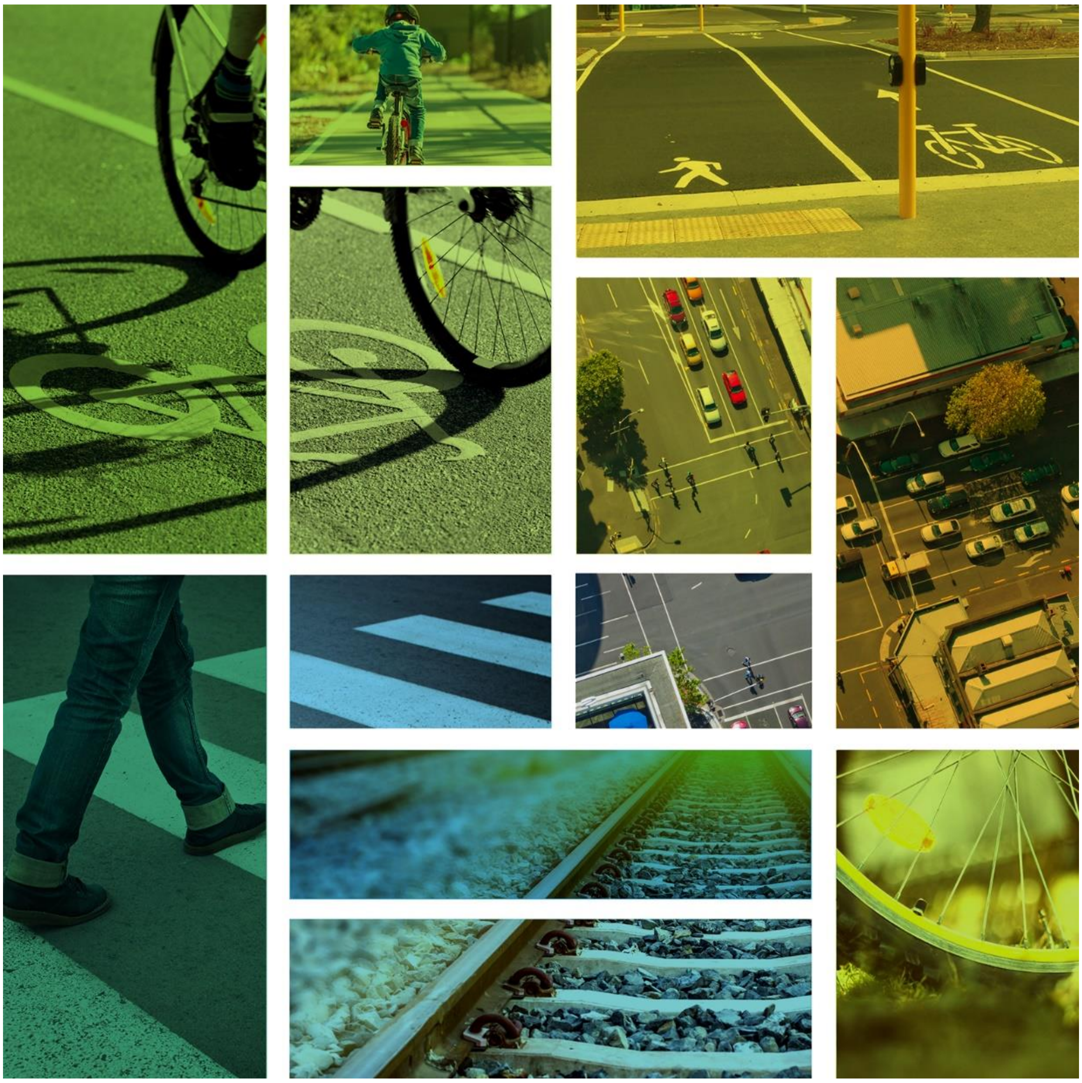

CONTEXTUAL FACTORS IN DRIVING FOR WORK CRASHES

A SYSTEMS ANALYSIS

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EXECUTIVE SUMMARY

Background

Work-related road safety is a strategic priority in the Road to Zero road safety strategy and across government agencies. Work-related road traffic fatalities are understood to make up around a third of all worker fatalities as well as a third of the national road toll. However, we currently know little about work-related fatal, serious, and minor injuries incurred through road traffic crashes, nor the contextual and system factors which contribute to these crashes. Safe System and socio-technical system crash analyses can yield useful insights into work-related crash contexts so that evidence-based initiatives can be planned accordingly.

Aims

Focussing on driving for work in light and service vehicles, the project aims were to:

- Determine the Safe System factors associated with fatal, serious injury, and minor injury crashes that occurred in light and other selected vehicles while driving for work.
- Explore socio-technical methods for analysing driving for work crashes or crash clusters.

Method

The project was carried out in three phases:

- Phase 1 – literature scan of work-related road casualty studies and phase 2 feasibility assessment and method development
- Phase 2 – analysis of 300 driving for work injury crashes (100 each of minor, serious, and fatal injury) occurring in light or service vehicles using a Safe System coding framework based on previous studies and statistical determination of case clusters
- Phase 3 – review of socio-technical approaches to road safety and completion of a pilot AcciMap showing how contextual factors contribute to driving for work crashes.

A project reference group was established to guide and input into the research. The group was represented by the AA Research Foundation, AA Driving School, Waka Kotahi, Ministry of Transport, and Worksafe.

Key findings from literature scan (Phase 1)

The literature scan identified a range of methodologies used to understand work-related (driving for work) traffic crashes and pointed to the importance of taking into account pedestrian and bystander injuries, coding a wide range of variables, and using crash characteristics to identify fatigue and speed-related crashes. Driving for work crash trends included a much higher representation of men and an older average age compared to general traffic crashes, with the transport sector and the construction industry bearing the highest burden of work-related traffic injury in Aotearoa New Zealand. Fatigue and speed were identified as common but underreported crash factors, while time pressures, stressful work demands, and poor organisational safety cultures were linked to unsafe driving behaviours and fatigue. Particularly for driving for work crashes occurring in light vehicles, gaps included a lack of research into vehicle and environmental factors, variable findings on driver factors, and a limited understanding of organisational and other upstream factors involved.

Key findings from Safe System analysis (Phase 2)

The Safe System crash analysis, as in previous analyses, showed that driving for work injury crashes are often linked to multiple system failures across Road and Roadside, Speed, Vehicle, and User components, and that a failure across a wider range of these components is linked to increasing crash severity. As is commonly found in other areas of road safety, driving for work crashes were often linked to rural roads, a lack of traffic division, seat belt non-use, low star-rated vehicles, and user distraction/inattention and fatigue.

However, the following areas were found to be prominent or relatively unique to driving for work crashes:

- Even more dominated by males with a more even age distribution than non-work related crashes
- Relatively large vehicles including buses, vans, utes, and light trucks being common driving for work vehicles.
- Involvement of vulnerable road users in urban areas, with buses often implicated
- Injuries tended to be sustained by other users rather than those driving for work
- Some indication that unpredictable manoeuvres were more commonly implicated
- A relatively high proportion of vehicles with no available rating, perhaps as more common cars were less likely to be work vehicles.

Conversely,

- Both speed and alcohol were less implicated in driving for work crashes compared with other studies, although very low speeds by heavy vehicles were often implicated in high severity injuries.
- Overall, extreme or reckless user behaviours were identified less frequently among people driving for work compared to road users in general crashes.
- In multi-party crashes, those driving for work were given a primary role in the crash in 42% of cases and were less likely to have primary responsibility in fatal crashes.

Three distinct work-related crash profiles were identified through a statistical cluster analysis:

Multiple vehicle crashes (n=188), often involving work vans, utes, and SUVs in side impact crashes, occurring across all land use types, and typically resulting in injury to non-driving for work drivers.

Vulnerable road user crashes (n=72), often involving professional drivers in vans or buses colliding head on with a pedestrian in an urban or commercial shopping area.

Single vehicle crashes (n=40) involving people driving vans or light trucks for work losing control on rural roads and hitting an object or rolling, with fatigue, non-seat belt use, and speed often implicated, and resulting in high worker injury rates.

Key findings from Socio-technical Systems analysis (Phase 3)

A pilot Accimap (map of causal factors from across the system) was completed for a crash in which a taxi driver was killed and six passengers injured. It demonstrated how decisions, actions, policies, and ways of working across a range of system levels contributed to the crash, from societal norms around driving fatigued and organisational pressures to accept jobs, to medication side effects and non-seat belt use. Of particular note was conflicting medical advice to the driver around whether they were fit to drive, and the lack of fatigue management on the part of the employer. Overall, the analysis showed that there were multiple factors involved, and also multiple points at which better policies or intervening actions could have prevented the crash from occurring.

Conclusions

The Safe System analysis of 300 driving for work crashes has shown that, as in previous studies, multiple failures across the Safe System are associated with higher severity crash outcomes. However, driving for work crashes are less likely to involve extreme behaviours compared with non-work-related crashes, and those driving for work are less likely to be ascribed primary responsibility than other road users. Other unique characteristics of driving for work cases include situations where other road users are implicated/harmed, where large vehicles and pedestrians have the potential to interact – sometimes at very low speed, where inattention may happen, and where vehicles without a star rating are involved. Several road safety issues common to crashes more generally were also identified such as undivided high speed roads, seat belt use, fatigue and distraction, and low star rated work vehicles. 'Upstream' contributing factors in driving for work crashes were explored using a socio-technical systems approach, with a worked example showing how wider system influences can be mapped and understood. Overall, there is a need to improve data quality and procedures for accessing and using incident related data so that effective interventions can be based on the best possible evidence. Building on this analysis and the three common driving for work crash types that have been identified in this study, it is recommended that a deeper understanding of the context around typical driving for work crashes be used to develop system-wide advocacy and policy responses.

CONTENTS

1. INTRODUCTION

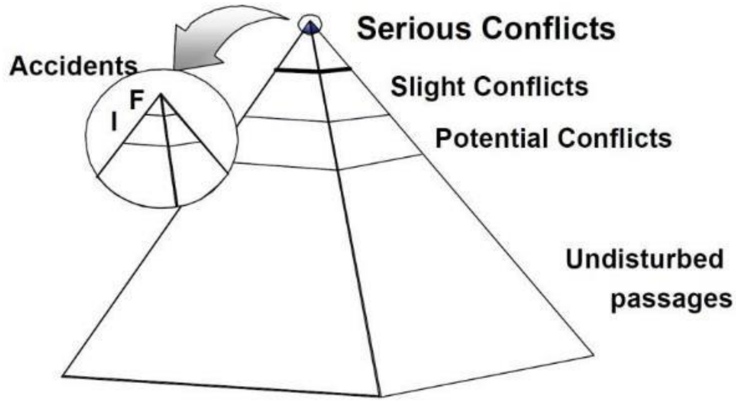
1.1. Background

Work-related road safety is a strategic priority in the new road safety strategy Road to Zero (Ministry of Transport (MOT), 2019) and is of strategic interest across a number of government agencies (e.g. MOT, Waka Kotahi, WorkSafe, ACC). The prevalence of work-related fatal injuries which were road traffic fatalities has been found to make up 30% of all worker fatalities (McNoe, Langley, & Feyer, 2005) and between 22%-36% of the national road toll (including workers, bystanders, and commuters; Lilley et al., 2019). Although not reported, it is likely that similar patterns may be apparent for serious injury and minor injury crash outcomes. Beyond this understanding, more contextual information is needed for work-related motor vehicle traffic crashes (WR MVTC), so that evidence-based initiatives can be planned accordingly.

One method for better understanding the context of and factors involved in traffic crashes is to analyse crash records from a Safe System perspective. A Safe System analysis framework developed and used in previous AARF and NZTA research projects (Hirsch, Mackie, Scott, & Thorne, 2018; Hirsch, Waters, Scott, Mackie, & de Pont, 2017; Mackie et al., 2017; Thorne, Hirsch, Blewden & Mackie, 2020) has proven to be useful in determining Safe System factors associated with casualties. These studies have shown that, for example, the higher the crash severity, the more likely it is that multiple system failures contributed to the crash outcome, and that fatal crashes were more likely to involve extreme behaviours than serious injury crashes.

However, fatal and serious injury crashes comprise only a small percentage of the overall crashes, conflicts, and interactions that happen daily on our roads (Figure 1) – and, although they are the crashes of strategic importance, they do not tell the whole story (Hydén, 1987). Therefore, there is value in also examining minor injury crashes to better understand underlying patterns within less severe, more common conflict scenarios. For some time now in New Zealand, minor injury crashes have been used to predict the overall risk of roads, so the concept is not new in road safety practice.

Figure 1: Interaction between road users as a continuum of events (Hydén 1987)



Conceptually, systems methods for analysing safety incidents are moving towards 'socio-technical' system approaches. This digs deeper, beyond immediately identifiable crash factors, to understand the technical and social context that contribute to incidents (Figure 2). For example, a Safe System analysis can help to identify that fatigue is frequently suspected in some kinds of fatal work crashes, along with certain road conditions. A socio-technical systems analysis can then obtain more context about what led to the driver being fatigued, or what planning, funding or maintenance actions led to these road conditions, thereby helping to pinpoint organisational actions that can ultimately lead to the prevention of fatigue crashes.

Figure 2: Levels of analysis of factors contributing to vehicle crashes

Truck driving is an important sub-area in the driving for work problem; however, there is already a considerable focus on truck driving through government agencies, and much less is known about the range of other vehicles that are used for work purposes and the risks associated with them. For these reasons, this project focused on work-related (driving for work) crashes occurring in light vehicles and some service vehicles only. More detail on the scope of the analysis is provided later.

To better understand the broad system factors associated with driving for work crashes occurring in light vehicles, we conducted a feasibility study, a literature scan and two systems analyses of injury crashes involving driving for work. A project steering group was formed to guide the project direction.

1.2. Aim

The project had two aims:

- To determine the Safe System factors associated with fatal, serious injury, and minor injury crashes that occurred in light and some service vehicles while driving for work.
- To explore socio-technical methods for analysing driving for work crashes or crash clusters.

1.3. Scope

The project was carried out in three separate phases, outlined below.

Phase 1 – feasibility of Phase 2

- A brief scan of existing work-related casualty literature to help position the project, identify themes, and review methodologies
- Assessment of the feasibility of identifying and coding 300 driving for work motor vehicle traffic crash cases (DFW MVTC), including the timeframe and the proportion of fatal, serious injury, and minor injury crashes these cases covered

- Establishment of a detailed method
- Confirmation of Phases 2 and 3 methods with the reference group.

Phase 2 – Safe Systems analysis

- Analysis of 300 DFW MVTC that occurred in light and service vehicles using a Safe System coding framework based on the method used in previous Safe System crash studies
- Examination of factors relating to the speed environment, roads and roadsides, vehicles, and road users involved in these crashes
- Statistical determination of clusters of cases containing similar attributes from the coding output
- Comparison of the findings with previous relevant studies including the analyses of deaths and serious injury crashes and of seatbelt crashes previously commissioned by the AA.

Phase 3 – Socio-technical systems mapping analysis

- Brief review of current progress in socio-technical approaches in New Zealand's transport sector
- Discussions with stakeholders to confirm how this method could be used in the driving for work context
- A pilot AcciMap (example of socio-technical method) to show how contextual factors contribute to driving for work crashes
- Identification of actions that should be followed up by agencies to further develop this method in New Zealand.

1.4. Structure of this report

The report is separated into three self-contained sections along with a combined discussion section at the end. The first section summarises the literature scan, the following two sections detail the two analyses completed as part of this project, each with an aim, method, findings, and discussion, and the final section comprises an overall discussion and conclusions. The four sections are as follows:

1. Summary of the findings from the Phase 1 scan of driving for work literature
2. Safe Systems analysis of 300 driving for work crashes (Phase 2)
3. Socio-technical systems mapping analysis of a driving for work crash (Phase 3)
4. Overall discussion and conclusions

1.5. Terminology

Some key terms used throughout the report are as follows:

- Driving for Work User; DFW Driver: the driver involved in each crash who has been identified as the primary driving for work person according to the study definition
- Other Party/Parties: any other parties involved in the crash – note party refers to either a vehicle and driver, or a vulnerable road user (excludes passengers)
- Other User(s): any other road users involved in the crash – note this includes drivers, passengers, and vulnerable road users
- Vulnerable road user(s); VRUs: motorcyclists, cyclists, and pedestrians, including people using scooters or mobility devices

2. LITERATURE SCAN

As part of Phase 1, a literature scan was completed to review methodologies, identify themes in the driving for work literature, and position the project. The findings of the literature scan are summarised in this section. For the full report, see APPENDIX B: LITERATURE SCAN REPORT.

2.1. Method

The literature scan method entailed reviewing academic and non-academic literature related to driving for work crashes, with a focus on methods used. Key word searches were conducted in Science Direct and Google Scholar using search terms such as “driving for work”, “crash”, “work-related”, “fatality”, “occupational”, “injury”. “Contributing factors”, “system influences” and “light vehicles” were also used as necessary to focus in on these areas. Literature was selected based on methodologies and findings relevant to this study.

2.2. Findings: Research methodologies

Several driving for work research methodologies were identified in the driving for work literature, with different goals. Coronial data and injury claims have typically been used to determine the overall burden or incidence rates of driving for work crashes, while vehicle use registration data enables identification of specific vehicle types and uses. Police reports and crash records tend to be used to examine crash contexts including demographic and roading environment factors, though variable data accuracy is a common concern. Finally, more upstream work-related factors associated with driving safety or crashes have been explored in studies using stakeholder interviews and focus groups, diary studies, and surveys and questionnaires, as well as thematic analyses of crash and safety intervention case studies and organisational safety policies. For a list of studies using each of these methodologies, see **Error! Reference source not found.** in APPENDIX B: LITERATURE SCAN REPORT.

Of note was also that definitions of driving for work vary from country to country and between different studies. For example, in some European countries, commuting to and from work is included while in most English-speaking countries it is not, and in some places the vehicle is only considered to be a workplace when used on worksites *(Mathern, 2019)*.

Key methodology points from the literature relevant to this study include:

- Including pedestrians and bystanders in the analysis of driving for work crashes *(Lilley, et al., 2019; McNoe et al., 2005; Langley et al., 2006; Sultana et al., 2007)*
- Consideration of occupations in the gig economy and/or grey fleet (personal vehicles used for work purposes), such as ridesharing and food delivery *(Ward et al., 2020)*
- Applying a broad definition of working as “working for pay, profit or payment in kind, assisting with work in an unpaid capacity, or being engaged in work-related activities even when on a break or away from the workplace, for example, rest stops taken during work-related travel” *(Lilley, et al., 2021, pp. 124-125)*
- Considering the “blameworthiness ratio” (driver role in/contribution to crash) and how it relates to other variables *(Clarke et al., 2005, p. 14)*

- Coding for fatigue and speeding, in the absence of police identification of these conditions, by identifying characteristics of driving behaviour that indicate fatigue (e.g., travelling on incorrect side of road for single vehicle crashes, running off road with no evidence of speeding) or speeding (e.g., losing control on a curve; *Boufous & Williamson, 2009, p. 468)*
- Coding a wide range of variables as limited coding can potentially significantly misrepresent the impact and effects of driving for work crashes *(McNoe et al., 2005; Ward et al., 2020)*.
- Coding vehicle, road environment, and work factors as well as those related to drivers and passengers *(Stuckey et al., 2010)*.

Several limitations of driving for work analyses were identified in the literature. These include data availability and accuracy. In particular, crash records made at the time of the crash, usually by police officers, are often incomplete or inaccurate with regard to participation in work activities, injury severity *(Clarke et al., 2005; McNoe et al., 2005; Ward et al., 2020)*, and notably in Aotearoa New Zealand, ethnicity *(Sultana et al., 2007)*. Additionally, data sourced sourced from insurance claims or worker compensation claims are limited by accurate self-reporting, willingness to lodge claims, and knowledge of claim eligibility *(Boufous & Williamson, 2009; Sultana et al., 2007; Ward et al., 2020).*

2.3. Findings: Driving for work trends

Demographic trends in work-related crashes include that men are significantly over-represented in injury statistics among people driving for work, and especially among those driving load-carrying vehicles *(Boufous & Williamson, 2009; Clarke et al., 2005; Driscoll, et al., 2005; Lilley, et al., 2021; McNoe et al., 2005; Stuckey et al., 2010; Sultana et al., 2007)*. Looking at age, in Aotearoa New Zealand, people driving for work aged 35-44 have the highest number of injuries overall, but serious and fatal injury numbers are higher in age groups 45 and above *(Lilley, et al., 2021; Sultana et al., 2007)*. Internationally, high fatality rates have also been identified among work drivers aged 65 years and older *(Boufous & Williamson, 2009; Driscoll et al., 2005; McNoe et al., 2005)*. Ethnicity was rarely examined; however, Lilley, et al. *(2021)* reported that the rate of work-traffic fatalities for Māori workers was almost three times higher than other ethnic groups in New Zealand.

Contextual factors involved in work-related crashes identified in the literature tended to focus on factors related to the driver and to their organisation. Both fatigue *(Anderson, et al., 2018; Boufous & Williamson, 2009; Clarke et al., 2005; Friswell et al., 2006; Husain et al., 2019; Marcus & Loughlin, 1996; Stuckey et al., 2010)* and speed *(Boufous & Williamson, 2009; Clarke et al., 2005; Freeman et al., 2008; Hirsch, et al., 2017; Stuckey et al., 2010; Wishart et al., 2017)* were identified as common issues that increase the risk of severe and fatal injuries in driving for work crashes. Other findings of interest include that fatigue is likely to be severely under-reported underreported *(Clarke et al., 2005; Friswell et al., 2006)*, while one study found that speeding behaviour seems to be regulated by the safety climate of the organisation *(Wishart et al., 2017).* Other driver factors associated with work-related traffic crashes include driver impairment or illness *(Copsey, et al., 2010; Lilley, et al., 2019)*, not wearing a seat belt *(Hirsch et al., 2017)*, driver distractions such as mobile phones, maps, and in-vehicle *technology (Rowland, 2018; Salmon & Lenné, 2015)*, and certain driving styles that can exacerbale work stress and job strain *(Useche et al., 2020).*

At an organisational level, people driving for work in the transport sector (including postal, warehousing, public utilities, storage and communication) were found to be the most frequent victims of driving for work fatalities and injuries in New Zealand *(Driscoll, et al., 2005; Lilley, et al., 2021; Sultana et al., 2007*). Interestingly, the construction industry in New Zealand was found to have higher driving for work fatality rates than Australia and the USA *(Driscoll, et al., 2005).* Internationally, taxi drivers have also been identified as having high serious crask risk *(Boufous & Williamson, 2009; Husain et al., 2019)*.

