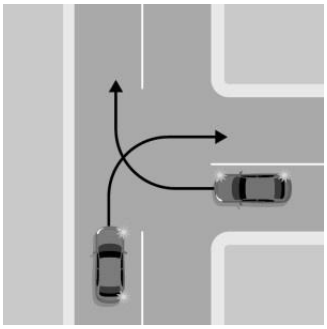
VIASTRADA
TRANSPORT PLANNING AND DESIGN

MACKIE RESEARCH
OPTIMISING HUMAN SYSTEMS

Driver competency and knowledge over time



Report prepared for
AA Research Foundation

February 2026

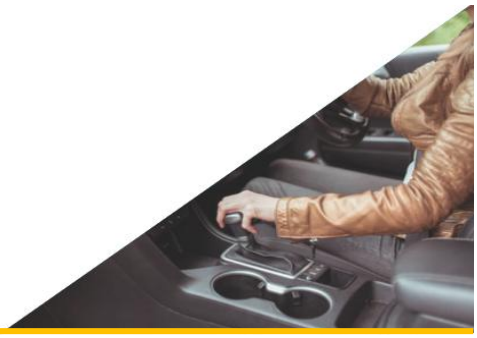
AA ResearchFoundation

This document has been prepared for the benefit of AA Research Foundation. No liability is accepted by ViaStrada Ltd, or any of its employees or sub-consultants with respect to its use by any other party.

<table>
<tr><th colspan="3">Quality Assurance Statement</th></tr>
<tr><td rowspan="3">ViaStrada Ltd
Level 1, 284 Kilmore St
Christchurch 8140
www.viastrada.nz
info@viastrada.nz

Mackie Research Ltd
1 Albert St
Auckland 1010
www.mackieresearch.co.nz
hamish@mackieresearch.co.nz</td><td>Project manager:</td><td>Glen Koorey</td></tr>
<tr><td>Prepared by:</td><td>Glen Koorey, Megan Gregory, Luca Ware (ViaStrada)
Hamish Mackie, Rebecca Luther, Sam Wrightson (Mackie Research)</td></tr>
<tr><td>Reviewed by:</td><td>Hamish Mackie, Megan Gregory</td></tr>
<tr><td>Project number:
Project name:</td><td colspan="2">1207-01
Driver competency and knowledge over time</td></tr>
<tr><th colspan="2">Document version</th><th>Date</th></tr>
<tr><td colspan="2">Final report</td><td>19/02/2026</td></tr>
<tr><td colspan="2">01 draft</td><td>10/12/2025</td></tr>
</table>

Executive Summary



Project Outline

This research examined how driver knowledge changes over time and how it could be reinforced as drivers move beyond initial licensing and adapt to evolving road environments and vehicle technologies. It focused on identifying whether knowledge gaps emerge over time including forgetting established road rules and traffic control devices (TCDs) or failing to learn new ones and adapt to changing road environments. The research also explored evidence-based and stakeholder supported options for maintaining driver knowledge throughout the driving life-course.

Specifically, the work addressed the following research questions:

1) Do drivers lose knowledge about existing road and traffic rules over time?
2) Do drivers fail to learn about new road rules and traffic control devices (TCDs) and/or fail to adapt their driving behaviours to the changing road environment?
3) What evidence-based knowledge development/maintenance options are available at different life-stages that would address any competence issues identified in research questions one and two?
4) Are any of these options a good fit in the New Zealand (NZ) context?

Research Approach

The research was undertaken in four parts:

Literature Scan

Covering studies of:

- Knowledge retention of road rules/TCDs over time and adaption to new rules/ changing environments
- Driver knowledge initiatives

Review of Road Rules & TCDs

Focusing on notable NZ road rule changes (e.g. give way rule) and new TCDs (e.g. countdown pedestrian signals) which have been rolled out since 1988.

Driver Survey

Which included questions about:

- Knowledge of established and recent road rules and TCDs
- Driving history and demographics to assess results by these characteristics

Workshops & Options Analysis

To consider the merits of intiatives to improve driver knowledge in NZ with:

- Subject matter experts
- A representative sample of NZ drivers

Findings - Literature Scan & Review of Road Rules and TCDs

A targeted scan of relevant literature found that there is limited research on driver knowledge retention and uptake over time. Available studies were mostly conducted in developing countries with less established licensing systems, while research in the Western World is limited. This may indicate that core safety issues linked to knowledge deficits have already been resolved in Western contexts, or that knowledge retention is considered a relatively lower priority for improving road safety.

Few studies explored interventions to improve driver knowledge, with most combining skill, attitude, and knowledge training, making it difficult to isolate the impact of knowledge alone.

Key findings for each research question are:

Research Question 1	Research Question 2	Research Questions 3/4
Studies of driver knowledge retention mostly indicate reduced comprehension among older drivers. There are limited studies that investigate knowledge alone.	There is very limited literature about experienced drivers not understanding new TCDs or failing to adapt driving behaviours to changing environments making it difficult to draw conclusions.	Brief and targeted knowledge interventions can be effective. Applying ergonomic principles to traffic sign design so they require less prior knowledge also has potential to enhance comprehension.

The review of historical changes to road rules and TCDs found that:

- Several key changes to NZ road rules and TCDs have occurred over recent decades, with public notification ranging from major campaigns to minimal information.
- The evolution of NZs transport system means drivers must navigate newer scenarios by applying basic knowledge to a range of dynamic conditions to ensure road user safety.

Findings - Driver Survey

Analysis of the driver knowledge survey undertaken found:

No evidence of a decrease in driver knowledge over time, except for a slight drop off at around 20 years post-licensing.

Limited differences in scores by demographics

Exceptions are lower scores among:

- Returning New Zealanders after living overseas
- Those with converted overseas licences

Newer rules and TCDs had lower rates of correct answers, suggesting a need to regularly remind people of newer rule changes.

Questions with greater safety implications had higher rates of correct answers. This suggests that knowledge which is highly relevant to drivers is reinforced and retained.

Possible link between very poor knowledge and crash risk, however, the sample size was small.

A separate analysis of young driver licensing history found that a history of unsafe driving behaviours correlated strongly with the frequency of tickets received and crashes having occurred, suggesting that driver attitudes, behaviours, and skills may affect safety performance more than knowledge alone.

Findings - Workshops & Options Analysis

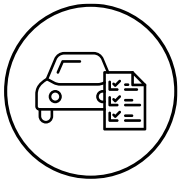
Workshops with industry experts and drivers found that:

- Applied knowledge and attitudes were perceived to have more important safety implications than knowledge alone by Subject Matter Experts and NZ drivers.
- Post-licence driver training initiatives have been shown to have limited safety effects, although some initiatives such as Ride Forever on-road motorcycle training show promise.
- Knowledge interventions should be considered alongside the Safe System and need to be weighed up against other options to improve road safety.

An options analysis, tested in the workshops supported the following driver knowledge development and maintenance initiatives:

Knowledge campaigns

Deemed useful but can take a lot of resources to be widely effective. They are however well supported by the public as an area for intervention.



Knowledge test for overseas visitors linked to permitted driving

Strongly supported by road user workshop participants. May be difficult to implement due to trade agreements.

Compulsory knowledge refresher at re-licensing

Was well supported by the public. However, the costs to administer and maintain these processes may not justify the potential benefits.

Conclusions & Recommendations

While most studies showed some evidence of reduced driver comprehension (of which knowledge is a pre-requisite) with age, this research found limited evidence to support knowledge loss over time. While there is limited available literature suggesting experienced drivers have reduced understanding of new TCDs or fail to adapt their driving behaviours to new traffic environments, the survey suggests that newer rules and TCDs are less well understood by NZ drivers. We identified and assessed a range of driver knowledge initiatives, with evidence suggesting that brief and targeted interventions can be effective for retaining information, but there is not a strong established link to safety outcomes.

We propose the following recommendations to address driver knowledge development/ maintenance:

- Improve understanding of the implication of knowledge deficits in crash risk.
- Ensure that road environments and TCDs are easy to understand and intuitive, so that the impacts of any knowledge deficits are minimised.
- The implementation of knowledge-focused interventions must be weighed carefully against other investments in road safety. However, promising options for the NZ context may include:
    - Targeted knowledge communication campaigns
    - Compulsory knowledge refresher at relicensing
    - Focused refreshers, training, or tests of road rules, TCDs, and difficult driving scenarios for overseas visitors and New Zealand residents who have lived overseas
    - Making initial licence education and testing broader in its focus, beyond rules and TCDs, to focus on good driving habits, attitudes, and practices

Abbreviations and acronyms

AA	NZ Automobile Association
GDE	Goals for Driver Education
GDLS	Graduated driver licensing system
LTNZ	Land Transport New Zealand
LTSA	Land Transport Safety Authority
NZTA	New Zealand Transport Agency (aka Waka Kotahi)
SME	Subject matter expert
TCD	Traffic control device (typically a road sign, marking, or traffic signal)

Table of Contents

List of Appendices

1 Introduction

1.1 Background

Providing everyday drivers with high-quality learning and skill development opportunities is important for competent road use and may have implications for safety. This includes not only optimising training and education during initial licensing but also ensuring that knowledge and skills are maintained and enhanced as drivers progress through different life stages.

To drive safely and responsibly, individuals need a combination of cognitive, physical, and attitudinal capabilities. Cognitively, drivers must know the road code, understand how to operate a vehicle, and be able to evaluate their environment and make safe decisions in real time. Physically, they require the sensory capacity and psychomotor skills necessary for safe vehicle control. Attitudinally, they need values, beliefs, and norms that promote safe driving.

Ensuring, as far as possible, that drivers possess these capabilities is the primary purpose of driver training, licensing, and enforcement systems. Existing systems, including New Zealand's, are underpinned by a broad and extensive body of research. While each jurisdiction's system has unique features, most begin by ensuring adequate knowledge and then require drivers to develop real-time skills through training and additional testing, often within a graduated licensing framework.

In nearly all cases, knowledge forms the foundation upon which driving skills are built. It is essential for safe and responsible driving, but alone it is insufficient. Drivers must also apply that knowledge in real time through practical skill, judgment, and appropriate attitudes. This principle is reflected in models such as the Goals for Driver Education (GDE) Matrix, where knowledge is embedded at each level and serves as the baseline requirement for all other competencies (Hatakka et al., 2002).

Despite the foundational role of knowledge in the safe and responsible operation of a vehicle, most modern licensing systems place little emphasis on ensuring that drivers maintain adequate knowledge throughout their driving life-course. This involves not only retaining existing knowledge but also acquiring and integrating new information as the road environment (e.g., sharrow markings or Give Way rule changes in 2012), the mix of road users, and vehicle technologies evolve. Consequently, our understanding of driver knowledge over the driving life cycle remains limited.

Once initial licences are obtained, broad-based re-testing of driver knowledge is very rare, resulting in limited population-level data to evaluate the role of knowledge in safe driving. In addition, post-licence education or training interventions tend to focus primarily on hazard and risk perception, and driving skills. Evaluations suggest that some forms of training can be effective in promoting the uptake of skills and hazard perception, but have shown no evidence to suggest they prevent road injuries or crashes (Beanland & Huemmer, 2021; Beanland et al., 2013; Ker et al., 2005; Turner et al., 2021). Some forms of training (e.g. skid training in off-road environments) have even been shown to increase violations and crash risk as they promote over-confidence (Ker et al., 2005; Turner et al., 2021). However, these evaluations provide little information specifically related to the foundational knowledge components of programmes, leaving the question of its efficacy largely unanswered.

Finally, crash data doesn't typically highlight knowledge gaps as a key causal factor. While, in many cases, an experienced driver may be able to compensate for a knowledge gap by making a 'logic' based decision in the moment, there may be some circumstances in which knowledge gaps represent a real risk to safety. An example might be in a busy urban intersection where a driver, distracted by trying to understand new road markings or signage, fails to detect a pedestrian and hits them.

1.2 Project aim & research questions

This project aims to assess how driver knowledge evolves as drivers progress through different life stages, moving further in time from initial training and licensing, and as road environments and vehicle technology change. The research also examines whether, and to what extent, gaps in knowledge emerge over time. Options for building driver knowledge where gaps are identified are also considered (e.g., through enhanced education or knowledge testing).

Specifically, the work will address the following research questions:

1) Do drivers lose knowledge about established road and traffic rules over time?
2) Do drivers fail to learn about new road rules and traffic control devices (TCDs) and/or fail to adapt their driving behaviours to the changing road environment?
3) What evidence-based knowledge development/ maintenance options are available at different stages that would address any competence issues identified in research questions one and two?
4) Are any of these options a good fit in the New Zealand context?

2 Methods

The research was undertaken in four parts, from which the findings came together to arrive at overall conclusions for the project. The scope and methods for these stages are described below.

2.1 Literature review

A scan of readily available New Zealand and international published and grey literature was conducted to address Research Questions 1-4. Over the years, an extensive body of knowledge has been built up in the field of driver training and education. The focus on this work is broad, covering general and occupational drivers, as well as the full driving life cycle. It includes consideration of both driving knowledge and skill development. For this literature scan, which focused on knowledge retention of road rules and traffic control devices, a clearly defined set of questions was developed to guide the search and to identify publications most relevant to the specific topic.

Based on this scope, a search strategy and set of search terms were developed (see Appendix A). Upon completion of literature scan, each document was sourced and stored electronically. The references were imported into Mendeley Reference Manager for ease of reference management.

Papers relevant to each research question were identified during an initial review. Following this, a summary of the findings from these papers was produced for each research question. These summaries were then integrated into a brief outline of the main findings relevant to the research question, conclusions that can be drawn, and any knowledge gaps (Section 3).

2.1.1 Limitations

- This work was not a systematic review of all literature related driver knowledge retention of road rules and markings. Rather, the intent was to quickly gather up-to-date information and identify key pieces of knowledge and good practice. As such, other relevant documents may be available that are not discussed within the review.
- The literature scan highlighted some knowledge gaps that would need to be addressed to fully answer the research questions. In particular, research on knowledge retention of drivers who are in the middle stages of the driving life cycle (i.e., middle aged drivers) is limited. Most research focuses on skill development in younger or older drivers.

2.2 Key changes to road rules and traffic control devices

Traffic control devices (TCDs) of all kinds (signs/markings/signals) and road user rules invariably change over time, to reflect new practices and technology or changes in the mix of road user types. To better understand the evolution of these changes over the past few decades in New Zealand, a scan was undertaken of notable changes recorded in official Government literature.

The following sources of data were used to find relevant information:

- New Zealand Legislation website - https://www.legislation.govt.nz/ for current or recent Acts, Amendment Acts, and Regulations
- NZ Legal Information Institute (NZLII) databases - https://www.nzlii.org/databases.html#nz_legis, particularly the sections on NZ Legislation covering repealed or historical Acts, Bills, and Regulations.
- NZ Gazette notices - https://gazette.govt.nz/, for newly introduced TCDs
- Internet Archive Wayback Machine - https://web.archive.org/ for older copies of existing or previous webpages from LTSA/LTNZ/NZTA

A search was undertaken as far back as 1988 (i.e. 37 years ago), which is when new symbolic traffic signs (based on similar international conventions) were first introduced to New Zealand, replacing the old text-based signage.

Section 4 describes the general review findings, while Appendix B summarises the key historical changes to TCDs and road rules in NZ over this period in more detail. Of particular note was the change from the old Traffic Regulations (originally enacted in 1976, with several subsequent amendments) to the new Land Transport Rules (particularly the Setting of Speed Limits Rule, Road User Rule, and Traffic Control Devices Rule, originally enacted in 2003-04 with several subsequent amendments) as prescribed by the 1998 Land Transport Act. It should also be noted that in several cases, a new traffic control device was first introduced by means of a *NZ Gazette* notice, with a subsequent incorporation into the relevant Rule at a later date.

2.3 Driver knowledge survey

As a baseline for the planned driver survey, a scan was also undertaken of the NZTA Road Code rules and associated TCD guidance, including some of the standard Theory Test questions asked (https://www.nzta.govt.nz/roadcode/theory-test-questions/). This was to allow us to compare driver knowledge of longer-term "historical" road rules and TCDs with those introduced more recently.

Using a combination of this information and the above rule/TCD change review (described further in Section 4), a draft set of questions were developed for a public survey. As well as 24 specific multi-choice questions on both historical and newer signs, road markings, road rules, and traffic scenarios to test their knowledge, the survey also asked questions about when drivers last sat a driving test, their driving history, crash history, and general demographic information.

Appendix C outlines the final set of questions used for the survey, following internal review and feedback from the AA. An online Qualtrics survey was created from these questions and Prime Research was contracted to obtain a suitable sample of at least 500 respondents. The survey was undertaken in September 2025. The resulting analysis of the responses and accompanying discussion is summarised in Section 5.

2.4 Options analysis & workshops

Two separate online workshops were undertaken to further interrogate the driver knowledge development/ maintenance options identified in the literature scan, and gather feedback on the quality of driver knowledge in New Zealand. To provide a framework for assessing the options, criteria for three terms- effectiveness, feasibility, and acceptability were developed (outlined in Appendix D).

1. The first workshop brought together New Zealand subject matter experts (SMEs) including driver educators and programme managers, road safety professionals from local government, human factors and behavioural science specialists, and academics (n= 12). Emphasis was placed on the effectiveness and feasibility of options.
2. The second workshop was held with New Zealand road users (n= 12) to test the acceptability of options and their willingness/ interest in participating in different interventions. Participants were recruited by Prime Research and the sample aimed to reflect the driving population (e.g., in gender, age, license type, ethnicity, representation of areas of New Zealand). A summary of participant demographics is provided in Appendix E.

The workshops were recorded and qualitative data from discussions and activities were analysed to identify themes and illustrative quotes. Section 6 discusses in more detail the findings from the two workshops and some conclusions drawn from these.

3 Literature review

3.1 Setting the scene

3.1.1 How drivers store and process information

Driving is an everyday activity for many people but is complex and demands a range of competences. Figure 3-1 presents a model of human information processing relevant to driving. Drivers perceive aspects of the driving task such as their vehicle, other traffic and the road environment and then process this based on their memory of things such as road rules, previous experiences, and understanding of how their vehicle handles when braking / acceleration / steering etc. They then respond accordingly. Their experience will serve as feedback to inform future decisions.

