	362
Pooled Variance	12.9	
Hypothesized Mean Difference	0	
df	615	
t Stat	0.24	
P(T<=t) one-tail	0.4	
t Critical one-tail	1.67	
P(T<=t) two-tail	**0.81**	
t Critical two-tail	1.96	

Two sample t-test (mean engine capacity)		
Engine capacity	**Control engine capacity**	**Treatment engine capacity**
Mean	1942.9	1946.6
Variance	389564.88	408074.49
SD	624.2	638.8
Observations	255	362
Pooled Variance	400429.9	
Hypothesized Mean Difference	0	
df	615	
t Stat	-0.07	
P(T<=t) one-tail	0.47	
t Critical one-tail	1.65	
P(T<=t) two-tail	**0.94**	
t Critical two-tail	1.96	

Two sample t-test (mean driving kilometres)		
Average recorded driving kilometres	**Control**	**Treatment**
Mean	5024.6	5244.01
Variance	18262714.6	16008080.2
SD	4273.5	4001.009
Observations	255	362
Pooled Variance	16939262.55	
Hypothesized Mean Difference	0	
df	615	
t Stat	-0.65	
P(T<=t) one-tail	0.26	
t Critical one-tail	1.65	
P(T<=t) two-tail	**0.51**	
t Critical two-tail	1.96	

Self-reported fines/driving offences in the last 12 months

In the last 12 months, have you been fined or charge with any of the following?

Fined in the last 12 months: Speeding up to 10km/h over the limit			
	Control	**Switchover**	**Treatment**
No	242	94	339
Yes	13	6	23
P value	**χ^2**	**DF**	
0.81	0.43	2	

Fined in the last 12 months: Speeding more than 10km/h over the limit			
	Control	**Switchover**	**Treatment**
No	229	94	342
Yes	26	6	20
P value	**χ^2**	**DF**	
0.08	5.12	2	

Fined in the last 12 months: Not wearing a seatbelt			
	Control	**Switchover**	**Treatment**
No	255	100	360
Yes	0	0	2
P value	**χ^2**	DF	
0.37	1.97	2	

Fined in the last 12 months: Other offences			
	Control	**Switchover**	**Treatment**
No	242	96	343
Yes	13	4	19
P value	**χ^2**	**DF**	
0.26	0.88	2	

Self-reported deviant driving behaviour in the previous four weeks

When driving in the last four weeks, how often have you done the following?

Get distracted by friends or other passengers			
	Control	Switchover	Treatment
All the time	0	0	3
Most of the time	2	1	6
Sometimes	54	13	54
Rarely	111	48	168
Never	88	38	131
P value	$\chi 2$	DF	
0.33	9.1	8	

Hold or use a mobile phone to talk while driving			
	Control	Switchover	Treatment
All the time	2	0	2
Most of the time	1	4	6
Sometimes	25	5	28
Rarely	50	10	69
Never	177	81	257
P value	$\chi 2$	DF	
0.06	14.7	8	

Hold or use a mobile phone to text			
	Control	Switchover	Treatment
All the time	0	0	1
Most of the time	5	1	4
Sometimes	18	5	24
Rarely	42	16	63
Never	190	78	270
P value	$\chi 2$	DF	
0.96	2.63	8	

Accelerate quickly from the traffic lights to get ahead			
	Control	Switchover	Treatment
All the time	5	2	16
Most of the time	25	3	28
Sometimes	74	33	115
Rarely	68	36	104
Never	83	26	99
P value	$\chi 2$	DF	
0.14	12.06	8	

Speed up to make it through an intersection on an amber light			
	Control	**Switchover**	**Treatment**
All the time	5	0	2
Most of the time	15	9	20
Sometimes	64	35	134
Rarely	80	25	112
Never	61	31	94
P value	**$\chi 2$**	**DF**	
0.4	8.3	8	

Brake hard because I didn't notice cars in front were slowing down			
	Control	**Switchover**	**Treatment**
All the time	0	0	1
Most of the time	5	0	6
Sometimes	51	17	76
Rarely	136	63	187
Never	63	20	92
P value	**$\chi 2$**	**DF**	
0.61	6.32	8	

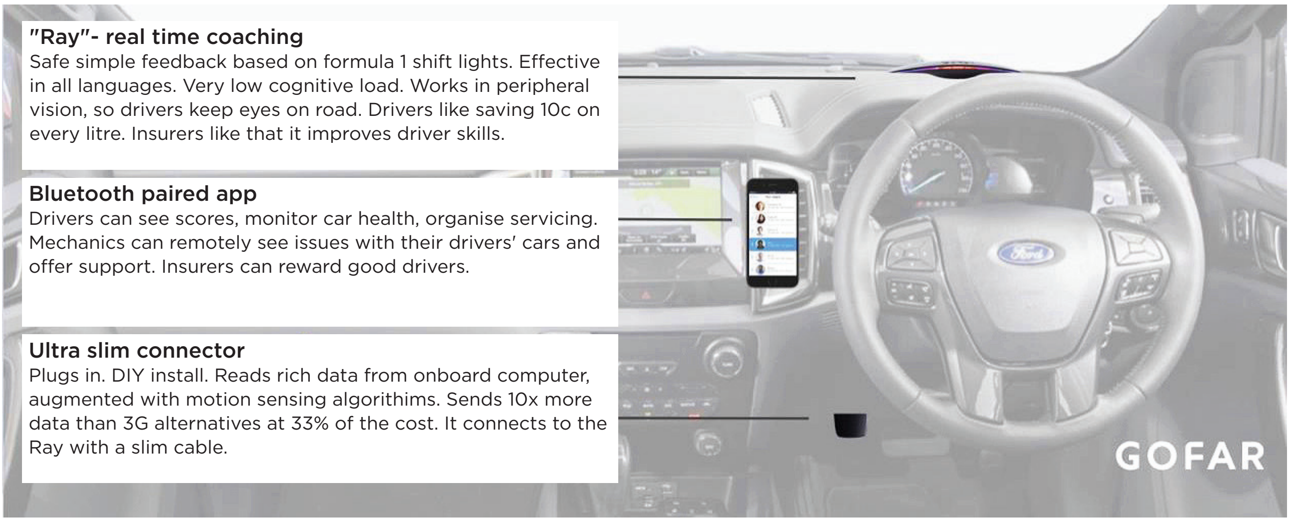
Drift out of my lane without realising			
	Control	**Switchover**	**Treatment**
All the time	1	0	0
Sometimes	13	9	22
Rarely	97	30	128
Never	144	61	212
P value	**$\chi 2$**	**DF**	
0.52	5.2	6	

Exceed the speed limit by 10km/h or less			
	Control	**Switchover**	**Treatment**
All the time	5	3	10
Most of the time	37	8	51
Sometimes	99	38	151
Rarely	80	37	110
Never	34	14	40
P value	**$\chi 2$**	**DF**	
0.7	5.5	8	

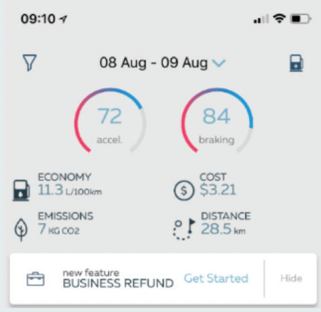
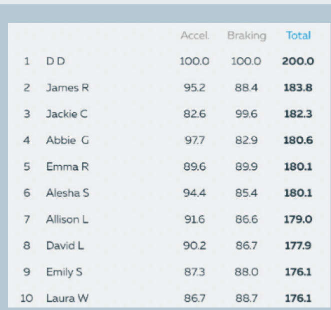
Exceed the speed limit by 10km/h or more			
	Control	**Switchover**	**Treatment**
All the time	0	0	2
Most of the time	7	1	18
Sometimes	48	18	54
Rarely	80	28	126
Never	120	53	162
P value	$\chi 2$	**DF**	
0.25	10.15	8	

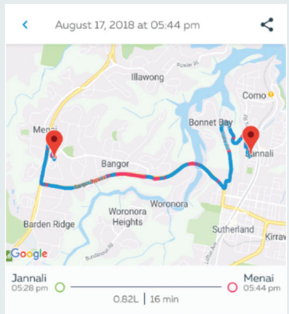
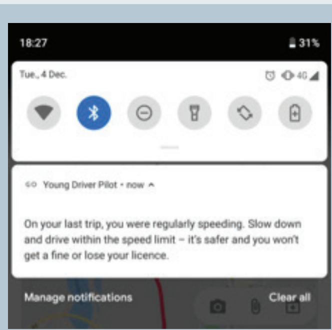
A.4 Overview of the telematics system

GoFar system set up



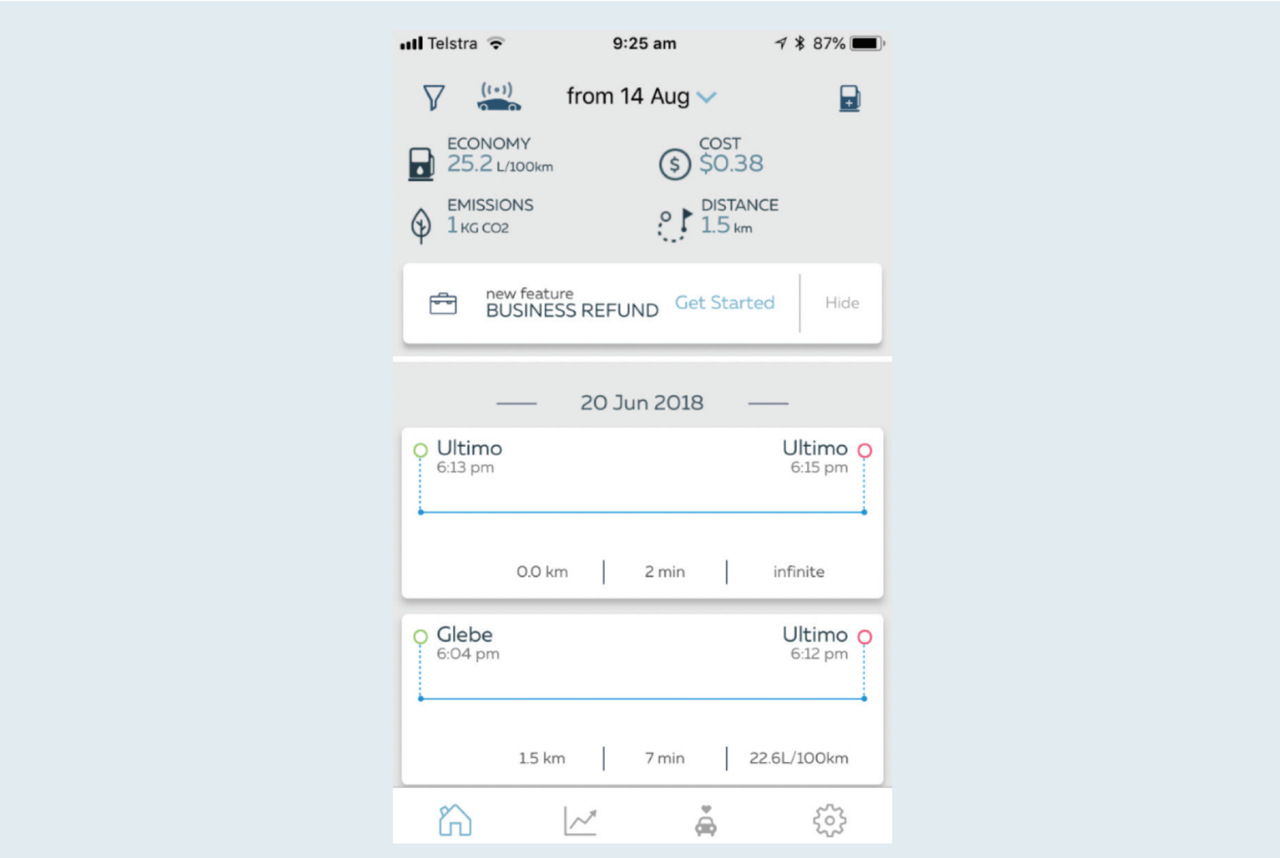
Treatment Group Feedback

<table>
<tr><th>Feedback</th><th>Example</th></tr>
<tr><td>Computed driving scores to provide a snapshot of a user's acceleration and braking performance. A higher score indicates better performance.</td><td>
</td></tr>
<tr><td>Leaderboard to provide performance ranking relative to other drivers in the trial.</td><td>