Risky and unsafe driving behaviour is found to be linked to the time pressure and stressful work demands placed on work-drivers, which can also increase effects of fatigue *(Husain et al., 2019; Rowland, 2018).* On the other hand, a strong, defined, and widely understood organisational safety culture was found to strongly influence safety behaviour and reduce driving errors *(Copsey, et al., 2010; Newnam et al., 2008; Wills et al., 2009; Wishart et al., 2017),* but can be difficult to implement, as many drivers work independently, away from a fixed base of operations *(Ward et al., 2020).*

Where vehicle and environmental factors were discussed, it was mainly in relation to freight and road haulage *(Clarke et al., 2005; Copsey et al., 2010).* However, one United Kingdom study found that workers driving company cars, vans/pickups, and large goods vehicles were more likely to be deemed at fault than the other parties they were involved in crashes with, for reasons of excess speed, observational failures, and fatigue or vehicle defects respectively. In contrast, workers driving buses, taxis, and emergency vehicles were more likely to be deemed victims of the road behaviour of other parties *(Clarke et al., 2005).*

2.4. Towards systems analyses for driving for work

As demonstrated by the findings above, while some influences on driving for work safety seem clear, there is still a significant knowledge gap in understanding the range of contextual factors influencing injury and fatality occurring while driving light vehicles for work. In particular, while there is a large amount of information on driver factors, it is highly variable and not necessarily relevant to the New Zealand context, and there is very little on vehicle, environmental, and wider contextual factors. Similarly, though several organisational factors are identified, our understanding of the upstream causes is limited beyond some key recent studies. A holistic and comprehensive systems approach is therefore required to understand the range of influences on work-related road safety and to design appropriate interventions *(Rowland, 2018).*

One way of considering the different levels at which we can seek to understand the influence of different factors on WR MVTC is shown in Figure 2 (see section 1: INTRODUCTION).

One model that has been used to understand the immediate context of different types of crashes is the Safe System analysis framework used to examine Safe System factors in studies of vehicle occupants not wearing seatbelts, pedestrian crashes, and differences between crashes causing serious injury and those causing fatality *(Hirsch et al., 2018; Hirsch et al., 2017; Mackie et al., 2017; Thorne et al., 2020).* These studies have facilitated an understanding of the types of environmental, vehicle, and road user factors associated with injury and fatal crashes, and how multiple system factors come together in crashes.

Taking the system approach a step further is research into the wider and upstream factors influencing road safety, such as organisational arrangements and government policies *(Salmon & Lenné, 2015; Salmon, 2020).* Taking socio-technical and socio-ecological approaches, these kinds of analyses have recently been carried out for workplace safety related to people driving heavy vehicles for work in New Zealand *(Tedestedt George, 2018; Tedestedt George et al.,* *2021)*. A systems approach has also been developed specifically for light vehicles used for work purposes by Stuckey, LaMontagne, & Sim *(2007)* in the United Kingdom.

The application of a systems analysis on driving for work research is supported by a recognition in the literature of the value it provides to fully understand the scale of the issue and the range of interventions at different scales needed to make an impact on safety *(Copsey et al., 2011; Newnam & Watson, 2011; Useche et al., 2020).* Further, Tedestedt George et al. *(2021)* recommend that methods for monitoring and mapping risk and harm related to driving for work are improved, and that ways of sharing data are established to leverage existing data from outside government and across government departments.

The current research project seeks to develop and apply two levels of systems analysis to better understand the immediate and wider contextual factors associated with crashes while driving for work in light vehicles. This deeper understanding of factors within the light vehicle driving for work context will fill this knowledge gap and facilitate decision-making around how best to reduce harm related to driving for work.

3. SAFE SYSTEM ANALYSIS

This section describes the Safe System analysis completed in Phase 2 of the project to explore contextual crash factors relating to each of the four Safe System elements (pillars): Roads and Roadsides, Speeds, Vehicles, and Users (MOT, 2019).

3.1. Aim

The central aim for this analysis was to determine the Safe System factors associated with fatal, serious injury, and minor injury crashes that occurred in light and some service vehicles while driving for work.

3.2. Method

3.2.1. Dataset selection

To include a range of driving for work crashes and to explore differences in minor, serious, and fatal crash trends, a total of 300 injury crash cases were selected: 100 fatal crashes, 100 serious injury crashes, and 100 minor injury crashes. Figure 3 (over the page) summarises the dataset selection approach, including the case definition.

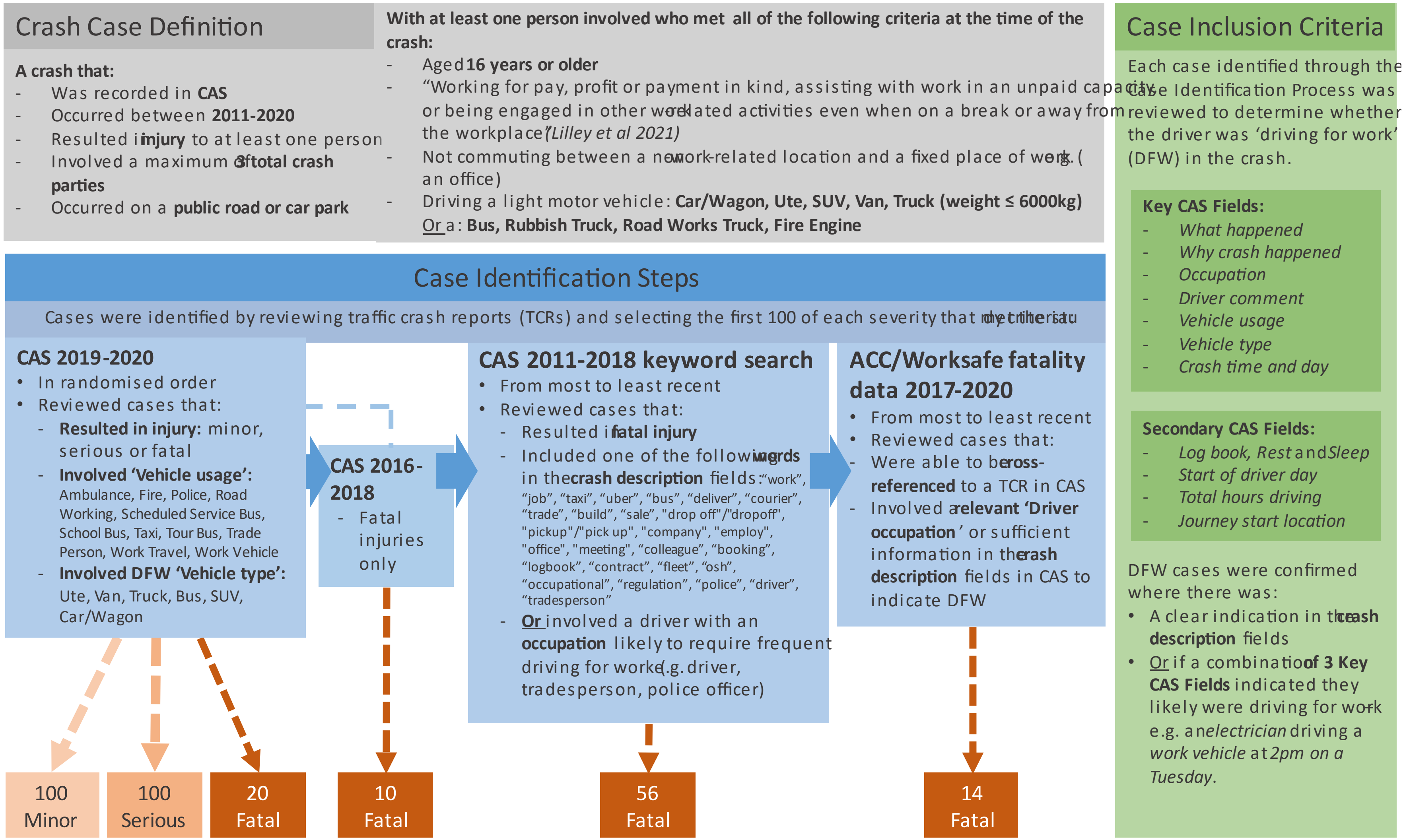
The aim was not to obtain a fully representative sample of driving for work crashes, but rather to analyse a wide range of driving for work crashes, in order to gain a broad understanding of the types of factors involved in these crashes and their relationship to crash severity (i.e. level of injury). In New Zealand there isn't yet a well-established profile for driving for work crashes, particularly for the subset (not including larger trucks) that was the focus of this study.

Case definition

The focus was on light vehicles able to be driven on a Class 1 driver licence (cars/wagons, SUVs, utes, vans, and light trucks), however, some service vehicles, such as buses and rubbish trucks were also included, as they have not typically been examined in existing studies looking at trucks/heavy freight driving for work.

Commuting to or from a fixed location of work was *not* included in the definition of driving for work in this study; however, travelling to and from non-fixed locations of work was included. This distinction was made to try and exclude cases where a person could choose their mode of travel, as opposed to cases where driving is a necessary part of a person's work. For example, an office worker driving to their office was considered commuting and therefore excluded, whereas a tradesperson driving to a job was counted as driving for work. Furthermore, crashes in which someone was engaged in work activities that involved driving for work, but not actively driving their work vehicle at the time of the crash, were also included, e.g. they were involved in a traffic crash while working after exiting their vehicle.

Figure 3. Safe System analysis dataset selection method



Note that in 19 out of the 300 crashes, two drivers were identified as driving for work as per the study definition. However, to facilitate the analysis by crash, only one person driving for work was counted as the 'primary' Driving for Work User (selected based on the driver for which the most detailed information was available), while the other was counted as an Other User in the analysis. In addition, some people identified as driving for work, but *not* as per the study definition (e.g. driving a freight truck weighing over 6000kg) were included as Other Users. Thus, not all Other Users in the study can be assumed to be 'bystanders' i.e. not involved in work activities at the time of the crash.

Case identification

A total of four different case identification stages were used to compile a database of 300 total crashes (see Figure 3). While all the minor and serious injury cases were confirmed after the first stage, sourcing additional fatal injury cases required the additional three steps.

Following a method feasibility assessment, Waka Kotahi's Crash Analysis System (CAS; the national crash database) was used as the primary case identification tool as it is readily accessible, includes traffic crash reports (TCRs) for crashes involving a range of driving for work types, and provides the large majority of information required for the Safe Systems analysis. CAS data searches comprised three of the four case identification steps.

In addition to data sourced from CAS alone, a table of work-related fatalities from January 2011 – May 2021 produced by WorkSafe[1] was also utilised to find additional fatal crashes when CAS filter and keyword search methods had been exhausted. The WorkSafe data were assumed to exclusively include accidents at the time of which at least one person involved was working (though it is acknowledged that the WorkSafe definition of working may differ from that of the current study, for example, it is understood to include commuting). The data were therefore filtered to include only vehicle crashes on public roads, following which key details, such as victim age, victim industry, and accident month, were used to match the WorkSafe case to a CAS TCR. Cases that involved a relevant Driver Occupation or had sufficient information in the Crash Description fields in the TCR to provide some context about the nature of driving for work were selected from most to least recent until the required number of cases were met.

The case identification process was completed in stages in order to prioritise more recent driving for work crashes and to enable random sampling where possible. As minor and serious injury crashes occur much more frequently than fatal crashes, we were able to identify 100 crashes of each severity using the first stage only (random sampling of CAS crashes from 2019-2020 with work-related vehicle usage). However, fatal driving for work crashes were rarer, and TCRs for more severe crashes, especially those resulting in fatality, were found to be less detailed than TCRs for less severe crashes. As such, multiple stages were required in order to identify 100 cases (see Figure 3 for detail).

This resulted in a less random dataset for fatal crashes than for minor and serious injury crashes, though given the smaller total pool of fatal crashes that occur, we expect that the included crashes provide a reasonable range of driving for work crash types from which we can draw conclusions about common crash factors and patterns.

3.2.2. Safe System analysis procedure

The 300 crash cases identified through the case selection process were then coded into a Safe System analysis coding framework. The coding framework used was a modified version of the coding frameworks used in previous Safe System analyses, in particular the Serious Injury

[1] 'Detailed fatalities data' spreadsheet available on the WorkSafe website: https://data.worksafe.govt.nz/editorial/fatalities_summary_table

Crashes study by Mackie et al (Hirsch et al., 2018; Hirsch et al., 2017; Mackie et al., 2017; Thorne et al., 2020). The most substantial modification entailed splitting the User pillar into two sub-pillars, Driving for Work (DFW) Users, and Other Users, in order to differentiate between crash factors related to the primary driver for work from those of Other Users involved in the crashes – i.e. to explore 'exposure' factors as well as those directly relating to the person driving for work. A limited amount of data were also coded for other vehicles involved, however, these were not used to 'trigger' the Vehicle pillar.

The coding framework is outlined in Figure 4 below. For each pillar of the Safe System (Roads and Roadsides, Vehicles, Speeds, and Users), a range of relevant variables (crash factors) were coded into the framework. The values of the variables in each pillar then determined whether that pillar was 'triggered' in each crash, i.e. implicated in either the occurrence or the severity of the crash. For crash factors where judgement was required to determine whether that factor was implicated, for example, evidence of fatigue or distraction, more detail about the criteria used to make a decision are provided in the relevant results section.

In addition, some User pillar variables were used to determine whether 'reckless' or 'extreme' behaviour was a key factor in the crash, as opposed to a relatively equitable contribution by multiple system factors. This is based on the Wundersitz and Baldock (2011) methodology adapted by Mackie et al for use in the Serious Injury Crashes study (2017), with some further modifications. Notably, while the Serious Injury Crashes study referred only to 'reckless' behaviours, the present study included some 'extreme' behaviours that are not necessarily reckless, for example, police pursuits. The reckless/extreme behaviours used in this study are outlined in Figure 4 over the page.

The data used to code each crash case into the framework were sourced from:

- Traffic Crash Reports (TCRs) reported in CAS
- Safer Journeys Risk Assessment tool (Mega Maps)
- Rightcar, Waka Kotahi's vehicle safety and efficiency rating tool
- Howsafeisyourcar.com.au
- Google Street View
- Monash University Accident Research Centre Vehicle Safety Ratings from 2017 (Newstead, Watson, Keall, & Cameron, 2017)[2]
- WorkSafe fatality data, as available (fatal cases selected via WorkSafe fatality data cross-referencing only).

The coding process involved reviewing the data available for each crash case and entering relevant details into a coding framework spreadsheet. Cases that were found not to contain sufficient crash detail, or where it became clear that they did not in fact meet the study definition of driving for work, were removed from the analysis and replaced with a new crash case.

The spreadsheet was designed to eliminate coding error by including drop-down lists rather than allowing for open-ended responses. In addition, the pillar trigger cells were automatically populated once the data were entered for each variable.

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[2] An updated report was published in 2020; however, it uses a different rating system which is more complex to interpret, therefore the 2017 ratings were used. This meant that vehicle models newer than 2015 were unable to be rated for aggressivity.

Figure 4: Safe System driving for work crash analysis coding framework

ANALYSIS PROTOCOL FOR ALL CRASHES

Crash Information

TCR coding
- Time, date, day
- Region, locality
- Crash ID no.
- Fatal/serious/minor
- Weather, lighting
- Road surface
- Number of parties (vehicles/road users outside vehicle) involved
- Crash code, movement
- Crash impact type

Speed

TCR coding
- Speed limit
- Speed advisory
- DFW vehicle speed
- Other vehicle speeds (if present)

Other data coding – *Mega Maps*
- Safe And Appropriate Speed (SAAS)
- Speed management priority

Speed Pillar trigger (one or more):
- Travel speed (any vehicle) > SAAS
- Travel speed (any vehicle) > speed advisory
- Top 10% priority for speed management
- *If relevant (i.e. VRU involved):*
  - Travel speed > 30km/h

Roads and Roadsides

TCR coding
- Location (midblock/intersection, car park, driveway)
- Intersection type
- Traffic control
- Number of lanes
- *If relevant:*
  - Street lighting
- Road side object struck
  - Y/N
  - What was struck (categories)
- Other notable factor mentioned in the TCR

Other data coding *Mega Maps*
- Road alignment
- Road function (ONRC)
- Land use
- Infrastructure Risk Rating (IRR)
- Annual Average Daily Traffic (AADT)
- Shoulder width

Google Street View:
- Sealed/unsealed
- Divided/undivided
- Road side barriers
- Fog lines
- *If relevant:*
  - Traffic calming
  - Footpath present
  - Crossing facilities
- Shoulder composition

Road System Pillar trigger (one or more):
- Struck nonfrangible roadside object
- IRR medium high or high
- Undivided ≥80km/h road + crossed the centre line
- *If relevant:*
  - Presence and composition of shoulder
  - No street lighting
  - No footpath or crossing facilities
- Other notable road and roadside factors

Vehicle

Driving for Work (DFW) Vehicle

TCR coding
- Vehicle type: car/ute/van/SUV truck/bus
- Vehicle year, age
- Make, model
- Current WOF/COF
- Trailer use
- Vehicle usage
- Vehicle ownership
- Extraordinary vehicle factors e.g. bald tyres

Other data coding *Right Car*
- Overall safety star rating (USCR/ANCAP)
- Driver safety rating
- Engine size (≤/>2000cc)
- Dual front airbags
- Side airbags
- Anti-lock braking system (ABS)
- Electronic stability control (ESC)

MUARC 2017 report
- Aggressivity

Web search
- Bonnet shape
- Gross vehicle mass (GVM)

Other Vehicle(s) – max 2

TCR coding
- Vehicle type: car/ute/van/SUV/light truck/medium-heavy truck/bus/motorcycle bicycle/none
- Vehicle year, age
- Make, model
- Current WOF/COF

Vehicle Pillar trigger (one or more):
- DFW vehicle ≥ 14 years
- *If relevant:*
  - DFW vehicle has no front airbags
  - DFW vehicle has no side airbags
- DFW vehicle has safety star rating ≤3
- DFW vehicle has no ABS
- DFW vehicle has aggressivity rating ≥20% benchmark
- DFW vehicle has no WOF/COF
- Large difference in vehicle mass/shape
- Any other relevant stated DFW vehicle defects

User

Driving for Work (DFW) User

TCR coding
- Mode
- Injury level
- Age, gender, ethnicity
- Occupation
- Trip purpose descrip.
- Licence type/status
- Driver role in crash (blameworthiness)
- Restraint use
- Alcohol presence + reading
- Drug use suspected
- Medical condition contributing + descrip.
- Evidence of fatigue
- Use of technology
- Evidence of distraction + descript.
- Emotional state + descrip.
- Too fast for conditions
- Start of driver day, hours driving
- Sleep in 24 hours prior
- Evidence of fatigue
- Hit and run
- Ran red light
- Loss of control
- Crossed centre line
- Left road to left
- Unsafe overtaking
- Other notable behaviour
- Passenger numbers, types
- Passenger injury levels

Other User(s) – max 2

TCR coding
- Mode
- Injury level
- Age, gender, ethnicity
- Occupation
- Trip purpose DFW as per study definition/ other DFW/not DFW/uncertain
- Licence type/status
- Driver role in crash (blameworthiness)
- Restraint use
- Alcohol presence + reading
- Drug use suspected
- Medical condition contributing + descrip.
- Evidence of fatigue
- Use of technology
- Evidence of distraction + descript.
- Emotional state + descrip.
- Too fast for conditions
- Hit and run
- Ran red light
- Loss of control
- Crossed centre line
- Left road to left
- Unsafe overtaking
- Other notable behaviour
- Passenger numbers, types
- Passenger injury levels

User Pillar trigger (one or more):
- Licence – learner, overseas, disqualified/no licence
- Clearly intoxicated
- ≥10% posted speed limit
- Too fast for conditions
- Medical event directly contributing to crash
- Distraction evident
- Fatigue evident
- Poor emotional state
- Hit and run
- Ran red light
- Unsafe overtaking

DFW User only:
- Age ≥75
- No seat belt
- Hours driving ≥6

Other User only:
- Age ≤16, ≥75

Reckless or extreme behaviour:
- BAC over limit for age = reckless
- Suspected alcohol = contributes
- Restricted or learner licence + alcohol presence/suspected = reckless
- ≥20km/h posted speed limit = reckless
- ≥10km/h posted speed limit = contributes
- No licence or disqualified = reckless
- Attempted suicide or murder = reckless
- Hit and run = reckless
- Unsafe overtaking = reckless

DFW User only:
- No seat belt = contributes

3.2.3. Inter-rater reliability

Prior to beginning the full analysis, two inter-rater exercises were completed to aid with coder training and ensure consistent treatment of crash cases. In the first exercise, three crash cases identified as involving someone driving for work as per the study criteria were coded independently by three members of the research team, and in the second exercise, a further five crash cases were coded.

Inter-rater reliability testing as described by Hirsch et al. in the national Pedestrian Deaths and Serious Injuries study (2018) was completed for the five cases analysed in the second exercise. All coding discrepancies were entered into an online kappa calculator[3] to assess the level of consensus in how cases were assigned to different categories. Kappa scores measure the rating reliability between two or more raters for qualitative variables, corrected for the likelihood that raters may agree by chance. Scores can range from -1.0 (perfect disagreement) to 1.0 (perfect agreement), with a score of 0.0 indicating the raters agreed at a level equal to chance. A score of 0.70 or above is generally viewed as adequate. A free-marginal kappa score was used in this study as there were no restrictions on how many cases could be assigned to each category (Siegel & Castellan, 1988).

For each crash, a total of 134 qualitative variables with predefined categories were coded (descriptions and numerical values were excluded). Of these, 100 variables had perfect agreement, scoring 1.0. For the remaining 34 variables, scores ranged from -0.55 to 0.77. The overall average for all variables was therefore 0.81.

Following the kappa assessment, all discrepancies in coding (including descriptions and numerical values) were reviewed, discussed, and a consistent approach agreed. In addition, unusual or difficult cases were discussed as they came up during the analysis. Finally, once coding was complete for the whole dataset, complex variables such as 'evidence of distraction/inattention' and 'extraordinary roads and roadsides factors' were reviewed and the coding adjusted as necessary.

3.2.4. Descriptive analysis

Once coding was complete, a descriptive analysis was carried out for each variable coded, using total crashes at each severity as the denominator. This enabled comparison across crashes regardless of the number of crash parties or road users involved or the number of people injured in the crash.

In order to understand how the driving for work crashes included in this study differ from other injury crashes, the findings have been compared to those from previous studies, in particular the Serious Injury Crashes study by Mackie et al. (2017). In addition, crash movement and time of day analyses were carried out on CAS records of all injury crashes occurring between 2011 and 2020 (inclusive) and compared to the corresponding analyses for the crashes in this study.

3.2.5. COVID-19 impact analysis

A brief analysis was also conducted to assess any potential impacts of COVID-19-related restrictions and behaviours on driving for work crashes. This involved separating the data into 'pre-COVID' and 'post-COVID' time periods – the latter including crashes from 21 March 2020 onwards. Relevant crash factors were then compared between the two time periods.

[3] www.justusrandolph.net/kappa/

3.2.6. Statistical cluster analysis

A statistical analysis was carried out to identify and define 'clusters' of crash factors (variables) that tended to occur together.