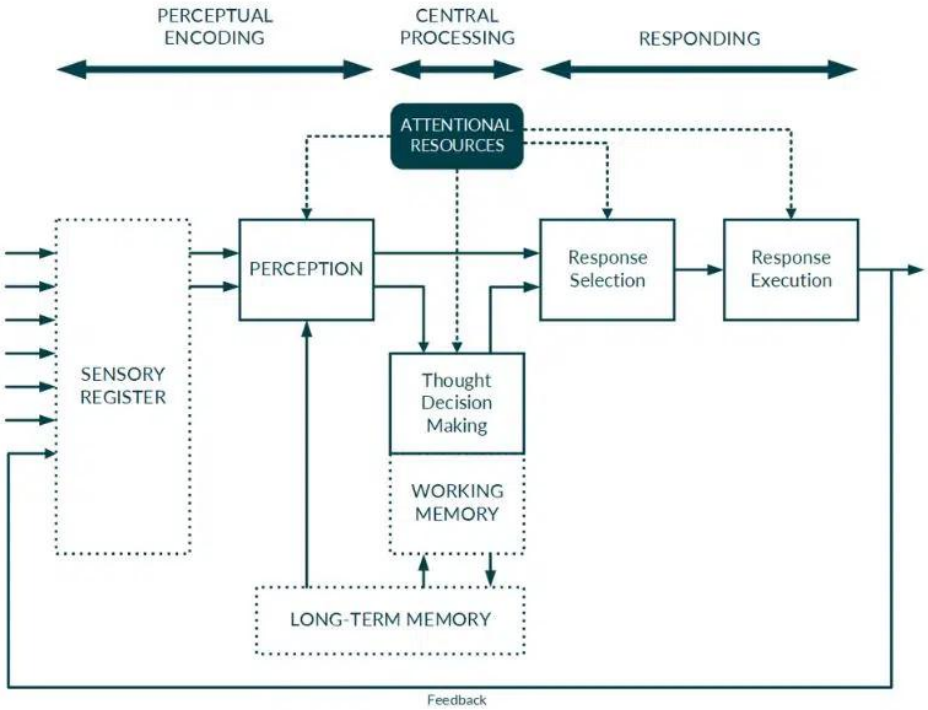


Figure 3-1: Model of Human Information Processing, adapted from Wickens et al. (2003) by SYSTRA (2022).

There are two types of memory in Figure 3-1. Working memory is available for immediate use for mental tasks such as learning and problem-solving but has a limited storage capacity and retention time. Long-term memory is the storage of information for later use and has a theoretically unlimited capacity. Each of these components of memory are crucial in the driving task – i.e. drivers must have a comprehensive knowledge base and context to draw on and the ability to retrieve the relevant information at the necessary time. However, memory alone is not sufficient – drivers must also have the necessary sensory, cognitive, and physical abilities to gather new information, process it, and respond appropriately in dynamic settings. Furthermore, it is possible to forget – this could be due to not properly storing the information in the long-term memory, having problems retrieving stored information, interference between different memories, decay of memories that aren't frequently used, or repression of unpleasant memories.

Drivers who can effectively perceive the relevant situations or devices while driving, and can retrieve a well-formed knowledge of rules, procedures, and scenarios, have more cognitive capacity to devote to other aspects of driving. Drivers who must devote a lot of attentional resources to trying to remember the implications of a rule or device are more likely to be distracted or make poor choices. Therefore, driver knowledge has predictable safety implications, even if it isn't a commonly identified safety issue.

3.1.2 What makes up driving competence

Competent driving requires a combination of physical, cognitive, and attitudinal capacities that support the safe and responsible operation of a vehicle.

Physically, drivers need adequate vision, hearing, cognitive skills, psychomotor coordination, and reaction times to drive safely. Cognitively, they require knowledge of the road code and safe driving practices, within a range of contexts. They must then be able to apply this knowledge in real time by managing their attention, processing information, and making timely decisions. Safe driving attitudes and beliefs are also an important component of safe decision making. Together, these elements ensure that a driver can respond effectively in the dynamic, often unpredictable, driving environment (Lindstrom-Forneri et al., 2010).

A widely used framework for defining driver competence and guiding development of education and training programmes is the Goals for Driver Education (GDE) Matrix (Hatakka et al., 2002). The GDE broadly describes the knowledge, skills, and higher order influences required to be a competent driver (see Figure 3-2).

Societal environment: Culture, legislation, enforcement, subcultures, social groups (norms, and values).

Personal characteristics, ambitions, and competencies: Lifestyle, peer group norms, personal values, attitudes, traits (e.g., sensation seeking).

Driving goals and planning: Choice of route, drive time, trip urgency, evaluation of own physiological condition (alcohol, fatigue) and social context and company in vehicle.

Driving in traffic: Knowledge and application of traffic rules. Observation and use of signals, signs, and markings. Anticipation of events, hazard perception, vulnerable road users, and difficult road conditions.

Vehicle control: Control of direction and position of car, car functioning, and protection systems (e.g., seatbelt, headrest, sitting position, tyre pressure)

Figure 3-2: Goals for Driver Education (adapted from Keskinen, 2014).

It should be noted that the focus of this study is core driving knowledge of road rules, TCDs, and navigating environments, which is only part of overall driver competence.

3.1.3 How driving competence is developed and maintained

Extensive research has been carried out, both in New Zealand and internationally, on the development and maintenance of driver competence. This work has formed the basis of modern driver training and licensing systems that have been implemented in many parts of the world. While each system is unique, most have common features such as a driving knowledge test, a practical driving test (or several in a graduated system), and frequently, restricted driving/licence for a set period.

New Zealand's licensing system contains these features. It assumes that core driving knowledge is acquired and tested at the first stage of competence development as a requirement for gaining a learner licence. The knowledge test, which covers rules, signs, markings, and safe driving practices requires a score of 32/35 to pass.[1] A further implicit test of knowledge is also provided by on-road examinations. These test the drivers' ability to apply knowledge in on-road situations, noting that the on-road test wouldn't necessarily isolate out a specific knowledge gap because a given error could be due to a range of issues (knowledge, attention management, reaction times etc.).

In most countries reviewed for this scan, once a licence is obtained, further knowledge testing is not required, even when exchanging a foreign licence. For older drivers, some licence renewal or age-related testing is common. However, this usually covers physical and cognitive functioning rather than core driving knowledge.[2] In most countries, a driving test is often only completed if a health professional stipulates an on-road test is needed to retain a licence due to medical or safety concerns.

The way driving competence assessments are structured in most countries, few checks of core driving knowledge are made throughout the driving life-cycle. This is potentially concerning given the changing driving environment, and research cited earlier indicating that drivers may have knowledge gaps.

3.1.4 Driver comprehension and knowledge gaps

It is widely understood that drivers are not always able to comprehend TCDs and rules. Papers that attest to limited driver comprehension include Ben-Bassat & Shinar (2015), Brashear et al. (1998), CBC News (2010), Hung & Tan (2024), Ng & Chan (2008), Schulz et al. (2020). For example, Charlton & Baas (2006) tested nine road signs, finding a 50% comprehension rate for the least understood (slippery when wet) and 94% for the best-understood (curve warning) in dynamic scenarios. The exact causes of driver comprehension failures remain unclear, though several plausible leads exist, including:

Long-term memory failure

When forming their driving knowledge base, drivers begin by studying the theory (i.e. road rules – which include requirements both for driver behaviour in certain situations and in response to TCDs) and then learning the practice of driving, which adds to their long-term memory via feedback loops so that they are eventually deemed sufficiently competent at driving. This process of learning continues beyond the licence tests, as drivers encounter new experiences throughout their driving life. However, if not reinforced, knowledge may be lost over time due to ageing, injury, or neurological conditions.

Knowledge gaps

There are many reasons why drivers may have gaps in their knowledge, for example due to:

a. **New drivers failing to learn all rules despite passing the test** – the licence test undertaken by any given candidate does not cover every single aspect of the Road User Rule, and candidates are only required to answer 32 out of 35 (91%) questions correctly to pass the test.[3] Also the test will not cover all aspects of driving theory in the 35 questions presented.

b. **Drivers not understanding the full extent of certain rules** – instead of committing the official wording of a rule to memory they may remember the required response to a situation, e.g. "when there's a green traffic signal, I can go". This may not include the realm of situations covered by the rule – for example, Auckland drivers are accustomed to having green arrows for right turns, and if driving in Christchurch may forget that they are also allowed to filter turn right as long as there is no red arrow and sufficient gaps in the opposing traffic.

[1] https://www.nzta.govt.nz/driver-licences/getting-a-licence/

[2] In the past, some states in America required a knowledge test, though it isn't clear how many still require this.

[3] https://www.nzta.govt.nz/driver-licences/getting-a-licence/

c. **Drivers forgetting infrequently encountered TCDs and/or rules** – not everyone is sufficiently exposed to all driving situations, for example those living in small towns may not have much experience with traffic signals or multi-lane roads. For example, Fernandez et al. (2020) identified a sign's abundance in the location where a driver passes through as a key factor in the driver's familiarity with that sign.

d. **Existing drivers not understanding new TCDs**– When new TCDs are introduced or changes are made to rules, information and education about the change may not reach existing drivers who are not tested on this change. Shinar et al. (2003) cited this as one of the reasons elderly drivers in Finland, Israel, and Canada had poorer sign comprehension than younger drivers.

e. **International drivers** – visitors to NZ can drive in NZ with an overseas licence (with a translation or an international driving permit if the licence is not in English) without having to sit a driving test, despite differences in TCDs and rules across countries. (Shinar et al., 2003) found drivers from Canada, Finland, Israel, and Poland showed 'disturbingly low' comprehension of foreign signs, often misinterpreting them due to lack of international standardisation, sometimes even as the opposite meaning.

f. **New Zealanders returning from long stays overseas** – who may have adapted to the foreign TCDs and/or rules that may have interfered with their memory of those specific to NZ.

g. **Health issues, impairment, and non-traffic-related accidents** – that may impact memory and cause drivers to forget aspects they previously understood.

h. **Older drivers' decline in cognitive function** – Older adults show declines in processing speed and attention, with medications further impairing cognition and have been linked to higher crash risk (Freed et al., 2024). Ben-Bassat & Shinar (2015) found older drivers aged 65 to 91 years performed significantly worse than younger drivers on both accuracy and response time when interpreting road signs. Brashear et al. (1998) reported that dementia patients were less able to identify signs than elderly drivers without dementia, with 11% versus 57% failing Indiana's driving test, respectively.

Perception

A further factor in limited driver comprehension is perception of TCDs. The more information drivers are exposed to, the slower recognition and retrieval from long-term memory occurs. Ben-Bassat & Shinar (2015) drivers took twice as long to interpret signs in road scenes versus isolated images, despite similar comprehension rates. Charlton & Baas (2006) showed better rates of comprehension of road signs when tested statically than when tested dynamically in a simulated driving experience. In real-world contexts, drivers are exposed to a wide range of information and may miss TCDs, focusing on those most relevant to their needs and goals (Shinar et al., 2003 citing Johansson and Rumar 1966, Shinar and Drory 1983).

Traffic control device design

A fourth factor is how TCD design affects thought-decision making processes. Shinar et al. (2003) summarised "to enhance comprehension, displays should embody as many of the following criteria as possible: spatial compatibility, conceptual compatibility, physical representation, familiarity, and standardization." Wontorczyk & Gaca (2021) found that among Polish drivers, symbol-only signs were more easily comprehended than signs with text and symbols.

Decision making

Lastly, decision making is not always a conscious process, rather drivers may have a sub-conscious response to previously encountered situations. For example, drivers are just as likely to stop at a stop sign without the words "stop" written on it, as they automatically recognise the red octagon and make sense of it based on their mental schema / long-term memory.

3.2 Driver knowledge over time

Research question #1: do drivers lose knowledge about existing road and traffic rules over time?

Driver comprehension tends to be the focus of much of the literature, as opposed to knowledge alone, which has much less focus. Nevertheless, stored information in long-term memory (knowledge) is a pre-requisite for comprehension, although sensory or processing limitations may also affect comprehension, such as that which emerges from the ageing process. This means it is difficult to determine the specific influence of age on driving knowledge from the literature.

There is some evidence that drivers lose comprehension over time. For example, Ng & Chan (2008) found comprehension of signs was correlated negatively with years of holding a licence in Hong Kong. Ben-Bassat & Shinar (2015) also found older drivers (aged 65 to 91 years) in Israel performed significantly worse than younger drivers (aged 25 to 30 years) in accuracy of identifying the meaning of road signs.

Similarly, Schulz et al. (2020) found in Germany, older drivers (>65 years old) showed lower traffic sign comprehension (TSC) speed and tended to interpret more recent traffic signs less accurately than younger drivers (18-35 years old). Furthermore, they identified cognitive decline as a factor in this: *"older participants showed poorer performances in processing speed and executive functions, whereas symbol processing, semantic memory performances and verbal abilities were similar to those of younger participants" and "higher level of cognitive functioning was associated with better TSC performance regardless of age"*.

Shinar et al. (2003) studied sign comprehension for five groups of drivers, which included three age-based groups: novice (those who had passed their theoretical test plus drivers who received their licence within the past year); university students (with at least two years driving experience); and older (licensed drivers at least 65 years old who had not taken a written or practical test in at least 10 years). This does not bridge the gap between younger and older drivers but does allow for finer examination of those in the early stages of driving. Patterns differed by country – in general there was little difference between novice drivers and university students, and older drivers tended to be the worst – however there are exceptions to both those statements.

What is generally lacking in the existing literature is studies with intermediate cohorts between "young" and "old". Studying drivers in their 30s to 50s might help further understand the contributions of the various factors in driver comprehension and how they change over time. There are some studies that have considered this, but results are limited and perhaps contradictory.

Taheri et al. (2022) studied Iranian drivers grouped in four 10-year bins, from 21-30 to 51-60, and found a weak positive relationship between driver age and their subjectively assigned score of sign useability. This seems contrary to the findings of other studies discussed above that driver sign comprehension decreases over time, although it is important to note that Taheri et al. (2022) did not assess comprehension and rather they explained the sign meanings, if needed, to help participants in assigning their useability scores. Comparisons between this usability study and other comprehension studies could suggest that, as driver knowledge decreases over time, their awareness of this knowledge gap also decreases, causing them to be over-confident.

Wontorczyk & Gaca (2021) studied sign familiarity and comprehension of Polish drivers and included age as a variable, with five bins from 18-25 to 56-65 (all except the first bin having 10-year ranges). Familiarity and comprehension scores for individual age groups were not stated. Statistically significant relationships between self-declared familiarity and age were identified for two of the four sign types – symbolic text regulatory signs and symbolic warning signs – with younger drivers having a higher familiarity. However, only symbolic text regulatory signs also had a statistically significant relationship for sign comprehension – in which younger drivers also performed better. This is some evidence for driver knowledge decreasing over time and could also suggest that younger drivers are more likely to be over-confident as their self-declared familiarity didn't always result in comprehension.

Tay (2010) found that only 11.4% of 2,394 existing drivers in Alberta, Canada understood the road rules sufficiently to pass a practice road rule test.

Conversely, Kirmizioğlu (2010) and Kirmizioglu & Tuydes-Yaman (2012) studied driver comprehension of signs in Turkey. Drivers aged 18-25 gave more wrong or not commented responses, drivers aged 26-35 gave more responses with the opposite meaning and drivers aged 46+ gave the most correct responses. Overall, this could be an example of driver knowledge improving with age / over time.

A limitation of the literature is that studies tend not to track driver knowledge over time and hence do not cover the degree to which older drivers had forgotten previously held knowledge (Question 1 of this research). Rather, they compare drivers of different ages during a moment in time. This is pragmatic but doesn't specifically compare the knowledge individual drivers lose (or gain) over time.

3.3 Driver adaptation to new aspects and changing environments

Research question 2: do drivers fail to learn about new road rules and TCDs and/or fail to adapt their driving behaviours to the changing road environment (e.g. increased road user mix)?

As well as retaining knowledge over time, drivers need to add to their knowledge base, to integrate changes to TCDs or rules. However, there is very limited literature investigating how well drivers adapt to new road rules and TCDs. We found only two studies that addressed this.

In Turkey, Kirmizioğlu (2010) and Kirmizioglu & Tuydes-Yaman (2012) studied drivers' comprehension of 39 traffic signs, which include previous and new versions for two signs that had been changed recently due to the European Union harmonisation process. Participants were not exposed to all signs, and each participant only saw one version for each of the signs that had been recently changed. The recently changed signs were among the signs most often interpreted with the opposite meaning and had high instances of people choosing not to comment but also reasonable familiarity, suggesting people had encountered the new signs while driving but did not understand them. It is not clear how much publicity or driver-education was provided around the time of the sign changes. The authors concluded a "need for more aggressive campaigning to publicise" the new signs.

Overall, this scan has identified a knowledge gap in the area of driver knowledge development over time, and this will be addressed in the survey of driver knowledge (Section 5).

3.4 Options to address driver knowledge at different stages

Research question #3: What evidence-based knowledge development/ maintenance options are available at different stages that would address any competence issues identified in research questions one and two?

There are a range of options for building and assessing core driver knowledge throughout the driving life-cycle. Some of these are outlined in a paper by Hawkins et al (1998) that focused on educating drivers about TCDs, they identified the following options:

- Educational programmes
- Communications campaigns
- Engineering options

Driver assessment/testing could also be added to this list as it may compel self-directed learning to pass the assessment. Available research on each of these options is described below.

3.4.1 Driver training and education

As highlighted by the GDE Matrix (above), knowledge of road rules, signs, and markings is only one aspect of overall driver competence. As such, typical driver training and education programmes cover a much broader range of competence requirements, for example physical vehicle control, risk perception, and driving attitudes.

An extensive body of literature on driver training and education is readily available covering both pre- and post-licence interventions. Interestingly, relatively little of it is specifically focused on knowledge building, and those studies that are available are often quite old. More recent research, particularly post-licence, has tended to focus on developing higher order skills such as attention management, situational awareness, risk perception, and decision making. In a few cases advanced vehicle operations, such as skid control, are the focus (Faus et al., 2023).

Only research and evaluations of training and education interventions with a clear knowledge component were reviewed for this work. This included some knowledge-specific interventions, as well as other broader interventions. For the broader interventions, it was usually impossible to isolate the effectiveness of knowledge development education and training. Although some interesting training approaches can be identified. Therefore, the following sections summarise research relevant to the development of driver knowledge of road rules, signs, and markings, setting out data where it is available, and drawing relevant inferences from broader studies where possible.

Several **knowledge-focused interventions** were identified during this scan and are described below. They tended to be smaller scale, more exploratory studies with most authors noting that more work would be needed to validate their findings and fully develop the interventions.

Two interesting game-based studies focused on core driving knowledge were identified. Li & Tay (2014) trialled a game-based approach for building driving knowledge. Their results suggested the game was an effective educational tool, engaging participants in active problem-solving related to signs, markings, traffic violations, and safe driving behaviours. Evidence of medium-term knowledge retention was found. Although exploratory, the authors concluded that game-based learning has the potential to reduce unintentional driving errors and violations stemming from knowledge gaps. Concurrently, a similar study was undertaken by a Brazilian research team (Rodrigues et al., 2015). This also focused on an interactive and educational 3D traffic rules game where players had to drive safely in traffic, respecting pedestrians, vehicles, traffic signs, markings, and rules. The authors indicate that the game was positively received by users and demonstrated potential as a training device. Unfortunately, performance data wasn't collected.