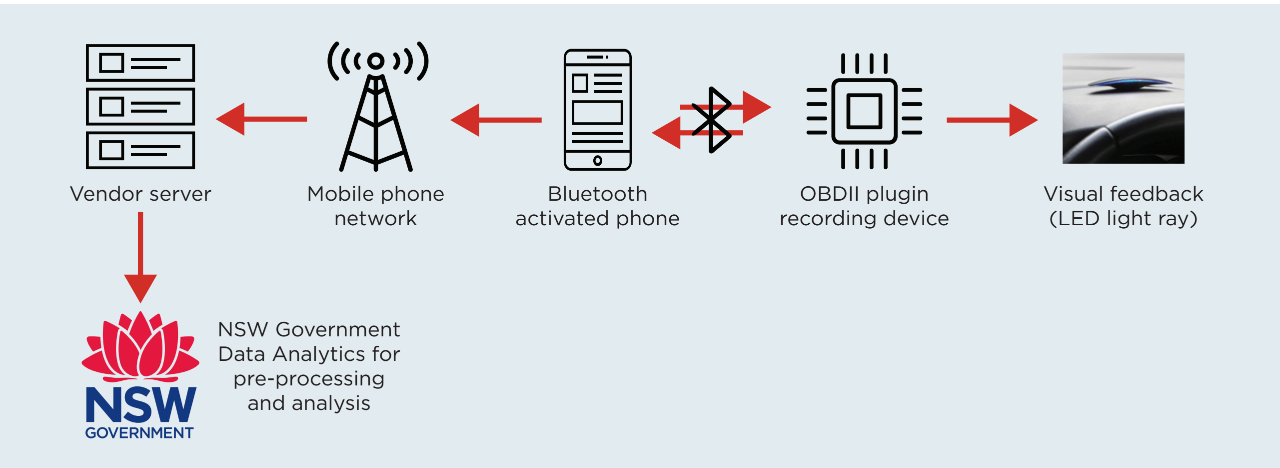
		Accel.	Braking	Total
1	D D	100.0	100.0	200.0
2	James R	95.2	88.4	183.8
3	Jackie C	82.6	99.6	182.3
4	Abbie G	97.7	82.9	180.6
5	Emma R	89.6	89.9	180.1
6	Alesha S	94.4	85.4	180.1
7	Allison L	91.6	86.6	179.0
8	David L	90.2	86.7	177.9
9	Emily S	87.3	88.0	176.1
10	Laura W	86.7	88.7	176.1
</td></tr>
<tr><td>Trip detail summary map to indicate locations where the driver was exceeding the speed limit or braking, turning or accelerating harshly. The highlighted red lines in the map below show where the user was speeding during their trip.</td><td>
</td></tr>
<tr><td>Post-trip push notifications informing the user if they spent more than 20 per cent of their driving time exceeding the posted speed limit. These were delivered about two minutes after the driver disengages the ignition so as not to induce drivers to reach for their mobile phones while driving.</td><td>
</td></tr>
<tr><td>The LED light ray sits above the driver dashboard (above steering column or centre) and changes colour if a driver is speeding or making harsh manoeuvres.

Only the treatment group LED light ray was configured to change colour. Control group colours are set at a constant blue and control group participants were advised that the sole purpose of the light ray was to indicate connectivity between their mobile phone and the recording device.</td><td></td></tr>
</table>

Control Group App Interface



Telematics data collection process



A.4.1 Safety surrogate indicators selected for the trial

Safety indicator	Reasons for inclusion
Speeding frequency – time spent driving over the posted speed limit as a percentage of non-idle driving time.	There is a well-recognised evidence-based relationship between increased crash risk and increased vehicle speed from a variety of research. The Centre for Road Safety, Transport for NSW (2010) in the analysis of the NSW Intelligent Speed Adaption Trial (ISA) used the percentage of time spent speeding to develop categories of speeding (e.g. <10km/h over limit, 10 to <20 km/h over limit) as surrogate safety measures.
Positive delta speed – the speed difference to the posted speed limit when driving above the speed limit.	Jun, Guensler and Ogle (2011) and Jun (2006) found drivers involved in crashes tended to drive at significantly higher mean speed and positive delta speed compared to drivers who were not involved in crashes, and showed a higher tendency of non-compliance with posted speed limits as measured by frequency of occasions where travel speed per mile exceeded 10 mph (16+ km/h) over the speed limit.
Average free speed – average free speed when the vehicle was travelling at least 75 per cent of the posted speed limit.	Elvik's (2004, 2009) meta-analysis of motor accident rates and road trauma data established an exponential relationship between the average speed and frequency and severity of road casualties. Specifically, Elvik finds that relative change in the number of accidents/accident victims is a function of the relative change in mean speed of traffic, raised to an exponent.[44] Reporting is based on average free speed, where the vehicle speed is at least 75 per cent of the posted speed limit. This excludes speeds where a driver was idling or driving through traffic and is assumed to be a more realistic reflection of speed selection.
Frequency and magnitude of longitudinal deceleration (braking): • ≤ -0.3g per 1,000km driven • ≤ −0.45g per 1,000km driven • ≤ −0.5g per 1,000km driven • ≤ −0.75g per 1,000km driven A g is a unit of acceleration. One g is the acceleration exerted by gravity (9.8m/s2). For reference, a deceleration of -0.75g is experienced when a vehicle slows down by 26.5km/h within 1 second.	Unsafe drivers (as categorised by involvement in crashes and/or near-crashes via data reduction using kinematic measures and video review) decelerate < -0.30g significantly more frequently than moderately safe or safe drivers.[45] The Spearman's correlation between the rate of hard stops (per 100 miles) and crash/near-crash rates (per 10,000 miles) for teenage participants was $\rho = 0.76$. This indicates a strong positive relationship between a higher crash and near-crash rates and more frequent hard stops.[46] Reviewing data from the 100-car study Dingus (2006) found that longitudinal deceleration with a threshold of ≤ −0.52 g detected 44.7 per cent of valid crashes, near-crashes and incidents, while 66.4 per cent of events detected were invalid.[47] Perez (2017) used a threshold of ≤ −0.65 g for longitudinal deceleration and applied a Receiver Operating Characteristic (ROC) curve to assess the specificity and sensitivity of the threshold. The ROC curve was used to suggest potential thresholds of future use by weighing the ability to detect valid (or true positive) events against the possibility of detecting false positive events. Based on the findings, the authors recommended a threshold of ≤ −0.75 g be used to detect crashes and near-crashes.[48]

44 Elvik R (2009). The Power Model of the relationship between speed and road safety: Update and new analyses. Report 1034/2009 (The Institute of Transport Economics. Norway).
45 Klauer, S. G., Dingus, T. A., Neale, V. L., Sudweeks, J. D., & Ramsey, D. J. (2009). Comparing real-world behaviors of drivers with high versus low rates of crashes and near crashes (No. DOT-HS-811-091).
46 Simons-Morton, B. G., Ouimet, M. C., Zhang, Z., Klauer, S. E., Lee, S. E., Wang, J., ... & Dingus, T. A. (2011). The effect of passengers and risk-taking friends on risky driving and crashes/near crashes among novice teenagers. Journal of Adolescent Health, 49(6), 587–593.
47 Dingus, T. A., Klauer, S. G., Neale, V. L., Petersen, A., Lee, S. E., Sudweeks, J. D., ... & Bucher, C. (2006). The 100-car naturalistic driving study, Phase II-results of the 100-car field experiment (No. HS-810 593).
48 Perez, M. A., Sudweeks, J. D., Sears, E., Antin, J., Lee, S., Hankey, J. M., & Dingus, T. A. (2017). Performance of basic kinematic thresholds in the identification of crash and near-crash events within naturalistic driving data. Accident Analysis & Prevention, 103, 10–19.

Frequency and magnitude of longitudinal acceleration events: • ≥ 0.35g per 1,000km driven • ≥ 0.58g per 1,000km driven For reference, an acceleration of 0.58g is experienced when a vehicle increases speed by 20km/h within 1 second.	The Spearman's correlation between individual rates of rapid starts and crash/near-crash rates for teenage participants was ρ= 0.75. This indicates a strong positive relationship between a higher crash and near-crash rates and more frequent rapid starts.[49] Similarly, Perez (2017) used a threshold of ≥ 0.50 g for longitudinal acceleration and applied a ROC curve to assess the specificity and sensitivity of the threshold. The ROC curve was used to suggest potential thresholds of future use by weighing the ability to detect valid (true positive) events against the possibility of detecting false positive events. Based on the findings, the authors recommended a threshold of ≥ 0.58 g be used to detect crashes and near-crashes.[50]
Frequency and magnitude of lateral acceleration events y≥|0.5|g per 1000 km driven.	Simons-Morton 2011 found the Spearman's correlations between individual rates of risky driving and crash/near-crash rates for teenage participants were ρ = 0.53 for hard left turns and ρ = 0.62 for hard right turns. The first finding indicates a moderately strong relationship between a greater number of hard-left turns and more crashes and near-crashes. The second finding indicates a strong relationship between a greater number of hard-left turns and more crashes and near-crashes.[51]

A.5 Development of a driver risk score

In addition to the surrogate safety indicators mentioned above, the NSW Data Analytics Centre (DAC) was commissioned to create a composite risk-score to measure and rank the relative riskiness of participant driving behaviour.

The risk score was created using a two-stage approach consisting of:

- supervised machine learning to identify individual risky trips and to identify the key features associated with those trips
- mapping individual trips back to the drivers responsible for making those trips and constructing a linear combination of variables to create the composite risk score, where 1 is defined as least risky and 100 is defined as most risky.

1. Supervised machine learning

The following g-force thresholds were used as proxies for risk events and used as the basis for training a supervised machine learning model:

- any deceleration ≤ -0.75g; or
- any longitudinal acceleration ≥ 0.58g; or
- any lateral acceleration ≥ |0.5g|

Any trips that registered an event at or exceeding the abovementioned thresholds were labelled as being "risky".

A supervised machine learning model (random forest ensemble method) was then applied to:

49 [1] Simons-Morton, B. G., Ouimet, M. C., Zhang, Z., Klauer, S. E., Lee, S. E., Wang, J., ... & Dingus, T. A. (2011). The effect of passengers and risk-taking friends on risky driving and crashes/near crashes among novice teenagers. Journal of Adolescent Health, 49(6), 587–593.
50 Perez, M. A., Sudweeks, J. D., Sears, E., Antin, J., Lee, S., Hankey, J. M., & Dingus, T. A. (2017). Performance of basic kinematic thresholds in the identification of crash and near-crash events within naturalistic driving data. Accident Analysis & Prevention, 103, 10–19.
51 [Simons-Morton, B. G., Ouimet, M. C., Zhang, Z., Klauer, S. E., Lee, S. E., Wang, J., ... & Dingus, T. A. (2011). The effect of passengers and risk-taking friends on risky driving and crashes/near crashes among novice teenagers. Journal of Adolescent Health, 49(6), 587–593.

- study the relationship between a risky trip and driving behaviours that were observed on that trip; and
- evaluate the relative feature importance of each variable and the extent to which it contributed to this risky trip.

Based on this methodology, DAC was able to identify a set of weighted risk factors for predicting the occurrence of a risky event:

- frequency of harsh lateral acceleration events (0.22)
- average trip speed (0.18)
- percentage of trip speeding time (0.16)
- average positive delta speed (0.16)
- frequency of longitudinal acceleration events (0.14)
- frequency of longitudinal deceleration events (0.14)

It should be noted that the abovementioned g-force thresholds are not purporting to represent actual crash or near-crash events, as there was no video dash-cam footage to confirm the occurrence of a crash/near-crash event. However, ARRB's literature review indicates that such thresholds can be appropriately used as surrogate safety measures as they have been demonstrated in other naturalistic driving studies as having a strong positive relationship with crash and near-crash events.

2. Linear combination

Once key features were identified and weighted, a linear combination of all risk factors was constructed[52] to score the riskiness of each trip.