Variables of interest

The following variables were considered most relevant in analysing and characterising the profiles of driving for work car crashes, and therefore included in the cluster analysis:

- For driving for work (DFW) Drivers:
  crash severity, crash time, crash impact type, traffic control, land use, ratio of posted speed limit against vehicle speed (in categories[4]), ratio of SAAS against vehicle speed (in categories), DFW vehicle type, overall safety rating, age (in bands), injury level, occupation classification, driver contribution, restraint worn, presence of alcohol or drugs, evidence of fatigue, total hours driving, evidence of distraction of inattention.
- For Other Parties involved:
  ratio of posted speed limit against vehicle speed (in categories), vehicle type, mode, injury level, driver licence type, presence of alcohol or drugs, and evidence of distraction or inattention. Note that, apart from vehicle type, all other variables have been combined to reflect both parties instead of each individual party's situation.

Multiple correspondence analysis

Statistical analyses were performed using software R (version 4.0.3); statistical packages 'FactoMineR' and 'factoextra' were utilised.

Given that the abovementioned variables are categorical (nominal) and there is no intrinsic ordering to the categories, multiple correspondence analysis (MCA) was conducted on the 300 crashes. MCA is a statistical approach to summarise and visualise data with two or more categorical variables and can be used to identify groups of individuals with similar profiles in their attributes available in the dataset. In MCA, categorical variables undergo a series of transformations and are decomposed to eigenvalues, which can be thought of as axes used to understand multidimensional data. In the transformed data space, axes are selected such that the first axis explains the most variance in the multidimensional data cloud. The second axis is selected to represent the next highest variation in the data and is orthogonal to the first axis.

Missing data were neither discarded nor imputed, instead, a missing category was created for each of the variables with missing values. This was done because some of the variables are missing by nature, for example, for single car crashes, other party mode would by default be missing. Imputation doesn't make sense for cases like this. All variables included in the MCA analysis were treated as nominal variables, and having a missing level would retain as much information as possible and not change the variable's type.

Cluster analysis

To identify groups with similar attributes, cluster analysis was performed on the MCA results obtained. To achieve the best clustering outcomes, the Hierarchical Clustering on Principle Components (HCPC) approach was employed. This approach conducts a clustering algorithm based on the MCA results and allows for consolidation between hierarchical clustering and partitioning clustering. Hierarchical clustering is based on Ward's criterion to minimise within cluster variance, whereas partitioning clustering minimises the total within sample variance. More specifically, partitioning clustering uses k-means algorithm to split the data into groups.

[4] 'In categories' refers to the grouping of quantitative data into nominal categories

Both hierarchical and partitioning clustering approaches yielded the same cluster identification in our analysis.

3.3. Findings: Descriptive analysis

3.3.1. Overview of crashes included in study

This section provides an overview of the crash cases that were included in the study. As outlined in the method, the study included 300 crash cases (100 of each of minor, serious, and fatal severity). These cases are not intended to provide a comprehensive picture of all driving for work injury crashes involving light or service vehicles, but rather to provide insight into some of the common factors associated with these types of crashes across crash severities, and consider how these are similar to and different from other types of injury crashes.

Given that fatal crashes were sampled differently from minor and serious crashes, that TCRs for more severe crashes tended to be less detailed[5], and that only crashes where it was possible to attain a reasonable level of certainty that a road user involved was driving for work at the time, some care needs to be taken in interpreting the data. Taking these limitations into account, the data can still provide useful insights into crash trends for driving for work crashes.

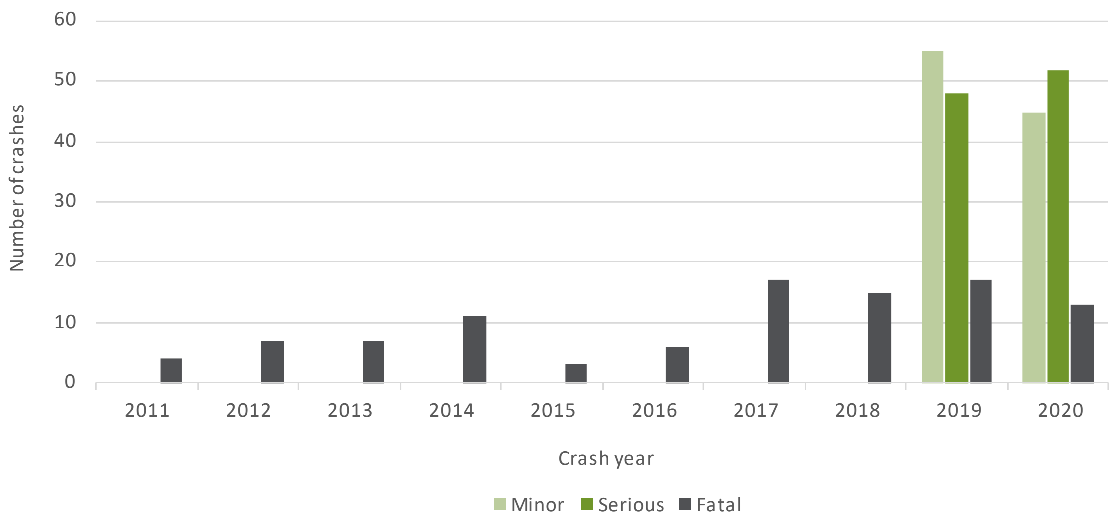
A note on terminology: though in some crashes more than one person was identified as driving for work at the time of the crash, except where stated otherwise, 'driving for work' and 'DFW' refer only to the *primary person* identified in each crash as *driving for work as per the study definition*.

Unless otherwise stated, graph percentages are proportions of the total crashes at that severity, i.e. X% of minor crashes, X% of serious crashes, or X% of fatal crashes.

Figure 5 shows that all minor and serious crash cases occurred in either 2019 or 2020 (roughly half in each). In contrast, the fatal crash cases are distributed from 2011 to 2020, with the majority (62%) taking place between 2017 and 2020. See Figure 3 for details of the selection process.

[5] As part of the case identification process, we noted that more severe crashes, especially fatal ones, tended to have less detail in the TCR, for example driver/witness statements lacking, few comments on possible causes, and frequent references to the Serious Crash Unit report (to which we did not have access) for more detail. This has been observed in previous studies, such as Hirsch et al., 2018.

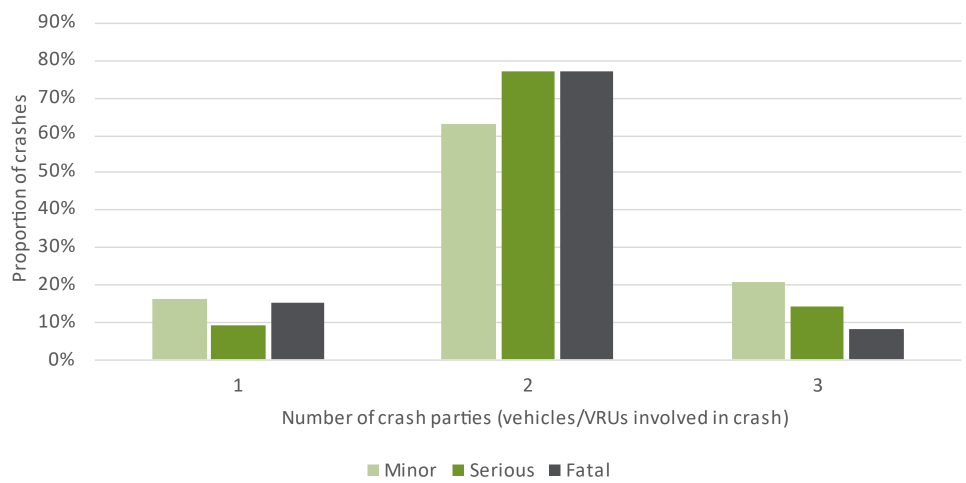
Figure 5: Year in which crash occurred



Most crashes included in the study (72%) involved two parties, that is, one person driving for work and at least one other driver, motorcyclist, cyclist, or pedestrian (Figure 6). Note that passengers are not counted as crash parties. A further 13% of crashes involved only one party (the person driving for work), and 14% involved a total of three parties (the person driving for work plus two others). Crashes involving more than three parties were excluded due to the complexity of coding multiple parties, as well as the relative rarity of crashes involving more than three parties.

There is some variability across different crash severities, with fewer two-party crashes being minor than for fatal and serious crashes, and fewer fatal crashes involving three parties.

Figure 6: Number of crash parties involved



Crash types varied significantly by crash severity (Figure 7). Minor crashes most frequently involved side impact or rear end type crashes, while both serious and fatal crashes most frequently involved head on and side impacts. Exactly half of fatal crashes (50%) were head on. Rollover, hit object, and other crash types together made up a total of 20% of all crashes. Note that pedestrian and other vulnerable road user crashes were coded using the same crash types as vehicle-on-vehicle crashes, e.g. a bus hitting a pedestrian front on was coded as a head on crash type.

Figure 7: Crash impact type

Crash movements for crashes in this study show a similar distribution to those for all injury crashes that occurred between 2011 and 2020 (Figure 8). Key differences include a higher number of pedestrian vs vehicle movements, especially at higher severities, and fewer lost control head on crashes (both on straights and bends) in the study crashes, though loss of control on bends remained the most common crash movement. There were also slightly more rear end/obstruction movements in the study.

Figure 8: Crash movement descriptions (Road Safety report movement group) – study crashes compared to all injury crashes 2011-2020

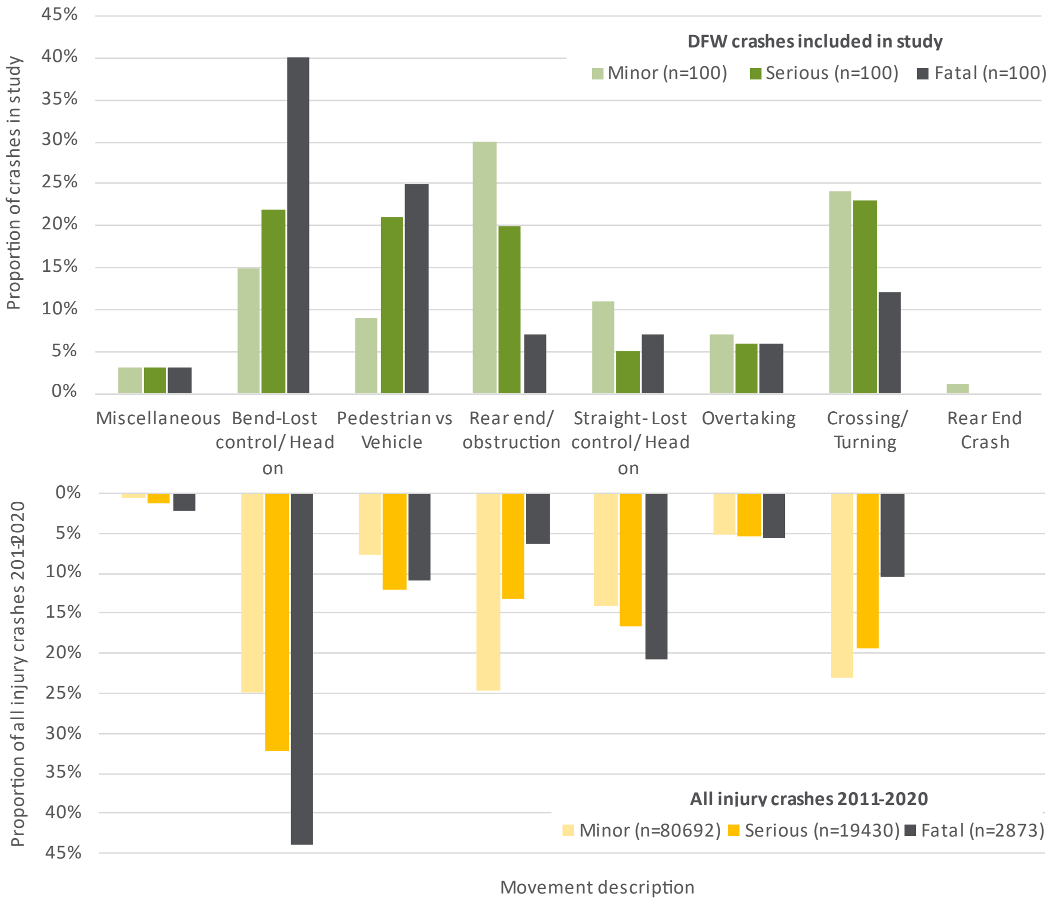
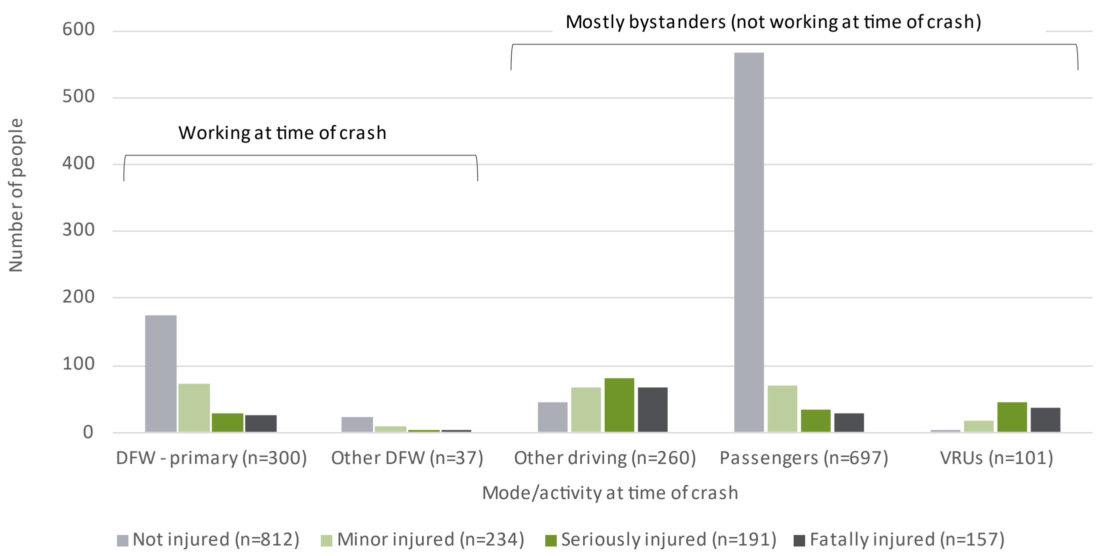


Figure 9 shows all people involved in the crashes included in the study by mode and activity at the time of the crash, as well as the level of injury sustained. Of the 812 people involved who were not injured, 567 were passengers, the large majority of whom (80%) were bus passengers. Note, however, that in some cases these bus passengers may have sustained injuries that were not reported in the TCR. Across all injury levels, 70% of passengers involved in the crashes were bus passengers in a total of 38 crashes (8%). In addition, note that 21 of the passengers travelling with someone driving for work were identified as also working at the time of the crash (i.e. they were not bystanders); however, they have been grouped together with all other passengers in the analysis.

Interestingly most people involved who were driving for work were not injured (58% of primary DFW drivers and 62% of other DFW drivers), i.e. in the majority of crashes, injuries were sustained by other road users only. In comparison, only 17% of other drivers and 2% of vulnerable road users (VRUs; motorcyclists, cyclists, and pedestrians) involved in these crashes were uninjured. While we cannot be certain how many Other Users were in fact also working at the time of the crash, it is clear that the driving for work crashes in this study resulted in injury primarily to people who did not appear to be working at the time, that is, to bystanders.

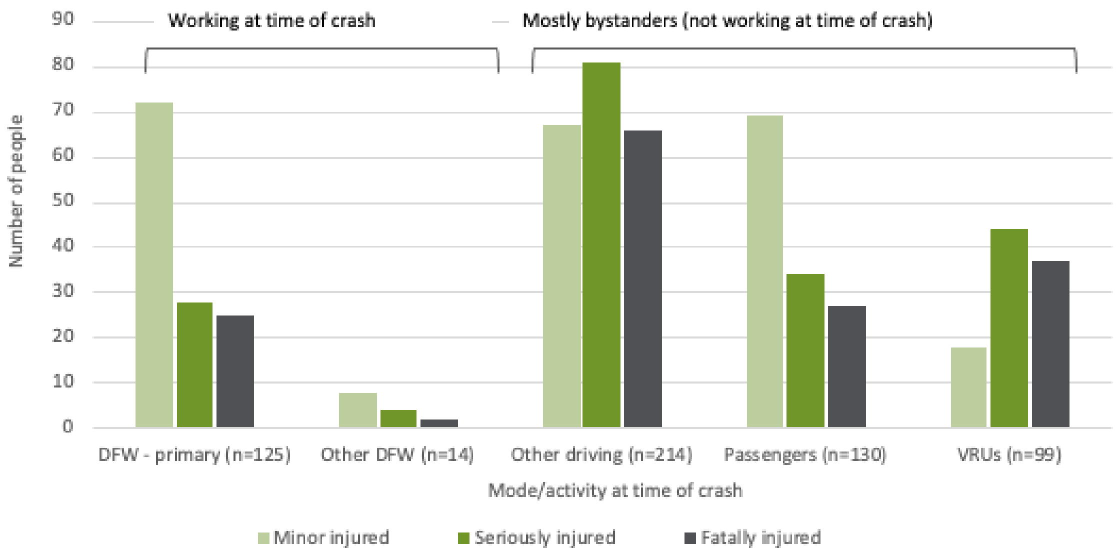
Figure 9: People involved across all crashes by injury sustained



DFW – primary is the main person identified in each crash case as driving for work according to the study definition; Other DFW includes secondary people driving for work as per the study definition as well as people driving for work that do not meet the study definition; VRUs are vulnerable road users i.e. motorcyclists, cyclists, and pedestrians; Bystanders are people who were not identified as working at the time of the crash.

Figure 10 shows the same data as Figure 9 but with non-injured people removed. This shows that people driving for work and passengers mostly received minor injuries in the crashes included in this study. In contrast, other people driving sustained similar numbers of minor, serious, and fatal injuries, while the large majority (80%) of all VRUs were seriously or fatally injured. This amounts to 23 motorcyclists, 11 cyclists, and 47 pedestrians (one on a scooter) who sustained fatal or serious injuries.

Figure 10: People injured across all crashes by injury sustained (i.e. excludes non-injured)

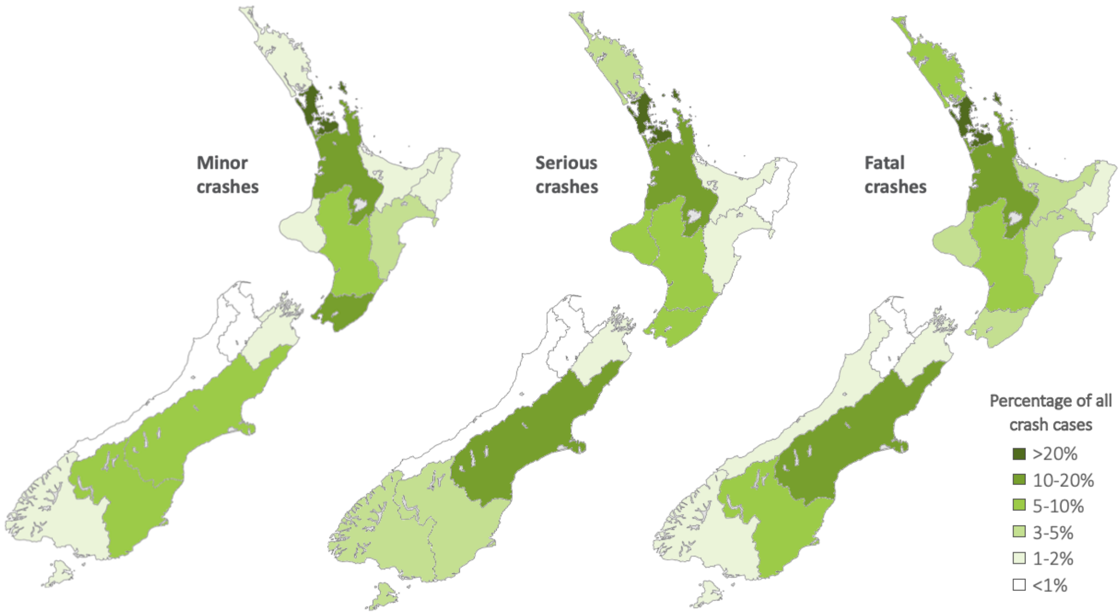


DFW – primary is the main person identified in each crash case as driving for work according to the study definition; Other DFW includes secondary people driving for work as per the study definition as well as people driving for work that do not meet the study definition; VRUs are vulnerable road users i.e. motorcyclists, cyclists, and pedestrians.

3.3.2. Geographic and temporal patterns

Crashes from all over Aotearoa New Zealand were included in the study. The most common crash region was Auckland, where around a third of all crashes occurred (31%), followed by Waikato, Canterbury, and Wellington (Figure 11). This generally reflects the large population sizes in these areas. Interestingly, Wellington crashes made up much more minor (14%) than serious (9%) or fatal (5%) crashes. Rural areas, on the other hand, were more strongly represented in higher severity crashes. In particular, Northland crashes made up only 2% and 3% of minor and serious crashes respectively, but 7% of fatal crashes.

Figure 11: Proportion of crashes in each region of New Zealand by severity



See crash numbers for each region in Table 5 in APPENDIX A: SUPPLEMENTARY TABLES AND GRAPHS

Crashes included in this study peaked between 7am and 9am in the morning (20% of crashes) and between 1pm and 5pm in the afternoon (34%; top half of Figure 12). Crashes of all severities occurred at fairly similar rates throughout the day, though a particularly high number of fatal crashes occurred between 3 and 5pm.

The crashes included in the study show a similar distribution throughout the day compared to all injury crashes occurring between 2011 and 2020 (shown in the bottom half of Figure 12). Small differences include a higher number of crashes occurring in the morning peak (7-9am) in the study data, and fewer in the evening (after 5pm). These differences are likely related to the times of day during which driving for work usually takes place (i.e. during standard working hours), as well as the sampling method, in which crash time of day (in relation to occupation) was one of the factors used to assess whether someone was most likely driving for work (see Case Inclusion Criteria in Figure 3).

The distribution of driving for work crashes in the study is similar to the overall distribution of road injuries and fatalities generally[6]. The main differences between the study crashes and all road injuries occurring from 2011-2018 are a lower number of driving for work crashes in the Bay of Plenty (6% of all road injuries compared to 2% of crashes in the study) and a larger proportion in Waikato (12% and 16% respectively). For fatalities, Bay of Plenty is again less represented in the study crashes (making up 8% of all road fatalities compared to 2% in the study), while Auckland was substantially over-represented (16% and 29% respectively).