Researchers have also considered whether different training approaches impact the effectiveness of symbolic traffic sign recognition. Ng & Chan (2011) assigned 36 participants to four training conditions (paired-associate learning, recall training, recognition training, and a control group) and tested the learnability of Mainland China traffic signs. Their results showed recall training was most effective, indicating that a good symbol-training program should include a question and feedback procedure. While exploratory, the study findings may be useful for designing core road knowledge training. Their findings were also supported by Maulina et al. (2022) who found that a short 3-minute video training intervention was effective for improving sign comprehension amongst motorcyclists.

One study provided some information about classroom-based methods for core driving knowledge training. While it was not the focus of the study, Anstey et al. (2018) used driver knowledge refresher training as a comparator when testing the effectiveness of tailored driving lessons for older drivers. The refresher training involved a 2-hour classroom-based session led by a driving instructor. Participants received a copy of relevant Road Rules Handbook and were provided with information on age-related physical changes, adaptations, road rule updates, safety tips, and applying road rules when driving. Results showed that the refresher course reduced dangerous/hazardous driver errors, although tailored driving lessons achieved a greater reduction.

Only one study identified in this scan, Ward et al. (2004), focused on knowledge-based driver education outside of pre-licensing and older drivers. The focus of this study was international driving. The research was designed to test comprehension levels of 100 international road signs and the effect of brief sign training. To facilitate an active learning process during training each participant was given a set of cards with the sign and its meaning to view for 5 minutes. Results showed that for many signs initial comprehension levels were low and critical confusions (serious errors) were high. However, after training comprehension dramatically improved, suggesting that brief, active training can produce relatively rapid results. This lends support to the findings of Ng & Chan (2011) and Maulina et al. (2022) described above.

Finally, an older study by Hawkins et al. (1998) used more traditional training methods to improve driver knowledge of TCDs. The impetus for the work was research showing drivers didn't fully understand some TCDs and a lack of information about how best to build this knowledge. The research team working with Texas state practitioners to implement an improvement plan with education, communications, and engineering components. The education component included:

- Revisions to the *Texas Drivers Handbook*
- Suggested emphasis areas for the curricula and course materials for driver education and driver safety courses
- Continuation of older driver outreach programs

Unfortunately, the research team had not evaluated this work at the time of this publication, and later publications were not identified in this scan. The work does, however, show a real-world attempt to improve TCD knowledge in the driving public.

Unlike knowledge specific training, a very large body of research is available on more **general driver training and education interventions**. For this reason, this scan has focused identifying systematic reviews and meta-analyses. As stated earlier, it is difficult to isolate out the impact of knowledge components of these programmes. However, relevant data and inferences are provided below.

Akabari et al (2021), provides a recent systematic review of systematic reviews on the contribution of driver education to improving road safety.[4] In reviewing the extensive body of earlier research, they note that both pre- and post-driver education has shown positive short-term outcomes in terms of improvements in knowledge and driving skills. However, an associated reduction in crashes and injuries has not been found. This finding also held for older drivers with several systematic reviews indicating that training had little or no direct impact on road safety in terms of crash or injury risk reduction. From the perspective of core driving knowledge, this study suggests that, unsurprisingly, training and education improves driving knowledge. However, it does highlight the difficultly of linking training and education to broader outcomes such as crash rates. It suggests a level of caution in terms of the cost-benefits likely to be achieved by requiring training/education on core driving knowledge.

Another systematic review and meta-analysis of old driver interventions has been undertaken by Fausto et al. (2021). This review sought to quantify the effects of different driving interventions among older adults on several outcomes (crashes, on-road driving performance, and self-reported errors). A wide range of interventions were considered including combinations of flexibility and coordination training, visual-perceptual training, cognitive training, and education (e.g., classroom driver refresher courses). Education and context-specific approaches were not successful in improving driving safety outcomes. Though the difficulties in designing evaluations and acquiring data to test these relationships should be noted.

Another similar review (Sangrar et al., 2019) reviewed older driver interventions with a slightly broader lens, considering effects of education and training on road safety knowledge, self-perceived changes in driving abilities, and behind-the-wheel performance. Thirty-three studies were included, with interventions ranging from classroom-based education to on-road feedback (or a combination of both). Only two interventions demonstrated between-group differences and improvements in older adults' knowledge of road safety. Key features of these were attendance at all educational sessions and pairing in-class education with in-vehicle training. Causative relationships between road safety knowledge and performance-based outcomes were not established.

The studies described above show the potential of training and education to result in improvements in core driving knowledge. Interestingly, some results appear to suggest that short, focused interventions may be sufficient. This may also suggest that a well-designed communications campaign could provide a sufficient learning opportunity for many drivers, although these suppositions require further testing and it should be noted that many of the studies described above are exploratory only.

The limited evidence for a relationship between driver education and training in general, and road safety outcomes such as crash reduction, does suggest that caution should be applied in recommending complex, or time-consuming driver knowledge training/education interventions. Given knowledge is only one component of competence, and designing evaluations and acquiring data to test long term outcomes is very challenging, it would likely be difficult to provide evidence of the cost-benefit of such an intervention.

One thing that was clear from baseline testing in several of these studies is that drivers in general, do not seem to keep up to date on core driving knowledge independently. For example, Hawley et al. (2018) notes that approximately 25% of research participants had not made sure they were up to date on driving regulations in the last five years. Given core driving knowledge is a fundamental enabler of safe driving, some type of intervention to help keep drivers up to date may well be beneficial.

[4] This study is particularly interesting because it draws together and considers the very large body of research in this area.

3.4.2 Driver assessments

While this scan did not identify literature specifically focused using assessments to promote for knowledge building, they are worthy of some consideration as a mechanism for encouraging drivers to update their core driving knowledge. The current New Zealand driving knowledge test functions in this way, providing a gateway through which drivers must pass for licensing. Drivers are required to take their own initiative, using information made available by NZTA, to study for the test. In this way, the test motivates drivers to build their driving knowledge.

Two older studies provide some indication about the potential of assessment as an approach. The first, Brashear et al. (1998), trialled the Traffic Sign Recognition Test (TSRT) for use in discriminating between dementia patients who continue to drive and normal elderly volunteers. The research team was interested in whether the TSRT could be used by medical professionals to quickly assess the relevant capacities of a licensed driver with dementia and determine whether they should continue to drive. Their results showed that patients with dementia performed worse on traffic sign recognition than elderly normal volunteers. Most concerning was the poor performance of the dementia group in identifying the "Stop" sign (76% correct compared to 98% of normal volunteers). However, the performance of the normal volunteers was also interesting with their knowledge of signs seeming somewhat low in several cases. Most particularly the following signs, slippery when wet (24% incorrect), no right turn (21% incorrect), and no passing zone (16% incorrect). While the study itself isn't specifically related to core driving knowledge building, it does demonstrate the use of assessments in evaluating knowledge through the driving life-cycle.

MacGregor et al. (2001) also used the TSRT to test the relationship between sign recognition and whether older drivers had recently had a crash. The TSRT was chosen because it was simple, inexpensive, objective, not based on self-report, and easy to perform. Results showed the TSRT could independently distinguish crash and non-crash groups. However, the authors note that the TSRT in its current form was not suitable as a screening test, with further research needed.

While the studies described above do not show knowledge assessments functioning as a knowledge building option, they do demonstrate the potential efficacy of knowledge testing, and highlight these tests as a quick, inexpensive form of driver assessment.

3.4.3 Communication campaigns

One relatively straightforward option for building knowledge in the general driving population is communications campaigns. Their potential is suggested by some findings on knowledge training/ education showing that short, targeted interventions could be successful, as described earlier.

This scan didn't yield any literature focused on designing campaigns to build core driving knowledge. Although, it was a component of the work done in Texas on improving driver knowledge described in Hawkins et al. (1998). While it was not identified, it is possible that grey literature exists within NZTA evaluating the impact of the publicity campaign on give way rule changes in 2012.

3.4.4 Engineering options

For traffic signs particularly, a knowledge improvement option discussed by Hawkins et al. (1998) is sign design. Through this scan, several studies examining the impact of design on driver sign knowledge/ comprehension were identified. The most relevant of these are discussed below.

It has long been understood that the way a sign is designed influences a drivers' ability to understand the meaning it represents Ben-Bassat (2019). Research has shown that clear and understandable road signs can be achieved by using standard shapes and colours, and by using symbols that comply with the compatibility principle of ergonomic symbol design, which is composed of three elements:

1. Spatial compatibility. Refers to the physical arrangement of information and directions in space, ensuring they are intuitive relative to their position.
2. Conceptual compatibility. Refers to using symbols and codes that conform to people's natural associations and expectations.
3. Physical representation. Refers to the similarity between the content of the sign and the reality it represents. (Sanders and McCormick, 1993, cited in Ben-Bassat (2019)).

Most research on sign design focuses on comprehensibility, or the extent to which a sign is understood and complied with in real world driving situations. Results of these studies have shown that while many road signs are well understood, some fail to be comprehended relatively often. For example, Ben-Bassat (2019) cites studies suggesting that warning signs such as 'termination of road', 'pedestrian' or 'crossing ahead', and 'no entry' are commonly not comprehended.

For studies testing comprehension of signs that participants, as licenced drivers, should already know, poor comprehension rates indicate that they have both, not retained the meaning of the sign from licensing training, *and* cannot derive meaning from the symbols used. This raises the feature of sign design most relevant to this scan, which is the learnability facet of sign comprehension.

Ben-Bassat (2019) notes that learning the meaning of signs is part of obtaining a driving licence. Therefore, it is important that they can be easily learned. The goal is that a driver learns the meaning of signs at licensing and remembers these meanings for many years to come. Enhancing sign comprehensibility and learnability means that drivers can learn meanings in 'real time' as they drive, potentially reducing the need for driver education/training.

Research has shown that well designed symbolic road signs can be learned more easily, even if they are not understood at first glance (Erdelyi and Haber, 1967; Cairney and Sless, 1982; Ng and Chan, 2007, all cited in Ben-Bassat (2019). Two of these studies were gathered during this scan and are described below.

Ben-Bassat (2019) investigated the learning of unfamiliar road signs and the effect of sign compliance with ergonomic principles of physical and conceptual compatibility on learnability. Participants learned 30 signs divided into 'ergonomic' and 'non-ergonomic' groups. Results showed a significant design main effect, with higher comprehension associated with the ergonomic signs. A significant learnability main effect was also found, with probability for improvement in sign recall being higher for ergonomic signs. The findings show the importance of ergonomic design in shaping both understandability and learnability of road signs. They have important implications for both licensed drivers learning new signs, and for newly licensed drivers and others with less familiarity such as tourists.

In their study of training design on sign knowledge (reported earlier), Ng & Chan (2011) also considered the relationship between traffic sign characteristics and training effectiveness. Their research, undertaken with unlicensed Hong Kong residents who had not previously learned the signs presented, showed that the principle of semantic closeness/conceptual compatibility was significant in determining sign effectiveness and ease of interpretation.

While the relationship between sign design and learnability is a relatively new area of sign comprehensibility, the results of studies undertaken do suggest that good design makes signs easier to learn. Complying with these principles of design could reduce the burden of learning and maintaining knowledge of signs, both for drivers and for road authorities who may otherwise have to provide alternative learning opportunities through education, training, or communications.

3.4.5 Conclusions

The research presented earlier in this report indicating that some drivers have knowledge gaps about road rules, signs, and markings is quite concerning, even if knowledge gaps are not evident in crash statistics. This core knowledge, used within broader information processing, helps drivers to safely navigate the driving environment. As such, it is a necessary pre-requisite for competent driving.

The scan of options for improving driver core knowledge identified several opportunities:

- Short, targeted training/education interventions.
- Communications campaigns
- Driver assessments at relicensing (prompting self-directed learning)
- Sign design

Any training and education options pursued, should be developed with due consideration to broader evaluations of the impact of training and education on outcomes such as reductions in crash rates. The relationship to these outcomes has generally been found to be quite weak. There are many methodological and data-related difficulties in conducting evaluations of this type. Nevertheless, the results do suggest that a cost-benefit analysis of a larger scale training or education intervention for core driving knowledge (only one component of competence) is unlikely to be favourable.

Another consideration is the practicality of implementing any proposed options within, or around, the New Zealand driver licensing system. This issue is discussed briefly below and will be explored in more detail in workshops that form a later part of this study.

3.5 Suitability of options for the New Zealand context

Research question #4: are any of the options to improve driver knowledge a good fit in the New Zealand context?

To determine whether any of the core driving knowledge development options discussed earlier are suitable for the New Zealand context, it is important to consider the existing driver training and licensing system. The key components of driver testing for licensing are provided in the infographic below (Figure 3-3).

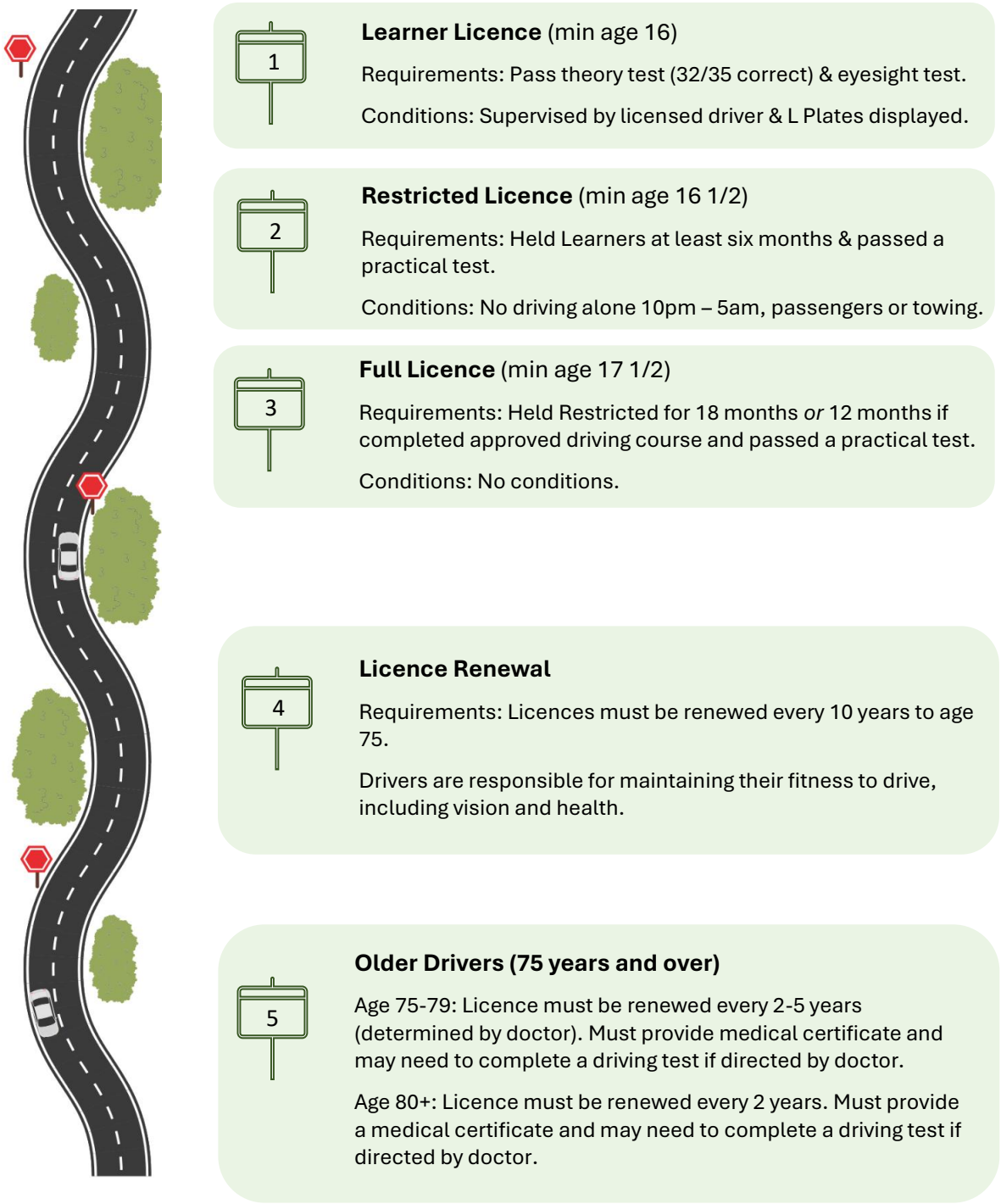


Figure 3-3: Core Components of NZ Driver Licensing System.

In addition to key driver testing points, New Zealanders also have access to training both pre- and post-licensing. While these courses are not mandatory, they can help new drivers build the core knowledge needed to gain their learner licence or refresh their knowledge.

While **pre-licensing education** in New Zealand is mainly centred around self-study of the Road Code, this is supported by community programmes, online tools, and optional courses. These range from learner licence preparation courses run by community providers, driving schools, and Māori and Pacific education providers to professional driving lessons. Examples include:

- Ready for the Road (Harmony Pasifika). A 20-hour programme for 16–18-year-olds covering Road Code study, learner licence prep, and responsible driving behaviours.
- Chamber Driver (Auckland Business Chamber). Free 3-day learner course for jobseekers (via MSD referrals) including Road Code tutoring, quizzes, and test bookings.
- Alert Driving School Auckland. NZTA-approved instructors provide learner licence lessons, including theory classes in Hindi, Gujarati, and Punjabi.

In New Zealand, **post-learner licence training and education** for car and commercial drivers is available through a variety of formal and informal options. These are designed to improve safety, confidence, fuel efficiency, and specific skills (e.g. driving in adverse conditions or with passengers). In general, core road knowledge is assumed. Examples include:

- Defensive Driving Course. It is designed for restricted or full licence holders. This course focuses on hazard identification, safe driving strategies, risk management, and defensive driving theory. It reduces the wait time to get a full licence and is often used by employers or young drivers wanting to build safe habits.
- Advanced Driving Courses (such as those provided by the AA, National Advanced Drivers School and Street Smart). These are courses aimed at experienced drivers seeking to upskill.
- Commercial Driver Training (e.g. TR Driver Training). Courses aimed at fleet or commercial drivers who regularly use vans or cars for work. Topics may include advanced handling techniques, fatigue and distraction management, emergency braking and skid control, driving in urban, rural, or hazardous conditions.
- Voluntary knowledge refreshers such as online road code quizzes, information on websites (e.g. AA road safety tips and DriveSafe for international drivers) and periodic updates through insurance or motoring organisations. These are useful for reinforcement of knowledge, keeping up with changes to laws or signs, and supporting a return to driving after a break.

For older drivers specifically, available education and training options include:

- Staying Safe (offered by Age Concern and NZTA). Free, classroom-based sessions (typically 4 hours) provided for adults aged over 65 years covering updated road rules and traffic signs, safe driving practices and hazard awareness, and alternate transport options.
- Community & Council-Supported Courses. Older driver refresher sessions, sometimes with assistance from occupational therapists and police, including interactive presentations, driving scenario discussions, refresher knowledge of laws, and reflection on driving habits.