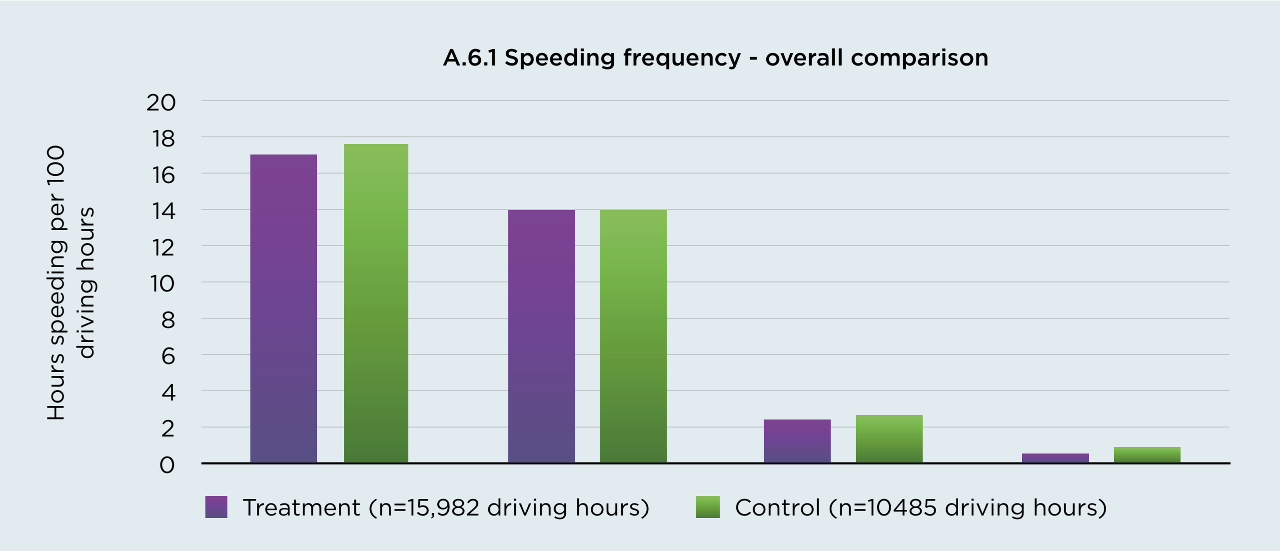
$$risk = \sum_{i=1}^{N} \alpha_i \, x_i = \alpha_1 \, x_1 + \alpha_2 \, x_2 + \cdots + \alpha_n \, x_n \, , \sum_{i=1}^{N} \alpha_i = 1$$

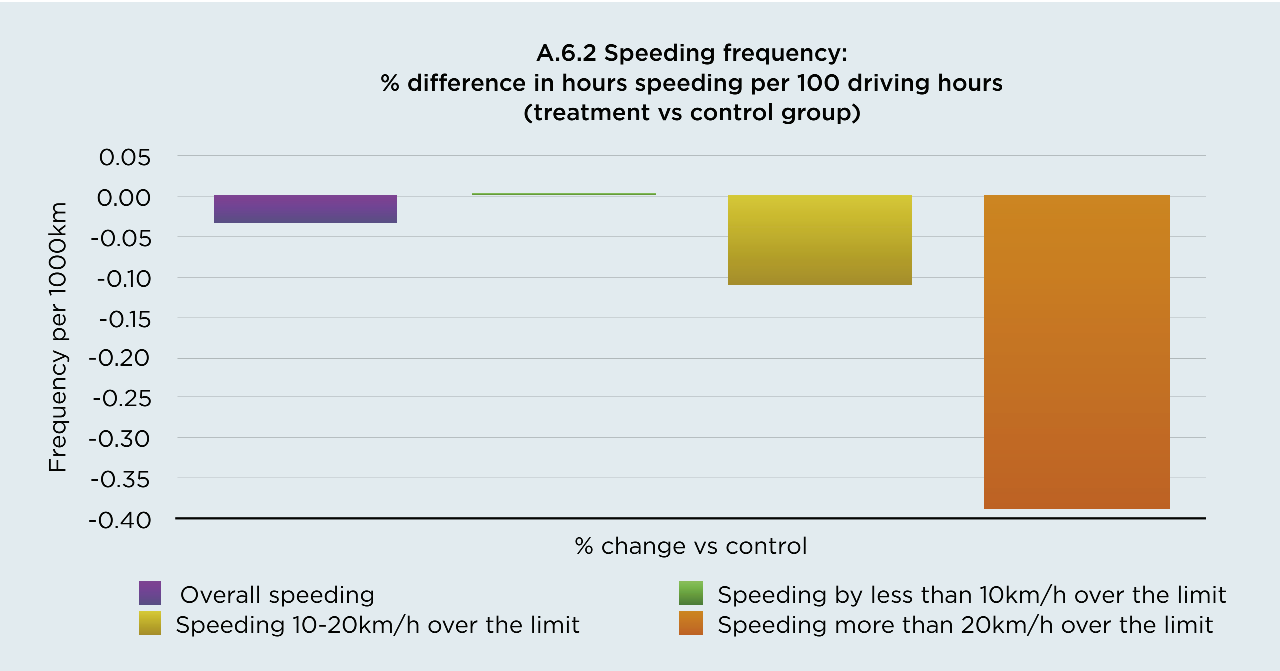
$$x_i - feature, \alpha_i - corresponding\ weight$$

Trips were then mapped back to the user responsible for making those trips and aggregated to create an individual risk score out of "100", with "100" being "most risky" and "0" being "least risky".

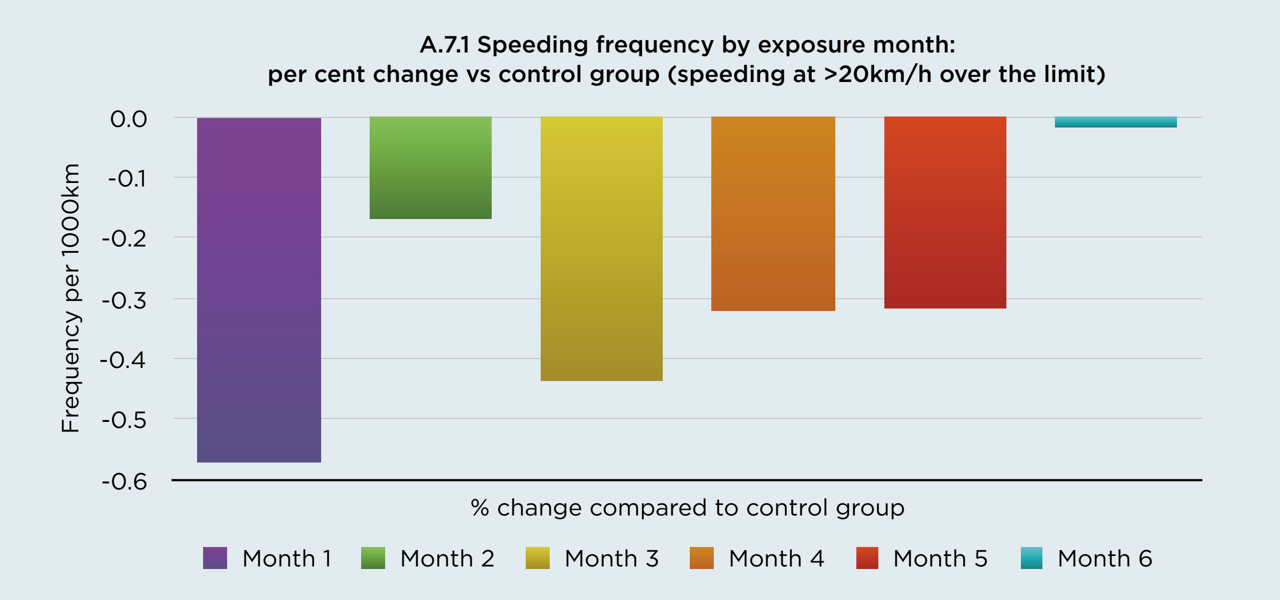
52 A score of "1" denotes "most risky" and a score of "0" denotes least risky.

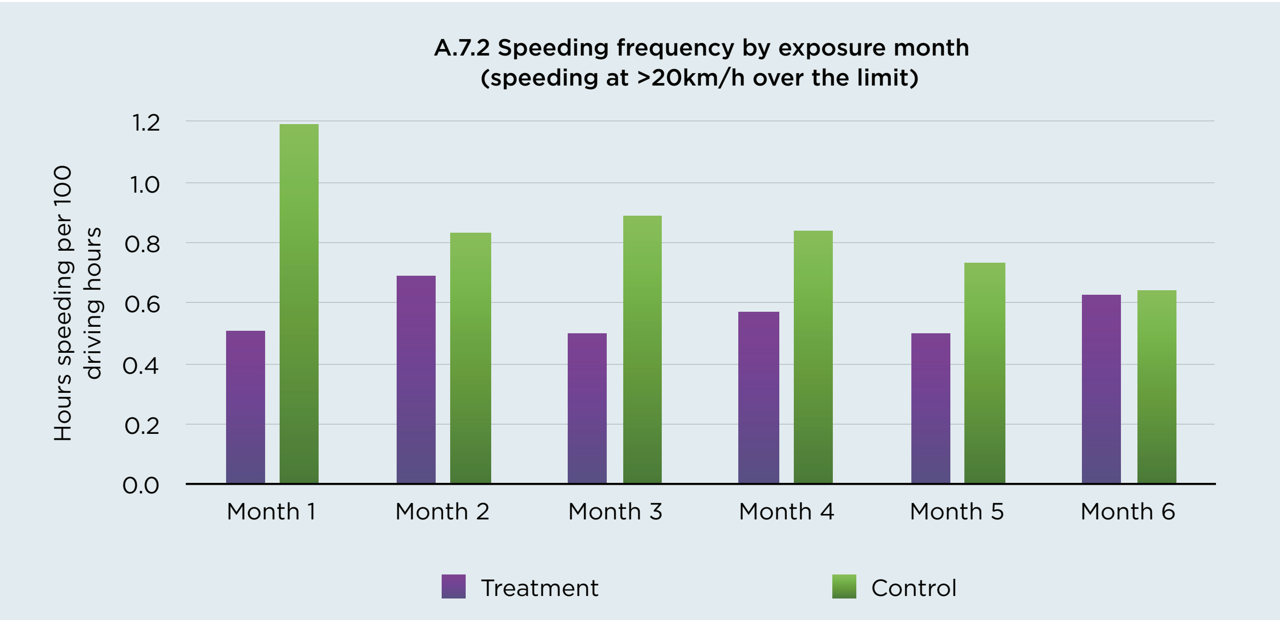
A.6 Speeding frequency (overall comparison)





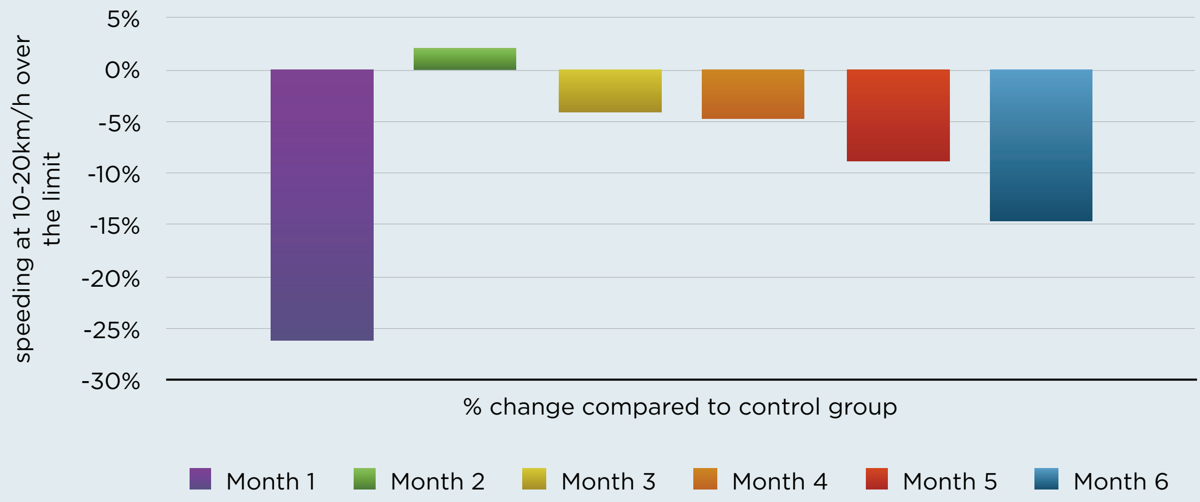
A.7 Speeding frequency by exposure month