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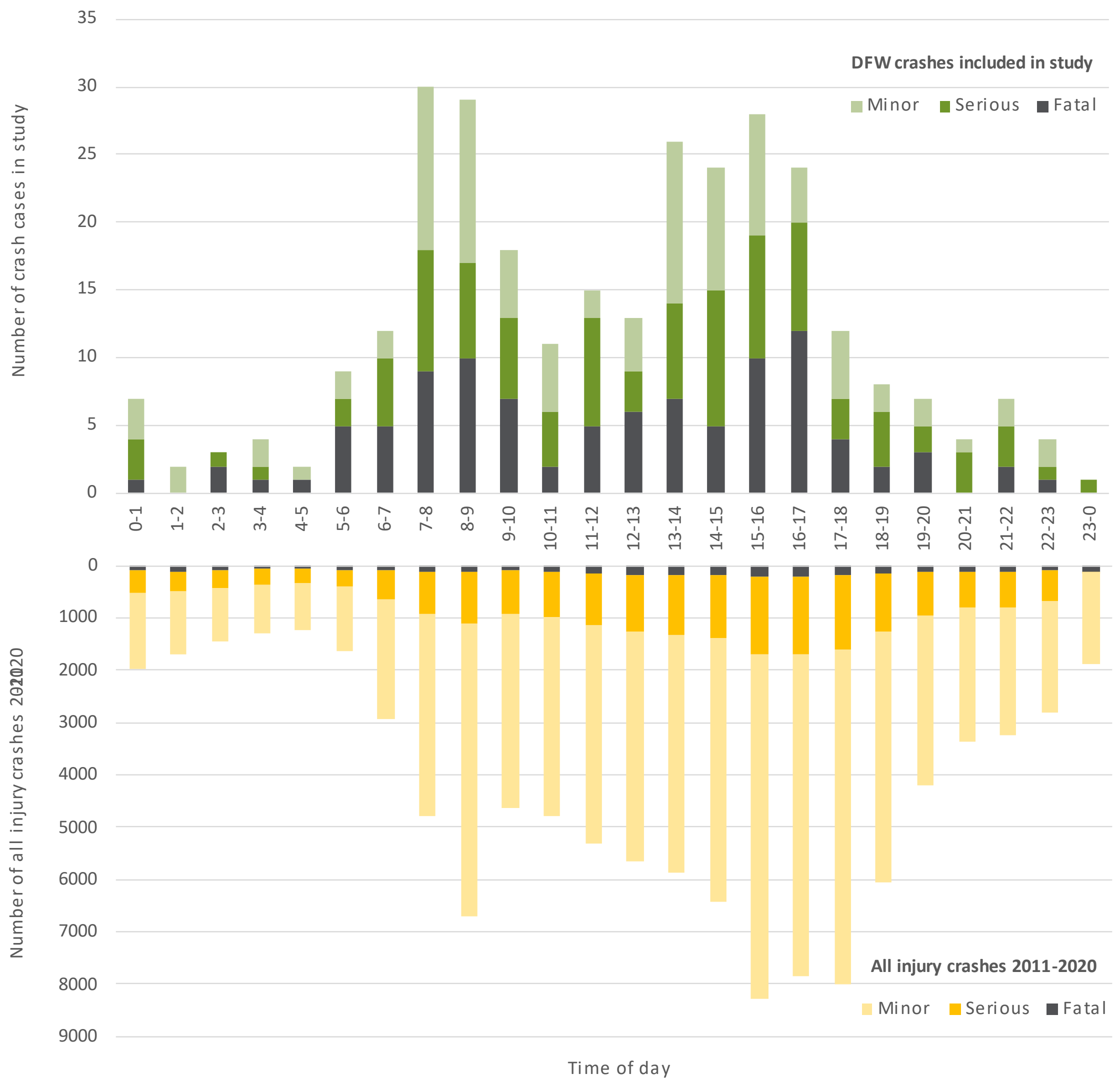
[6] Ministry of Transport (n.d.) *Te Marutau — Ngā tatauranga ā-tau: Safety — Annual statistics.* Accessed 27 January 2022 at https://www.transport.govt.nz/statistics-and-insights/safety-annual-statistics/regional-stats/

Figure 12: Crash time of day – study crashes compared to all injury crashes 2011-2020



With regard to day of week, most crashes included in the study (84%) occurred on a weekday, with slightly higher rates of serious and fatal crashes relative to minor crashes on Tuesdays, Wednesdays, and Thursdays. In contrast, the data for all injury crashes from 2011-2020 show a slightly higher rate of weekend crashes (72% occurred on a weekday) compared to the study data, with serious and fatal crash rates also highest at weekends.

3.3.3. System pillar involvement at each crash severity

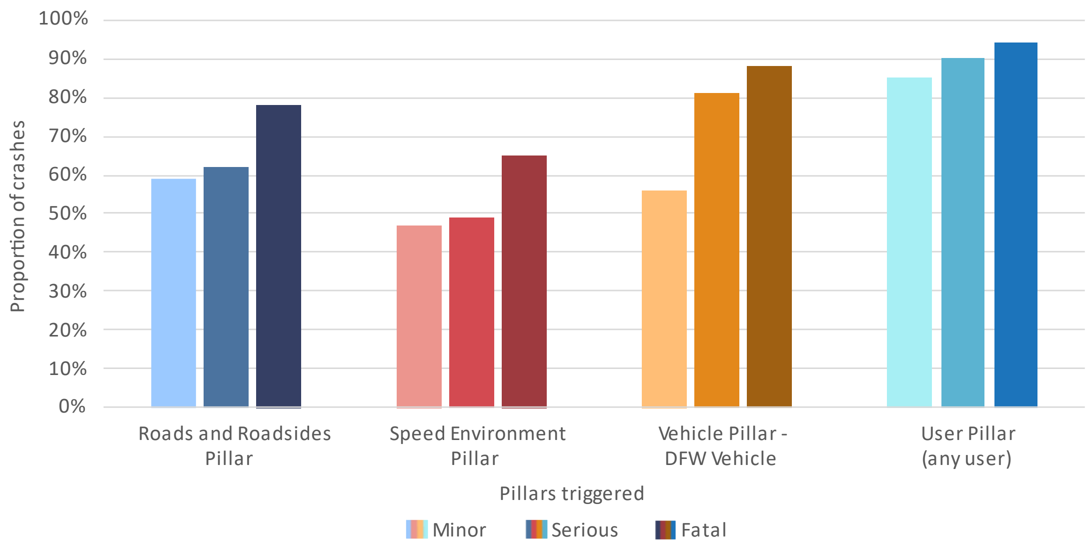
An important component of this Safe System analysis is to explore how failures in different parts of the system influence crash outcomes. By analysing the implication of each pillar and factor at different crash severities, we can start to understand the role that different elements of the Safe System play in determining not just whether a crash happens, but the severity of crashes that do happen.

Figure 13 shows the frequency with which each Safe System pillar was 'triggered' or implicated in each of the minor, serious, and fatal crashes in the study. All pillars were triggered in at least 50% of crashes, except for the speed pillar in minor and serious crashes. The user pillar was triggered most frequently, consistent with previous Safe System analyses and research indicating 90-95% of crashes result from human error (Dewar, Olsen, & Gerson, 2007; Mackie et al., 2017).

All pillars show an association between the frequency of the pillar being triggered and crash severity, i.e. all pillars were most frequently triggered in the fatal crashes included in this study, followed by serious crashes, and were least frequently triggered in minor crashes. This is more markedly the case for the Roads and Roadsides, Speed Environment, and Vehicle pillars than for the User pillar, suggesting that, while these pillars are implicated less consistently, they may have more influence on crash outcomes.

Interestingly, while both the Roads and Roadsides and the Speed Environment pillar appear to play more of a role in determining whether a crash results in serious injury versus fatality (rather than minor versus serious injury), the Vehicle pillar shows a more marked increase in frequency between minor and serious crashes. This suggests that vehicle factors may play a significant role in determining whether road users sustain light or severe injury, while road and speed environment factors are more critical in preventing fatalities in a driving for work context.

Figure 13: Proportion of crashes involving each Safe System pillar by crash severity

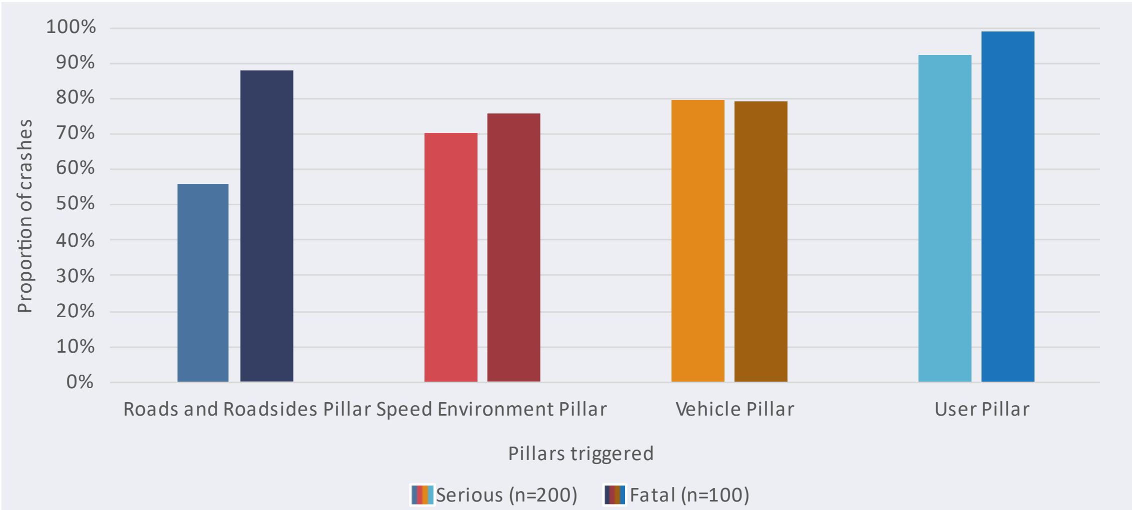


Data from the earlier Serious Injury Crashes Safe System analysis (Mackie et al., 2017) have been re-graphed below to facilitate comparison of the driving for work data presented in the current study with data for single car and car-car crashes (serious and fatal crashes only; Figure 14). Note, however, that the pillar triggers for each pillar differ somewhat between studies (e.g. distraction/inattention was a user pillar trigger in this study but was not assessed in the Serious Injury Crashes study), as well as the crash types included (e.g. vulnerable road users included in this study), so comparisons can provide only an indication of the differences and similarities between the study findings.

The overall trends are similar between the two datasets, though the Speed Environment pillar was triggered much less frequently in fatal and especially serious injury crashes in the current study. This is likely due to lower rates of speeding among people driving for work, as well as the use of a slightly less sensitive Speed Environment trigger in the current study (posted speed limits exceeding the SAAS were not used as a trigger; see 3.3.5 Speed environment pillar).

The earlier study also showed a more marked difference in the frequency with which the Roads and Roadsides pillar was implicated for serious compared to fatal crashes, and a less marked difference between these crash severities for the Speed Environment and Vehicle pillars. For the vehicle pillar, this is likely related to the larger mass of work vehicles (fewer light and medium-sized cars, more vans, utes, and light trucks) on average relative to all vehicles, indicating that vehicle factors play a greater role in determining crash outcomes in crashes that involve someone driving for work. Alternatively, these differences may simply be due to the inclusion of a wider range of road users and vehicles in the present study, or differences in the sampling method.

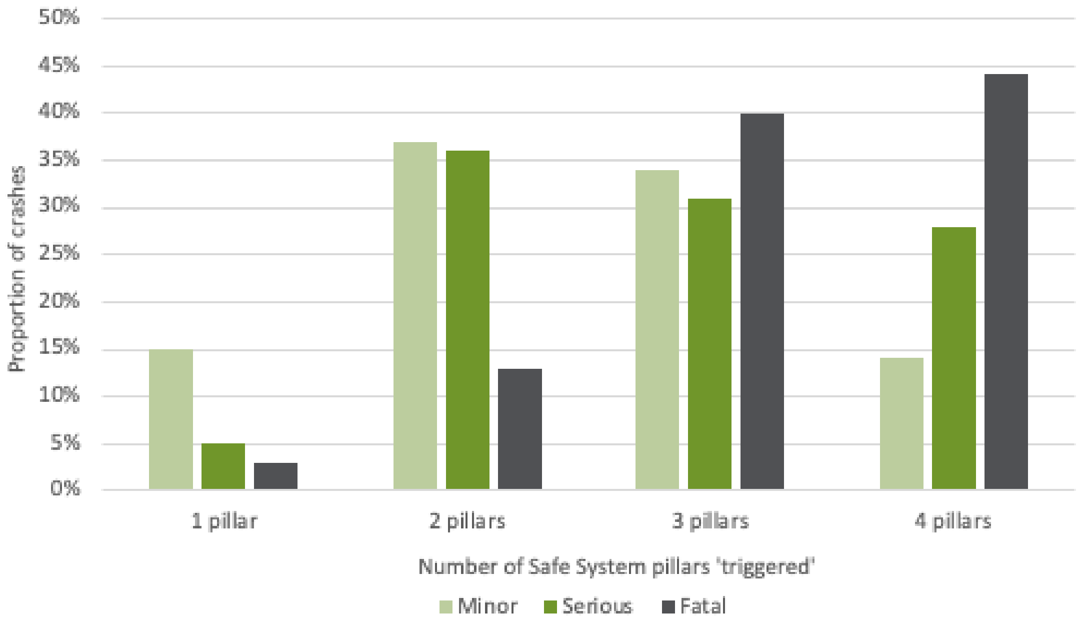
Figure 14: Data from Serious Injury Crashes study (Mackie et al., 2017) – Proportion of crashes involving each Safe System pillar by crash severity



The proportion of crashes in which one, two, three, or all four pillars were implicated is depicted in Figure 15 below. As in previous Safe System analyses (Hirsch et al., 2018; Mackie et al., 2017; Thorne et al., 2020), the more severe the crash outcome, the more pillars tend to be implicated, i.e. the more system components that fail. This aligns with systems theories such as the Swiss Cheese Model, which asserts that adverse events occur when multiple elements of a system fail (Reason, 1990). While this pattern is clearer between serious and fatal crashes than between minor and serious, it is apparent at the lower and upper ends (i.e. when either one or all four pillars are implicated) that the overall trend holds true when minor crashes are included as well.

Compared to the Serious Injury Crashes study (data not shown; Mackie et al., 2017), these driving for work data follow the same pattern of pillar implication at varying crash severity. However, while in the earlier study fatal outcomes only became more likely than serious injuries once four pillars were activated, in the present study this is already the case when only three pillars are activated. As above, this may be related to the greater range of vehicle masses and inclusion of vulnerable users in the present study, whereby large differences in mass between crash parties can lead to severe outcomes even with fewer system components failing.

Figure 15: Proportion of crashes triggering multiple Safe System pillars by crash severity



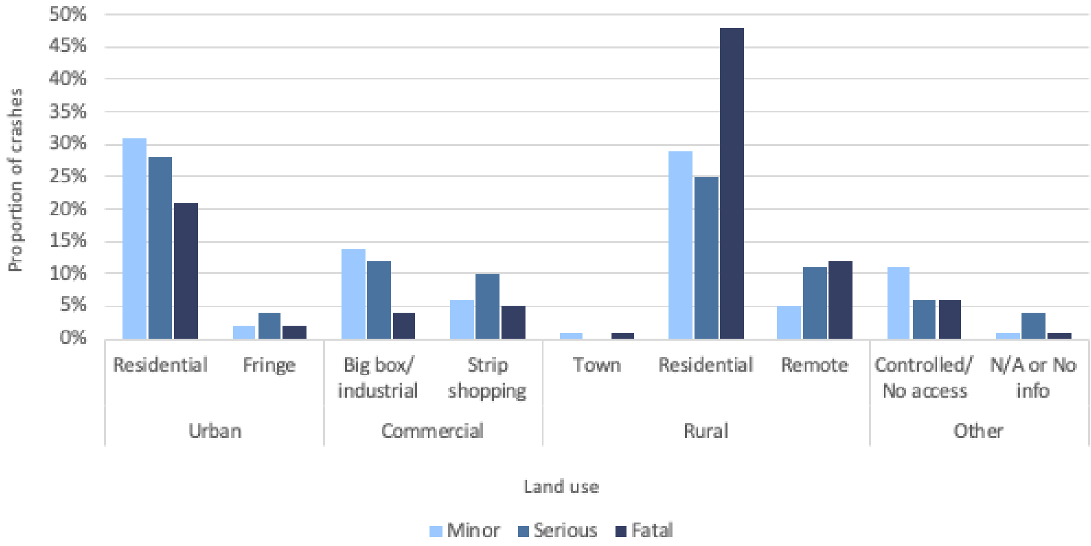
It is interesting to note, however, that if the User pillar is separated into two pillars, one for the user driving for work, and another for any Other Users involved, it is only once four pillars are implicated that fatal crashes become more common than serious ones (see Figure 44 in APPENDIX A: SUPPLEMENTARY TABLES AND GRAPHS). In this alternative analysis, crashes involving all five pillars are comparatively rare, but are also more likely to be fatal or serious than minor.

3.3.4. Roads and roadsides pillar

The roads and roadside pillar relates to the physical environment where the crashes occurred.

Land use around the locations where crashes in this study occurred are shown in Figure 16 below. Overall, 29% of crashes occurred in urban areas, 44% in rural, and 17% in commercial strip shopping or industrial areas. Urban residential and commercial industrial areas tended to have somewhat less severe crashes, while fatal crash outcomes were more common in rural residential and remote areas. This is likely due in large part to the higher travel speeds of most rural roads.

Figure 16: Land use – proportion of crashes by severity

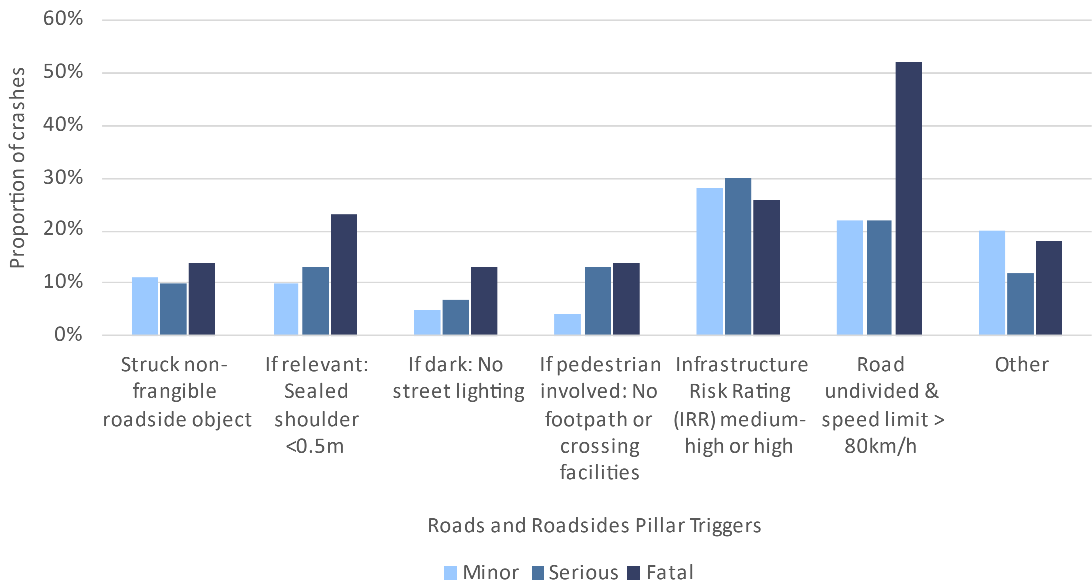


Analysis of road type based on the One Network Road Classification (ONRC) system shows over a third (36%) of crashes occurred on arterial roads, including 42% of serious and 32% of fatal crashes. However, the roads with proportionally more serious injury and fatal crashes were regional strategic (14% of serious and 23% of fatal crashes), national strategic (11% and 16%), and access roads (4% and 9%), many of which have speed limits of 100 km/h. 98% of crashes took place on sealed roads.

Over half of all crashes in this study occurred mid-block (58% minor, 54% serious, and 65% of fatal crashes), with the remainder at intersections. Of the crashes taking place at intersections, 23 were at traffic signals, a further 23 at stop signs, and 42 at give way signs.

Figure 17 shows which crash factors could trigger the Roads and Roadsides pillar, and how frequently each crash factor (pillar trigger) was implicated. The graph shows that an undivided road with a speed limit of over 80 km/h was implicated most frequently in fatal crashes, pointing to a mismatch between speed limits and the physical environment, and the consequences of having unprotected traffic in high speed environments. Overall, two thirds (65%) of crashes occurred on undivided roads, and almost three quarters (74%) of fatal crashes.

Figure 17: Roads and roadsides pillar triggers – proportion of crashes activating each trigger by crash severity



While implicated in fewer crashes than the undivided road/speed limit pillar trigger, sealed shoulder width[7], a lack of street lighting at night, and the absence of a footpath or crossing facilities where pedestrians were involved were also strongly correlated with crash severity.

Of the total of 55 crash cases involving a pedestrian, 49% involved a pedestrian crossing where there was no crossing facility. This is a higher proportion than in previous pedestrian Safe System studies, where lack of crossing facilities was implicated in closer to a third of crashes (Hirsch et al., 2018; Thorne et al., 2020). One possible explanation for this finding is the high number of bus crashes included in the present study (due to the case identification method), which often involve a pedestrian crossing the road, and often where crossing facilities don't exist nearby: 9 of the 27 cases in which lack of crossing facilities was implicated involved a bus. With regard to land use, 11 of the 27 occurred in urban residential areas (in 4 cases of which a child ran into the street), 8 in commercial shopping strip areas, and 6 in commercial big box/industrial areas.

In addition, of 18 crashes (7%) involving a cyclist (note no cycling-specific triggers were included), 10 occurred at intersections and 8 mid-block. In 14, the cyclist was riding along the road, with a further 3 taking place on the footpath and one on a dedicated cycle lane, in which the Driving for Work User turned across the cycle lane in front of the cyclist.

Lack of street lighting in urban areas was implicated in 25 crashes, 5 of which involved pedestrians or cyclists. The remaining 20 all took place on rural roads, mostly with speed limits of 100 km/h, and approximately half (9) were single vehicle crashes, with the other half (11) involving at least one other vehicle. Thirteen involved the driving for work driver crossing the centreline.

The road Infrastructure Risk Rating (IRR) was implicated slightly more frequently than in the Serious Injury Crashes report (28% compared to 23% respectively; Mackie et al., 2017), possibly

[7] Where relevant to the nature of the crash, i.e. a wider shoulder would have provided more recovery or manoeuvring space (e.g. crashes where a vehicle crossed the edge line, or crossed the centreline into the path of an oncoming vehicle)

indicating that driving for work crashes tend to occur on more roads with poorer infrastructure than other (car only) crashes. Notably however, close to half (45%) of all crashes, and 53% of fatal crashes occurred on roads with a medium IRR (which did not trigger the pillar). The other pillar triggers used here varied slightly from the Serious Injury Crashes report, making comparison difficult.

Other roads and roadsides factors implicated in this study included: obstructed vision due to a bend, dip, or crest in the road, parked cars or traffic, vegetation, or a wall (7% of all crashes); wet, icy, or windy road conditions (5%); narrow sections of road or bridge (4%); and gravel surface (1%).