As the examples listed above show, there are a range of options for building and refreshing core driving skills and knowledge in NZ, although these are typically targeted at pre-licence or older drivers. There didn't appear to be much knowledge refresher content in post-learner licence training and education, which tends to focus on advanced driving skills.

While it is unclear how many drivers make use of the education and training options available, these courses do provide potential opportunities to refresh core driving knowledge. Examples of options are listed below, these and others will be considered during project workshops:

- Include a short knowledge refresher session in driving training courses.
- Optional knowledge refreshers or courses for general or older drivers.
- Short core knowledge refresher or test to be completed at relicensing or as part of medical assessments for older drivers.

3.6 What can be learned from the literature?

The literature scan focused specifically on the acquisition, use, and maintenance/enhancement of knowledge that supports safe and responsible driving.

Fundamental psychological knowledge of human information processing provides a framework for understanding driving as a psychomotor task and highlights the contribution of fundamental knowledge (held in memory). Most particularly, the importance of knowledge in providing drivers with more cognitive capacity to devote to other aspects of driving was noted. Drivers who must devote attentional resources to, for example, understanding road markings or signage are more likely to be distracted or overloaded. Therefore, driver knowledge has predictable safety implications even if it is not evident in crash literature.

There are a wide range of reasons that drivers may not have important driving knowledge; these are described in the review above and listed below:

- New drivers failing to learn all rules despite passing the test
- Drivers not understanding the full extent of certain rules
- Drivers forgetting infrequently encountered TCDs and/or rules
- Existing drivers not properly integrating updates
- International drivers who are unfamiliar with NZ-specific rules and contexts
- New Zealanders returning from long stays overseas
- Health issues, impairment, and non-traffic-related accidents
- Older drivers' decline in cognitive function

Despite the importance of knowledge, research on driver knowledge is limited in New Zealand and internationally. Existing studies have mixed results, with a few indicating reduced knowledge among older drivers. Some studies also have design limitations that limit their relevance to questions about knowledge specifically. Consequently, they cannot provide definitive answers, highlighting a research gap, addressed to some extent by the driver survey.

Few studies have explored interventions to improve driver knowledge throughout the driving life-cycle. Most combine skill, attitude, and knowledge training, making it difficult to isolate the impact of knowledge alone. Evidence does suggest that brief, targeted knowledge interventions can be effective, although a lack of evidence for safety benefits suggests caution is needed for any intervention. Applying ergonomic principles to design easily understood signs also has potential. The options analysis in this project may therefore provide valuable insights into knowledge-specific interventions currently lacking in the research literature.

4 Key changes to road rules and traffic control devices

TCDs of all kinds (signs/markings/signals) and road user rules invariably change over time, to reflect new practices and technology or changes in the mix of road user types. To better understand the evolution of these changes over the past few decades in New Zealand, a scan was undertaken of notable changes recorded in official Government literature and the findings are summarised below.

4.1 Key road rule changes

Some of the key changes to road rules in the past few decades have included:

- Requiring all cyclists to wear an approved helmet in Jan 1994
- Introducing painted (flush) medians in Sep 1997
- Increasing the speed limit for heavy vehicles towing trailers to 90km/h in May 2004
- Introducing bus/cycle/transit "special vehicle lanes" in Feb 2005
- Prohibiting the use of handheld mobile phones while driving in Nov 2009
- Increasing the minimum age for driver licensing from 15 to 16 years old in Aug 2011
- Changes to the give way rules at intersections in Mar 2012
- Reducing the maximum legal alcohol limits to 250µg/L breath and 50mg/L blood in Dec 2014
- Introducing offences and penalties for driving while under the influence of drugs in Mar 2023

Public notification about these changes varied. For example, ahead of the major give way rule changes in early 2012, there was notification about them from Sep 2011, but an intensive public information campaign was only run in the month leading up to the change date (25 March 2012), with national advertising starting 10 days before the change (see Figure 4-1). The February start date was necessary to avoid public confusion and minimise the risk of people starting to use the new rules too early.

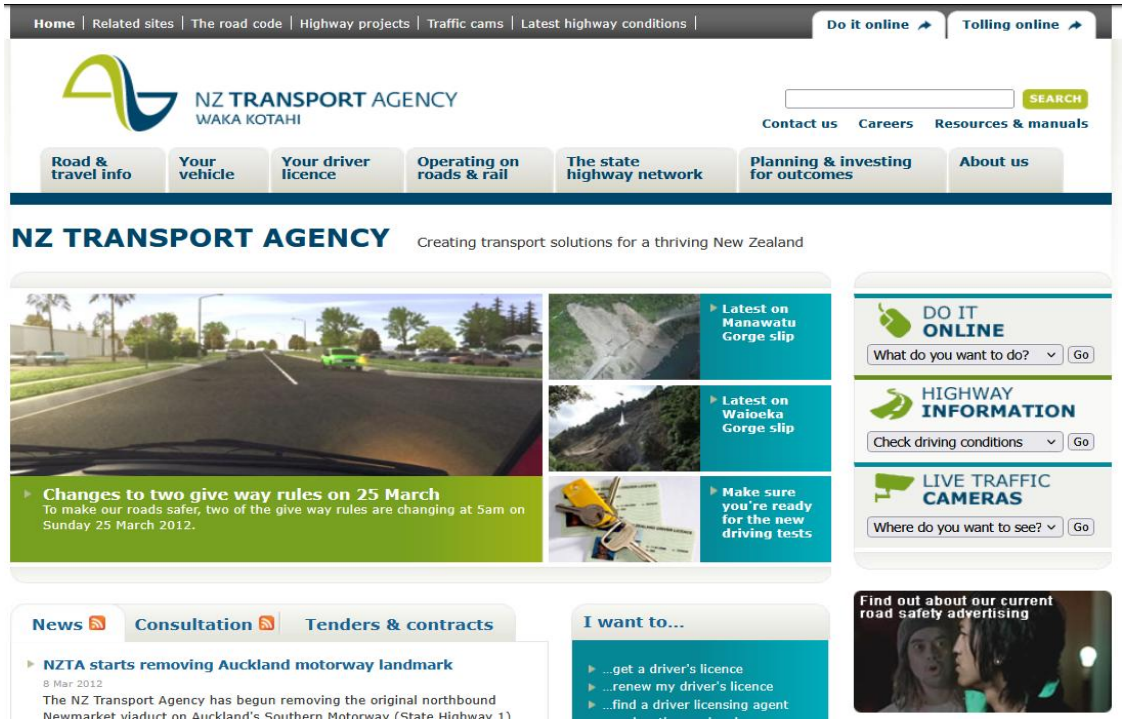


Figure 4-1: Screengrab from NZTA website homepage on 8th March 2012 - give way rule changes featured.

Similar advertising via TV, radio, posters and online were used to advertise the drop in alcohol limits ahead of the change in Dec 2014.

Other rule changes were not as broadly advertised, and often required searching through the relevant section of the LTNZ/NZTA website to find details of the new changes (e.g. changes to young driver licensing ages, and the introduction of special vehicle lanes).

4.2 Newly introduced or changed traffic control devices

Some of the key changes to traffic signs, markings and signals in the past few decades have included:

- Introducing new symbolic road signs in Sep 1988
- Introducing red and amber traffic signal arrows in Aug 1990
- Introducing new traffic signals for bus, bicycles, and pedestrian crosswalks in Apr 1998
- New cycle/bus/transit lane signs and markings in Feb 2005
- Introducing countdown pedestrian signals in Apr 2011
- Introducing cycle sharrow markings in Dec 2016
- Revoking the use of Limited Speed Zone (LSZ) signs in Jun 2019
- Introducing Rural Intersection Speed Zone variable speed limit signs in Jun 2022

Again, public notification varied, with some details simply updated on the relevant Road Code webpage. Even then, there was often a delay in official notification, such as the introduction of cycle sharrow markings, which were not presented online by NZTA until late 2020 (although several local councils had already promoted them separately earlier following initial trials, e.g. Wellington City, Christchurch City).

The revocation of the Limited Speed Zone (LSZ) speed sign was another situation that attracted relatively little public notice, so it is possible that some people are not aware that it no longer exists. This sign designated a maximum speed limit of 100 km/h, but that was reduced to only 50 km/h if dangerous conditions such as bad weather existed. The 2003 *Setting of Speed Limits Rule* first signalled that RCAs should review all limited speed zone areas and replace them with a new permanent speed limit. A 2007 *Setting of Speed Limit Amendment* set the final date for these reviews as Jul 2009. However, the NZTA Road Code website did not record its removal from its Speed Limits webpage until Oct 2012, and the sign itself was not officially removed from the TCD Rule until Jun 2019.

4.3 Other changes to traffic environments

Beyond changes to road rules and TCDs, the evolution of New Zealand's transport system means that correct knowledge of various newer traffic scenarios is also needed, such as:

- When to enter a special vehicle lane to turn left
- Safely overtaking a cyclist when there is no dedicated cyclist space
- Safely overtaking on high-speed roads when no passing lane exists.

Scenarios such as these often require 'in the moment' knowledge – applying basic knowledge to a range of dynamic conditions to ensure road user safety. There was an emphasis on this kind of knowledge by workshop stakeholders, as outlined later.

5 Survey of driver knowledge

A survey of New Zealand drivers was conducted to test their knowledge of rules and other changes (to address Research Questions 1 and 2). The survey questions and response options are detailed in Appendix C. The survey results were analysed in relation to several factors including driver age, time since last training or testing, crash history, and other demographic factors. The results are summarised below.

5.1 Analysis of findings – general statistics

A total of 535 respondents completed the survey, with the gender, ethnicity and location proportions roughly matching the expected demographics. Figure 5-1 summarises the breakdown of reported driver licence types; nearly 80% of respondents had full licences, with a roughly equal split of learner and restricted licences, and only 15 with either an overseas licence or one converted from overseas.

Licence type		
NZ Learners	52	9.7%
NZ Restricted	45	8.4%
NZ Full	423	79.1%
Valid overseas licence	10	1.9%
Converted from o'seas	5	0.9%

Figure 5-1: Breakdown of survey respondents' driver licence types.

Figure 5-2 lists the breakdown of how many years respondents had held their current driver's licence. There were no notable trends (and appear to be broadly in line with New Zealand demographics), with about 20% of respondents having held their licence for more than 40 years, and about 15% for 6-10 years.

Years held licence		
<1 year	32	6.0%
1-2 yrs	47	8.8%
3-5 yrs	59	11.0%
6-10 yrs	81	15.1%
11-15 yrs	36	6.7%
16-20 yrs	46	8.6%
21-30 yrs	74	13.8%
31-40 yrs	52	9.7%
>40 years	108	20.2%

Figure 5-2: Distribution of years held driver's licence by survey respondents.

Respondents were asked how frequently they typically drove and Figure 5-3 summarises the reported answers. More than 80% of respondents reported driving at least twice a week.

Driving frequency		
2+ times a day	253	47.3%
2+ times a week	192	35.9%
2+ times a month	46	8.6%
Once a month or less	44	8.2%

Figure 5-3: Distribution of average driving frequency by survey respondents.

When asked about how many crashes respondents had been involved in where they were fully or partially to blame, over half had never had such a crash and about 90% had never had an injury crash. As shown in Figure 5-4, less than 20% of respondents had been involved in 2 or more crashes, and less than 2% in 2 or more injury crashes. Over 40% of such reported crashes had occurred more than 10 years ago.

#Crashes		
0	284	53.1%
1	150	28.0%
2	76	14.2%
3	15	2.8%
4	4	0.7%
5	6	1.1%

#Inj crashes		
0	482	90.1%
1	45	8.4%
2	7	1.3%
3	1	0.2%

Figure 5-4: Reported crash frequencies by survey respondents with full/partial blame.

Respondents were also asked whether they had lived overseas for more than one year and, if so, how long since they had returned to New Zealand. As shown in Figure 5-5, about 60% had never lived overseas for more than one year, while for over 20% this had occurred more than 10 years ago. Only about 6% had returned to New Zealand within the past 2 years.

When returned from living overseas >1 year		
In the past year	19	3.6%
1-2 years ago	17	3.2%
3-5 years ago	26	4.9%
6-10 years ago	33	6.2%
>10 years ago	116	21.7%
Never >1 year overseas	324	60.6%

Figure 5-5: Time since survey respondents had returned from living overseas for more than one year.

5.2 Analysis of findings – driver knowledge scores

The 24 driver knowledge questions and their possible response options are detailed in Appendix C.4.1. Figure 5-6 shows the distribution of driver knowledge test scores (out of a maximum of 24) across all

respondents. The lowest score was 5/24 while the highest score was 23/24, with an overall average of 16.3 or about 68%.

The best answered questions (with about 95% of respondents correctly answering) were questions relating to using a cycle lane, giving way to a cyclist when on a side road, and what a red arrow signal means. Only about 7% of respondents correctly determined what a "B" signal meant, while about only one third of respondents correctly knew about using a mobile phone when driving and approaching a zebra crossing with a central island.

Score/24		
4	0	0.0%
5	1	0.2%
6	1	0.2%
7	3	0.6%
8	4	0.7%
9	6	1.1%
10	4	0.7%
11	16	3.0%
12	15	2.8%
13	34	6.4%
14	37	6.9%
15	53	9.9%
16	89	16.6%
17	74	13.8%
18	75	14.0%
19	61	11.4%
20	37	6.9%
21	17	3.2%
22	7	1.3%
23	1	0.2%
24	0	0.0%

Figure 5-6: Distribution of driver knowledge test scores by survey respondents.

To test whether the relative "age" of different rules may have an effect on driver knowledge, the questions were split into those based on rule changes within the past 15 years, those from 15-25 years ago, and those that were a rule more than 25 years old. Figure 5-7 shows the breakdown; interestingly the older rule questions performed somewhat better than the newer rule questions, which might reflect the well embedded knowledge that many older drivers have about these.

	Age of rule	*No. of qn's*	Ave score
NEW	<15 yrs ago	*8*	**62.5%**
MID	15-25 yrs ago	*6*	**62.5%**
OLD	>25 yrs ago	*10*	**75.8%**

Figure 5-7: Average driver knowledge test scores by relative age of the rule.

The questions were also differentiated in terms of the type of answer being asked; namely:

- ***Give way*** priority decisions
- The ***meaning*** of specific signs or TCDs

- The ***choice*** of appropriate driving behaviour
- Specific maximum or minimum ***values***

Figure 5-8 summarises the differences in scores by different question types. Perhaps not surprisingly, respondents performed best regarding the questions about give way priority, while performing less well when asked to recall specific values for certain situations (e.g. the maximum legal speed for a vehicle towing a trailer) – albeit this sample of questions was rather small.

	No. of qn's	Ave score
Give Way	*6*	**81.6%**
Meaning	*8*	**63.5%**
Choice	*7*	**69.4%**
Value	*3*	**49.9%**

Figure 5-8: Average driver knowledge test scores by type of questions.

Separately, we also subjectively assessed the relative safety outcomes for incorrect responses. For example, getting the driver priority wrong at a STOP-controlled intersection may result in a "high" adverse safety outcome; the same issue at a roundabout (where speeds are lower and crash types are more managed) may be only a "moderate" adverse safety outcome. Conversely, not knowing the correct speed limit for a towing vehicle is likely to have a "low" adverse safety outcome.

Figure 5-9 summarises the differences in scores between questions with varying relative safety outcomes. Of note is the fact that the scores generally increase as the relative safety outcomes increase; in particular the average score for questions deemed to have high adverse safety outcomes is about 15 percentage points greater than the score for questions deemed to have moderate adverse safety outcomes. Furthermore, while each of the three relative safety groups has a similar top score per question, the minimum score increases as the relative safety increases. This suggests that drivers do pay more attention to safety-critical rules than those with less immediate safety implications.

Rel. safety	*No. of qn's*	Ave score	Score range
Low	*6*	**61.2%**	7.1% - 95.9%
Moderate	*11*	**64.5%**	32.0% - 95.1%
High	*7*	**79.4%**	60.7% - 95.5%

Figure 5-9: Average driver knowledge test scores by relative safety outcome of questions.

Table 5-1 presents the accuracy scores for each of the seven questions in the high adverse safety outcome group, and discusses the outcomes. Within the group, there is a substantial variation in response accuracy. There are few obvious trends regarding the types of questions most or least likely to be answered correctly. The two questions involving giving way to vulnerable users (Q6 and Q12) had the highest scores. The question with the worst score (Q17) also involved cyclists, however this was the only question in this group relating to guidance (the road code) rather than legislation. Other results are more surprising, for example, Q10 and Q12 both rely on the "top of the T goes before me" rule, but Q10 had a lower score than the group average whereas Q12 had the highest score of the whole group.

Table 5-1: Analysis of responses to high safety outcome questions

Question number and description	***Accuracy score***	***Discussion***
Q1: Give way requirements at STOP controlled cross-roads	*60.9%*	Suggests that respondents didn't interpret the question correctly - they either identified themselves as driving the car on the STOP controlled road, or thought it was a 4-way STOP.
Q6: Give way requirements at footpath / shared path intersecting driveway	*93.3%*	A good accuracy rate; second-highest response rate for this group. Incorrect responses suggest a small proportion of people still don't understand that footpath and shared path users have priority at driveway crossings.
Q10: Give way requirements head of T vs stem of T (vehicle vs vehicle)	*75.3%*	A better response accuracy than Q1, possibly due to the relative recency of the right turn rule change and associated education campaign ("Top of the T goes before me"). Furthermore, this question was arguably easier to interpret than Q1, and it was only possible to develop two sensible response options hence someone guessing is more likely to strike the correct answer.
Q12: Give way requirements head of T (cyclist) vs stem of T (vehicle)	*95.5%*	The best accuracy rate in this group and second-highest overall. Further suggests that the give way rule change education was effective (especially since, unlike Q10, this question had three response options). People who answered Q10 incorrectly were more likely to also answer Q12 incorrectly, suggesting errors were more due to misunderstanding the head of the T rule than misunderstanding the status of cyclists.
Q16: Response to rural intersection activated warning signs	*88.8%*	A reasonable accuracy rate (third highest in this group). Most incorrect respondents seem to not understand that the variable speed sign is regulatory rather than advisory.
Q17: Ideal behaviour when passing a cyclist	*60.7%*	The lowest average score in this group. Possibly due to this being a question about the road code (i.e. advisory) rather than a road rule (mandatory). Most incorrect responses were the first option - lower than ideal separation but slow passing speed.
Q18: Give way requirements at uncontrolled cross-roads	*80.9%*	It is surprising to the research team that this had a higher average score than Q1, given people are expected to be more familiar with STOP control than uncontrolled intersections and the associated "give way to your right" rule. Possibly due to respondents becoming more adept at understanding the questions by the end of the survey, and Q18 only having two response options (compared with three for Q1).

5.3 Driver knowledge – test score patterns

Various survey respondent attributes were compared against the average test scores to determine whether there were any notable patterns. Firstly, test scores were compared against the length of time that respondents had held a driver's licence. Figure 5-10 summarises the average test scores across each group *(recalling that the average score overall was 16.3/24)*.