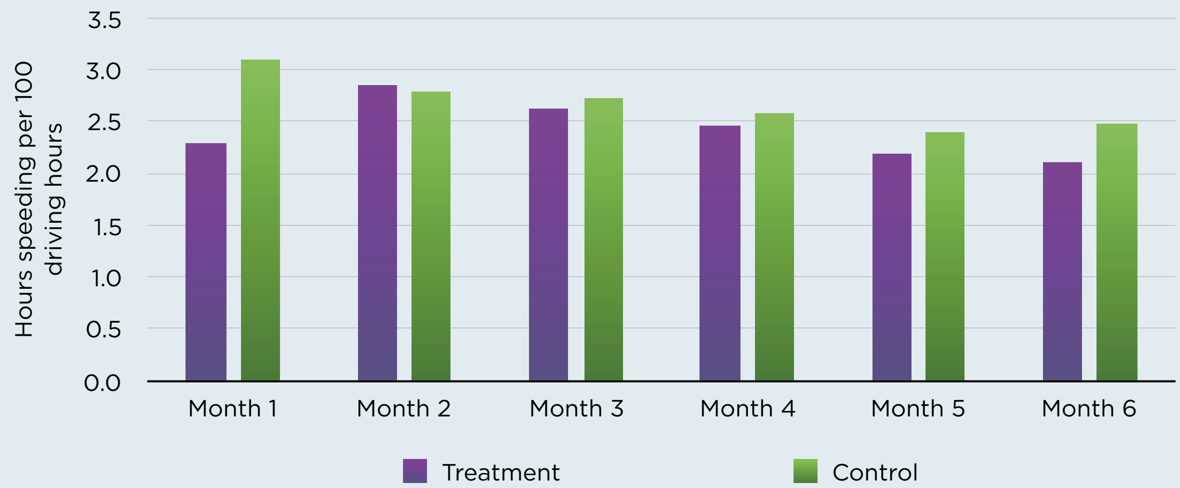


Hours speeding per 100 driving hours	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Treatment no. driving hours	4639	2884	3013	2469	2231	696
Control no. driving hours	2667	2103	2015	1375	1225	1100

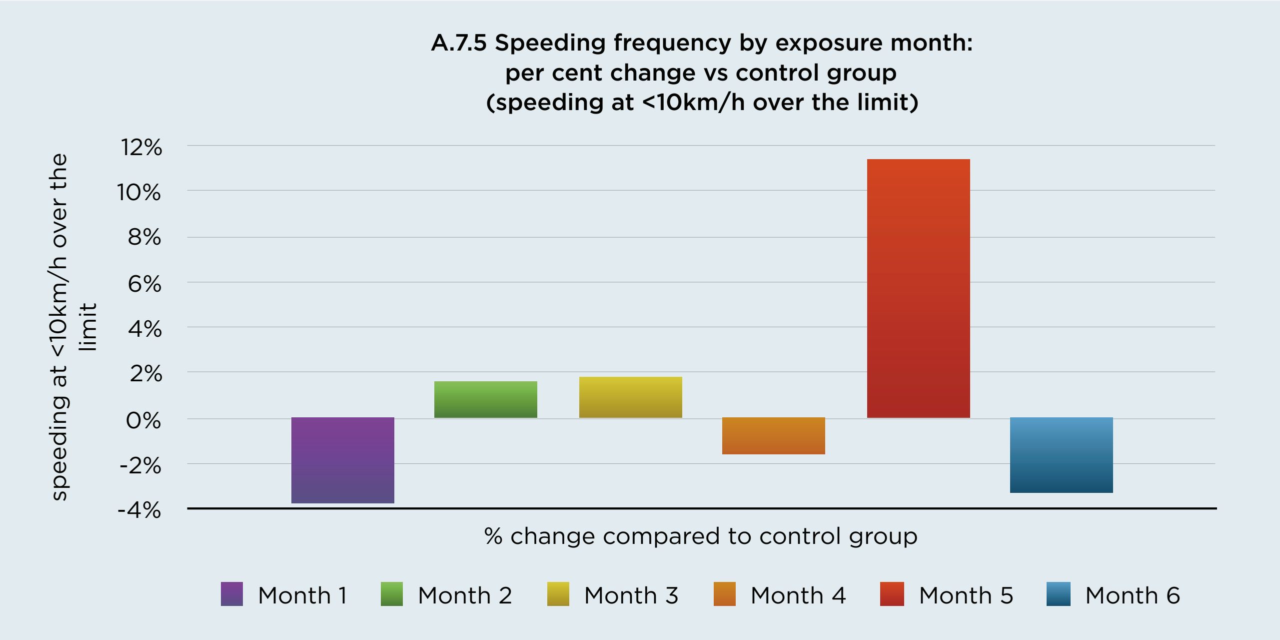
A.7.3 Speeding frequency by exposure month: per cent change vs control group (speeding at 10-20km/h over the limit)

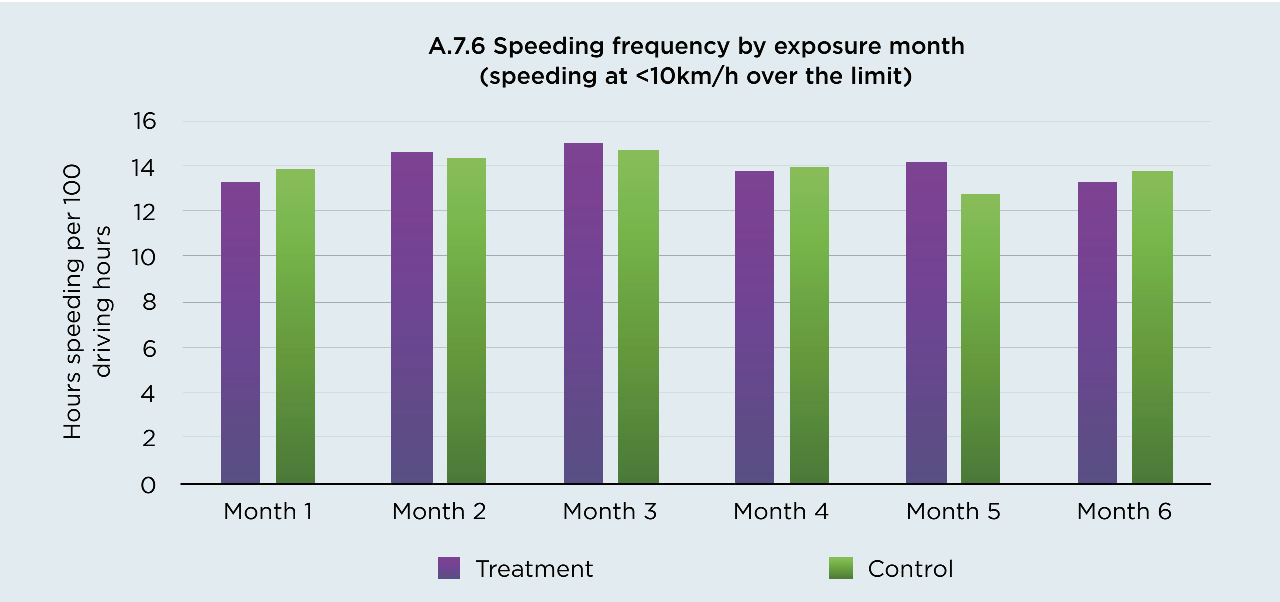


A.7.4 Speeding frequency by exposure month (speeding at 10-20km/h over the limit)

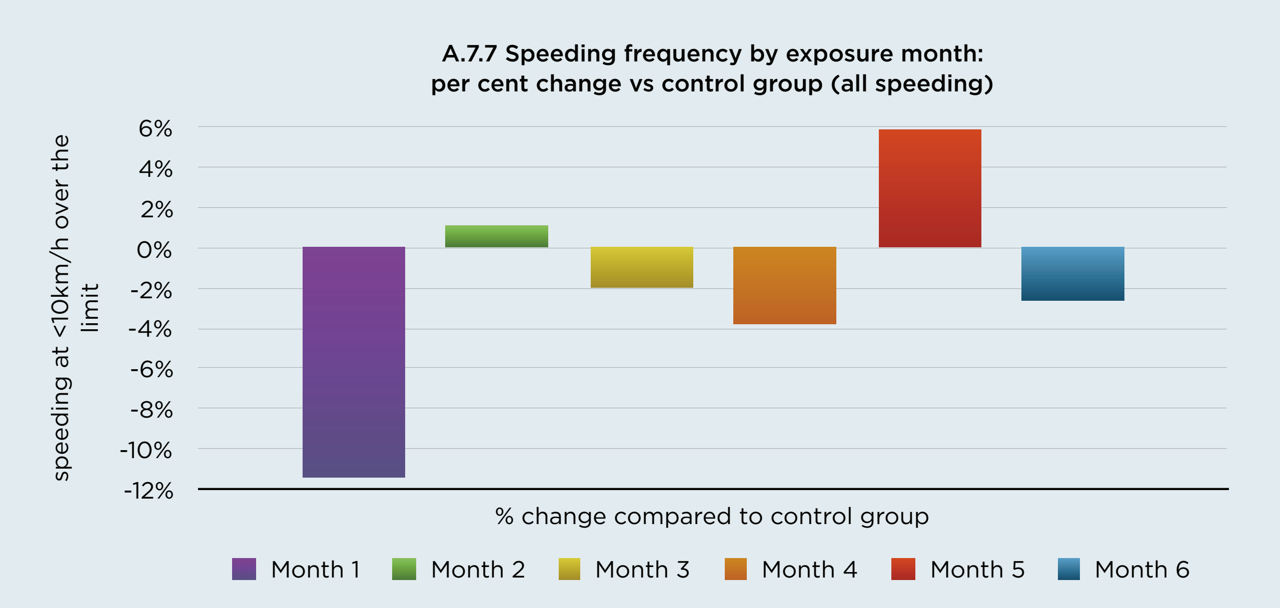


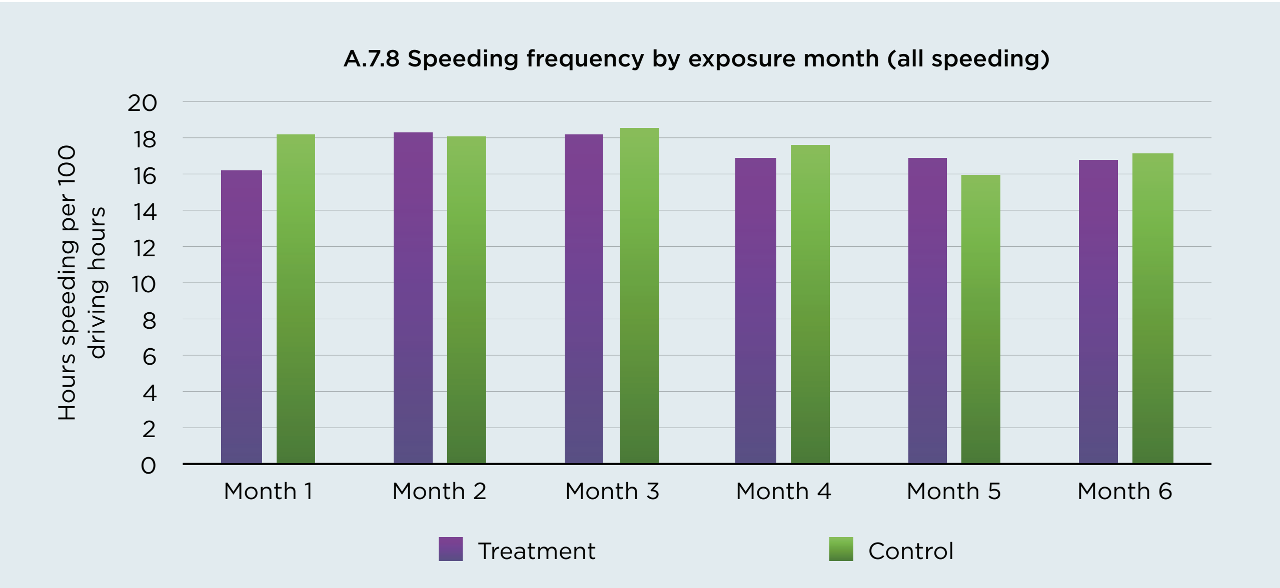
Hours speeding per 100 driving hours	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Treatment no. driving hours	4639	2884	3013	2469	2231	696
Control no. driving hours	2667	2103	2015	1375	1225	1100