3.3.5. Speed environment pillar

The speed environment pillar relates to the way roads are set up with regard to speed, including posted speed limits, speed advisories, and Safe And Appropriate Speeds (SAAS) as defined in MegaMaps, as well as the behaviour of road users within that environment.

Figure 18 below depicts the posted speed limits at each crash location. The default urban and rural speed limits of 50 km/h and 100 km/h respectively are common across crash severities due to the high proportion of roads on which these speed limits are in place. However, crashes on 100 km/h roads were much more likely to be fatal (making up 50% of all crashes on 100 km/h roads) than minor or serious, while 21% of crashes on 50 km/h roads in this study resulted in a fatality. This pattern is consistent with, though starker than the findings of the Serious Injury Crashes study (Mackie et al., 2017), and reflects the widely accepted understanding that the forces resulting from crashes at high speeds are less survivable than those at lower speeds (ITF, 2016).

A curious finding in the present study is that there is little difference between the proportion of minor and serious crashes occurring at these speeds, with slightly fewer serious injury crashes occurring on 100 km/h roads than minor ones. This may be for a range of reasons: not all vehicles were travelling at high speeds (in 8 minor and 5 serious crashes, all vehicles were travelling at 50km/h or lower); crashes were of a lower impact type (11 minor involved rear end impacts compared to 4 serious); there tended to be less size difference between Driving for Work and Other User vehicles in minor crashes (vehicle mass implicated in 3 minor compared to 9 serious crashes); and possibly also due to some subtlety around the distinction between minor and serious crashes, which could result in overlap between the two severities.

Figure 18: Posted speed limit at crash location by crash severity

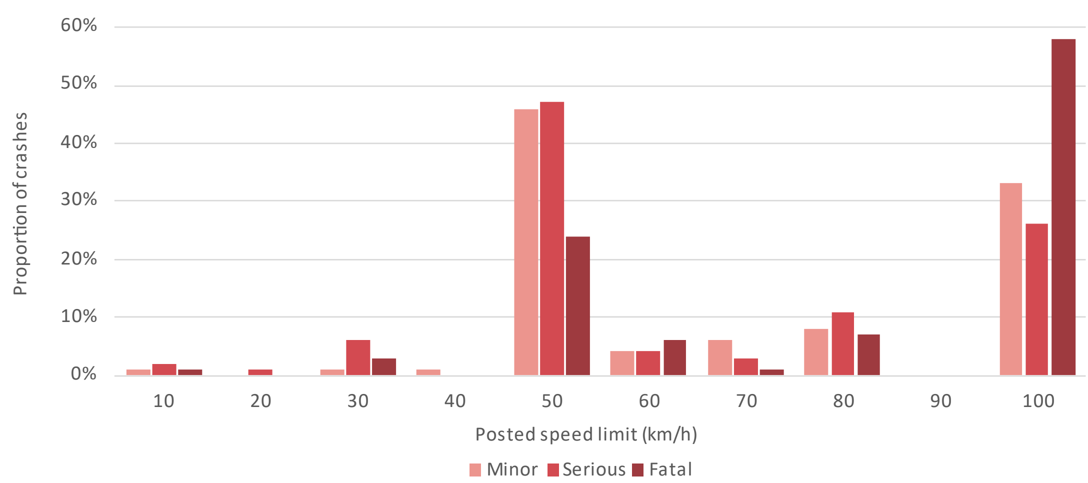
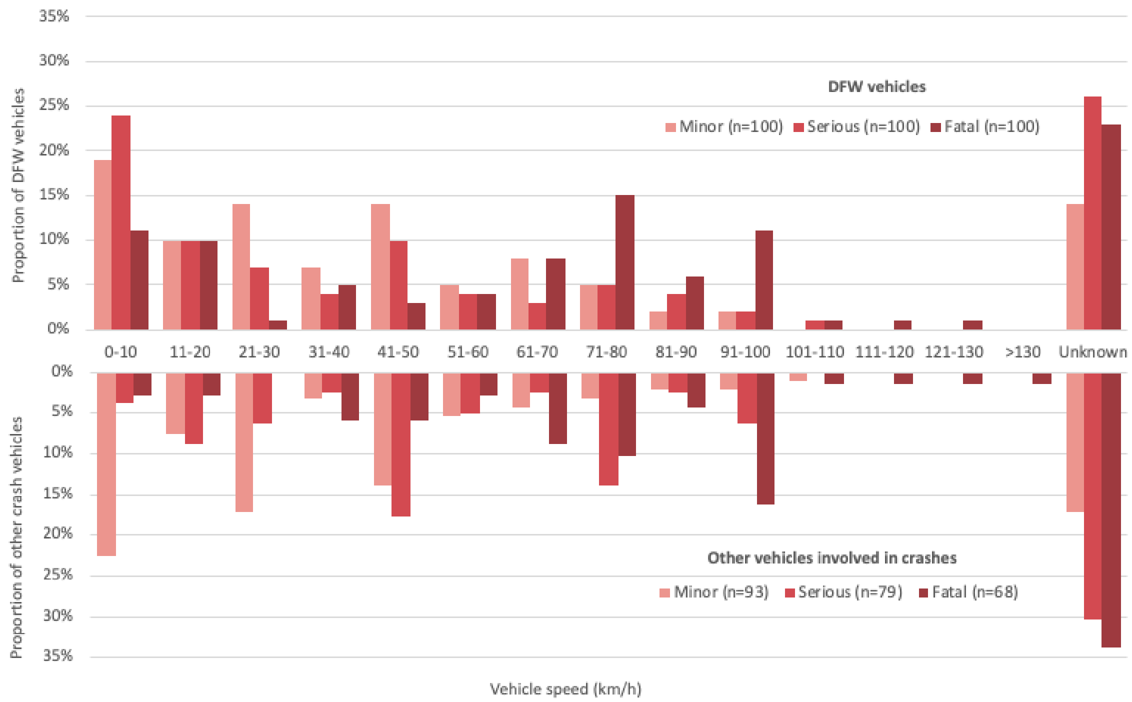


Figure 19 below, which depicts travel speeds at the time of the crash, again demonstrates the relationship between speed and fatal outcomes. Proportionally more serious and especially fatal crashes occurred at speeds of 41 km/h and above, while the large majority of minor injury crashes occurred at speeds of 50 km/h or lower.

However, some serious and fatal crashes still occur at low speeds, and this is particularly the case for driving for work vehicles travelling at speeds of 20 km/h or less. A similar trend of some high severity crashes at low speeds was observed in the earlier pedestrian Safe System analyses (Hirsch et al., 2018; Thorne et al., 2020) and indeed, of the 55 serious and fatal crashes occurring at driving for work vehicle speeds of 20 km/h or less (18% of all crashes), 24 involve a pedestrian or cyclist, many of whom were children or older adults and therefore likely to be more susceptible to serious or fatal injury. Overall, work vehicles have a larger mass than the vehicle fleet overall, and this would exacerbate injury risk for vulnerable road users.

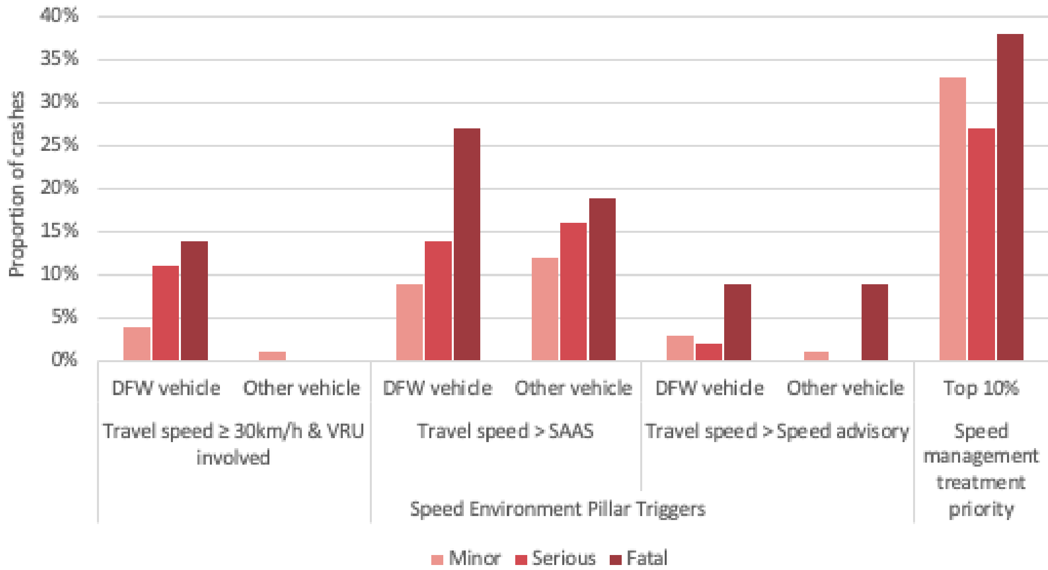
The speed of Other Users largely explains the severe outcomes in the 31 serious and fatal crashes at 20 km/h or less that do not involve a pedestrian or cyclist. 11 of these involved motorcyclists, who are similarly vulnerable to crash forces as pedestrians and cyclists, and all of whom were likely to be travelling at least 50 km/h. A further two crashes involved a driving for work vehicle being hit by a train, and the remaining 18 involved at least one other vehicle travelling at a speed of at least 40 km/h (where an estimated speed is recorded in the TCR). These crashes often involve the Driving for Work User making an unpredictable manoeuvre, such as turning into or out of a driveway or side street, pulling back out into traffic, or temporarily parking on the side of the road, often in locations where the speed limit is 70 km/h or higher.

Figure 19: Vehicle travel speeds at time of crash for driving for work vehicle (top) and other vehicles (bottom) – proportion of crashes by crash severity



The crash factors which could trigger the speed environment pillar in this study are shown in Figure 20 below, along with the proportion of minor, serious, and fatal crashes in which they were triggered. All were implicated more frequently in crashes of higher severity than those of lower severity, further reinforcing the importance of speed in determining crash outcomes.

Figure 20: Speed environment pillar triggers – proportion of crashes activating each trigger by crash severity



The crash severity trends are similar to those reported in the Serious Injury Crashes study (Mackie et al., 2017), however, the crash factors were triggered to different extents. Note also that the current study did not include 'speed limit exceeds the SAAS' as a trigger as this would include crashes in which speed was not necessarily a contributing factor. The speed environment pillar in this study was therefore less sensitive to those features of the speed environment that do not appear to have influenced driver behaviour.

Travel speeds exceeding the SAAS was implicated slightly less frequently in the current study (at least one vehicle exceeded the SAAS in 27% of crashes, compared to around a third in the Serious Injury Crashes study), which may be due in part to people driving for work being less willing to take risks such as speeding compared to the general population, as well as that the large majority of crashes in this study took place during the day and especially at peak traffic times, when speeding is less likely due to congestion. Taking into account that not all crashes included another driver, we see that a slightly greater proportion of non-driving for work drivers (21% of other drivers, including motorcyclists) also exceeded the SAAS than drivers driving for work (17%). While this is still a lower rate than in the Serious Injury Crashes study, it provides some indication that people driving for work may speed less than the general population.

3.3.6. Vehicle pillar

The vehicle pillar takes into account the type, size, design, and condition of the vehicles involved in each crash.

Figure 21 shows the types of vehicles involved in the crashes included in this study by proportion of total driving for work (top) and other (bottom) vehicles. Note that for the Driving for Work vehicles, the proportion of vehicles is equivalent to the proportion of crashes (one Driving for Work vehicle per crash); however, for the other vehicles involved, the number of vehicles involved per crash varies. Furthermore, some 'other vehicles', particularly light and medium/heavy trucks, are also likely to have been in use for work at the time of the crash, however, they are not counted as Driving for Work in this study.

The graph shows that a much greater proportion of other vehicles were cars (42%), compared to Driving for Work vehicles (20% were cars). Driving for Work vehicles were more likely to be utes (15% of all driving for work vehicles), vans (26%), light trucks (13%), and buses (18%) compared to other vehicles. Three percent of Driving for Work vehicles were medium/heavy trucks – 7 rubbish trucks and 2 road works trucks. Eight percent of Other User vehicles were motorcycles, 6% bicycles, and a further 19% of Other Users were pedestrians (includes two people on scooters) at the time of the crash.

With regard to crash severity, cars were associated with a higher proportion of minor crashes, as were vans, to a lesser extent. SUVs, medium/heavy trucks, and buses are all implicated more frequently in high severity than low severity crashes, most likely as a result of their large mass and high/one-box[8] bonnet shapes (Huang, Siddiqui, & Abdel-Aty, 2011).

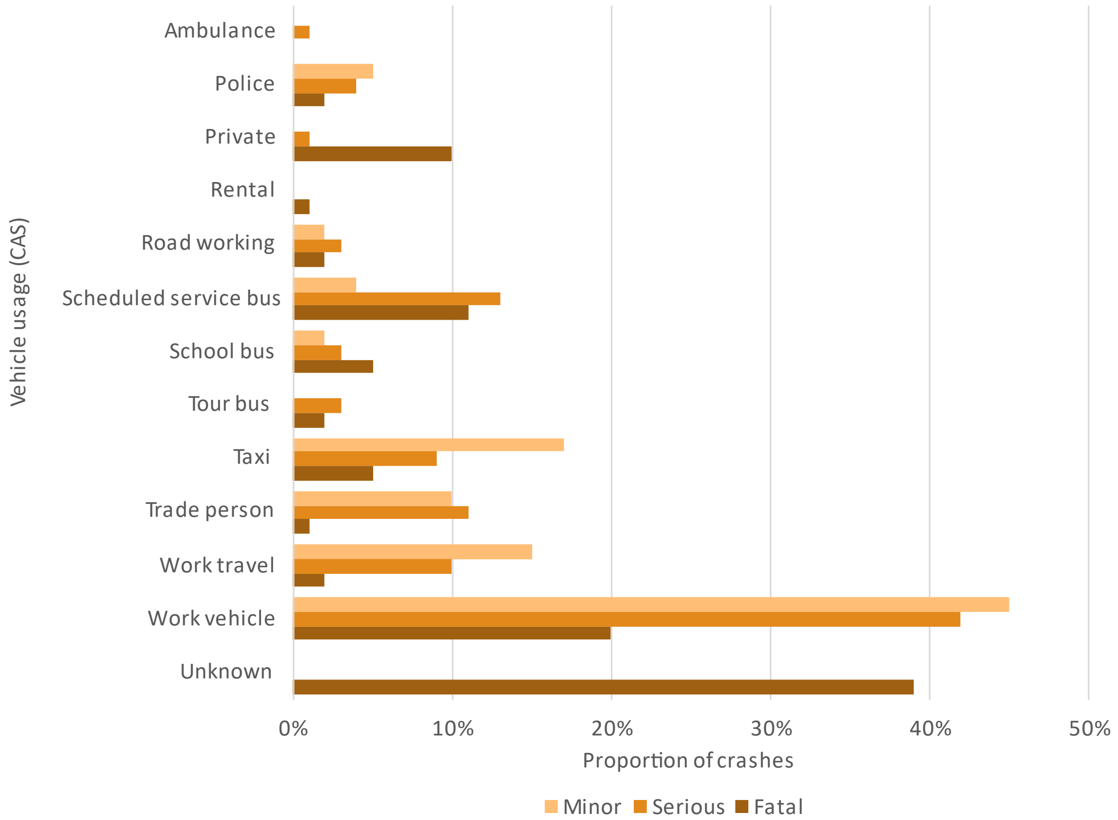
Surprisingly, utes are not especially implicated in higher severity crashes, nor light trucks, possibly due to the type of work for which they tend to be used. Utes have also increased substantially in popularity over the last few years, which may partially explain their lower representation in the fatal crashes, as these go back to 2011. Motorcycles are also implicated more frequently in high severity crashes (as are pedestrians, labelled 'None (i.e. pedestrian)' in the graph below), in this case, due to their greater vulnerability as a result of not being encased in a vehicle. Somewhat counterintuitively, bicycles were more common in minor and serious injury crashes, which is likely due to the relatively small sample size.

Figure 21: Vehicle type for driving for work vehicle (top) and other vehicles (bottom) – proportion of vehicles by crash severity

[8] One-box is a car body configuration typical of vans, where there is no distinct bonnet separate from the driver compartment, i.e. the front of the vehicle is relatively straight up and down.

The vehicle usage classification recorded in TCRs since 2018 is shown for the driving for work vehicle in Figure 22 below. The 'work vehicle' category was most common, with scheduled service buses, taxis, tradespeople, and 'work travel' each contributing around 10% of cases.

Figure 22: Vehicle usage type (from TCR) for driving for work vehicle – proportion of crashes by crash severity

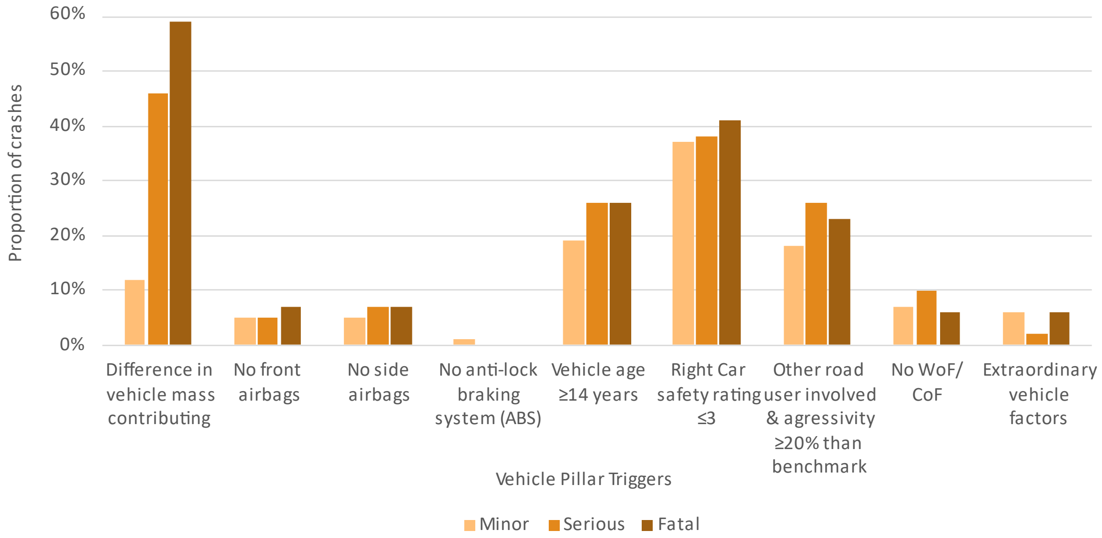


The crash factor triggers for the vehicle pillar are depicted in Figure 23 below. The most frequently implicated trigger, as well as that with the strongest relationship to crash severity, is difference in vehicle mass. This factor was implicated when there was a substantial difference in size or mass between the driving for work vehicle and another vehicle or road user (e.g. ute vs small car or vulnerable road user) that contributed either to the occurrence or the severity of the crash. In 95% of cases where this trigger was implicated (111 out of 117), the driving for work vehicle was larger/greater mass than the other vehicle or road user, including 76 crashes involving a vulnerable road user.

In addition, vehicle aggressivity based on Monash University Accident Research Centre models (Newstead et al., 2017) was implicated in only 23% of crashes, in large part due to the limited availability of ratings for rarer vehicles, trucks, and buses, as well as vehicles less than five years old (due to the age of the report – see 3.2.2 Safe System analysis procedure). However, for the 96 driving for work vehicles for which aggressivity ratings were available, 90% had a rating below the recommended level, with three quarters (76%) receiving the lowest rating of 60% below benchmark (not shown; note Figure 23 only shows poor aggressivity ratings where another road user was involved). This relationship between vehicle mass/frontal shape and crash severity aligns with previous analyses showing vans, trucks, SUVs, and utes being implicated more frequently in fatal than serious crashes involving pedestrians (Hirsch et al., 2018).

Further correlations between pillar triggers and crash severity, while comparatively weak, include vehicle safety ratings (see Figure 24), vehicle age (note the relationship is much stronger when looking only at vehicles 16 years or older), and lack of air bags. Extraordinary vehicle factors include 13 crashes (4%) where the driving for work vehicle was towing a trailer or car. In 4 of these cases, the crash was cause by a trailer wobbling, shearing off, or disconnecting, and in another, by a towed car crossing the centreline on a corner. Heavily laden vehicles or trailers were also considered a crash factor in a total of 4 crashes. There were also single cases involving large blind spots, brake failure, bull bars, a passenger in the cargo compartment, and a lack of fuel.

Figure 23: Vehicle pillar triggers for driving for work vehicle – proportion of crashes activating each trigger by crash severity



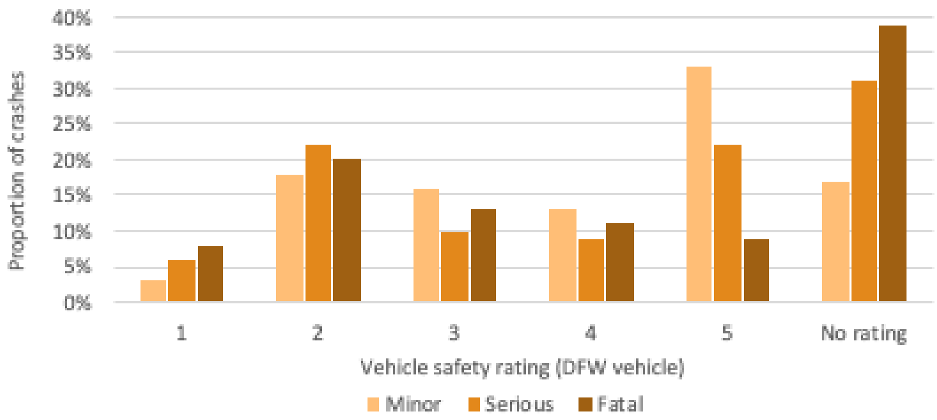
Other interesting points to note include the relatively rare implication of lack of airbags and anti-lock braking system (ABS) compared to the Serious Injury Crashes study, where these were implicated in up to 80% and 25% of crashes respectively (Mackie et al., 2017). Note, however, that air bag information was unknown for over 40% and ABS for almost 60% of all driving for work vehicles in this study, including 92 buses and trucks for air bags and 95 for ABS. Of the cars, SUVs, utes, and vans for which no air bag (34 vehicles) or ABS (81) information was recorded, around 80% were 10 years old or older.

Vehicle age was also implicated only around half as much in the present study compared to the Serious Injury Crashes study. In contrast, low vehicle safety ratings are implicated at around the same level in both studies (around 40% of crashes), suggesting that work vehicles involved in crashes may be newer than other vehicles involved in crashes, but not necessarily safer. Finally, rates of no WoF/CoF for driving for work vehicles were the same as other vehicles (not shown) at 8% of all crashes, which is lower than in the Serious Injury Crashes report, and for both user types, lack of WoF/CoF was implicated more frequently in serious crashes than either minor or fatal ones.