Total	Ave Score	Yrs held licence	
32	16.5	<1 year	
47	16.4	1-2 yrs	
59	16.3	3-5 yrs	
81	16.4	6-10 yrs	
36	16.3	11-15 yrs	
46	15.1	16-20 yrs	<<
74	16.0	21-30 yrs	
52	16.5	31-40 yrs	
108	16.9	>40 years	
535	16.3		

Figure 5-10: Average driver knowledge test scores vs length of time held licence.[5]

In general, no substantial trend was observed in the score results in relation to the length of time that someone had held a licence. The scores do appear to dip slightly to a low point at 16-20 years of holding a license and then increase again, however no feasible explanation for this has been identified and it may simply be a statistical anomaly.

It was not clear whether longer-term drivers might not be so familiar with more recent road rules. Therefore, separately we also investigated whether there was a relationship between scores for the 8 "new" rule questions and length of time with a licence. Figure 5-11 presents a breakdown of this analysis *(noting that the average score for "new" questions was 5.0/8)*.

Total	Ave Score	Yrs held licence	
32	4.8	<1 year	<<
47	5.0	1-2 yrs	
59	5.1	3-5 yrs	
81	5.2	6-10 yrs	
36	5.2	11-15 yrs	
46	4.7	16-20 yrs	<<
74	4.8	21-30 yrs	<<
52	4.9	31-40 yrs	
108	5.1	>40 years	
535	5.0		

Figure 5-11: Average driver knowledge test scores for new rule questions vs length of time held licence.

The pattern was somewhat similar to the previous assessment, with a slight dip in scores around the 20-year mark, and possibly also a drop with very recent licence holders. However, again there did not appear to be any correlation between longer times with a licence and test scores.

Separate comparisons were also checked of average test scores against various other demographic attributes and driving attributes. These are presented below (Figure 5-12 to Figure 5-14). No clear patterns were identified, although European drivers appeared to perform slightly better than other

[5] Note that potentially significant exceptions in the data are highlighted by "<<"

ethnicities (which probably also corresponds with the demographics in the various places of residence).

Total	Ave Score	Place of Residence
199	16.1	Greater Auckland
60	16.5	Greater Wellington
50	16.7	Greater Christchurch
141	16.4	Medium city or town
53	16.3	Smaller town
32	16.5	Rural areas/settlem'ts

Figure 5-12: Average driver knowledge test scores vs Place of residence.

Total	Ave Score	Ethnicity
346	16.5	European
43	16.0	Māori
28	15.9	Pacific
89	16.0	Asian
29	15.8	Other

Figure 5-13: Average driver knowledge test scores vs Ethnicity.

Total	Ave Score	Driving Frequency
253	16.2	2+ times a day
192	16.5	2+ times a week
46	17.0	2+ times a month
44	16.0	Once a month or less

Figure 5-14: Average driver knowledge test scores vs Driving frequency.

Figure 5-15 reviews the average test scores against respective licence types. The most notable difference was the low scores for those with overseas licences – although it must be acknowledged that the sample size is relatively small.

Total	Ave Score	Licence type
52	15.9	NZ Learners
45	16.3	NZ Restricted
423	16.5	NZ Full
10	11.5	Valid o'seas licence <<
5	17.6	Converted o'seas

Figure 5-15: Average driver knowledge test scores vs Licence type.

Separately we also compared the effect of test scores against the time since respondents returned from an extended time overseas. Figure 5-16 presents the average scores versus time returned. Perhaps not surprisingly, those respondents who had returned from overseas in the previous few years scored less well in terms of recalling road rules (albeit the sample size is only a little over 10%).

Total	Ave Score	Returned from o'seas	
19	14.9	In the past year	<<
17	15.7	1-2 years ago	<<
26	14.8	3-5 years ago	<<
33	16.1	6-10 years ago	
116	16.5	>10 years ago	
324	16.5	Never >1 year o'seas	

Figure 5-16: Average test scores vs Time since returned from living overseas for more than one year.

5.4 Driver knowledge – crash patterns

To estimate the approximate annual rate of crashes that respondents had been involved in with full/partial blame, an assumed mid-point was assigned to the years that each person had held their licence for. For example, someone who stated having had their licence for "11-15 years" was assigned an assumed licence length of 13 years. Figure 5-17 lists the entire breakdown of assumed values.

Yrs held lic.	Ave yrs
<1 year	0.5
1-2 yrs	1.5
3-5 yrs	4
6-10 yrs	8
11-15 yrs	13
16-20 yrs	18
21-30 yrs	25
31-40 yrs	35
>40 years	45

Figure 5-17: Assignment of years held driver's licence to assumed average years.

The overall net result across all respondents is an average of about 0.12 crashes per year. Figure 5-18 shows the relationship between average crashes per year ("Accs per Yr") and the number of years that respondents have held a licence. This shows a generally decreasing trend, which matches the typical pattern of crash risk versus driver experience identified in much of the relevant literature.

Accs per Yr	Yrs held lic.	
0.75	<1 year	<<
0.35	1-2 yrs	<<
0.14	3-5 yrs	
0.08	6-10 yrs	
0.03	11-15 yrs	
0.06	16-20 yrs	
0.03	21-30 yrs	
0.02	31-40 yrs	
0.02	>40 years	

Figure 5-18: Average number of crashes per year vs Years held a driver's licence.

A separate analysis was undertaken comparing respondents' test scores against their crash history. Figure 5-19 presents the average crash rates in comparison to the test scores grouped into 5-point bands, with sample sizes for each group listed on the right. While it is arguably a small sample, it is notable how those who scored very poorly in the driver knowledge test also appeared to have roughly *three times* the average crash rate of the total survey population.

Grouped scores	Accs / Yr	Sample	
<10	0.35	15	<<
10-14	0.07	106	
15-19	0.12	352	
20+	0.17	62	

Figure 5-19: Average number of crashes per year vs Grouped test scores.

Average crash rates were also compared against driver licence types; Figure 5-20 summarises the breakdown. While again, the relative crash risk for learner and restricted licence holders is as might be expected, there is a particular concern for those holding overseas licence or having converted an overseas licence to a New Zealand one. Again though, there is the caveat that this comes from a small sample of just 15 respondents and, intriguingly, the five with converted licences actually had the highest average test scores.

Accs per Yr	Lic. type	
0.19	NZ Learners	
0.26	NZ Restricted	<<
0.09	NZ Full	
0.33	Valid o'seas licence	<<
0.41	Converted o'seas	<<

Figure 5-20: Average number of crashes per year vs Driver licence type.

5.5 Other issues identified by survey participants

At the end of the survey, participants were asked "are there any aspects of road rules or traffic signs/markings/signals that you find confusing while driving?" Excluding those who responded with variations of "no", 185 people responded to this question and these responses were categorised

allowing up to two categories per respondent, as some people included multiple ideas in their responses. Table 5-2 describes the categories along with any prevalent sub-themes and insightful quotes from participants, plus a count of the responses per category.

Table 5-2: Categories of responses to "road rules or traffic signs/markings/signals that you find confusing while driving" question

Category	Count
Admit some level of confusion, but no details given	36
Sign / marking meaning	28
Give way rules • Multiple references to the survey question scenarios, especially uncontrolled cross roads • Giving way when there's no right turn arrow	21
Driving in unfamiliar environments / TCDs not encountered before / Rules applied infrequently • Often cited as the underlying reason for some of the other confusion categories • Several responses from those who live in towns and feel confused when occasionally driving in cities.	21
Signs / markings - perceived flaws • Often in relation to bus lanes, speed limits, or visibility issues • Too many signs in general or in certain locations	17
Roundabouts • Give way rules at roundabouts • Indicating at roundabouts • Multiple lanes / lane changes at roundabouts	17
Complaints - other road users • Other drivers not following rules (e.g. speed, alcohol, indicators, orange traffic lights) • Single mentions of: foreign drivers, families living along state highways, and cyclists with no lights	14
Bus lanes / signals - meaning or use • Those not familiar with bus lanes / signals • Those who do encounter bus lanes / signals but find them confusing	10
Visibility issues • "I just think the signs should be bigger so they are easier to see/read." • "The beams of other cars confuse me as for a moment I lose all focus" • "The changing speed signs in towns are having people looking up and is a danger to children, etc as they may be crossing and not seen."	10
Lane use / merging • Turning at intersections / roundabouts with multiple departure lanes • Which lane to be in while driving on multi-lane roads • "Keeping to the left lane when not overtaking on multi-lane roads"	7
Temporary traffic management • "Too many road cones and hazard signs when work is being done, you start to ignore them after a while" • "Work zone temporary speed limit signs when no one is present - are they still as applicable as permanent speed limit signs?"	7
New TCDs / Rules • "I need regular updating as signs etc change quite regularly" • "Changing to new signs can be confusing"	5
Complaints - speed limits / traffic calming devices	4

Category	Count
Intersections (without specific mention of rules or TCDs)	4
Rule Doesn't apply to me (e.g. don't drink, don't drive)	4
Speed limits / traffic calming devices (assumed confusion rather than complaint)	4
Doesn't apply to me (e.g. don't drink, don't drive)	3
Māori language on signs (unclear if these comments were confusion or solely complaint)	3
Pedestrian crossings	3
Survey feedback	3
Confusion due to physical or cognitive conditions • Specifically, colour-blindness, dyslexia	2
Crash / hazard response	2
Cycle lanes / cycleways / cycle markings / cycle signals	2
Response unclear	1
Retrospective correcting a question	1
Other categories (1 comment each): • Busy roads • Clearways • Complexity • Complaints - lack of enforcement • Drink driving / alcohol limits • Passing cyclists • Railway crossings • Right turn arrows • T2 lanes meaning / use	8

5.6 Discussion of survey results

While there were a few notable trends identified in the driver knowledge survey results, there were also several situations where no clear pattern was identified.

A key finding was that (contrary to the initially hypothesised theory) the number of years someone had held a drivers' licence was not a strong determinant of related knowledge about Road Rules and TCDs. Only a slight dip in average scores at about 20 years of holding a licence suggests some reminding at that age (and maybe at every 10-year renewal interval) might be useful.

Respondents seemed to perform slightly less well regarding newer Road Rules / TCDs, again probably suggesting a need to regularly remind people of newer Rule changes. It was somewhat worrying too that those who had the lowest knowledge of Rules/TCDs tended to be linked with higher crash risks. Encouragingly though, respondents did seem to understand better the more safety-critical rules. While it might be useful to remind people of some of the value-based rules, arguably they are less safety critical in most situations.

It is worth noting that, for obtaining a learner licence, a driver needs to correctly answer at least 32 out of 35 test questions (i.e. 91.4%) and yet the vast majority of survey respondents got much lower percentages in this survey. While the wording of the questions used in our survey was somewhat different to that of the learner theory test, and the sampling of question subject matter and difficulty may not be comparable, the scores for this survey suggests that the standard learner test is not necessarily a good proxy for wider knowledge and practical ability.

Given the reported crash risks, the survey results identified some groups that may be worth targeting for more focused updating or training around road rules and TCDs:

- Overseas licence holders (or converted from overseas)

- People recently returned from living overseas

The survey data suggests that, rather than knowledge or comprehension, it may be more a case of driver attitudes, behaviours, and skills that influences a driver's safety performance. This will be explored further in Section 6, but a Dec 2024 NZAA survey of young drivers (up to 25 years) and their driver licensing and learning to drive history identified some similar trends in this area.[6]

A series of questions in the NZAA survey asked whether in the past 3 months, participants had done any of thirteen listed poor driving behaviours ranging from alcohol/drug offences, mobile phone use, speeding, seatbelt use, or ignoring licence restrictions. A "relative risk score" was determined for each respondent based on the assumed combined frequency of the behaviours and this was compared against the stated numbers of crashes involved and tickets received.

The relationship between driving risk scores and corresponding ticketing and crash histories shows up quite strongly, as seen in Table 5-3; overall, a history of more frequent unsafe driving behaviours correlates strongly with the frequency of tickets received and crashes occurred.

Table 5-3: Driving behaviour risk score vs ticket/crash frequency.

Sample size	*Relative Risk Score*	*Ave no. tickets*	*Ave no. crashes*	*Combined total*
90	***0***	0.21	0.09	***0.30***
201	**Between 1 and 9**	0.28	0.21	***0.50***
325	**Between 10 and 49**	0.38	0.30	***0.67***
261	**Between 50 and 199**	0.62	0.44	***1.06***
130	**Between 200 and 499**	0.74	0.72	***1.45***
24	**500+**	0.88	0.71	***1.58***

The role of driver knowledge versus driver skills also shows up when comparing the relative pass rates at various licence stages. Data from NZTA across 2014-23 shows that about 75% of drivers passed their learner licence on the first attempt, about 54% passed their restricted licence test on the first attempt, and about 70% passed their full licence on the first attempt.

Those results appear to align with the respective context for each stage: the learner test is *theory*-based only (making it easier to revise for), the restricted test involves a *practical* driving test (which requires more skill in a dynamic environment), and the full test also involves a practical test, but the drivers will have had more driving experience by then.

[6] More details can be found in the ViaStrada report "Driver training and licensing progression: Effect on crash risk and traffic offences", partial report prepared for AA Research Foundation, November 2025.

6 Options for improving driver knowledge

The literature scan and a review of New Zealand post-licence driving interventions identified some options for developing driver knowledge. These were further developed within the project team and then tested in workshops with industry experts and drivers. The aims of workshops were to:

1. Gather general feedback from experts and drivers on their views about the quality of driver knowledge in New Zealand, its maintenance across the driving life cycle, and common knowledge gaps they had noticed.
2. Test knowledge development options in terms of:
    - Effectiveness: the likelihood of an option improving driver knowledge consistently across the target group.
    - Feasibility: the likely planning, infrastructure, resourcing, and cost associated with an option.
    - Acceptability: the likelihood of the driving public viewing an option as a desirable and/or reasonable requirement.

6.1 General feedback on NZ driver knowledge

Feedback from the workshops provided a useful insight into perceptions about New Zealand driver knowledge in general. The views of SMEs and the general driving public are summarised below.

6.1.1 Subject matter expert feedback

SMEs highlighted the importance of considering driver-knowledge improvement options within a safe-system view of road safety. One noted that "*using knowledge interventions to improve road safety is challenging, given the lack of evidence for the role of knowledge in complex systems*." The key point raised was that any investment in knowledge interventions needs to be weighed against other investments with a stronger evidence base for reducing crashes (e.g., speed interventions or improving attitudes towards risky behaviours). However, another SME also pointed out the lack of information (also identified in this review) about the role of knowledge in crashes.

Questions were raised about the baseline knowledge drivers gained through sitting the driving knowledge test to get their learner licence. Several driving instructor SMEs felt that it is possible to memorise the questions to pass the test and then not retain the information, '*learner drivers just memorise the rules, they don't necessarily understand them. When it comes to applying them, it falls out of their head.'* This suggests that for some, knowledge of road rules, signs, and markings may be incomplete even shortly after attaining their learner licence. The survey findings also reinforced this point given the mean score was well below what is needed to pass the learner licence test.

SMEs noted a contrast between learner and experienced drivers whereby learners may have higher 'theoretical' knowledge but poor applied knowledge, whereas experienced drivers may have lower 'theoretical' but stronger applied knowledge. This may mean that experienced drivers have had greater cumulative exposure to a range of scenarios and are possibly more reliant on picking up cues and following other drivers. This also may lead to incorrect behaviours being picked up that are not corrected in some circumstances. They also felt that once drivers are licensed, few are interested in improving their knowledge or skills, 'there's no interest in being a better driver, they're quite happy with just being licensed'. This suggests that voluntary knowledge improvement options are unlikely to get high uptake.

For both learner and experienced drivers, SMEs felt that the relevance of the knowledge/rule to everyday driving influenced the likelihood of it being remembered. This means that rules related to urban driving, for example, may not be remembered by those who primarily drive rurally. One SME

offered the following example, '*I did my learner licence for a motorcycle licence and memorised everything, promptly did the test, walked out and forgot it all as it had no relevance to me at that time*.'

The way knowledge is communicated was also considered to be a factor in whether it is retained. The example provided related to following distance, with an SME commenting that the '2 or 4 second rule' (depending on conditions) is much more memorable than a specific following distance.

In terms of the knowledge of specific driver groups, SMEs noted variation in the capacity of drivers to read signs and interpret them due to language barriers, disability, and cognitive decline. The example of refugee drivers was raised. It was noted that despite passing a learners' test, refugees tend to have poor application of road rules and apply driving behaviours from overseas to New Zealand roads. This can raise risks when they are learning and adapting to driving in New Zealand. One SME gave the example of the high crash rate for refugee drivers in Ashburton.

SMEs who have been involved in regions where significant changes such as road space reallocation have occurred found that even though there was no road rule change, drivers experienced stress/ higher cognitive load processing the infrastructure added to intersections. *'In Wellington we rolled out a cycle network at a rapid pace. While not changing the road rules, this is creating some quite different intersections. People are getting confused about how the road rules apply at these new style intersections causing a lot more thinking, delayed decisions, and stress.'*

6.1.2 Driver feedback

In the driver workshop there was a general perception that New Zealand drivers have poor knowledge particularly around give way rules at crossroads, signalling at roundabouts, checking mirrors/blind spots, maintaining following distances, merging, and driving around trucks. Lack of rule compliance was also raised, with a perception that some people chose to disobey various rules to suit their own needs/attitudes. Examples given included speeding, using a phone while driving, and changing lanes without indicating.

Drivers felt that there was low motivation for drivers to improve their knowledge in the absence of a specific requirement for them to do so, '*I don't think that most people would go to a website [to seek knowledge], when they can just continue with their behaviours*.' Incentives were considered key to getting people to take time to improve their knowledge.

The older cohort within the workshop noted the limited driver training/knowledge provided at the time they went through initial licensing, suggesting that the completeness of their knowledge wasn't tested at the time. Another concern raised around age was about guidance/knowledge for individuals and families about when and how older drivers should transition away from driving.

6.2 Knowledge improvement options

Several knowledge improvement options, in a range of permutations, were tested at expert and driver workshops. Six of these options are presented below. They were selected as they attracted the most discussion across the workshops and provide a broad range of approaches for consideration. Each is discussed in terms of perceived effectiveness, feasibility, and acceptability as defined in the report method section. The criteria used to assess these options is presented in Appendix D.

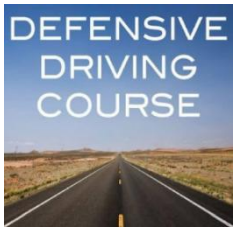
KNOWLEDGE IMPROVEMENT OPTIONS

Knowledge Communication Campaigns

Purpose: To **encourage** drivers to refresh driving knowledge, or to learn new rules/signs/markings (e.g., NZ give way rule changes).

Delivery: Any media that can deliver short, focused messages.

Content: NZ road signs, markings, and rules. Focus on those less commonly encountered, where change has occurred in the previous 5 years.