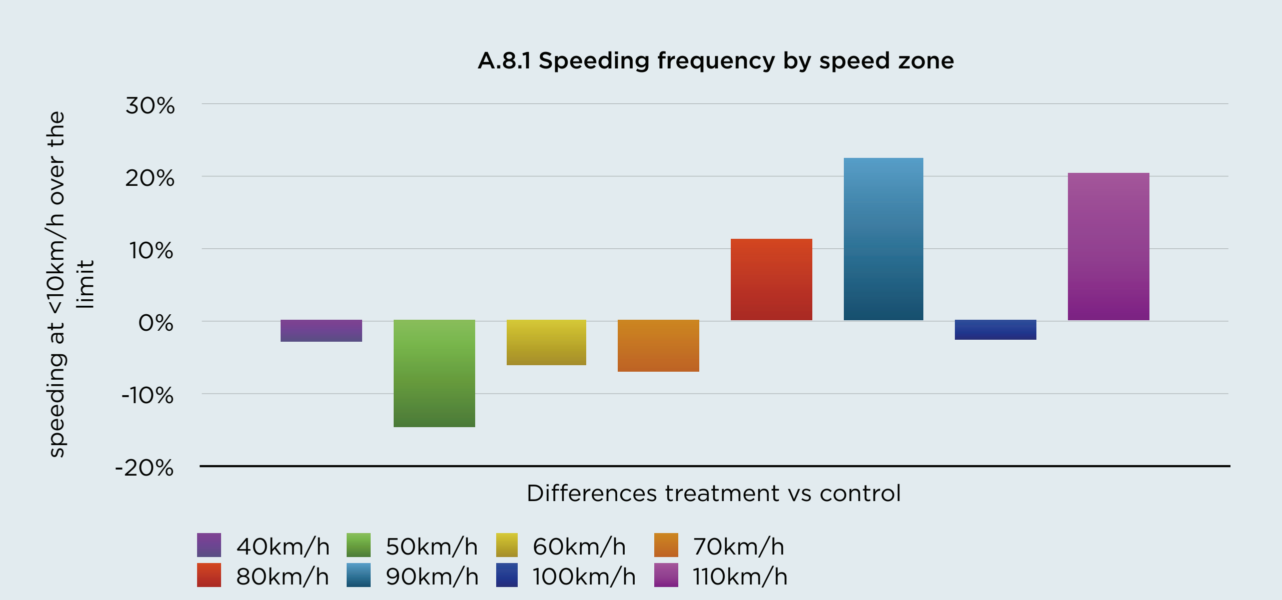
Hours speeding per 100 driving hours	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Treatment no. driving hours	4639	2884	3013	2469	2231	696
Control no. driving hours	2667	2103	2015	1375	1225	1100

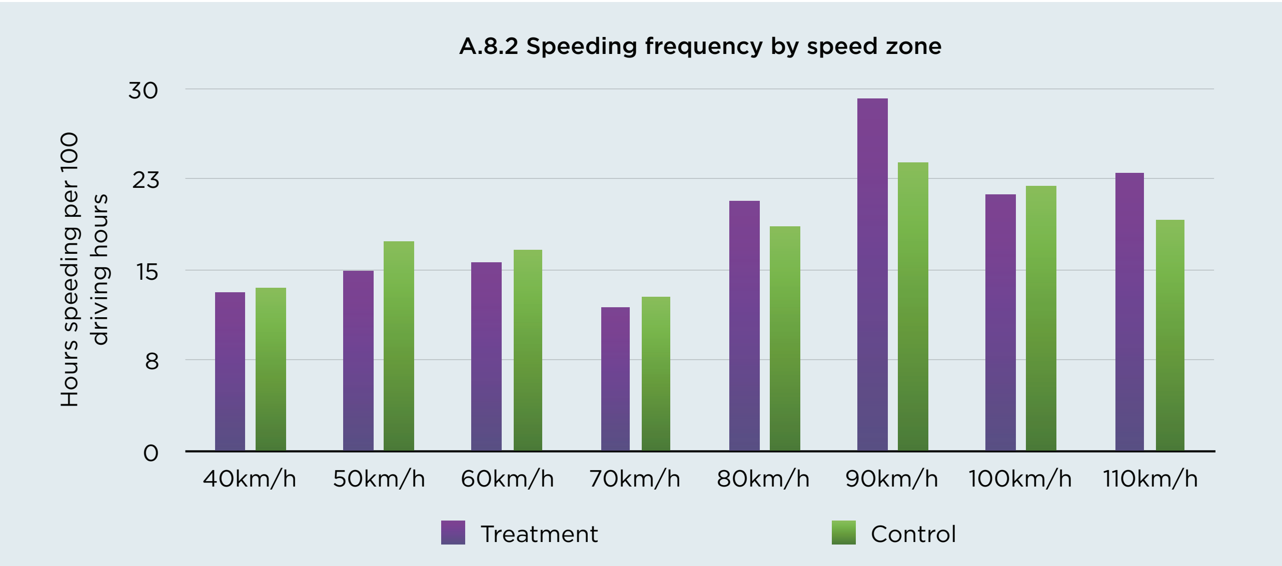




Hours speeding per 100 driving hours	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Treatment no. driving hours	4639	2884	3013	2469	2231	696
Control no. driving hours	2667	2103	2015	1375	1225	1100

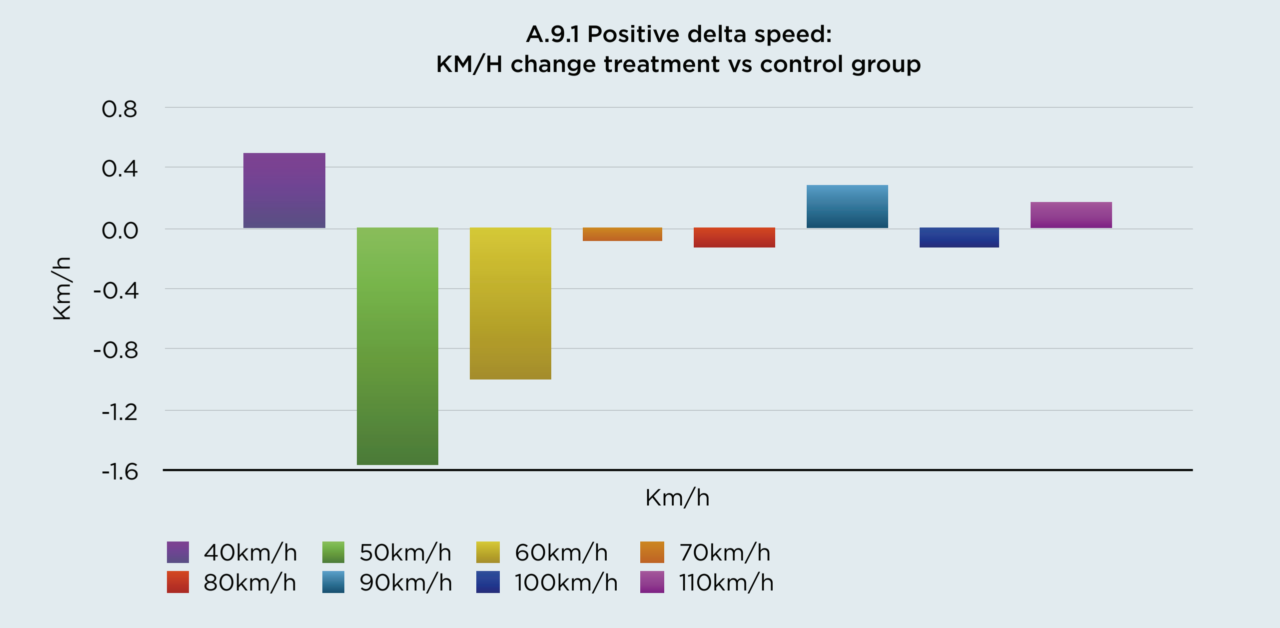
A.8 Speeding frequency by speed zone

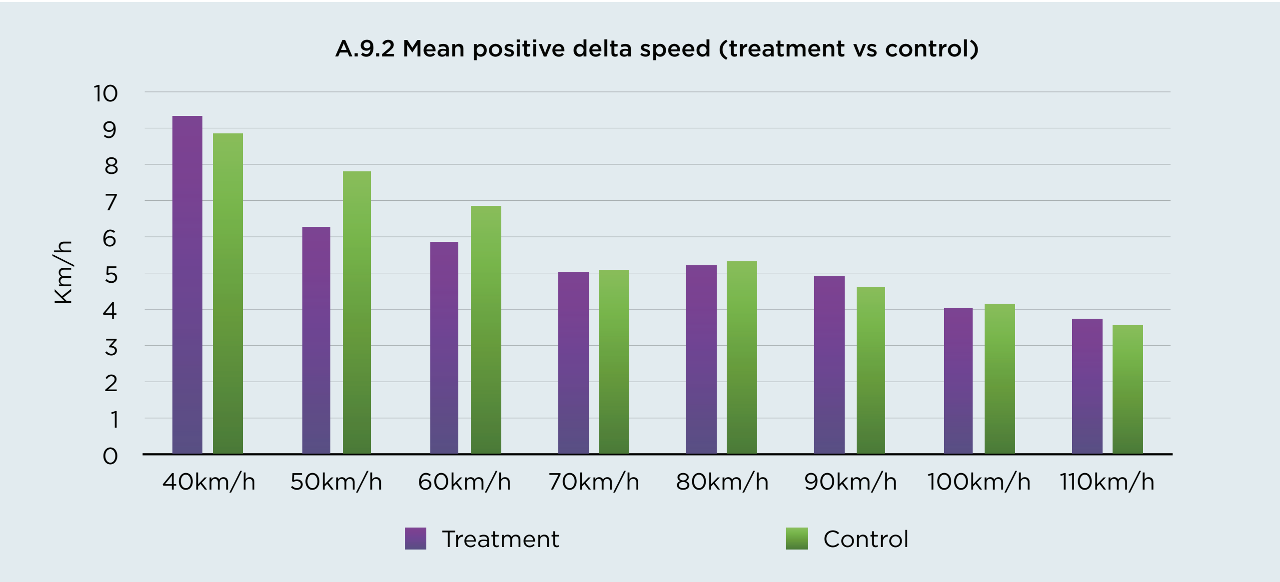




Hours speeding per 100 driving hours	40km/h	50km/h	60km/h	70km/h	80km/h	90km/h	100km/h	110km/h
Treatment	275	4572	4324	1669	1960	335	1526	1271
Control	179	3254	2719	920	1403	209	1083	731