A further breakdown of driving for work vehicle safety ratings is provided in Figure 24 below. This graph demonstrates that more minor crashes involved 5-star vehicles than did serious and fatal crashes), while 3- and 4- star ratings are somewhat mixed. As expected, 1- and 2- star ratings show a positive correlation with crash severity, as do vehicles for which no safety rating was available (39% of driving for work vehicles in this study, 81 of which were trucks and buses, as well as 5 vans and 1 SUV).

Looking more closely at 1-, 2-, and 3-star rated vehicles, 58 out of 116 (50%) were vans and further 22 (19%) were utes. Occupation-wise, technicians and trades workers (37 crashes) and labourers (17) were over-represented in low star-rated vehicle crashes relative to their proportion of total crashes in the study, while professional drivers were under-represented (28).

Figure 24: Right Car vehicle star safety ratings for driving for work vehicles – proportion of crashes by crash severity



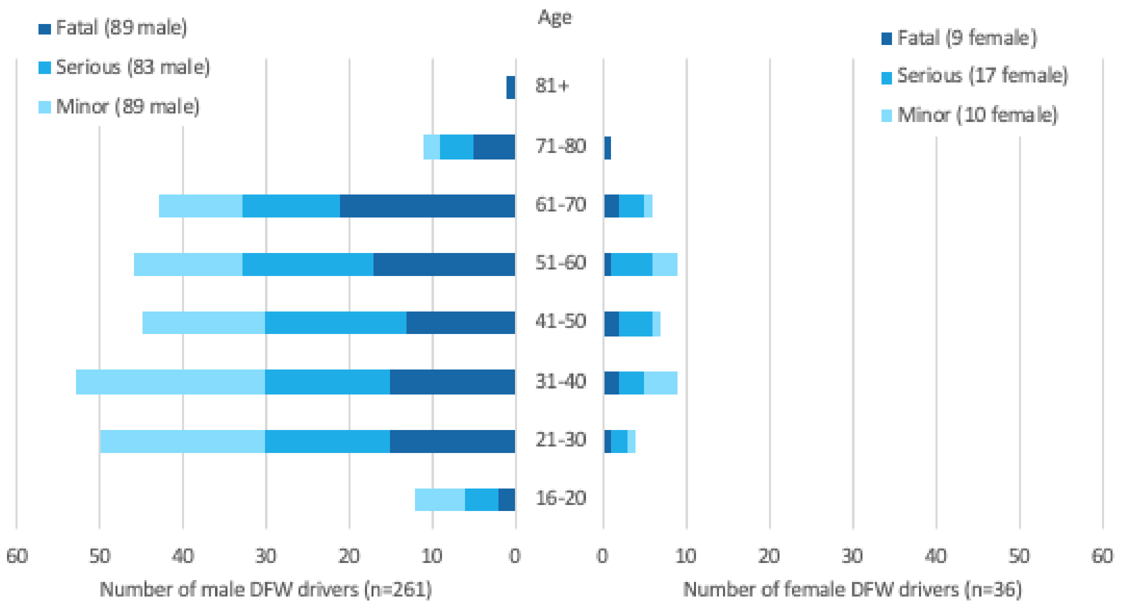
3.3.7. Road user pillar

The road user pillar pertains to characteristics, conditions, and behaviours of the individual road users involved in the crash. In this section, the demographic and occupational characteristics of the Driving for Work User are detailed, following which the pillar trigger factors for each of the Driving for Work Users and Other Users are outlined.

Below is a population pyramid showing the age and gender of the Driving for Work Users involved in the crashes in this study (Figure 25). Driving for work users were predominantly male (88%) with a fairly even age spread between 21 and 70 years of age. Younger male drivers (ages 21-40) made up a slightly larger number of overall crashes, but the proportion of crashes resulting in fatality increased from age 51. Relative to their proportion of crashes overall, male drivers made up a slightly greater proportion of fatal crashes (90%) while serious crashes were more likely to involve female drivers (17% compared to 12% of overall crashes).

Compared to the age and gender distribution of drivers in the Pedestrian Deaths and Serious Injuries (Hirsch et al., 2018) study (driver demographics were not explored in the Serious Injury Crashes and Seat Belts analyses), the Driving for Work Users involved in crashes in this report were more likely to be male (88% compared to 63% of drivers involved in a crash where a pedestrian was fatally or seriously injured), and had a much more even age distribution (Hirsch et al., 2018). The more extreme gender difference makes sense, given that men are much more likely to have jobs that involve a significant amount of driving (e.g. tradesperson, professional driver; Callister & Didham, n.d.). With regard to the age distribution, possible explanations include that people with occupations involving large amounts of driving for work tend to be older, or that they tend to be more risk averse when driving for work than at other times, thereby smoothing out the peak normally seen for young male drivers. This may support the findings where a lower proportion of driving for work crashes involve extreme behaviours compared with all crashes.

Figure 25: Age and gender distribution – number of Driving for Work Users by crash severity



Note: two Driving for Work Users with age unknown and one with gender unknown are excluded (n=297).

Ethnicity of the driver for work was also reviewed, with 52% of drivers where an ethnicity was recorded in the TCR being of European/Pākehā ethnicity, 18% Māori, 17% Asian, 9% Pacific, 5% other. Note that almost a third (30%) of TCRs did not have an ethnicity recorded for the Driving for Work User. Compared to the overall Aotearoa New Zealand population makeup in 2018 of 70% European/Other, 17% Māori, 16% Asian, 8% Pacific, and 2% Middle Eastern/Latin American/African (note these percentages add to more than 100% as census participants can record multiple ethnicities; Stats NZ, n.d.) there is therefore some indication that other ethnicities are over-represented in the data relative to European/Pākehā drivers. The only clear trend by severity was a lower proportion of Asian ethnicity drivers represented in serious and fatal crashes (8% and 7% respectively) compared to minor crashes (20%).

Figure 26 below shows the ANZSCO (Australian and New Zealand Standard Classification of Occupations) occupation group of Driving for Work Users in the study. The classifications included the following occupations in this study:

- Managers: farmers, restaurant and sales managers, supervisors
- Professionals: analysts, building inspectors, chefs, government agency staff, engineers, nutritionists, surveyors, veterinarians
- Technicians and trades workers: see Figure 27
- Community and personal service workers: ambulance officers, au pairs, baristas, caregivers, council workers, nurse aides, police officers, security personnel, teacher aides
- Clerical and administrative workers: administrators, library assistants, postal workers
- Sales workers: retailers, salespersons, shop assistants, storepersons
- Machinery operators and drivers: see Figure 27
- Labourers: bricklayers, cleaners, concrete workers, fencers, fisheries workers, housekeepers, labourers, road workers, scaffolders, steel fixers, waterside workers.

The most common occupation group was, unsurprisingly, Machine operators and drivers at 37% of all crashes, followed by Technicians and trades workers at 20%. Both occupation groups require substantial amounts of driving and would therefore be expected to feature in a large proportion of crashes. Labourers made up a further 9% and Community and personal service workers 8% of all crashes. Both Machine operators and drivers and Technicians and trades workers were also most strongly represented in fatal compared to lower severity crashes. Clerical and administrative workers and Professionals also had relatively high representation in fatal crashes compared to other crash severities; however overall numbers of drivers in these occupations were low.

Figure 26: Driver occupation group (ANZSCO) for Driving for Work Users – proportion of crashes by crash severity

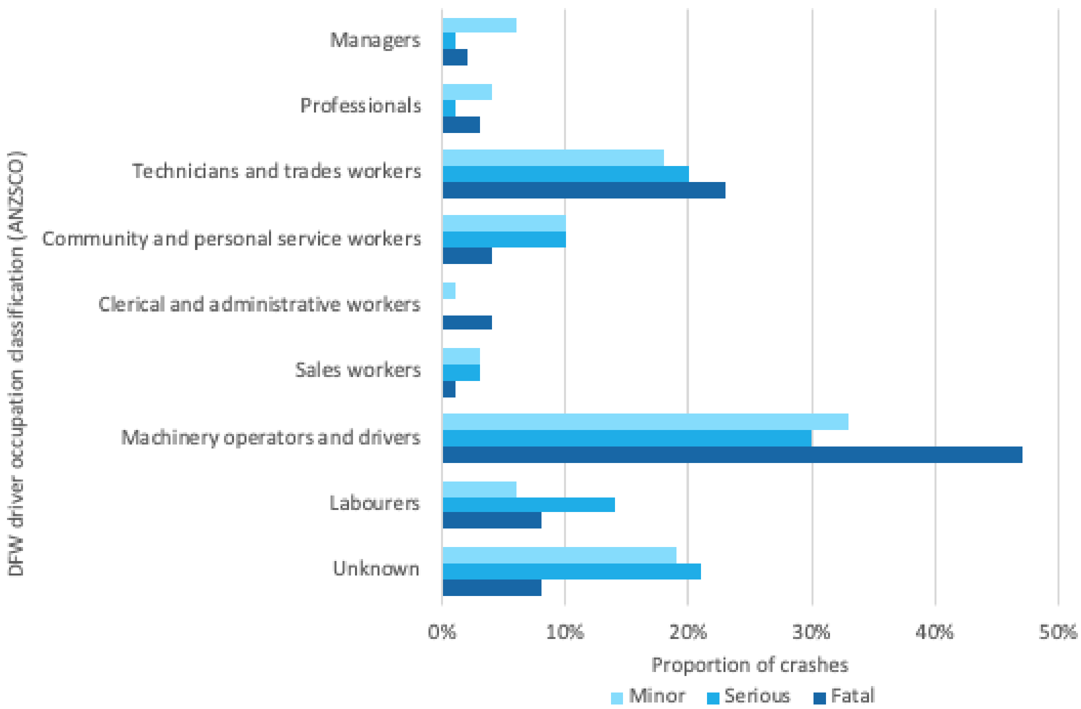
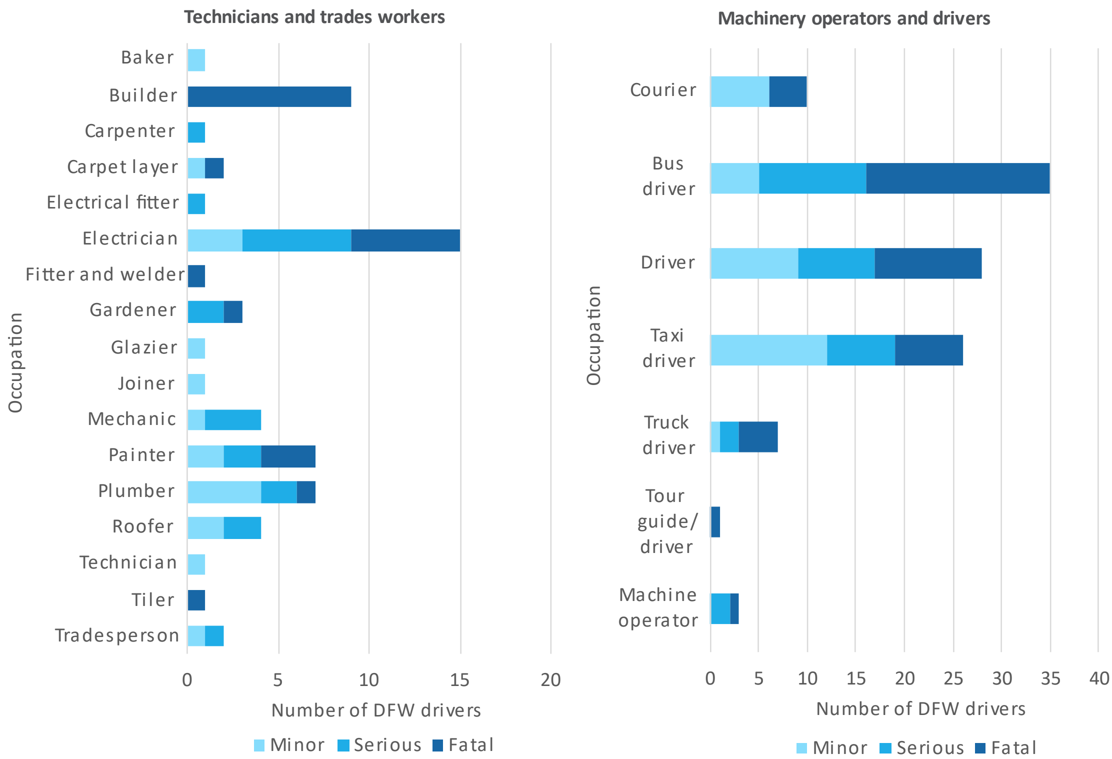


Figure 27 shows a further breakdown of the two most common occupation groups into individual occupations, as recorded in the TCR. Looking more closely at Technicians and trades workers, builders, electricians, and painters all occurred frequently in the data (likely as there are lots of them and they drive for work a lot) as well as showing up more often in the fatal crash data. Potential reasons for the link with crash severity include frequent driving, possibly on high speed roads, or fatigue related to long working hours, hard physical work, and early morning starts. Unusually, builders appear only in fatal crashes (9 in total). Six of these occurred on roads with a 100 km/h speed limit and one with an 80 km/h speed limit, and all Driving for Work vehicles were utes (5), vans (3), or light trucks (1), suggesting that vehicle mass/shape and speed played a role in crash severity.

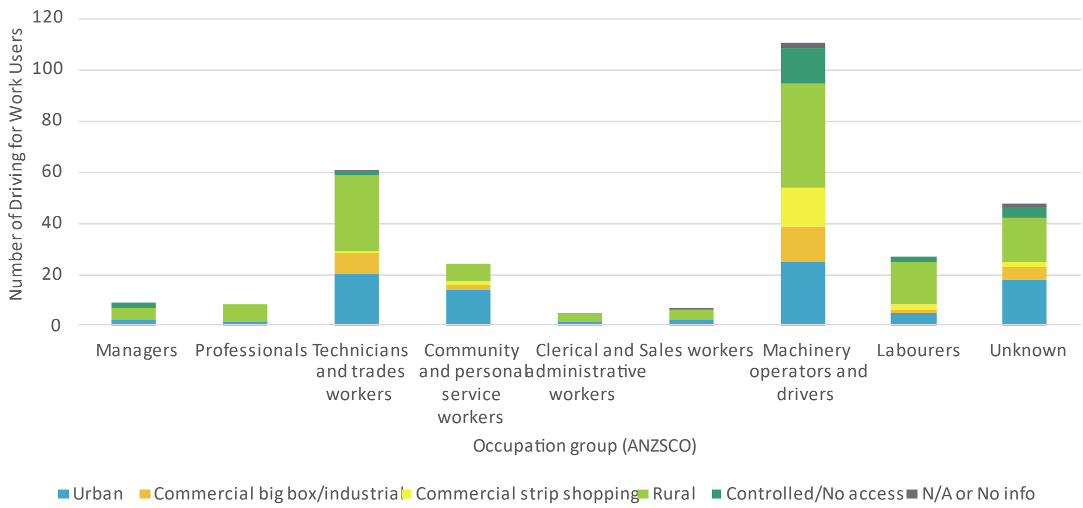
For Machinery operators and drivers, bus drivers, general drivers, and taxi drivers featured frequently in the data. The bus driver occupation was associated with more severe crashes, again due to vehicle size/mass, especially where vulnerable road users were involved. Taxi drivers, on the other hand, tended to be involved in less severe crashes which were generally in lower speed areas (69% of taxi driver crashes occurred in areas with speed limits of 50 km/h or lower), and often at intersections where vehicles tend not to be travelling at full speed.

Figure 27: Breakdown of driver occupations for Technicians and trades workers (left) and Machinery operators and drivers (right) – number of Driving for Work Users by crash severity



In Figure 28 below, Driving for Work User occupation group is broken down by land use where the crash occurred (across all crash severities combined). Rural crashes are shown to make up a large proportion of crashes across all occupation groups, while most crashes on commercial strip shopping and controlled or no access roads involved machinery operators and drivers.

Figure 28: Land use of crash road by occupation group – number of Driving for Work Users



Passengers were present in the (primary) Driving for Work vehicle in a total of 29% of crashes, including 26% of minor, 26% of serious, and 34% of fatal crashes (note that in a further 18% of fatal crashes, passenger numbers were unknown). This includes a total of 14 crashes where passengers were colleagues/also working at the time of the crash, 14 crashes involving taxi or

Uber passengers, and 33 with bus passengers. Passenger type at the time of the crash was unable to be determined in a further 37 crashes, most of which were fatal (23 crashes).

Crashes in which there were bus passengers in the driving for work vehicle tended to be more severe (regardless of whether passengers were injured or not) due to bus mass/size and the nature of the crashes included. Information on the levels of injury sustained by all passengers is provided in 3.3.1 Overview of crashes included in study.

On average, vehicle occupancy for Driving for Work vehicles in the study was 2.8, with a slightly lower rate of 2.6 across all vehicles. However, excluding crashes where the Driving for Work vehicle was a bus,[9] the vehicle occupany rate for Driving for Work vehicles was only 1.3. This is lower than the average occupancy for vehicle trips in Aotearoa New Zealand, which was 1.5 in 2011-2014 (Ministry of Transport, 2015).

While focusing on user culpability in crashes is inconsistent with a system approach, examining to what extent the actions of users driving for work contributed to a crash can provide insights into overall driving for work crash patterns. Figure 29 below shows the crash role of users driving for work at the time of the crash, as recorded in the TCR (i.e. as concluded by the attending officer). Note the data include single party as well as multi-party crashes.

Interestingly, while the Driving for Work User was deemed to play the primary role in 'causing' the crash in about half of crashes (48%), the data show a negative correlation with crash severity. In contrast, while crashes in which the Driving for Work User was deemed to have played no role in causing the crash were slightly fewer (44%), these crashes were more likely to have resulted in severe injury. This could indicate that the mistakes people driving for work make tend to be less critical, or occur in places where severe injury is less likely e.g. in urban areas and at intersections where speeds tend to be lower.

Looking only at multi-party crashes, the Driving for Work user was ascribed the primary role in 42% of crashes, and no contribution in 49%. They were ascribed the primary role in fewer fatal crashes (36% of all multi-party fatal crashes) than either serious (43%) or minor (45%) crashes.

Further, of the total of 97 crashes involving a VRU, the Driving for Work User was deemed to have played the primary role in half (48) of them. However, for crashes involving at least one other driver and no VRUs, they were recorded as playing the primary role in around a third (37%) of crashes.

Analysing crash role by vehicle type shows that people driving SUVs for work, though low in numbers (14 crashes in total), were much more likely to be deemed the primary contributor to the crash (8% of primary contribution crashes vs 1% of no contribution crashes). People driving vans (29% vs 24%), cars (22% vs 19%) and light trucks (15% vs 11%) were also slightly over-represented in crashes where the Driving for Work User was considered the primary contributor to the crash. In contrast, people driving buses for work were more often found not to have contributed to the crash (10% of primary contribution crashes vs 27% of no contribution crashes.

[9] Bus crashes were excluded from the final vehicle occupancy calculation because bus passengers were rarely injured in the crashes included in the study: only 8% of 462 bus passengers were injured in the 55 crashes in which the Driving for Work vehicle was a bus.

Figure 29: Role in crash for Driving for Work User (from TCR) – proportion of crashes by crash severity

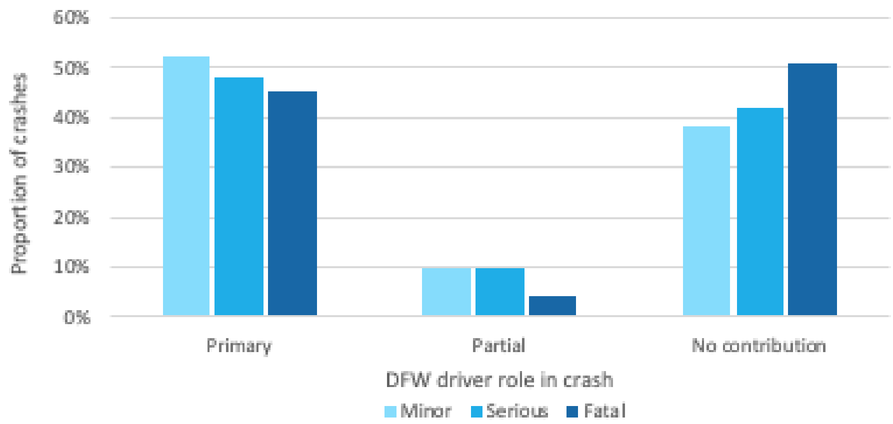
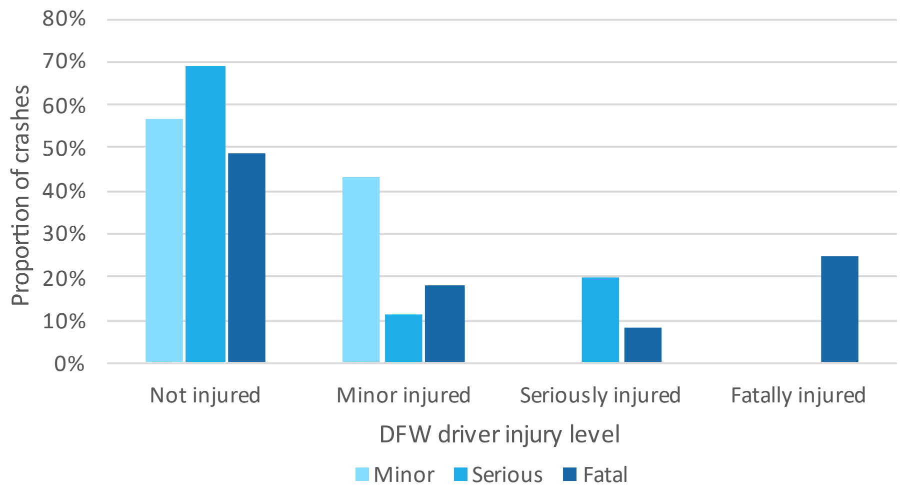


Figure 30 below shows the proportion of crashes in which the Driving for Work User sustained minor, serious, fatal, and no injuries. From this graph we can see that Driving for Work Users were fatally injured in a quarter (25%) of fatal crashes, seriously injured in a fifth (20%) of serious crashes, and minor injured in fewer than half of minor crashes (43%). Thus at all crash severities, but especially in more severe crashes, the person(s) most severely injured was not the primary Driving for Work User, rather it was an Other User involved in the crash.

Further, if we remove the 40 single party crashes from the analysis to look only at crashes involving at least one other road user (not shown), the primary Driving for Work User was fatally injured in only 14% of fatal crashes, seriously injured in only 13% of serious crashes, and minor injured in only 35% of minor crashes. This further reinforces the findings from 3.3.1 that the victims of driving for work crashes tend not to be the people themselves driving for work, but rather other road users.

Figure 30: Level of injury sustained by Driving for Work Users – proportion of crashes by crash severity



The various conditions and behaviours user that could trigger the user pillar in this study are detailed in Figure 31 (Driving for Work User) and Figure 32 (Other Users) below. Note that multiple factors could be implicated in a single crash, i.e. the pillar triggers are not mutually exclusive.