Knowledge Checks in Driver Training

Purpose: To **ensure** that drivers have adequate driving knowledge (leveraging advanced driver training as a delivery option).

Delivery: Delivery could be built into training in any way that fits the style of the course. Should include knowledge check (quiz or similar).

Content: Key knowledge areas, particularly rules, signs, and markings that are safety critical, infrequently encountered, or introduced recently.

Optional Knowledge Refreshers or Courses (general or older drivers)

Purpose: To **encourage** and incentivise drivers to refresh driving knowledge.

Delivery: A wide range of delivery options. Could be marketed and delivered collaboratively by road safety organisations. Could include insurance discounts.

Content: NZ road signs, markings, and rules, focusing on those less commonly encountered, or where change has occurred in the previous 5 years.

Knowledge test for tourists and new or returning to residents

Purpose: To **ensure** tourists and new/returning residents have safety critical driving knowledge.

Delivery: Range of options, for example, short online intervention and knowledge test with certificate of completion to provide to rental agencies (note: no verification built into this process).

Content: NZ road signs, markings, and rules, focusing on the most safety critical, and any that differ significantly from other countries.

Compulsory Online Refresher at Relicensing

Purpose: To **encourage** drivers to refresh their driving knowledge at key points in the driving life-cycle (e.g., every 10 years at licence renewal).

Delivery: Short (20 minute) online game/quiz-based driver knowledge intervention and an online test that provides a certificate of completion to be presented at relicensing.

Content: NZ road signs, markings, and rules, focusing on those less commonly encountered, or where changed has occurred in the previous 5 years.

Compulsory Online Test at Relicensing

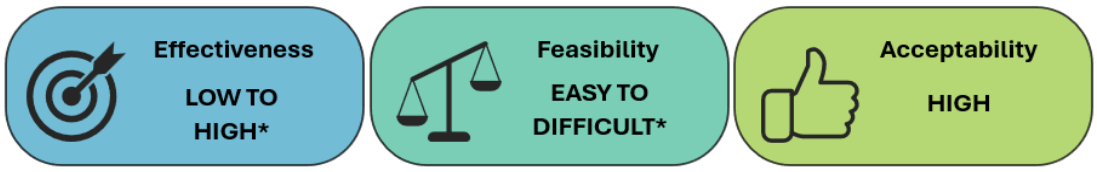
Purpose: To **ensure** all drivers have adequate driving knowledge at key points in the driving life-cycle (e.g., every 10 years at licence renewal).

Delivery: Short (20 minute) online game/quiz-based driver knowledge intervention and online test that provides a certificate of completion to be presented at relicensing to enable driver to take a formal test at licence centre.

Content: NZ road signs, markings, and rules, focusing on those less commonly encountered, or where changed has occurred in the previous 5 years.

6.3 Options analysis

6.3.1 Knowledge communication campaigns



Both SMEs and drivers raised concerns about the potential reach and impact of communication campaigns. Although, interestingly, drivers were able to give several examples of old campaigns that had 'stuck with them' such as the Give Way rule change campaign in 2012.

'I think the campaigns in the past have been particularly successful with me. You can't miss them.'

"I still remember the 'top of the T comes before me'. I wasn't even a driver at the time, but it's stuck with me."

SMEs with experience in rolling out knowledge communications campaigns indicated that higher levels of resource than might be anticipated are required to run a very effective campaign. One commented that the give way rule change campaign required a team of six working full time for 18 months and additional wider monthly stakeholder meetings with Police and other organisations. It was noted that most knowledge type campaigns do not have this level of resource available.

It was felt that resource/effort for communications campaigns should be considered strategically, with high-risk changes such as road rules being given a lot of resource compared to knowledge refreshers/general education campaigns because these may have low effectiveness unless the knowledge is highly relevant to the target audience. Further to this, it was noted that campaign effectiveness is challenging to measure because while measuring understanding of a message is simple, linking this to behaviour change is challenging.

6.3.2 Knowledge checks in driver training

Poor ratings for option effectiveness were given both by SMEs and drivers. Both groups felt that uptake of driver training courses, particularly post-licensing is very low and therefore this approach would achieve little reach for a knowledge intervention.

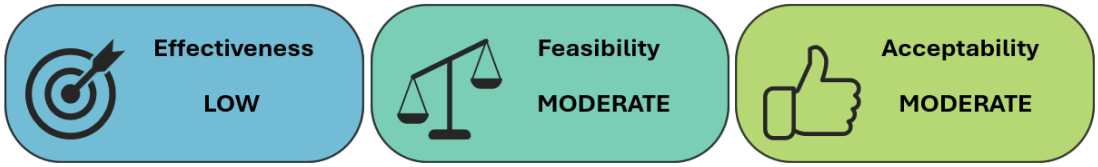
'It can be difficult to get uptake in an attention poor world.'

SMEs felt that it would be difficult to get younger drivers to engage. However, they felt that workplace courses can be effective and get greater reach because they can lead to a culture of talking about road rules and road safety.

Drivers noted that advanced driver courses often are not feasible in terms of time for those with full-time jobs and families, and they are also costly. Based on comments throughout the workshop, it could be inferred that even incentives may not be sufficient to encourage drivers to expend their time on a course. Although drivers agreed that workplace interventions may get more uptake.

* With very high investment knowledge campaigns can be effective but this usually not feasible. With low levels of investment knowledge campaigns tend to be highly feasible is usually not effective.

6.3.3 Optional knowledge refreshers or courses



Both SMEs and drivers felt that optional knowledge refresher interventions were unlikely to be effective because they wouldn't reach many drivers. Driver comments indicate that time-poor drivers are unlikely to feel the benefits of completing the intervention outweighs the costs, even if incentives are offered.

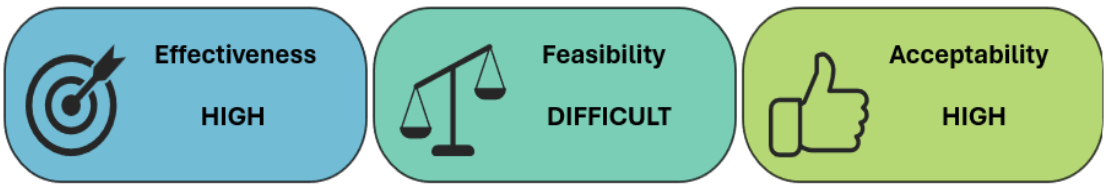
'There is already stuff all over the internet, but unless there is a reason for people to access it, they won't.'

SMEs noted that there are existing courses that target specific groups such as older drivers and existing online resources such as the 'Drive' website provided by NZ Government / NZTA / ACC. They felt there is potential for old driver courses to be structured differently to get more benefit, including targeted knowledge refreshers, currently 'it's generally a morning tea with a couple of questions and arguments about road rules.' In terms of feasibility, the existing funding pool and structure to build into make this approach one of the more feasible options.

Some felt that there are key life points where drivers may be more likely to engage with optional knowledge refreshers, most particularly:

- Older drivers who may have more intrinsic motivation to take part in courses because they fear losing their licence. In the case of older drivers, knowledge imparted should go beyond road rules, signs, and markings. They would also benefit from effective information about the stage of transitioning away from driving due to medical limitations.
- New parents for whom road safety may become a more salient issue as they prepare for/raise young children.

6.3.4 Knowledge test for tourists/people with visas/returning to NZ



SMEs quickly identified a major feasibility barrier with this option. They noted that requirements for international drivers are tied to trade agreements that include agreed barriers to entry to NZ. Any option related to limiting international drivers' ability to drive in New Zealand (through testing) would likely infringe these agreements and therefore be very politically infeasible to achieve.

Despite this, there was strong support in principle for this option and a perception that it is likely to be effective (noting that these workshops did not include any tourists). Drivers in particular strongly supported a familiarisation test and perceived New Zealand roads to be vastly different and more difficult than elsewhere in the world.

Drivers suggested this test could be part of the car hiring process and suggested different tiers of testing for drivers coming from different locations. For example, those travelling from Australia would have minimal requirements, whereas those travelling from countries who drive on the right side of the road might have higher requirements. The incentive for rental companies to implement this requirement would need to be worked through.

6.3.5 Compulsory knowledge refresher at relicensing (not linked to licence retention)

While drivers viewed this option very favourably, SMEs views were more moderate. Drivers felt that an option that had a level of compulsion through a link to licence renewal would provide sufficient motivation for drivers to complete the refresher.

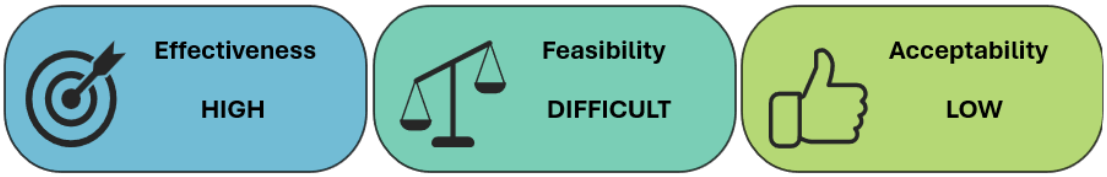
Drivers felt that the providing the refresher online would increase its acceptability by making it more convenient and ensuring that it doesn't have a financial effect (e.g., through lost work time).

'I like the idea of the online knowledge refresher as things do change, and it might be a shock to some people and give them the opportunity to realise where their knowledge is lacking.'

Drivers also felt that using the refresher to provide information and correct answers on questions that people got wrong would provide further benefit.

SMEs were more restrained in their support for this option, although they still felt it could provide some benefit. The concern expressed was around the political will to make changes of this type to the licensing system, especially something as extensive as producing a new intervention from scratch.

6.3.6 Compulsory knowledge test at relicensing (linked to licence retention)



Support for linking passing a knowledge test to licence retention was very low. While this option was considered very likely to be effective in refreshing knowledge, there were significant concerns about the feasibility and a very low level of acceptability amongst drivers.

These views were expressed both in terms of a system that required all drivers to pass a knowledge test at relicensing and those aimed at older drivers that might include retesting knowledge in combination with medical checks such as cognitive tests.

SMEs felt that logistically this kind of approach would be a very big undertaking that would be unlikely to provide the kind of benefits required to make the case from a cost/benefit perspective. Drivers' greatest concern in terms of acceptability was that the approach would place an additional barrier at licensing and could substantially affect someone's life if they failed the test. However, an interesting contrasting view was provided by one participant who considered that '*if you can't pass the knowledge test you shouldn't be on the road, and that it's a privilege to drive, and that comes with responsibilities*.' This does raise an interesting point where driving is seen by many as a civil right, and yet it is a safety critical activity with the potential for considerable harm when things go wrong.

6.3.7 Other options identified during workshops

A few additional options were identified during workshops and are listed below:

- **Making the learner licence test more applied and broader in its focus**: SMEs suggested that having a more applied learner licence may have a high impact. It was noted that there is much room for improvement in the foundational learning that novice drivers receive and take through their life (across multiple aspects of the Graduated Driver Licensing System). There is an opportunity to take a much more holistic and structured approach to education/ training /licensing covering good driving habits, attitudes, and practices as is done in other countries such as Australia, the United Kingdom, and Ireland. The Australian learner licence was suggested as an example because it has a range of education modules and associated quizzes. It is more difficult to rote learn and focuses on attitudinal and high-risk behaviours.
- **Enforce / increase penalties for incorrect behaviours**: Some drivers felt that enforcement would be more likely to achieve behaviour change, '*people learn very fast when they are fined*.'

6.4 Discussion of options to improve driver knowledge

A range of options for improving driver knowledge were identified and tested during this phase of the project, with the views of SMEs and drivers being gathered. When responses across all of the options are considered, the following general themes emerge:

- SMEs felt that the implementation of any knowledge focused interventions must be weighed carefully against alternative investments in road safety from across the safe system. There may be other areas where a greater cost/benefit can be obtained. Drivers, however, did see some benefit to knowledge interventions due to road environment changes over time (although they felt that attitudes and applied knowledge may be bigger issues).
- There appeared to be a general view that knowledge could be more effectively embedded during initial driver licensing. Some felt that the current system allowed people to 'rote learn' for the test and then quickly forget. Systems such as Australia and California were highlighted as potential exemplars.
- Completely optional interventions were considered unlikely to be effective due to low uptake levels. There was a general theme that people were unlikely to go out of their way to participate in initiatives.
- By contrast, linking re-licensing to passing a knowledge test was very unacceptable to drivers who felt this could provide a significant re-licensing barrier and that failing could have a large impact on people.
- The option perceived to be a 'fair balance' was the compulsory knowledge test at relicensing that was not linked to licence retention. In this case, drivers felt the compulsion of having to present a completion certificate was sufficient to achieve uptake but that the option was more feasible and acceptable.
- There appeared to be some support for targeting specific driver groups, particularly tourists and refugees who were perceived to be more likely to have knowledge gaps. The same system that might be used for licensing could be employed.

7 Conclusions & Recommendations

This project aimed to assess how driver knowledge evolves as drivers progress through different life stages, moving beyond initial training and licensing, and as road environments and vehicle technology changes. It also examined whether gaps in knowledge emerge over time and evidence-based options for developing and maintaining driver knowledge at different life stages.

Knowledge is a foundational component of driver competency but, for established drivers, *applied* knowledge in a range of scenarios and driving attitudes, built from experience, are more important. Attitudes and applied knowledge also appear to have greater safety implications than knowledge or comprehension alone.

However, it is difficult to unpick knowledge deficits in crash data and a nuanced view around contributing factors to crashes is needed, to more comprehensively investigate the role of knowledge in crashes. Crash investigations that seek a deeper understanding of the contributing factors to crashes including the contexts where knowledge deficits about rules, TCDs, or typical environments, would deepen our understanding of the role of knowledge deficits in crash risk.

Few studies have explored interventions to improve driver knowledge throughout the driving life cycle. Most combine skill, attitude, and knowledge training, making it difficult to isolate the impact of knowledge alone. Evidence does suggest that brief, targeted knowledge interventions can be effective and that applying ergonomic principles to design easily understood signs has potential.

While this study did not find a trend of diminishing driving knowledge over time, more recently introduced TCDs, rules, and traffic scenarios are sometimes less understood such as when to enter special vehicle lanes, safely overtaking cyclists, and safely overtaking on two-lane high-speed roads. Likewise, we found that New Zealanders who learnt to drive overseas or returning drivers tended to have lower knowledge of road rules/TCDs, and those with very poor knowledge of rules may be at higher risk of reported crashes. It may also be that drivers are able to focus on the areas of safe driving that matter most, as we found that survey respondents had better knowledge of areas with higher safety implications.

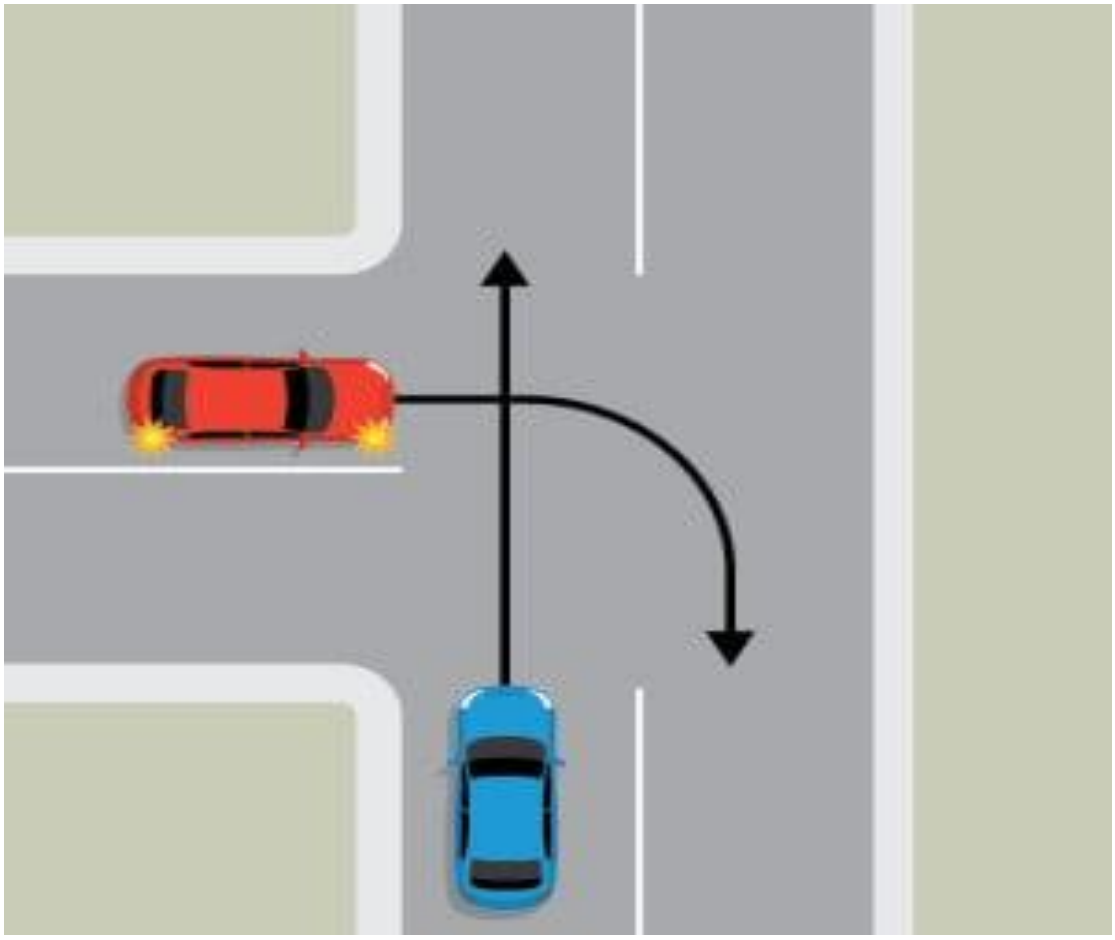
Post-licence driver training has generally been shown to have limited safety effects. However, there is likely to be significant support for knowledge communication campaigns, refreshers at relicensing, and knowledge refreshers or tests for overseas visitors/those who learnt to drive overseas/have recently returned to NZ, although the merits of such activities should be considered alongside other initiatives to improve road safety.

7.1 Recommendations

We propose the following recommendations to address driver knowledge development/ maintenance:

- Improve understanding of the implication of knowledge deficits in crash risk. This may require a more detailed interrogation of crash literature or assessment of crash records and statements by the relevant parties. Alternatively, more deeply exploring drivers' experiences and where they have difficulty understanding how to negotiate various situations (e.g. safely overtaking a cyclist when not dedicated cycling space exists), would be useful to then tailor licensing, training, and communication material.
- Ensure road environments and TCDs are easy to understand and intuitive, so that the impacts of any knowledge deficits are minimised. This might include paying particular attention to the design and placement of signs, markings, and other roadside features, as they appear to drivers, particularly in complex environments.