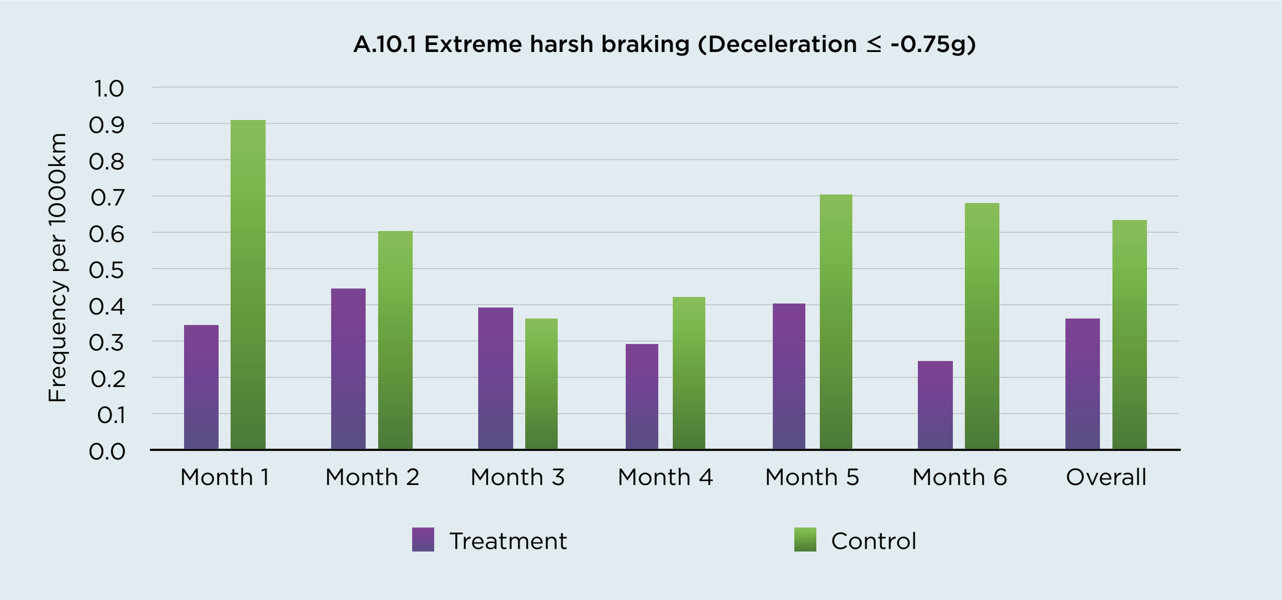
A.9 Average Positive Delta Speed (speeding severity)

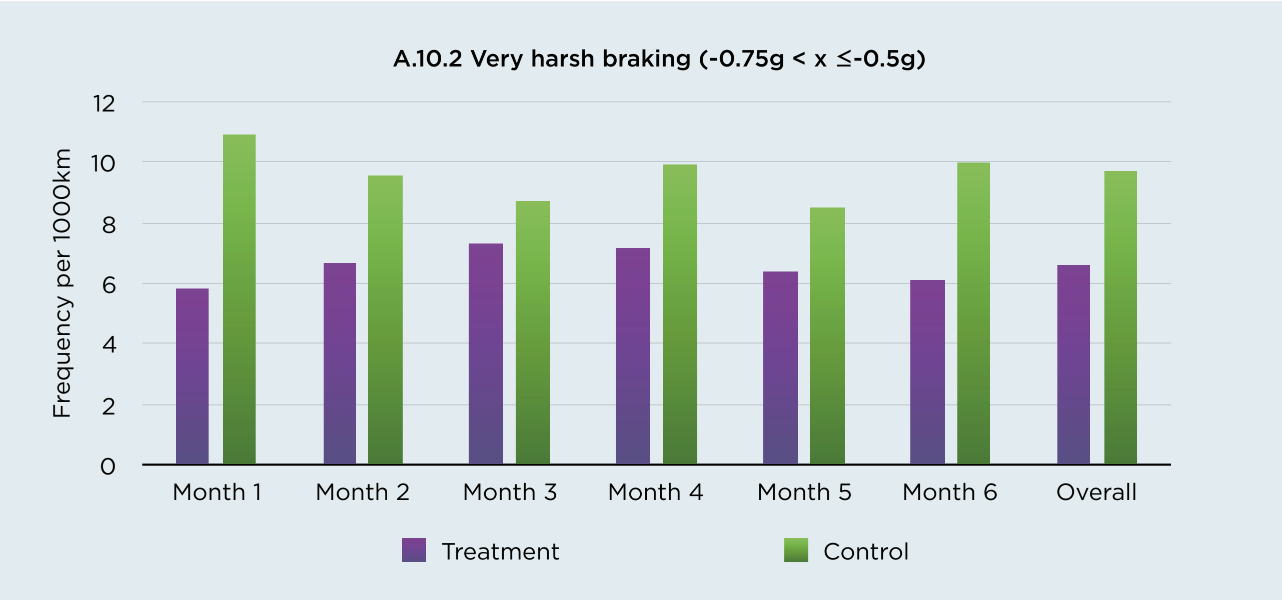


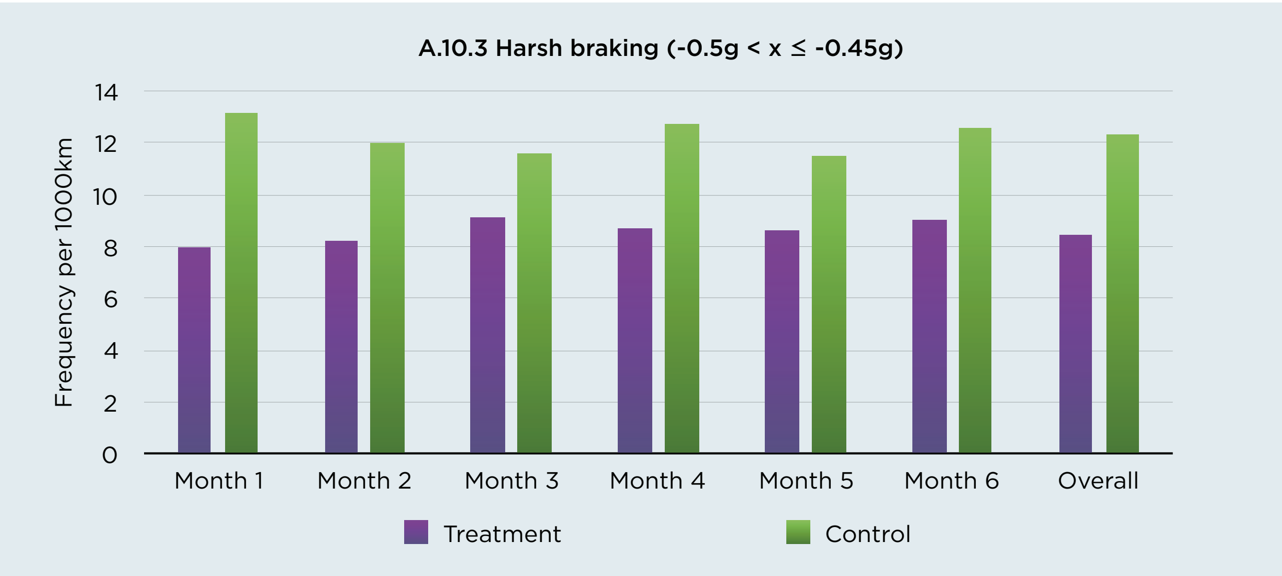


A.10 Harsh braking

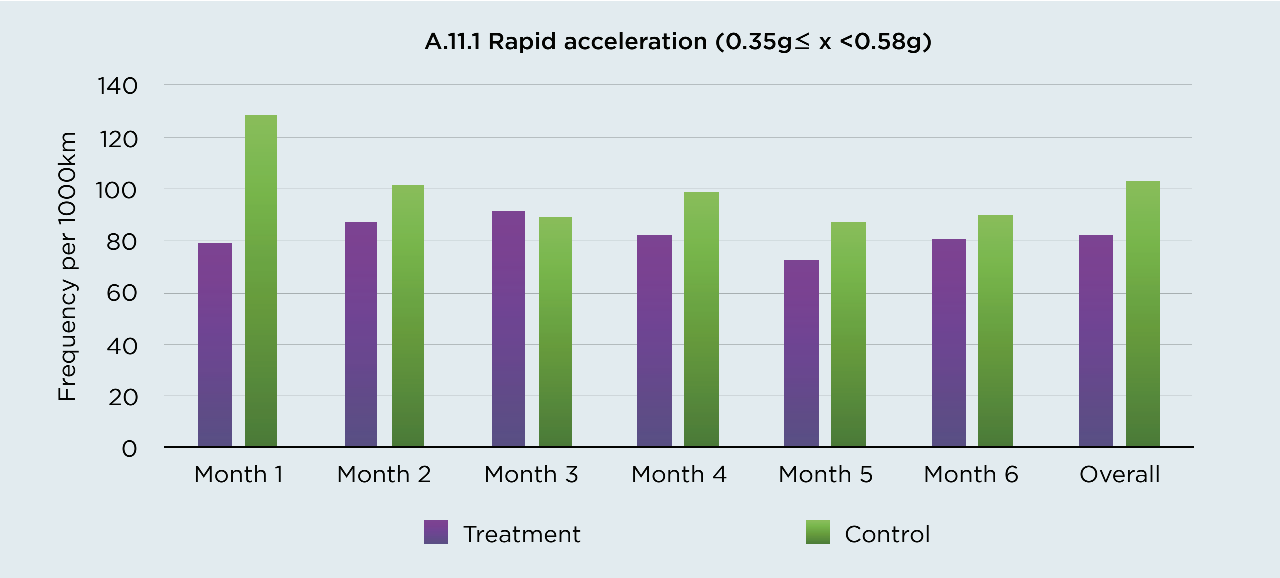
Charts below depict the occurrence of harsh braking events per 1000 km of driving.