The pillar triggers include several crash factors that are not usually directly described in the TCR and therefore require some judgement to determine whether they are implicated in the crash:

- Medical event – implicated when the crash description or driver comments indicated the crash was wholly or in part due to a medical condition or event (e.g. evidence of heart attack or fainting, mentions suffering from pain in leadup to crash)
- Inattention/distraction evident – implicated when either the nature of the crash indicated the user could not have been paying full attention to their environment (e.g. drifted across centreline without reason, hit a pedestrian despite no visibility obstructions) or when the driver comment or crash description suggests they were distracted (e.g. playing with radio, focusing on traffic in other direction, stepped into path of oncoming traffic) or inattentive (e.g. fell asleep, perceived another road user to have appeared out of nowhere). Note that medical events, fatigue, and poor emotional state were also coded as inattention/distraction where it was apparent that these mental states had contributed to a lack of full concentration.
- Fatigue evident – implicated when the nature of the crash, crash description, driver comments, total hours driving, or number of hours of sleep in the 24 hours prior indicated the user fell asleep or was feeling tired at the time of the crash (e.g. drifted over centreline or fog line and failed to correct immediately, has no recollection of leadup to crash, mentioned feeling sleepy)
- Poor emotional state – implicated when the crash description or driver comments indicated the user was likely upset, angry, or overexcited (e.g. evidence of altercation, mentions recent breakup).

Note that the above factors, particularly evidence of fatigue, are heavily dependent on the attending officer's assumptions, the driver's statement, and any witness statements. As such, in cases where there is no driver or witness statement, as is particularly common in TCRs for more severe crashes due to crash party incapacitation or shock, evidence of fatigue and other mental states is less likely to be identifiable than for minor crashes. In addition, drivers may be unwilling to report factors such as fatigue to police. The presence of these mental states is therefore likely underestimated in the data.

Further, 'Too fast for conditions' is a TCR field completed by the attending officer, rather than a judgement made by the coder. It was noted during the coding process that in some cases a road user was recorded as not travelling too fast for the conditions, despite speeds well in excess of speed advisories or other road conditions, and therefore also likely underestimates the role of speed in these crashes.

Finally, while it is useful to make some comparisons between the crash factors triggered by the Driving for Work User and those triggered by Other Users, it should be kept in mind that 40 crashes (13%) were single party crashes involving a Driving for Work User (sometimes with passengers) and no Other Users. Therefore, all things being equal, we would expect to see slightly higher rates of the user pillar being triggered for Driving for Work Users compared to Other Users.

The user pillar trigger graph for Driving for Work Users shows that inattention/distraction was the most commonly triggered user crash factor, triggered in just over a third of crashes (36%), but was more strongly associated with lower severity crashes. A summary of the types of distraction and inattention identified is shown in Table 1 below. Note that use of technology such as maps and mobile phones was coded; however, numbers were low (identified in only 7 crashes), it was difficult to ascertain whether or not the technology use was related to the crash e.g. if they reported looking at something prior to checking traffic and pulling into road, and TCR reporting is likely to be unreliable. As such, instances where technology or other items did appear to have distracted the driver are counted under distraction in the table. Similarly, stress related to work and other circumstances were very rarely reported in the crash TCRs and so were not included in the analysis.

Table 1: Types of distraction/inattention for Driving for Work User – number of users by crash severity

Distraction/inattention summary	Crash severity			
	Minor	Serious	Fatal	Total
Distracted	5	1	3	**9**
Driving too close to centreline	2	0	0	**2**
Failed to see another vehicle approaching (e.g. at intersection, before pulling into lane, U-turn)	8	6	1	**15**
Failed to see a stationary vehicle	1	1	0	**2**
Failed to see vehicle in front slowing/stopping	4	1	0	**5**
Failed to see motorcyclist/moped	1	2	2	**5**
Failed to see cyclist	5	6	1	**12**
Failed to see pedestrian/scooter	1	7	3	**11**
Failed to see approaching train	0	0	2	**2**
Forgot handbrake	0	1	1	**2**
(Likely) fell asleep	2	4	7	**13**
Following too closely	4	0	0	**4**
Impaired	0	0	2	**2**
Inattentive - crossed centreline	1	1	6	**8**
Inattentive (other)	3	3	1	**7**
Looking for gap in traffic	1	0	1	**2**
Misread traffic signal	1	2	1	**4**
Not enough checking when reversing/starting forward	3	2	2	**7**
Total	**42**	**37**	**33**	**112**

Non-use of seat belt was observed more frequently than expected, occurring in 14% of all crashes, which is similar to the rate of drivers in the Serious Injury Crashes study (Mackie et al., 2017). Non-use was strongly correlated with more severe crash outcomes; however, a closer look at the data shows that 15 of the 42 crashes involved bus drivers not wearing seat belts, and only three of these resulted in injury to the driver themselves (2 fatal, 1 minor). The crash outcomes in these crashes were therefore related more to vehicle mass than restraint use. Looking only at the 18 cases where the user driving for work was injured, seven cases involved professional drivers (3 bus, 2 taxi, 2 truck) five involved technicians or tradespersons (including 2 electricians), and 4 involved labourers.

Fatigue was implicated in 6% of crashes for Driving for Work Users and was associated with higher severity crashes. In a total of 13 crashes (4%), it was either clear or likely that the driver had fallen asleep (Table 1). As noted previously, these numbers are likely to be an underestimate, given the reliance on (often lacking) driver testimony and officer crash summaries. Total hours driving and total hours of sleep in previous 24 hours were also analysed in the framework; however, this information was recorded as unknown in over two thirds of crashes, especially more severe ones (52% minor, 64% serious, 90% fatal). Compared to the Serious Injury Crashes report, rates of falling asleep among users driving for work in the present study were around half those of drivers in the earlier study (Mackie et al., 2017).

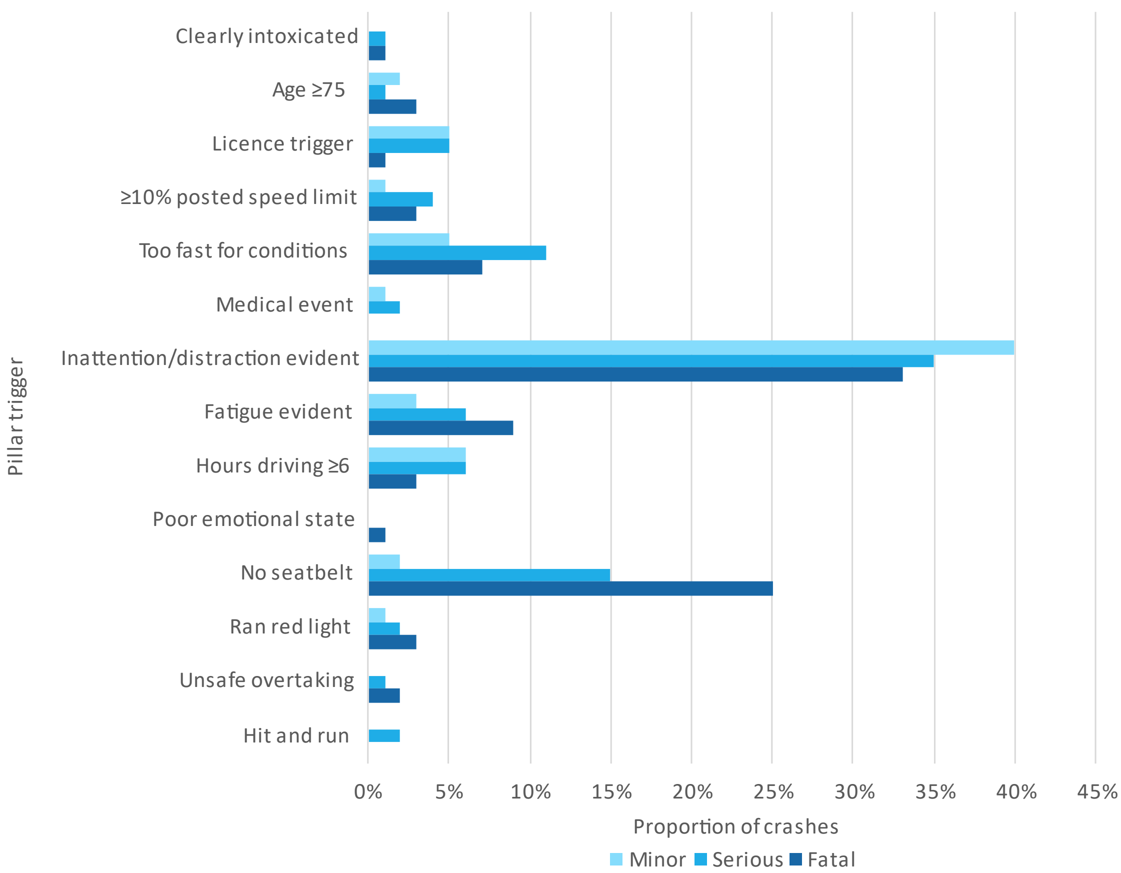
While red light running was relatively rare, it was correlated with high crash severity. A total of six crashes involved the driver for work failing to see or comply with a red traffic signal – three involved a bus driver and two (including one bus driver) occurred at train signals.

Intoxication, speeding, and licence issues were implicated in relatively few crashes compared to the Serious Injury Crashes (Mackie et al., 2017) and national Pedestrian Deaths and Serious Injuries studies (Hirsch et al., 2018). Only two crashes were identified in which the Driving for Work User was clearly intoxicated, though alcohol or drugs were present or suspected in a total of 11% of cases (9% minor, 13% serious, 10% fatal).

Exceeding the speed limit by 10 or more km/h was recorded in 3% of crashes overall, and 'too fast for conditions' in 8%. Interestingly, 4 of the 8 drivers travelling at 10+ km/h over the speed limit were police officers involved in pursuits or responding to emergency calls, meanwhile, of the 23 driving too fast for the conditions, 7 were labourers, 6 were tradespersons, and 6 were professional drivers of different sorts. These crashes happened on roads with a range of speed limits, both rural and urban. Relative to their overall representation in crashes in this study, this suggests that drivers in labour and trade occupations may be more likely to take risks while driving for work.

Finally, Driving for Work User licence issues (learner, disqualified, overseas, or no licence) were implicated in 4% of crashes overall, with an additional 4% of crashes where the Driving for Work User held a restricted licence (no correlation with crash severity).

Figure 31: User pillar triggers for Driving for Work User – proportion of crashes activating each trigger by crash severity



Inattention/distraction was implicated to a very similar extent for Other Users (36% of total crashes) as for Driving for Work Users. Table 2 below summarises the various types of distraction and inattention identified for Other Users.

Table 2: Types of distraction/inattention for Other Users – number of users by crash severity

Distraction/inattention summary	Crash severity			
	Minor	Serious	Fatal	Total
Crossed heedless of traffic (pedestrian)	4	7	7	**18**
Distracted	5	2	2	**9**
Driving too close to centreline	2	0	0	**2**
Failed to see another vehicle approaching (e.g. at intersection, before pulling into lane, U-turn)	9	7	8	**24**
Failed to see a stationary vehicle	1	3	1	**5**
Failed to see vehicle in front slowing/stopping	3	4	0	**7**
Failed to see motorcyclist approaching	1	1	0	**2**
(Likely) fell asleep	0	2	2	**4**
Filtering through traffic (pedestrian)	0	2	2	**4**
Following too closely	1	1	0	**2**
Impaired	2	2	4	**8**
Inattentive - crossed centreline	0	2	9	**11**
Inattentive (other)	1	2	2	**5**
Misread traffic signal	3	1	0	**4**
Standing in road	0	1	0	**1**
Unsupervised child entered road	0	2	3	**5**
Wrong pedal	1	1	0	**2**
Total	**33**	**40**	**40**	**113**

Note more than one user may be counted per crash.

Most user pillar triggers were triggered more often for Other Users than for Driving for Work Users (note seat belt use and hours driving were not measured for Other Users). This is despite Other Users being involved in only 87% of crashes overall. Notable exceptions were fatigue, which was implicated more frequently for Driving for Work Users, and red light running, implicated at a similar rate for both user groups.

More frequently implicated Other User triggers include intoxication (4% of crashes), very young or old age (12%), licence issues (13%), too fast for conditions (12%), poor emotional state (3 %), and unsafe overtaking (4%). However, in the case of intoxication, licence issues, and too fast for conditions, the rates for Other Users in this study are still much lower than in the Serious Injury Crashes study. This is again likely related to the time of day and nature of (identifiable) driving for work crashes, meaning that even people who are not driving for work are less likely to engage in risky behaviours than they might be at other times (e.g. evenings and weekends) or locations.

Figure 32: User pillar triggers for Other Users – proportion of crashes activating each trigger by crash severity

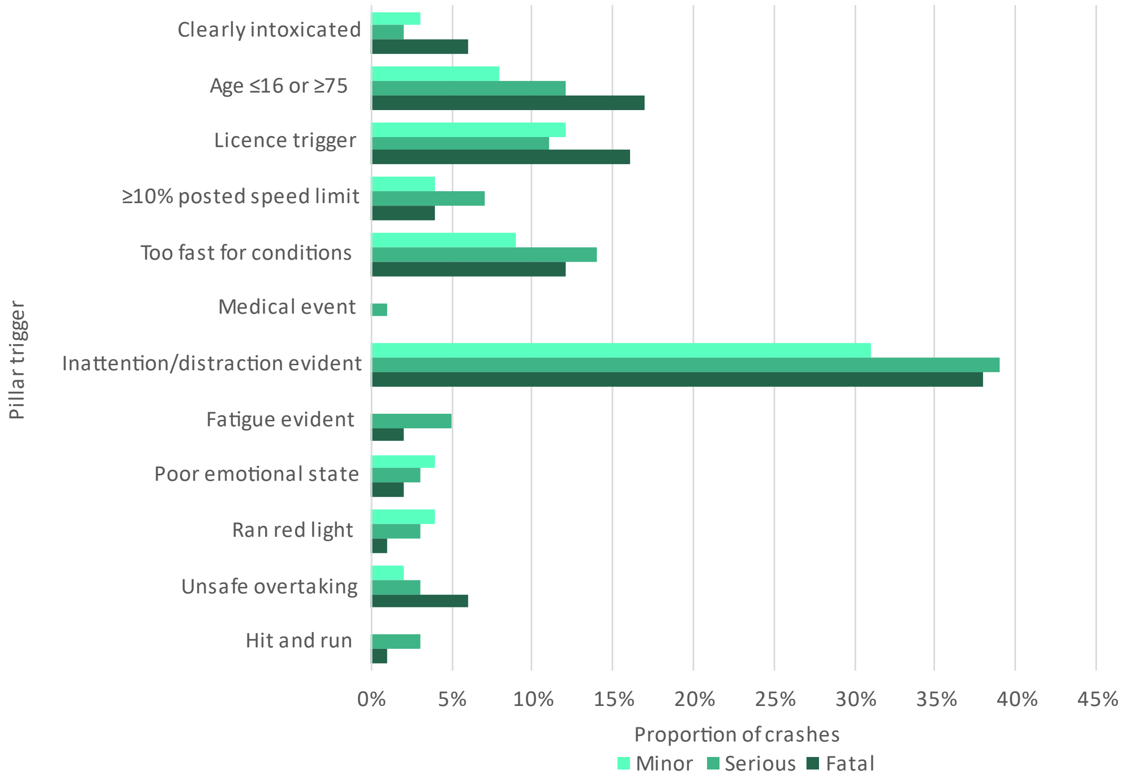
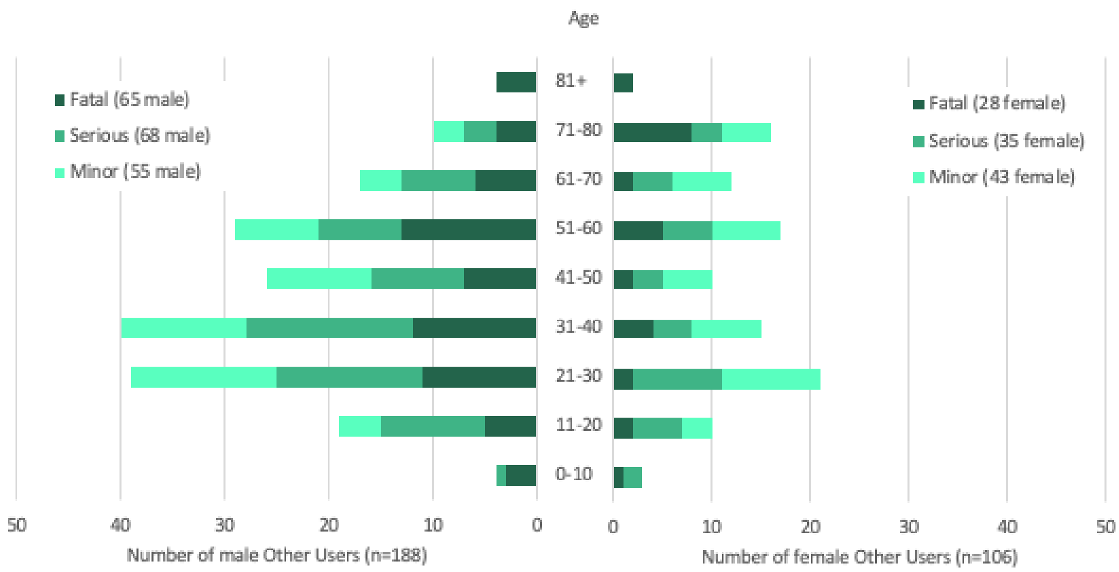


Figure 33 below shows a population pyramid for Other Users. As with Driving for Work Users, men were involved in many more of the study crashes than women (64%), though to a lesser extent. The age distribution of Other Users is also more reflective of crash casualties across crashes generally, peaking among young adult men[10].

[10] Ministry of Transport (n.d.) *Te Marutau — Ngā tatauranga ā-tau: Safety — Annual statistics.* Accessed 27 January 2022 at https://www.transport.govt.nz/statistics-and-insights/safety-annual-statistics/regional-stats/

Figure 33: Age and gender distribution – number of Other Users by crash severity



Finally, the involvement of 'reckless' or 'extreme' behaviours, as opposed to system failures, was also examined for both driving for work and Other Users in this study. The concept is based on an Australian study by Wundersitz et al. (Wundersitz & Baldock, 2011; Wundersitz, Baldock, & Raftery. 2014), though the crash factors used to trigger reckless/extreme behaviour in this study, outlined in Figure 4 in the Method section, are adapted from those used in the Serious Injury Crashes study (Mackie et al., 2017).

Figure 34 below shows the proportion of crashes in which the user pillar was triggered alongside the proportion in which reckless/extreme behaviour was identified, for driving for work compared to Other Users. Note Other User does not include seat belt non-use as a contributing factor to reckless/extreme behaviour (because this was not coded for efficiency reasons) and is therefore slightly more conservative than the criteria for the Driving for Work User. Other users were also present in only 87% of crashes overall. Nonetheless, Figure 34 graph shows that reckless or extreme behaviour was more frequently identified among Other Users (15% of all crashes) than those driving for work (6%). Reckless/extreme behaviour was also more likely to be triggered in serious and fatal crashes, particularly for Other Users, compared to minor crashes.

Also of note in Figure 34 is the user pillar trigger comparison. The user pillar was triggered in a similar number of crashes for Driving for Work Users (57% of all crashes) compared to Other Users (55%), indicating overall similar rates of characteristics, behaviours, and conditions that contributing to the occurrence of crashes (and supported by the crash role comparison in Figure 29). Both user pillars also show a clear relationship between crash severity and the frequency with which the pillar was triggered; however, this relationship was more pronounced for Other Users, suggesting their behaviour may play a slightly stronger role in determining crash severity.

Figure 34: Frequency of user pillar triggers and of reckless/extreme behaviour for Driving for Work Users and Other Users – proportion of crashes by crash severity

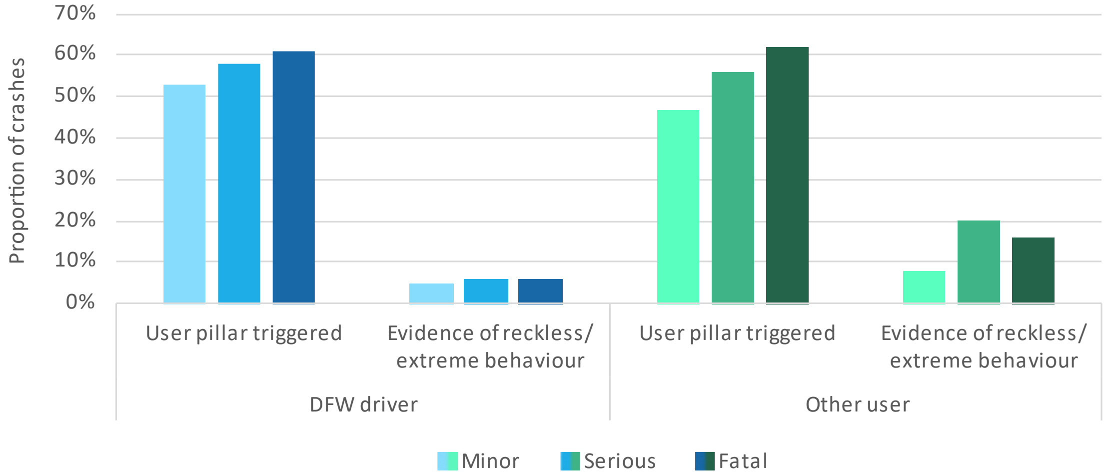


Figure 35 and Figure 36 show the proportion of crashes in which reckless or extreme behaviour was identified in the driving for work crashes explored in this study compared to the serious and fatal crashes examined in the Serious Injury Crashes study (Mackie et al., 2017). The reckless/extreme behaviour criteria used in this study for Driving for Work Users are slightly broader (less conservative) than the reckless behaviour criteria applied in the Serious Injury Crashes analysis, with the exception of non-seat belt use not being considered for Other Users in this study. The earlier study did not include unsafe overtaking, hit and runs, or pursuits, and counted disqualified/no licence as only a contributing factor toward reckless behaviour (rather than an immediate trigger, as in the present study). Overall, this means it was 'easier' for users driving for work to qualify as behaving recklessly or extremely in the present study.

Despite this, the graphs show that reckless or extreme behaviours were less frequently involved in driving for work crashes compared to overall serious and fatal crashes in Aotearoa New Zealand. This is particularly the case for fatal crashes, in which almost half of the crashes in the earlier study involved reckless behaviour, compared to only a fifth of fatal driving for work crashes. As discussed previously, this likely reflects the inclusion of vulnerable road users in the driving for work study, whom are more likely to be injured even at low speeds, and the larger size and mass, on average, of driving for work vehicles, as well as the conditions under which driving for work is more common generally (e.g. during the day, at peak traffic times).