- The implementation of knowledge-focused interventions must be weighed carefully against other investments in road safety from across the Safe System and road user centred interventions that focus on higher levels of the GDE Matrix, such as values, attitudes, and social norms, which have stronger links to crash risk. However, promising knowledge interventions for the New Zealand context include:
    - **Knowledge communication campaigns** – with significant effort for larger rule changes (such as the earlier give way rule change), and smaller campaigns for other purposes.
    - **Compulsory knowledge refresher at relicensing**, possibly paying particular attention to recent changes and safety critical rules, TCDs, and driving situations. It is unlikely that making license retention dependent on passing a knowledge test would be supported, however.
    - **Focused refreshers, training, or tests of road rules, TCDs, and difficult driving scenarios for overseas visitors and New Zealand residents who have lived overseas**. This would need to consider the requirements, incentives, and potential barriers (e.g. trade conditions that prevent access of visitors to driving in New Zealand). A first step should be reviewing the earlier NZTA Visiting Drivers Programme, to better understand what has already been learned and what initiatives are deemed most useful for ongoing development beyond what is already in place, such as drivesafe.org.nz.
    - **Making initial licence education and testing broader in its focus**, moving beyond rote learning of road rules and TCDs, with more focus on good driving habits, attitudes, and practices. Since post-license initiatives have limited effect on safety outcomes, it seems important to intervene when driving habits are still being developed. This is common practice in other countries such as Australia, the United Kingdom, and Ireland.



8 References

Anstey, K. J., Eramudugolla, R., Kiely, K. M., & Price, J. (2018). Effect of tailored on-road driving lessons on driving safety in older adults: A randomised controlled trial. *Accident Analysis and Prevention*, *115*, 1–10. https://doi.org/10.1016/j.aap.2018.02.016

Ben-Bassat, T. (2019). Are ergonomically designed road signs more easily learned? *Applied Ergonomics*, *78*, 137–147. https://doi.org/10.1016/j.apergo.2019.02.009

Ben-Bassat, T., & Shinar, D. (2015). The effect of context and drivers' age on highway traffic signs comprehension. *Transportation Research Part F: Traffic Psychology and Behaviour*, *33*, 117–127. https://doi.org/10.1016/j.trf.2015.07.009

Borowsky, A., Shinar, D., & Parmet, Y. (2008). The relation between driving experience and recognition of road signs relative to their locations. *Human Factors*, *50*(2), 173–182. https://doi.org/10.1518/001872008X288330

Brashear, A., Unverzagt, F. W., Kuhn, E. R., Glazier, B. S., Farlow, M. R., Perkins, A. J., Hui, S. L., Braslhear, A., & Hui, S. L. (1998). Impaired traffic sign recognition in drivers with dementia The affected group was also test-ed with a neuropsychological battery (NB) designed to. *American Journal of Alzheimer's Disease*, 131–137.

CBC News. (2010). Driving: How well do you know the rules of the road. *CBC News*. https://www.cbc.ca/news2/pointofview/2010/10/driving-do-you-know-the-rules-of-the-road.html

Charlton, S. G. ., & Baas, P. H. . (2006). *Assessment of hazard warning signs used on New Zealand roads: Research Report 288*. Land Transport New Zealand.

Devlin, A., & McGillivray, J. (2016). Self-regulatory driving behaviours amongst older drivers according to cognitive status. *Transportation Research Part F: Traffic Psychology and Behaviour*, *39*, 1–9. https://doi.org/10.1016/j.trf.2016.02.001

Faus, M., Alonso, F., Esteban, C., & Useche, S. A. (2023). Are Adult Driver Education Programs Effective? A Systematic Review of Evaluations of Accident Prevention Training Courses. *International Journal of Educational Psychology*, *12*(1), 62–91. https://doi.org/10.17583/ijep.8805

Fausto, B. A., Adorno Maldonado, P. F., Ross, L. A., Lavallière, M., & Edwards, J. D. (2021). A systematic review and meta-analysis of older driver interventions. *Accident Analysis and Prevention*, *149*. https://doi.org/10.1016/j.aap.2020.105852

Fernandez, J. J., Paringit, M. C., Salvador, J. R., Lucero, P. I., & Galupino, J. G. (2020). Understanding of traffic signs by drivers in the city of Manila, Philippines. *Transportation Research Procedia*, *48*, 3037–3048. https://doi.org/10.1016/j.trpro.2020.08.183

Freed, S. A., Staplin, L., Sprague, B. N., & Ross, L. A. (2024). *State of Knowledge on Older Drivers*.

Hatakka, M., Keshinen, E., Gregersen, N., Glad, A., & Hernetkoski, K. (2002). From control of the vehicle to personal self-control; broadening the perspectives to driver education. *Transportation Research Part F: Traffic Psychology and Behaviour*, *5*(3), 201–215.

Hawkins, H. G., Lancaster, S. M., Rhodes, L. R., President, P. E., & Fette, B. R. (1998). *Helping Drivers Understand Traffic Control Devices: Implementing Research Results* (Issue 512).

Hawley, C. A., Smith, R., & Goodwin, L. (2018). Road safety education for older drivers: Evaluation of a classroom-based training initiative. *Transportation Research Part F: Traffic Psychology and Behaviour*, *59*, 505–523. https://doi.org/10.1016/j.trf.2017.11.009

Hung, Y. H., & Tan, Y. (2024). How symbol and text combine to promote sign comprehension: Evidence from eye-tracking. *Displays*, *83*. https://doi.org/10.1016/j.displa.2024.102709

Kirmizioğlu, E. (2010). *Analysis of Comprehension of Traffic Signs: A Pilot Study in Ankara, Turkey*. Thesis submitted to the Graduate School of Natural and Applied Sciences, Middle East Technical University.

Kirmizioglu, E., & Tuydes-Yaman, H. (2012). Comprehensibility of traffic signs among urban drivers in Turkey. *Accident Analysis and Prevention*, *45*, 131–141. https://doi.org/10.1016/j.aap.2011.11.014

Li, Q., & Tay, R. (2014). Improving drivers' knowledge of road rules using digital games. *Accident Analysis and Prevention*, *65*, 8–10. https://doi.org/10.1016/j.aap.2013.12.003

Lindstrom-Forneri, W., Tuokko, H. A., Garrett, D., & Molnar, F. (2010). Driving as an everyday competence: A model of driving competence and behavior. *Clinical Gerontologist*, *33*(4), 283–297. https://doi.org/10.1080/07317115.2010.502106

MacGregor, J. M., Freeman, D. H., & Zhang, D. (2001). A traffic sign recognition test can discriminate between older drivers who have and have not had a motor vehicle crash. *Journal of the American Geriatrics Society*, *49*(4), 466–469. https://doi.org/10.1046/j.1532-5415.2001.49095.x

Maulina, D., Siregar, E. S., Rachma, T. A., Nashria, S. A., & Irwanda, D. Y. (2022). How effective is training for improving traffic sign comprehension? Examining the interaction between training and sign type among motorcyclists. *IATSS Research*, *46*(4), 614–622. https://doi.org/10.1016/j.iatssr.2022.11.002

Ng, A. W. Y., & Chan, A. H. S. (2008). The effects of driver factors and sign design features on the comprehensibility of traffic signs. *Journal of Safety Research*, *39*(3), 321–328. https://doi.org/10.1016/j.jsr.2008.02.031

Ng, A. W. Y., & Chan, A. H. S. (2011). Investigation of the effectiveness of traffic sign training in terms of training methods and sign characteristics. *Traffic Injury Prevention*, *12*(3), 283–295. https://doi.org/10.1080/15389588.2011.556171

Oviedo-Trespalacios, O., Truelove, V., Watson, B., & Hinton, J. A. (2019). The impact of road advertising signs on driver behaviour and implications for road safety: A critical systematic review. *Transportation Research Part A: Policy and Practice*, *122*, 85–98. https://doi.org/10.1016/J.TRA.2019.01.012

Rodrigues, M. A. F., Macedo, D. V., Serpa, Y. R., & Serpa, Y. R. (2015). Beyond fun: An interactive and educational 3D traffic rules game controlled by non-traditional devices. *Proceedings of the ACM Symposium on Applied Computing*, *13-17-April-2015*, 239–246. https://doi.org/10.1145/2695664.2695915

Sangrar, R., Mun, J., Cammarata, M., Griffith, L. E., Letts, L., & Vrkljan, B. (2019). Older driver training programs: A systematic review of evidence aimed at improving behind-the-wheel performance. *Journal of Safety Research*, *71*, 295–313. https://doi.org/10.1016/j.jsr.2019.09.022

Schulz, P., Labudda, K., Bertke, V., Bellgardt, S., Boedeker, S., Spannhorst, S., Kreisel, S. H., Driessen, M., Beblo, T., & Toepper, M. (2020). Age effects on traffic sign comprehension. *IATSS Research*, *44*(2), 103–110. https://doi.org/10.1016/j.iatssr.2019.10.001

Shinar, D., Dewar, R. E., Summala, H., & Zakowska, L. (2003). Traffic sign symbol comprehension: A cross-cultural study. *Ergonomics*, *46*(15), 1549–1565. https://doi.org/10.1080/0014013032000121615

SYSTRA. (2022, August 31). *The most important model – Human Factors in ETCS design*. Https://Www.Systra.Com/Australia/News/the-Most-Important-Model-Human-Factors-in-Etcs-Design/.

Taheri, F., Torshizi, Y. F., Saremi, M., & Pronin, M. (2022). Effects of traffic sign design and personal characteristics on the usability of traffic signs. *Work*, *71*(4), 917–925. https://doi.org/10.3233/WOR-213636

Tay, R. (2010). *Alberta Drivers' Knowledge of the Road Rules.* .

Ward, S. J., Wogalter, M. S., & Mercer, A. W. (2004). Comprehension and Training of International Road Signs. *Human Factors and Ergonomics Society 48th Annual Meeting*.

Wickens, C. D., Lee, J., Liu, Y. D., & Gordon-Becker, S. (2003). *Introduction to Human Factors Engineering* (Second). Prentice Hall PTR.

Wontorczyk, A., & Gaca, S. (2021). Study on the relationship between drivers' personal characters and non-standard traffic signs comprehensibility. *International Journal of Environmental Research and Public Health*, *18*(5), 1–19. https://doi.org/10.3390/ijerph18052678

Appendix A Literature Review Search Strategy and Terms

A.1 Search strategy

The search terms outlined below were used as the basis of a literature search completed using Google Scholar. The search was tightly focused on retention of knowledge about road rules and TCDs, but covered the full driving life-cycle, and considered findings from commercial driver studies.

To manage the scope while still ensuring coverage, an initial search was completed for seminal papers related to each question area (e.g., systematic reviews or foundational research). Reference sections of these papers were checked to identify any further key papers. Following this, further scans for other relevant studies were completed.

To identify any grey literature and to ensure that the scan had considered the work of the most relevant research and government institutions, a specific search of databases at the following organisations was completed:

- New Zealand Transport Agency
- New Zealand Ministry of Transport
- Monash University Accident Research Centre (Australia)
- National Highway Traffic Safety Authority (United States)
- Swedish National Road and Transport Research Institute (VTI)
- Department for Transport (UK)

A.2 Search terms

Based on the research questions, a set of search terms were developed outlined below:

- Driver education
- Driver training
- Road rules knowledge
- Driver competence
- Traffic sign comprehension/knowledge
- Road marking comprehension/knowledge
- Road rules comprehension/knowledge
- Road signs
- Road markings
- Road rules
- Driver licensing
- Older drivers
- Younger drivers
- International drivers
- Commercial drivers
- Re-licensing training
- License renewal knowledge test
- License renewal training
- Road rule change communication
- Road sign change communication
- Innovations in driver education
- Innovations in commercial driver education

Appendix B Summary of historical changes to NZ TCDs and Road Rules 1988 - 2024

Summary of notable changes found, in descending chronological order:

***** *indicates date that the Rule comes into force, not the date it was signed off*

Date*	**Regulatory instrument(s)**	**Feature(s) being introduced or changed**
Mar 2024	NZ Gazette Notice 2024-au1214	Introduce cycle warning sign supplementary plates for **MERGING** and **CROSSING**.
Oct 2023	Land Transport (Road User) Amendment Rule 2023	Add a definition for **clearways** and introduce rules restricting parking in them.
Apr 2023	NZ Gazette Notice 2023-au1409	Trials of two-aspect **combined pedestrian & cycle signals**.
Mar 2023	Land Transport (Drug Driving) Amendment Act 2022	Introduces offences and penalties around driving while **under the influence of drugs**.
Jun 2022	NZ Gazette Notice 2022-au2170	Introduce **Rural Intersection Speed Zone Variable Speed Limit** signs.
Apr 2022	Land Transport Rule: Traffic Control Devices (Kura/School Signs) Amendment 2022	Replace "SCHOOL ZONE" supplementary signs with **"KURA SCHOOL"** supplementary signs.
Mar 2022	NZ Gazette Notice 2022-au756	Introduce **goods vehicle (GV)** lane signs and markings.
Oct 2021	NZ Gazette Notice 2021-au4249	Introduce **shared path behavioural** markings and **cycle loop detection** markings.
May 2021	Land Transport Rule: Traffic Control Devices Amendment 2021	Introduce new supplementary plates for **cyclists merging** at temporary roadworks.
Apr 2021	NZ Gazette Notice 2021-au1615	Introduce **MARAE** pedestrian warning sign.
Aug 2020	Land Transport Rule: Traffic Control Devices Amendment 2020 NZ Gazette Notice 2020-au3532	Introduce provisions for **roadway art** markings on lower risk environments. Introduce **contra-flow cycling** (left-right) signs.
Jan 2020	Land Transport (Wheel Clamping) Amendment Act 2019	Introduce rules and penalties around **wheel clamping** incorrectly parked vehicles in private areas.
Jun 2019	Land Transport Rule: Traffic Control Devices Amendment 2019	Define **bus-only lanes** and **heavy vehicle lanes**. Revoke Limited Speed Zone (**LSZ**) signs (see Jul 2009).
Nov 2018	NZ Gazette Notice 2018-au5600	Introduce new supplementary signs for **giving way to cyclists and pedestrians** at crossings/intersections. Introduce **cyclists on narrow bridge** advisory speed sign. Introduce **contra-flow cycling** (up-down) signs.
Jun 2018	NZ Gazette Notice 2018-au3033	Trial of **Rural Intersection Speed Zone Variable Speed Limit** zones.

Date*	Regulatory instrument(s)	Feature(s) being introduced or changed
Apr 2018	NZ Gazette Notice 2018-au1574	Trials of two-aspect **cycle "Barnes Dance" signals**.
Sep 2017	Land Transport (Road User) Amendment Rule 2017 Land Transport Rule: Traffic Control Devices Amendment 2017	Define **electric vehicles** (EVs) and allow them to use bus or transit lanes where signed and to use the "B" traffic signal if applicable. Introduce signs and markings for **EV** lane use and charging station parking.
Aug 2017	Land Transport Amendment Act 2017	Introduce regulations around **small passenger service vehicles** (e.g. Uber) as an alternative to taxis.
Jul 2017	NZ Gazette Notice 2017-au2557	Trial of **directional cycle traffic signals**.
Apr 2017	NZ Gazette Notice 2017-au1661 NZ Gazette Notice 2017-au1804	Introduce **heavy vehicle lane** markings. New **Cycle path crossing** signs/markings over driveways.
Dec 2016	Land Transport (Road User) Amendment Rule 2016 Land Transport Rule: Traffic Control Devices Amendment 2016	Require motorists to stop or give way to **cyclists on a path crossing the road** controlled by a stop/GW sign. Introduce **cycle "sharrow"** markings.
May 2016	NZ Gazette Notice 2016-au3006	New **cycle hook turn** signs ahead of intersections.
Dec 2014	Land Transport Amendment Act (No 2) 2014	Reduce the **maximum legal breath/blood alcohol limits** from 400 to 250µg/L breath and 80 to 50mg/L blood.
Dec 2013	NZ Gazette Notice 2013-au7975	Trial of **cycle "sharrow"** markings.
Nov 2013	Land Transport (Road User) Amendment Rule (No 2) 2013	Extend the mandatory use of **child restraints** to children under 7 yrs (previously under 5 yrs).
Mar 2012	Land Transport (Road User) Amendment Rule 2011	Change the **Give Way rules** to give priority to vehicles turning left, and to vehicles on the non-terminating road.
Oct 2011	Land Transport (Road User) Amendment Rule 2011	Allow cycle, moped & motorcycle riders to use the **"B" traffic signal** when lawfully in a bus lane. Require drivers **entering/exiting driveways** to give way to users of a shared or cycle path.
Aug 2011	Land Transport (Road Safety and Other Matters) Amendment Act 2011	Increase the **minimum age for driver licensing** from 15 to 16 years old. Require drivers under 20 years old to have **zero alcohol** in their system while driving. Introduce provisions around the use of **alcohol interlock devices**.
Apr 2011	Land Transport Rule: Traffic Control Devices Amendment 2010	Introduce **countdown pedestrian signals** and rules around their operation. Addition of **pedestrian symbol marking** for paths. Introduction of new modular components to define **parking sign** restrictions and requirements
Feb 2011	NZ Gazette Notice 2011-au647	Introduce a **Shared Zone** sign.
Mar 2010	NZ Gazette Notice 2010-au1566	Introduce a **No Cruising Zone** sign.

Date*	Regulatory instrument(s)	Feature(s) being introduced or changed
Nov 2009	Land Transport (Road User) Amendment Rule 2009	Define a **mobile phone**, and prohibit their use while driving, unless the phone is fixed to the vehicle. Allow cyclists to make **hook turns** at intersections. Exempting cyclists from using **arm signals at roundabouts** if impracticable to do so. Stating obligations towards riders of **mobility devices and wheeled recreational devices** at intersections/crossings. Introduce rules around using **shared paths**, particularly regarding speed, giving way, and considerate behaviour.
Jul 2009	Land Transport Rule: Setting of Speed Limits Amendment 2007	Require RCAs to review all **limited speed zones** by Jul 2009 and replace them with another permanent speed limit.
Jan 2008	Land Transport (Road User) Amendment Rule (No 2) 2007	Prohibiting unauthorised parking in any parking area reserved for **disabled persons**.
Feb 2007	NZ Gazette Notice 2007-au523	Introduce **ramp signal** traffic signs.
Jan 2006	Land Transport Amendment Act 2005	Define a **mobility device** (prev. “invalid carriage”), which can be declared as not a motor vehicle.
Feb 2005	NZ Gazette Notice 2005-au1093	Add a **GIVE WAY supplementary plate** below the R2-3 Roundabout triangle.
Sep 2005	Land Transport (Road User) Amendment Rule 2005	Allow for mopeds to be used in **bus and transit lanes**.
Feb 2005	Land Transport (Road User) Rule 2004	Introduce **special vehicles lanes** (cycle, bus, transit) and rules around their use. Introduce **“wheeled recreational devices”** and rules around their use. Remove the requirement for cycle riders to use a **“reasonably adequate cycle track”** where available.
May 2004	Traffic Amendment Regulations (No 2) 2004	Increase the **speed limit for heavy motor vehicles** towing a trailer or trailers from 80 to 90 km/h.
Jan 2001	Traffic Amendment Regulations 2000	Introduce rules related to **school crossing points**.
Feb 2000	NZ Gazette Notice 2000-au1189	Introduce a **KEEP LEFT UNLESS PASSING** sign.
Apr 1998	Traffic Amendment Regulations 1998	Introduce **“B” traffic signals** for buses. Introduce **bicycle traffic signals**. New front/rear **lighting and reflector** requirements for bicycles. Introduce **pedestrian crosswalk signals** with red/green human figures instead of WAIT/CROSS wording. New **SLOW VEHICLE BAY** and **bus/transit lane** signage.
Sep 1997	Traffic Amendment Regulations 1997	Introduce **flush medians** and limits overtaking or stopping/parking on them.