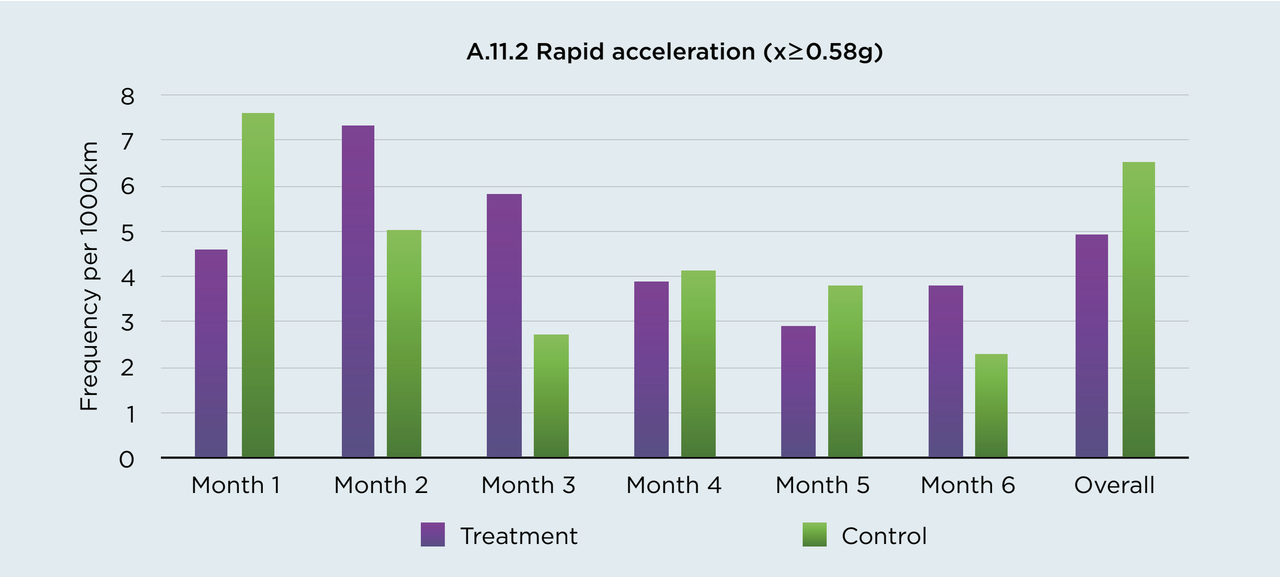




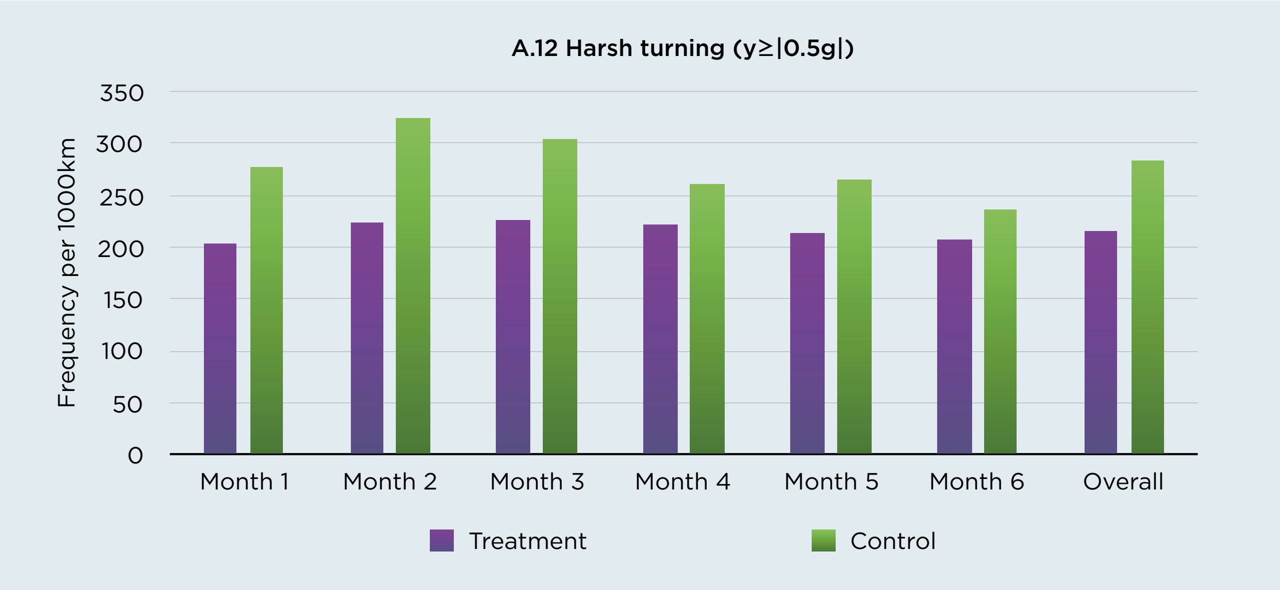


A.11 Rapid acceleration

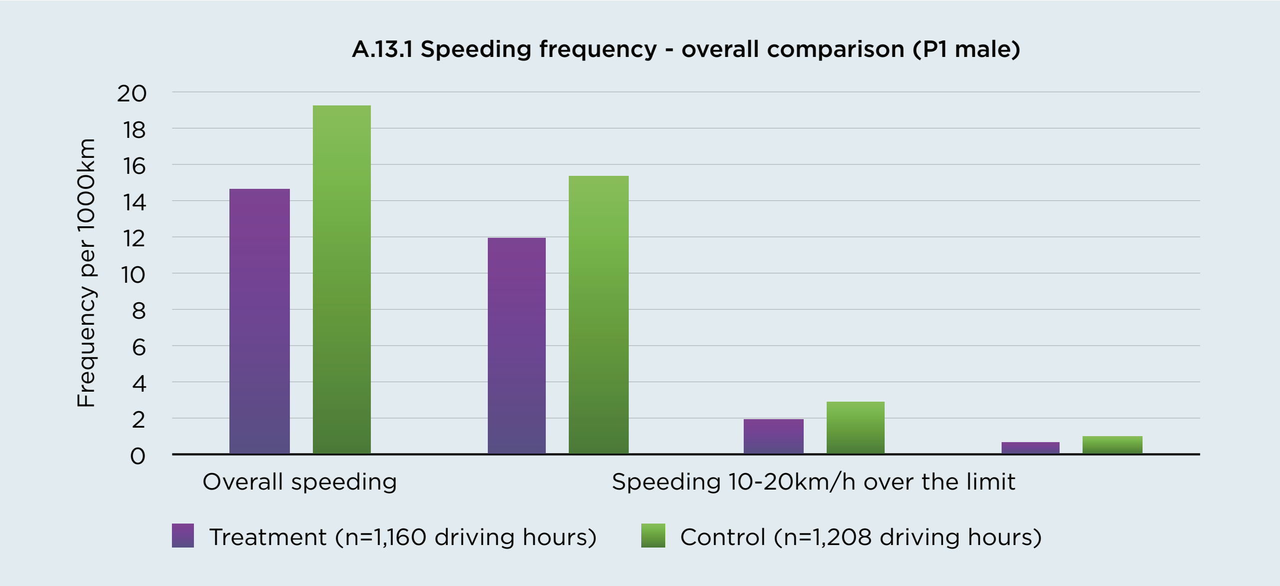


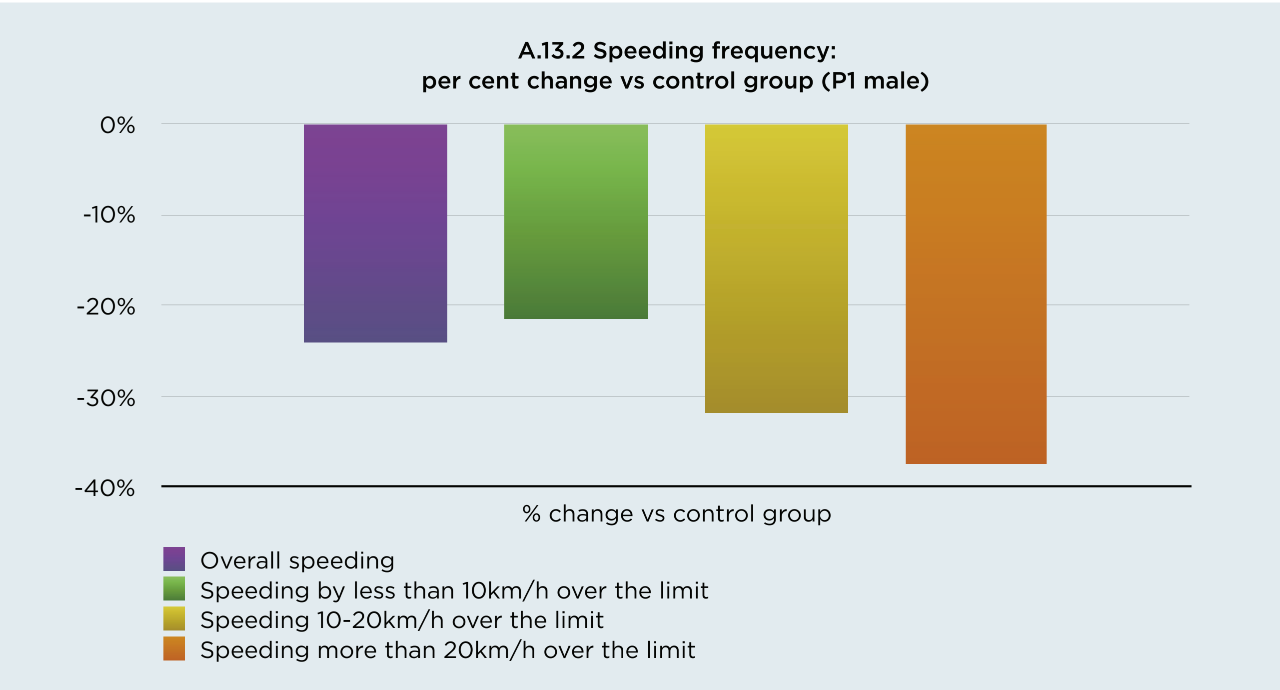


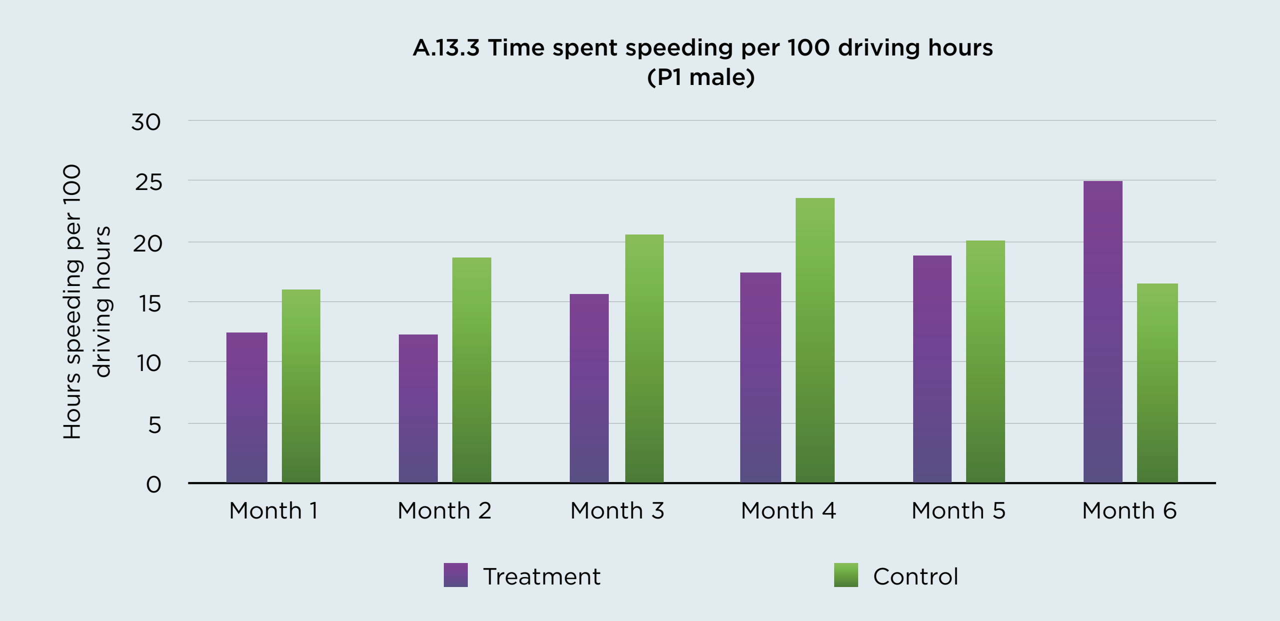
A.12 Harsh turning



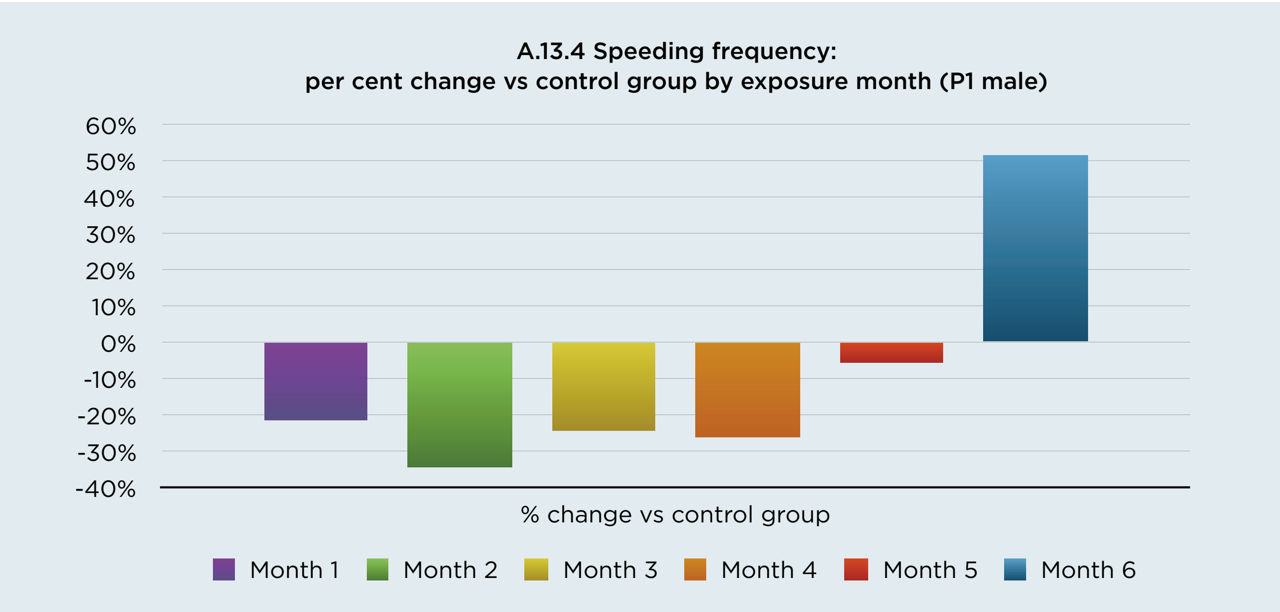
A.13 Speeding frequency (P1 male treatment vs P1 male control)



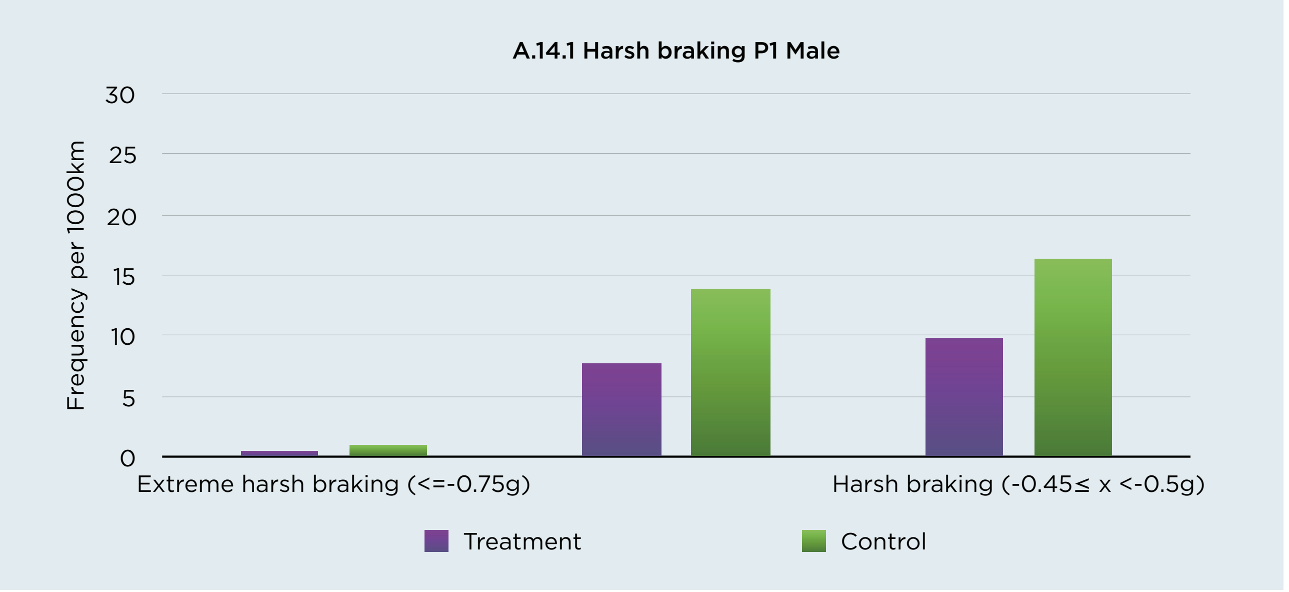


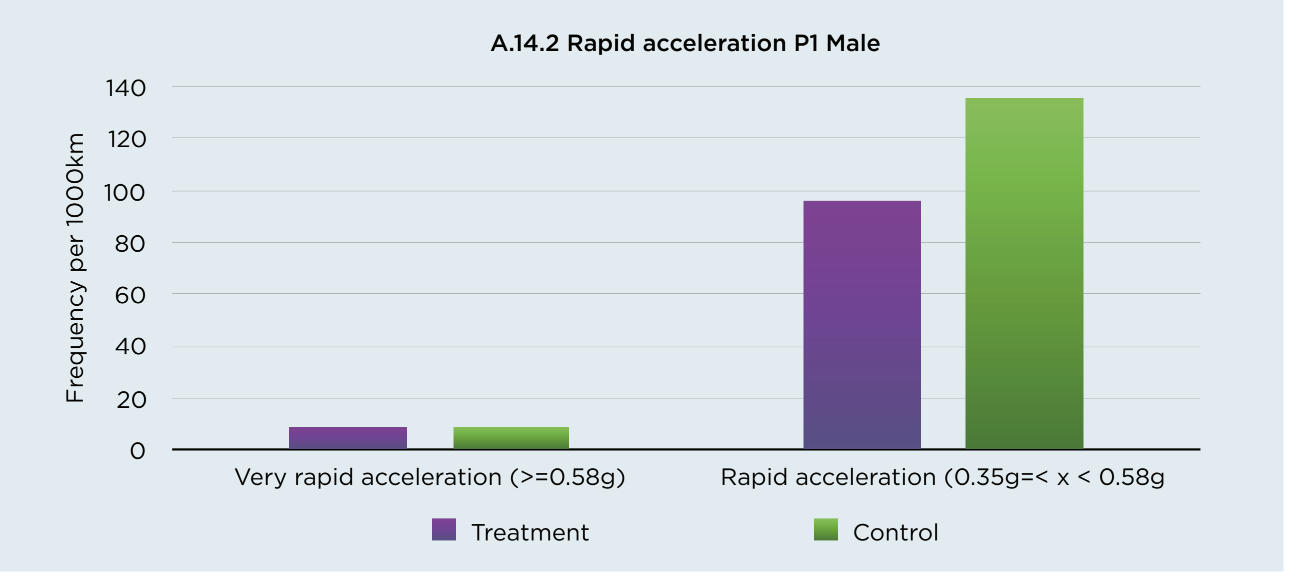


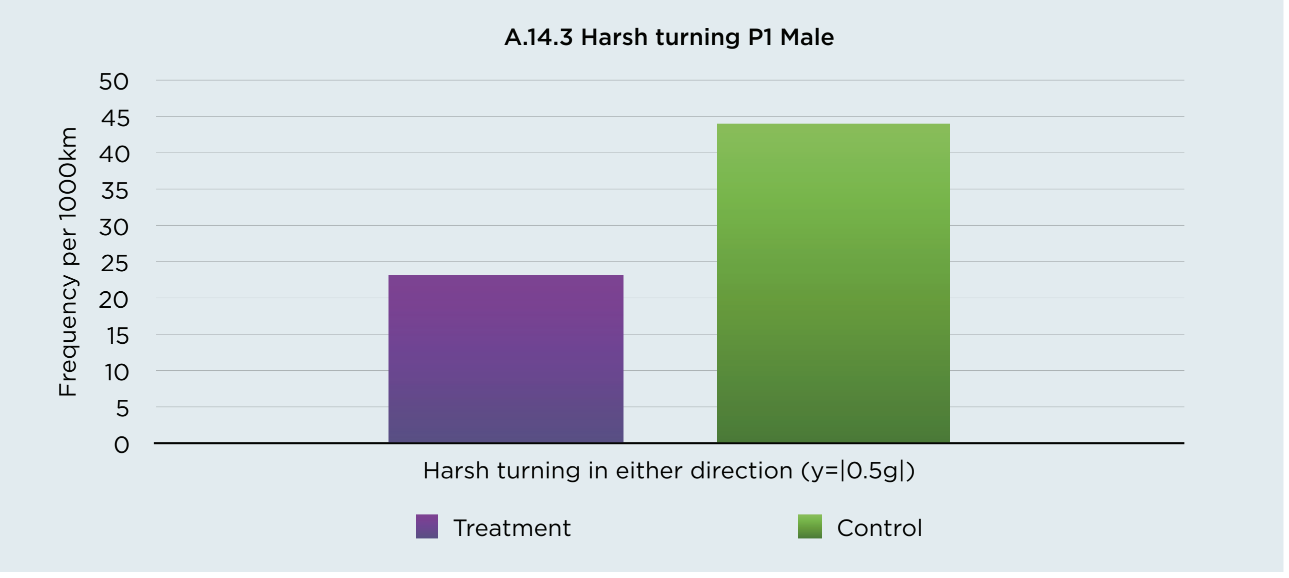
	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Treatment	395	267	179	150	141	28
Control	214	313	297	180	90	114



A.14 Harsh braking, acceleration and turning (P1 male treatment vs P1 control)







A.15 Elvik's summary estimates of exponents by traffic environment

Summary estimates of exponents by traffic environment						
	Rural roads/freeways		Urban/residential roads		All roads	
Accident or Injury Severity	Best estimate	95% confidence interval	Best estimate	95% confidence interval	Best estimate	95% confidence interval
Fatal accidents	4.1	(2.9, 5.3)	2.6	(0.3, 4.9)	3.5	(2.4, 4.6)
Fatalities	4.6	(4.0, 5.2)	3.0	(-0.5, 6.5)	4.3	(3.7, 4.9)
Serious injury accidents	2.6	(-2.7, 7.9)	1.5	(0.9, 2.1)	2.0	(1.4, 2.6)
Seriously injured road users	3.5	(0.5, 5.5)	2.0	(0.8, 3.2)	3.0	(2.0, 4.0)
Slight injury accidents	1.1	(0.0, 2.2)	1.0	(0.6, 1.4)	1.0	(0.7, 1.3)
Slightly injured road users	1.4	(0.5. 2.3)	1.1	(0.9, 1.3)	1.3	(1.1, 1.5)
Injury accidents - all	1.6	(0.9, 2.3)	1.2	(0.7, 1.7)	1.5	(1.2, 1.8)
Injured road users - all	2.2	(1.8, 2.6)	1.4	(0.4, 2.4)#	2.0	(1.6, 2.4)
PDO - accidents	1.5	(0.1, 2.9)	0.8	(0.1, 1.5)	1.0	(0.5, 1.5)

Source: TØI-report 1034/2009
Confidence interval specified informally

A.16 Estimated per cent crash reductions based on observed average speed differences from Young Drivers Telematics Trial.

Estimated per cent crash reductions based on observed average speed differences from Young Drivers Telematics Trial.						
Speedzone	**Differences in mean travelling speed (treatment – control)**	**Fatal crashes**	**Serious Injury crashes**	**Moderate Injury crashes**	**Minor / Other Injury crashes**	**Non-casualty (towaway) crashes**
40km/h	-0.34kmh	-1.9%	-1.1%	-0.7%	-0.7%	-0.6%
50km/h	-1.13km/h	-5.9%	-3.4%	-2.3%	-2.3%	-1.8%
60km/h	-0.26km/h	-0.8%	-0.4%	-0.3%	-0.3%	-0.2%
70km/h	+0.04km/h	0.3%	0.2%	0.1%	0.1%	0.1%
80km/h	+0.42km/h	2.3%	1.5%	0.6%	0.6%	0.8%
90km/h	+0.17km/h	0.8%	0.5%	0.2%	0.2%	0.3%
100km/h	+0.4km/h	1.8%	1.1%	0.5%	0.5%	0.6%
110km/h	+0.8km/h	3.3%	2.1%	0.9%	0.9%	1.2%

*With the exception of 90km/h and 110km/h zones, results are statistically significant at p<0.01
**It should also be noted that Elvik's categorisation of crash severity differs from NSW Centre for Road Safety classifications. For purposes of this analysis it is assumed that: "Fatal crashes" is the equivalent of "Fatal accidents"; Serious injury crashes is the equivalent of "Serious injury crashes", Moderate injury accidents is the equivalent of "Slight injury accidents", Slight injury accidents is the equivalent of "Slight injury accidents", Non-casualty (towaway) crashes is the equivalent of "Property damage only" accidents

A.17 Yearly average number of crashes by severity and speed zone. Data based on the number of crashes involving motor vehicle controllers aged 17-25, 2013-2017 (NSW Centre for Road Safety 2018)

Yearly average no. of crashes by severity and speed zone. Data based on the number of crashes involving motor vehicle controllers aged 17-25, 2013-2017 (NSW Centre for Road Safety 2018)					
Speedzone km/h	**Fatal crashes**	**Serious Injury**	**Moderate Injury**	**Minor/Other Injury**	**Non-casualty (towaway)**
40	5	161	203	186	247
50	54	1841	2500	1675	4579
60	56	1595	2170	1831	3644
70	16	463	650	603	1088
80	53	621	647	388	1040
90	10	96	104	83	208
100	108	789	751	364	1152
110	24	201	216	121	490
*30km/h zone and unknown zones excluded **Numbers rounded down					

A.18 Estimated community savings as a result of telematics use

	Fatal crashes	Serious Injury crashes	Moderate Injury crashes	Minor/Other Injury crashes	Non-casualty (towaway) crashes	Total
Annual crashes prevented	2	59	57	41	83	
Inclusive Willingness to Pay values per crash	$8,416,164	$562,779	$95,395	$87,374	$10,139	N/A
Total savings (Inclusive WTP)	$16,832,328	$33,203,961	$5,437,515	$3,582,334	$841,537	**$59,897,675**
Human capital approach values per crash	$2,446,936	$564,843	$-	$-	$-	N/A
Total savings (Human capital approach)	$4,893,872	$33,325,737	$1,188,906	$855,178	$-	**$38,219,609**

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Website www.sira.nsw.gov.au

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