Date*	Regulatory instrument(s)	Feature(s) being introduced or changed
Jan 1997	Traffic Regulations 1976 Amendment No. 29 1996	Introduce new signs and markings at and approaching **railway level crossings**.
Apr 1996	Traffic Regulations 1976 Amendment No. 28 1996	Allow RCAs to set **temporary speed limits** other than 30km/h at roadworks.
Jan 1995	Traffic Regulations 1976 Amendment No. 27 1994	Introduce **Shared Zones**, and the rules around their use. Introduce **"T" traffic signals** for light rail.
Jan 1994	Traffic Regulations 1976 Amendment No. 24 1993	Require all bicycle riders to wear an approved **safety helmet**.
Aug 1990	Traffic Regulations 1976 Amendment No. 21 1990	Introduce **red and amber traffic signal arrows**.
Sep 1988	Traffic Regulations 1976 Amendment No. 17 1988	Introduction of new **symbolic traffic signs**.

Appendix C Driver knowledge survey undertaken

Survey opening text

Hello, and thank you for taking the time to complete this survey!

This survey aims to investigate how well you understand several road rules and traffic signs/markings/signals and scenarios when driving around New Zealand. We're also interested in your driving history, including driver licensing and details of any crashes you have had.

The survey will take approximately **10 minutes** to complete; we thank you for your time.

Survey questions

C.1 Demographics

First, a few questions about yourself:

C.1.1 Age

What is your age in years?

(text answer)

C.1.2 Gender

- Female
- Male
- Another gender
- Prefer not to answer

C.1.3 Usual place of residence

Where do you normally reside and do most of your travelling?

- Greater Auckland
- Greater Wellington
- Greater Christchurch
- Other medium city or town (incl. Whangārei, Hamilton, Tauranga, Rotorua, New Plymouth, Gisborne, Napier, Hastings, Whanganui, Palmerston North, Nelson, Timaru, Dunedin, Invercargill)
- Smaller town
- Rural areas and settlements

C.2 Licence details and driving history

C.2.1 Type of licence (class 1 - cars)

What type of driver's licence do you currently hold?

- NZ Learners
- NZ Restricted
- NZ Full
- Valid overseas licence
- NZ licence converted from overseas licence

C.2.2 How many years have you held the above licence?

(this should be approximately when you last sat your practical or theory test for your current licence, or converted from an overseas licence)

- Less than 1 year
- 1-2 years
- 3-5 years
- 6-10 years
- 11-15 years
- 16-20 years
- 21-30 years
- 31-40 years
- More than 40 years

C.2.3 If you have spent more than one year living and driving overseas in the past, when did you move or return to NZ?

- I have never spent more than one year living overseas
- In the past year
- 1-2 years ago
- 3-5 years ago
- 6-10 years ago
- More than 10 years ago

C.2.4 On average, how frequently have you driven in the past year?

(this could include 5-minute trips, hour-long drives, or journeys of several hours)

- At least 2 or more times a day
- At least 2 or more times a week
- At least 2 or more times a month
- Once a month or less

C.3 Crash history

Think now about ***up to five*** previous crashes (injury or non-injury) that you have been involved in where you had ***full or partial blame*** for causing the crash:

Enter the details of each crash below, from most recent to earliest.

(skip logic: if choose NEVER had a 1st/2nd/3rd/etc crash, then stop asking further questions)

C.3.1 Crash #1

When was this crash?	How severe was this crash for the most significantly injured parties?	What type of crash was it?
Most recent at-fault crash: • In the past year • 1-2 years ago • 3-5 years ago • 6-10 years ago • More than 10 years ago • I've NEVER had a crash that was fully/partly my fault *{default}*	• Non-injury crash (vehicle or property damage only) • Minor injury crash (requiring GP or outpatient treatment) • Serious or fatal injury crash (requiring hospital treatment)	• Overtaking and lane changing • Head-on collision • Lost control on a straight or corner • Collision with an object or stationary vehicle • Rear end collision • Turning or crossing at an intersection • Merging with other traffic • Manoeuvring or parking • Hit a pedestrian/cyclist

C.3.2 Crash #2 {if any}

When was this crash?	How severe was this crash for the most significantly injured parties?	What type of crash was it?
Next most recent at-fault crash: • In the past year • 1-2 years ago • 3-5 years ago • 6-10 years ago • More than 10 years ago • NEVER had a 2nd crash that was fully/partly my fault *{default}*	• Non-injury crash (vehicle or property damage only) • Minor injury crash (requiring GP or outpatient treatment) • Serious or fatal injury crash (requiring hospital treatment)	• Overtaking and lane changing • Head-on collision • Lost control on a straight or corner • Collision with an object or stationary vehicle • Rear end collision • Turning or crossing at an intersection • Merging with other traffic • Manoeuvring or parking • Hit a pedestrian/cyclist

C.3.3 Crash #3 {if any}

{repeat…} • NEVER had a 3rd crash that was fully/partly my fault *{default}*	{repeat…}	{repeat…}

C.3.4 Crash #4 {if any}

{repeat…} • NEVER had a 4th crash that was fully/partly my fault *{default}*	{repeat…}	{repeat…}

C.3.5 Crash #5 {if any}

{repeat…} • NEVER had a 5th crash that was fully/partly my fault *{default}*	{repeat…}	{repeat…}

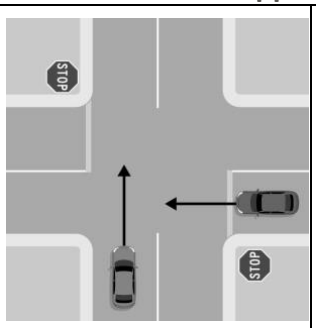
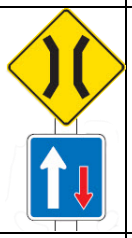
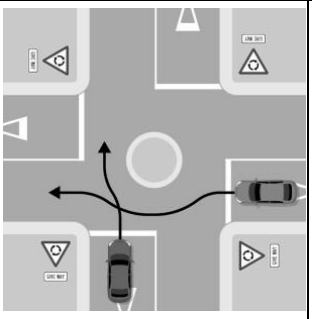
C.4 Driving knowledge and understanding

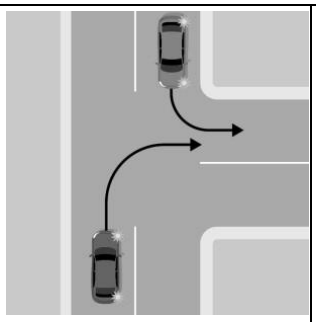
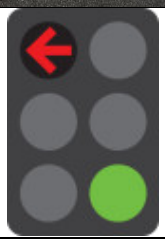
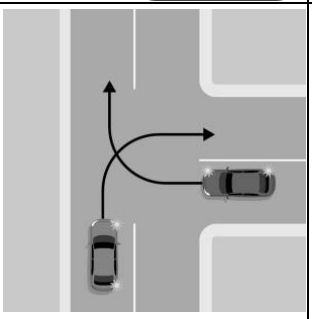
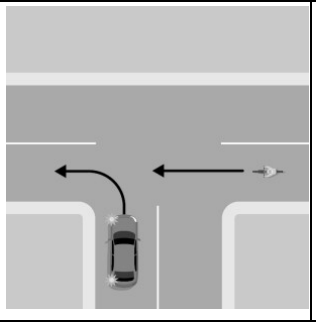
Now we would like to test your understanding of various road rules, traffic signs, markings, signals and other driving scenarios. There are **24** multi-choice questions that we would like to ask you.

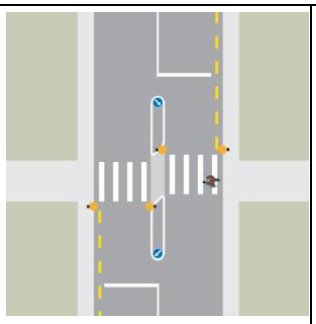
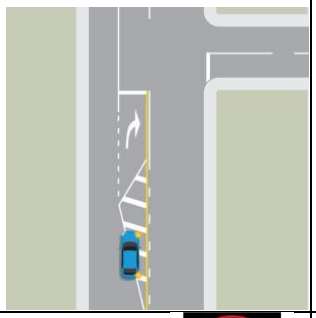
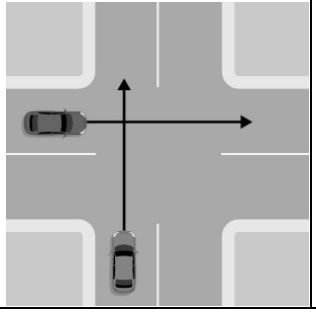
(Notes:

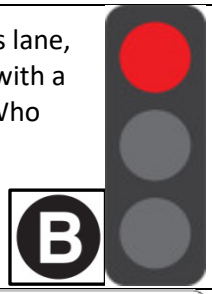
- *In the survey presented to respondents, the response options were randomly ordered, with the correct answers shown in **bold***
- *the question wording and associated images have been developed specifically for this survey; they are generally not direct copies of the learner theory test questions; this aims to avoid effects of rote learning without practical understanding, as well as accounting for questions not currently in the learner test, and more recent Rules and traffic control devices)*

C.4.1 Please select the correct or most appropriate answer for each of these questions

1. If you are travelling straight through at a STOP controlled cross-road junction and another vehicle is travelling across from your right, who must give way? 	• You must give way to the other car • **The other car has to give way to you** • You must come to a complete stop and then continue
2. When approaching a one-lane bridge, do you have to give way if you see this sign? 	• Yes • No, you can proceed straight on • **No, but check for vehicles already on the bridge before driving on**
3. What should you do when you see this sign? 	• It's a "Limited Speed Zone", where the maximum speed limit is 100 km/h, but only 80 km/h if dangerous conditions such as bad weather exist • It's a "Limited Speed Zone", where the maximum speed limit is 100 km/h, but only 50 km/h if dangerous conditions such as bad weather exist • **This is no longer a legal sign**
4. If you are travelling straight through at a roundabout and another vehicle is travelling across from your right, who must give way? 	• **You must give way to the other car** • The other car has to give way to you
5. What is the least distance of clear road you MUST have in front of you when you have finished passing another vehicle?	• 50 m • **100 m** • 200 m
6. When entering or leaving a driveway, must you give way to people using a footpath or shared path?	• **Yes** • Only cyclists or other wheeled users • No

7. If you are turning right at an uncontrolled intersection and an approaching vehicle is turning left into the same street, who must give way? 	• **You must give way to the other car** • The other car has to give way to you
8. Can you drive in, park/stop in, or cross a painted cycle lane? 	• Yes, you can drive along a cycle lane • Yes, you can stop or park in a cycle lane • **No, except within 50m of entering/leaving a side road, driveway, or parking space, and the way is clear of any cyclist**
9. If you are at a signalised intersection wanting to turn left and you see these traffic signals, can you go? 	• **No** • Yes • Only if the way is clear
10. If you are turning right from a main road into a side road at an uncontrolled T-junction and another vehicle is turning right out of the side road, who must give way? 	• You must give way to the other car • **The other car has to give way to you**
11. What is the maximum legal speed for a vehicle towing a trailer?	• 80 km/h • **90 km/h** • 100 km/h
12. If you are turning left out of an uncontrolled side road and a person cycling is approaching from your right, who must give way? 	• The cyclist should give way to you • You can go if they are in a painted cycle lane • **You have to give way to the cyclist**

13. While approaching a zebra pedestrian crossing with an island in the middle, you see a person starting to cross on the opposite side. What should you do? 	• Stop and give way to the pedestrian crossing the road • **Continue through unless the pedestrian reaches the middle of the road**
14. If you encounter someone cycling in the middle of a lane with this symbol, what should you do? 	• Speed up and overtake them • Give yourself at least 0.5m between you and the rider and pass slowly • **Slow down and follow the person cycling until the road widens and you can pass safely, or use another lane to pass them**
15. If you are about to turn right from a right-turn bay, can you drive over the white diagonal lines leading up to it? 	• **Yes** • No
16. You are driving along a rural road and you see one of these signs start to flash. What should you do?  	• Continue travelling at the same speed limit, but keep an eye on side traffic • Slow down and give way to any side road traffic pulling out • **Slow down to 60 km/h until you have passed the intersection ahead**
17. Ideally, what should you do when passing a person cycling? 	• Give yourself at least 0.5m between you and the rider and pass slowly • Give yourself at least 1.5m between you and the rider and get past quickly before any oncoming traffic • **Allow at least 1.5m between you and the rider if you can, otherwise wait for a clear space to pass on a narrower road.**
18. If you are travelling straight through at an uncontrolled cross-road junction and another vehicle is 	• You must give way to the other car • **The other car has to give way to you**

travelling across from your left, who must give way?	
19. At an intersection with a bus lane, the following traffic signals with a white "B" light are shown. Who can go? 	• Buses and trams only • Buses, trams, and people on bicycles • **Buses, trams, people on bicycles, mopeds and motorbikes** • All vehicles can go
20. Can you drive through a shared zone? 	• No, you can't • **Yes, you can, but you should drive slowly and give way to pedestrians (who in turn, should not hold up traffic)** • Yes, you can, and you have right of way
21. Can you use a mobile cellphone while driving?	• Never • Only when you are stopped at traffic lights • **Only if it physically secured ("hands free"), or to make an emergency call when you are unable to safely stop**
22. If you are cycling on a path you see this sign, what should you do? 	• It's a shared path - continue riding as per normal • Get off and walk your bike • **Slow down and ride in a careful and considerate manner** • You must give way to pedestrians at all times
23. If you see this sign while driving, what does it mean? 	• **Pedestrian (zebra) crossing ahead** • Railway level crossing ahead • Bridge decking or grated surface ahead • Cattle grid ahead
24. What are the maximum allowable breath and blood alcohol limits for fully licensed drivers over 20 when driving?	• 400µg/L breath or 80mg/L blood • **250µg/L breath or 50mg/L blood** • 150µg/L breath or 30mg/L blood

C.4.2 Any other issues while driving

Finally, are there any aspects of road rules or traffic signs/markings/signals that you find confusing while driving?

(free text answer)

Thank you for your time! Click Submit to complete the survey

Appendix D Criteria developed to assess intervention options

D.1 Effectiveness

Low	Moderate	High
• No targeted strategy to reach driver groups. • Provides knowledge content and perhaps optional self-assessment with no testing or verification. • Limited underpinning theory or supporting evidence.	• Planned strategy to reach specific groups. • Provides knowledge content and assessment with completion verified but with no assurance of learning. • Based on theory, but with limited supporting evidence.	• Planned strategy that ensures reach to all target groups. • Provides knowledge and controlled assessment with verification of learning quality. • Based on theory with strong supporting research.

D.2 Feasibility

Easy	Moderate	Difficult
• Minimal planning with low-cost infrastructure and setup. • Few extra staff needed with little training. • No driver knowledge verification required.	• Some planning required (months) with moderate-cost infrastructure or digital set-up (e.g., website development). • Some extra staff & training supports are needed. • Training completion verified but not linked to license retention.	• Planning required over years with high-cost infrastructure or digital systems needing specialist support. • Many extra staff are needed with ongoing training required. • Driver knowledge verification required and linked to license retention.

D.3 Acceptability

Low	Moderate	High
• Significant concerns. Unlikely to be supported by the public. • No or low public interest in undertaking the intervention. • Risks, or impacts outweigh benefits.	• Some concerns, but manageable. Mixed public support. • Some public interest in taking the intervention. • Benefits and drawbacks are relatively balanced. Acceptable with adjustments.	• Few or no concerns. Strong public support. • Strong public interest in undertaking the intervention. • Benefits clearly outweigh risks.

Appendix E Driver workshop participant demographics

	Driver Workshop Participant Summary								
	Age	**Ethnicity**	**Gender**	**Working Status**	**Household income**	**Driving Frequency**	**License Type**	**Area NZ**	**Settlement Type**
#1	67	Māori	Female	Retired	$100k - $125k	Multiple times a week	NZ Full	Dunedin, Otago	Rural
#2	27	Māori, Pacific Isla	Female	Working full time	$125k - $150k	Daily	NZ Full	Whangarei, Northland	Suburban
#3	57	Māori	Female	Full time student	$100k - $125k	Daily	NZ Full	Papakura, Auckland	Suburban
#4	18	NZ European	Male	Full time student	Under $30k	Multiple times a week	NZ Restricted	Dunedin, Otago	Urban
#5	19	Indian	Male	Student, P-T work	Under $30k	Once a month	NZ Learners	Christchurch City	Suburban
#6	82	NZ European	Male	Retired	$50k - $75k	Multiple times a week	NZ Full	Ngaruawahia, Waikato	Suburban
#7	36	NZ European	Female	Working full time	$100k - $125k	Daily	NZ Full	Wellington City	Suburban
#8	40	Asian	Male	Working full time	More than $150k	Daily	NZ Full	Auckland City	Suburban
#9	69	NZ European	Male	Working full time	$75k - $100k	Daily	NZ Full	Woodend, Canterbury	Rural
#10	39	NZ European, Mā	Male	Working full time	$75k - $100k	Daily	NZ Full	Wellington City	Suburban
#11	56	NZ European	Female	Working full time	$75k - $100k	Daily	NZ Full	Timaru, Canterbury	Rural
#12	40	NZ European	Female	Working full time	$75k - $100k	Daily	NZ Full	Christchurch City	Suburban
	Distributions								
Mean	45.8	European (50%)	Male (50%)	Full time (58%)	150k + (8%)	Daily (66%)	Full (84%)	Auckland (16%)	Urban (8%)
Std	19.5	Maori (25%)	Female (50%)	Part time (0%)	125-150k (8%)	Weekly (25%)	Restricted (8%)	Canterbury (33%)	Suburban (67%)
Range	18-82	Pasifika (8%)		Student (25%)	100-125k (25%)	Monthly (8%)	Learner (8%)	Wellington (16%)	Rural (25%)
		Asian (8%)		Retired (16%)	75-100k (33%)			Otago (16%)	
		Indian (8%)			50-75k (8%)			Waikato (8%)	
					<50k (16%)			Northland (8%)	