Figure 35: System failures and reckless/extreme behaviours in minor, serious, and fatal driving for work crashes – driving for work and Other Users combined

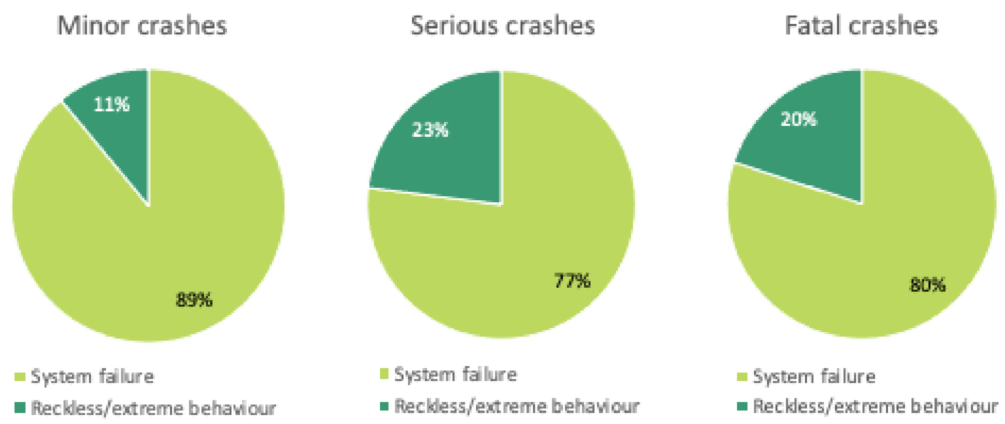
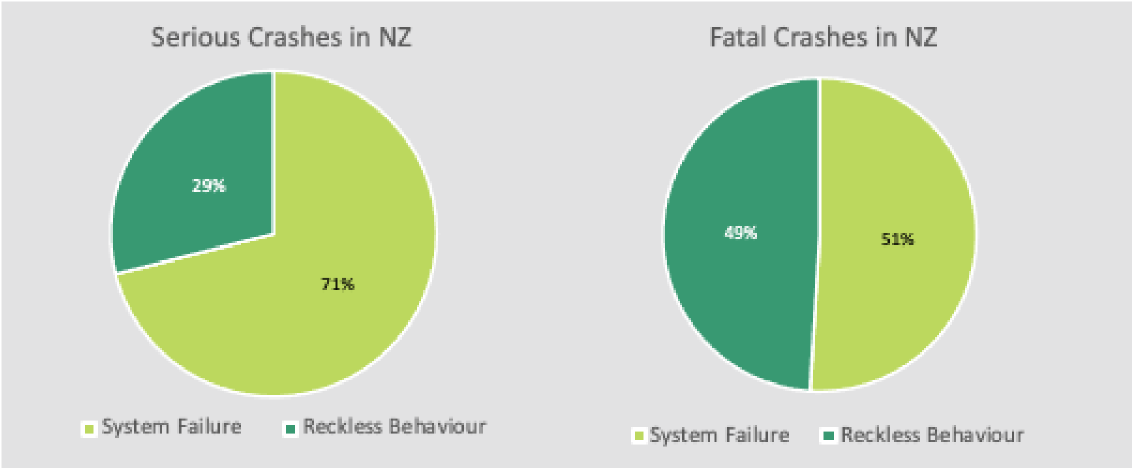


Figure 36: Data from Serious Injury Crashes study (Mackie et al., 2017) – System failures and reckless behaviours in fatal and serious crashes in NZ



3.4. Findings: COVID-19 impact analysis

A brief analysis was conducted of crashes which occurred before COVID-19 lockdown restrictions were implemented (on March 21st 2020) compared to those which occurred after this date. While restrictions were not continuous from March 21st, they were in place for several months initially, with Auckland experiencing a second lockdown later in the year, and COVID-19 impacts can extend beyond immediate restrictions. Hence, data were split into a simple pre and post analysis to assess whether COVID-19 and associated restrictions impacted on driving for work crashes.

Note that a larger proportion of crashes in the dataset took place pre-COVID (two thirds of minor and serious crashes, 91% of fatal), with particularly few fatal crashes (9) included in the post-COVID dataset. This is primarily due to the longer duration of the pre-COVID sample period, particularly for fatal crashes; the overall numbers of each crash severity included in the study were similar for 2019 and 2020 (see Figure 5).

Figure 37 below shows a remarkably similar time of day pattern for crashes occuring pre compared to during and post-COVID restrictions. Overall, 80% of crashes occurred between 6am and 6pm pre-COVID, compared to 81% for crashes in the later time period. Day of week data is also fairly similar (not shown), with 15% of crashes occurring on the weekend and 19% during/post.

Figure 37: Crash time of day – pre (top) vs during and post (bottom) COVID restrictions

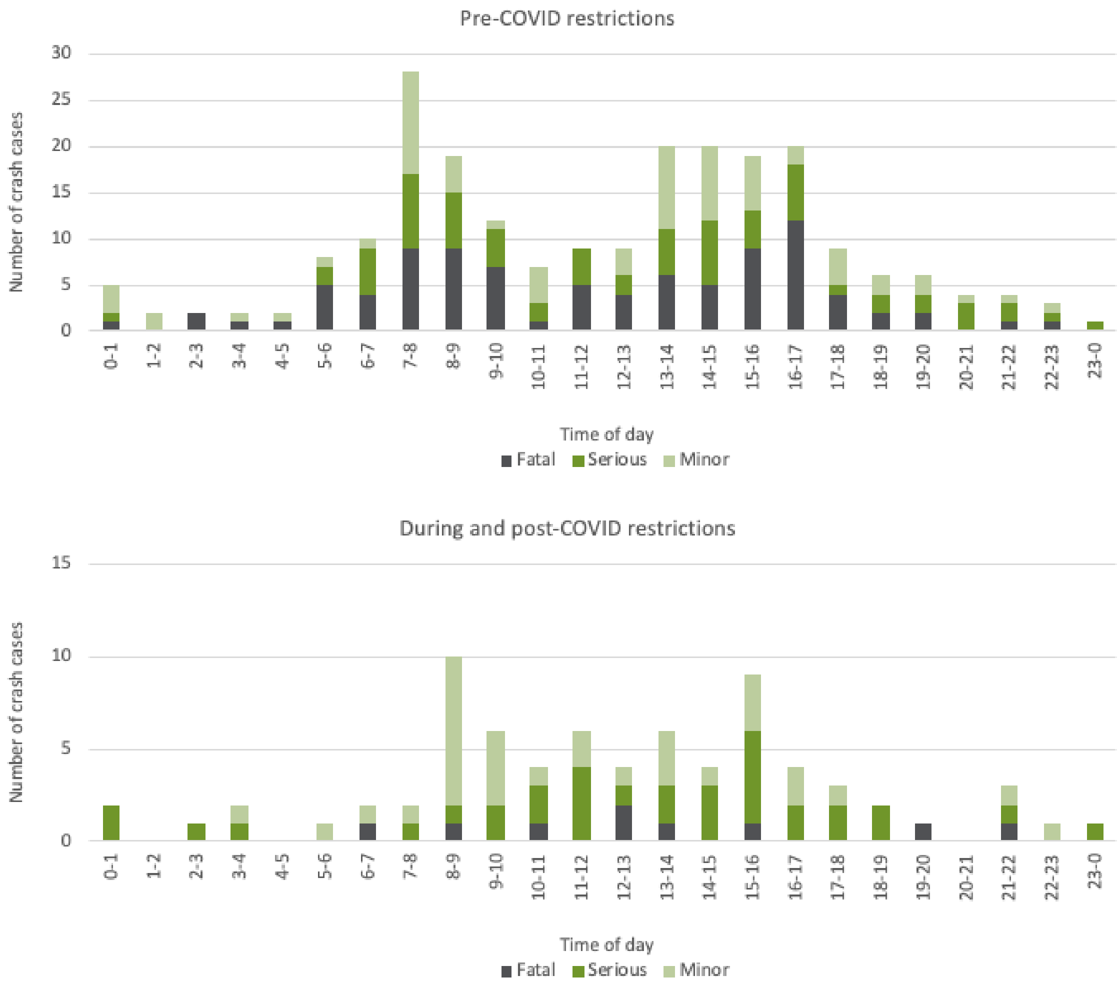


Figure 38 below provides an overview of the pillars triggered in crashes pre compared to during and post-COVID restrictions. Taking into account that increased variability is likely due to smaller sample sizes, the pillars were triggered in a similar proportion of crashes in both time periods.

Figure 38: Proportion of crashes involving each Safe System pillar by crash severity – pre vs during and post-COVID restrictions

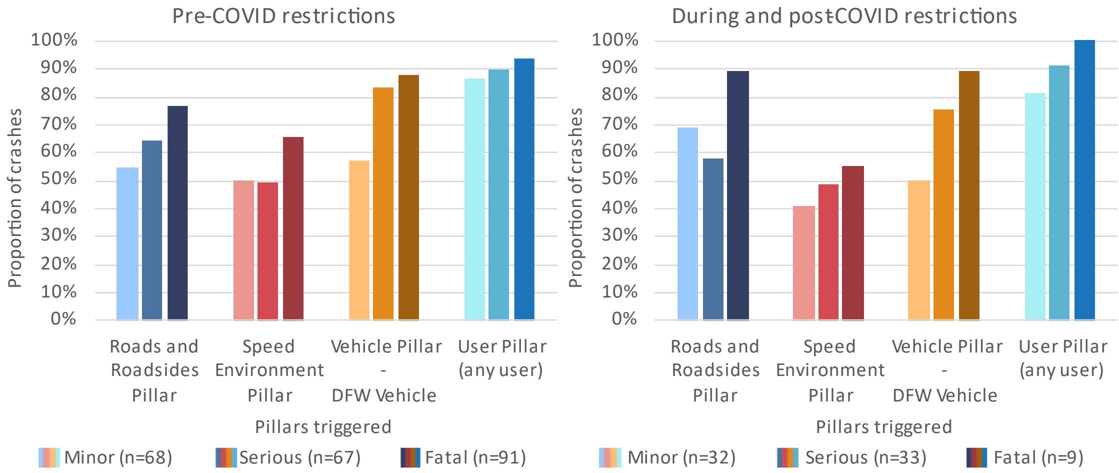
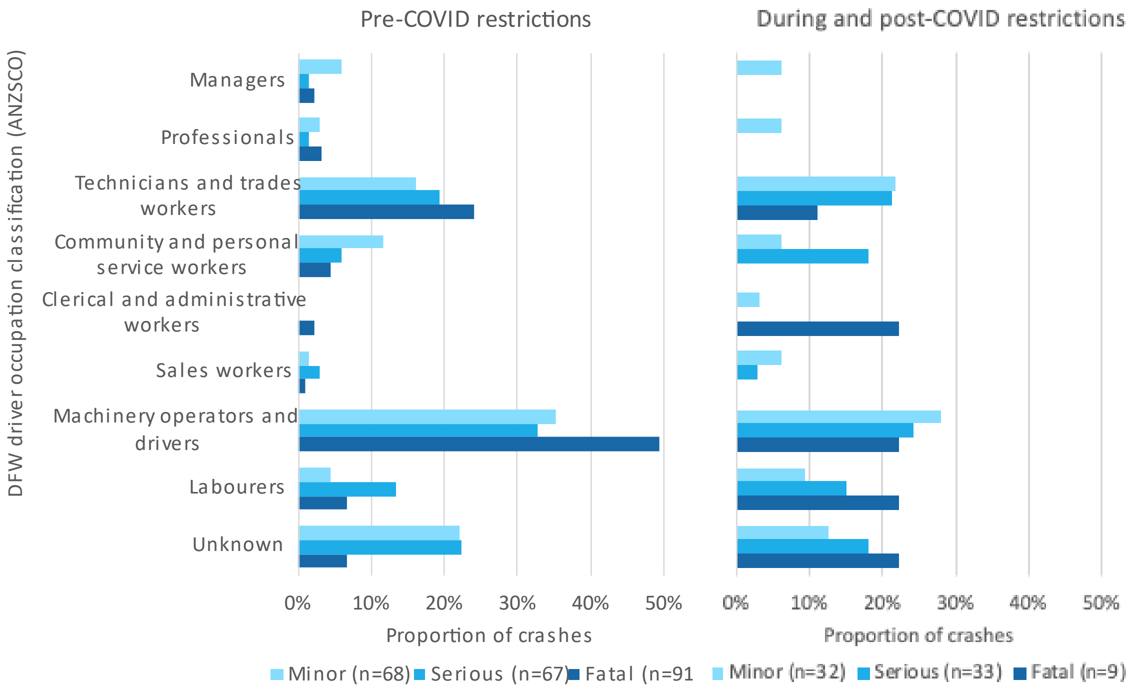


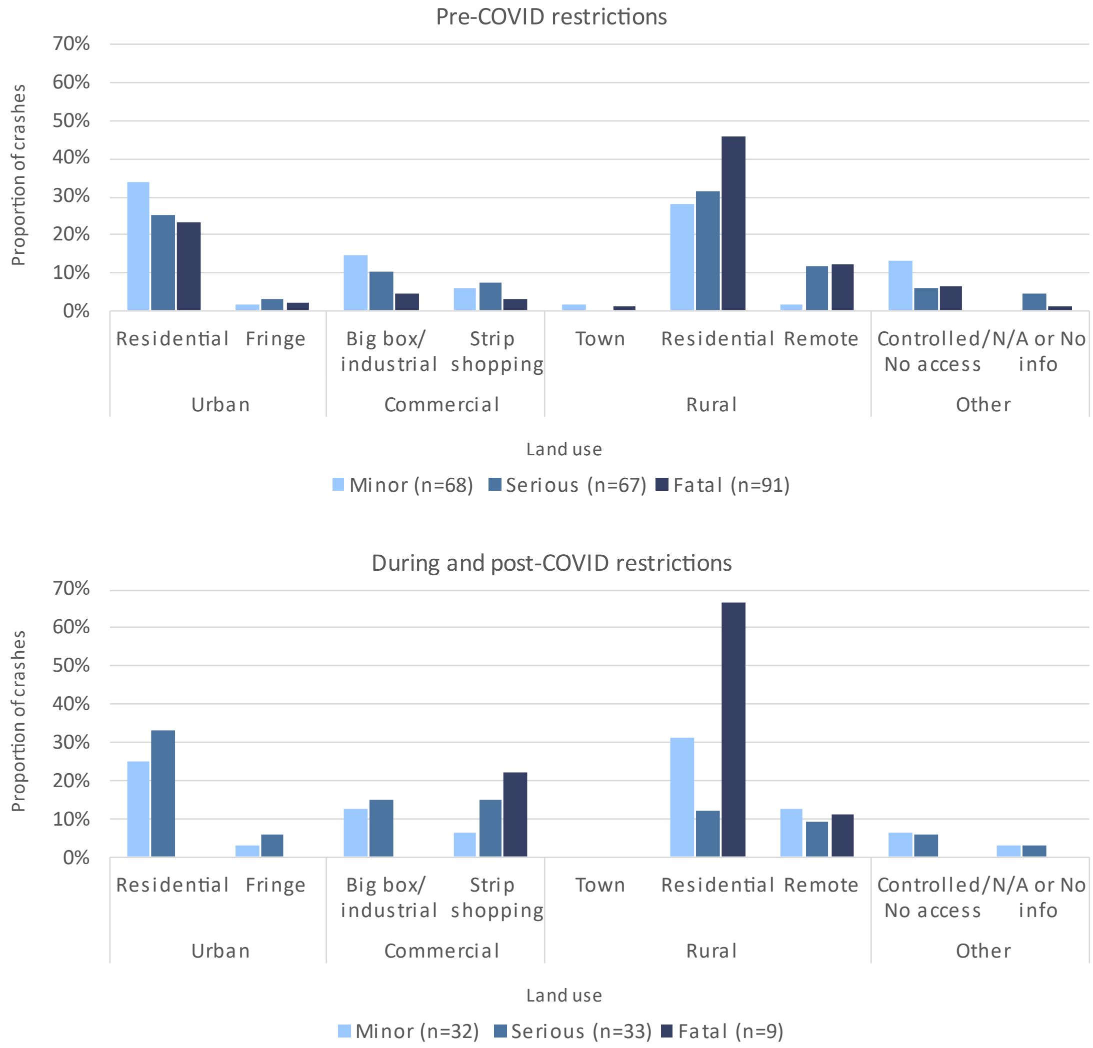
Figure 39 below shows that, compared to pre-COVID, fewer crashes involved Machinery operators and drivers (i.e. professional drivers), more crashes involved Labourers, and around the same proportion involved Technicians and trades workers during and post-COVID restrictions. Crashes involving Machinery operators and drivers primarily included bus and taxi drivers during and post-COVID restrictions (7 and 6 of 19 total Machinery operators and drivers crashes), while truck and other drivers were implicated less frequently than pre-COVID. This may reflect the designation of taxi and bus drivers as essential workers during lockdowns, which possibly meant they made up a greater proportion of total driving for work traffic, and therefore driving for work crashes, than pre-COVID.

Figure 39: Driver occupation group (ANZSCO) for Driving for Work Users – proportion of crashes by crash severity pre vs during and post-COVID restrictions



Compared to pre-COVID restrictions, more crashes occurred during and post-COVID restrictions in strip shopping areas and, for fatal crashes, in rural residential areas, while urban residential areas saw fewer fatal crashes (Figure 40). Note, however, the low numbers (n=9) for fatal crashes in the later time period. Of the six fatal rural residential crashes during/post-COVID, five were on roads with a 100 km/h speed limit (the other was 80 km/h), two were single-party crashes and four were vehicle-vehicle crashes, including one motorcycle. Four involved a user drifting over the centreline (three Driving for Work Users, one Other User).

Figure 40: Land use – proportion of crashes by severity pre (top) vs during and post (bottom))COVID restrictions



Finally, for Driving for Work Users, exceeding the posted speed limit by 10+ km/h occurred in a similar number of crashes pre and during/post-COVID restrictions (3%), but a slightly greater number of crashes involved drivers travelling 'too fast for conditions' in the later time period (7% pre vs 11% during/post). The occupations of the drivers travelling too fast for conditions in the eight crashes during/post-COVID restrictions were four Labourers (various kinds), two Technicians and trade workers, and two Machinery operators and drivers. Half of these crashes occurred on 100 km/h roads with significantly lower speed advisories (all single-party crashes – possibly fatigue-related), and the other half occurred on 30-50 km/h roads (one single-party crash, two three-party crashes, and one pedestrian crash).

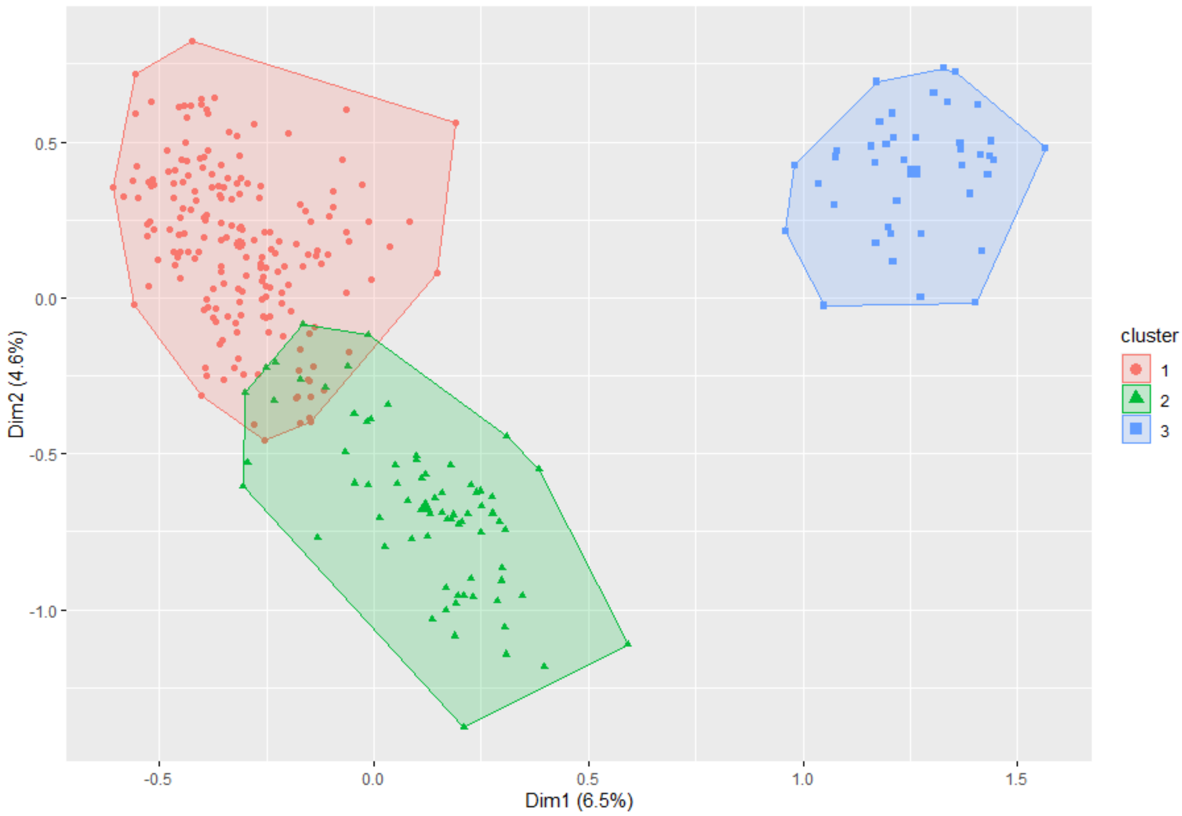
Overall, the data do not point to significant differences in the types of crashes that occurred during and post-COVID restrictions compared to pre-COVID. The main differences overall were fewer professional drivers being involved in crashes relative to other occupations, slightly more crashes occurring in strip shopping and rural residential areas, and an slight exacerbation of trends of driving too fast for the conditions among Labourer occupation types. These findings would seem to be consistent with the changes in daily patterns that COVID lockdowns and subsequent periods have caused.

3.5. Findings: Statistical cluster analysis

The Hierarchical Clustering on Principle Components analysis approach (see 3.2.6 Statistical cluster analysis) yielded three data clusters, each containing 188, 72, and 40 crash cases respectively. These are shown in Figure 41.

Note that Dim1 (dimension 1, displayed on the x axis in Figure 41) was found to explain the most variance in the transformed data space (6.5% of the variance). Dim2 (dimension 2, shown on the y axis below) explains the second greatest amount of variance in the transformed data space, at 4.6%. Together, the two axes explain 11.1% of the variances in the data. A scree plot of each dimension's contribution to the explained variances is shown on the first page in APPENDIX C: CLUSTER ANALYSIS.

Figure 41: Cluster results achieved using the Hierarchical Clustering on Principal Components algorithm – Consolidated with K means



The crash factors which most strongly defined the clusters include Number of crash parties/vehicles involved, Other User vehicle type and mode/activity, Other User injury level, Other User alcohol or drug use, Other user distraction inattention and Crash impact type. The composition and main characteristics of each cluster are described in Table 3 below.

Table 3: Descriptions of crash cluster profiles (%s are of total crashes in that cluster)

		Cluster 1 (188 crashes) 	Cluster 2 (72 crashes) 	Cluster 3 (40 crashes) 
Number of crash parties		2-3 crash parties *80% two parties, 20% three*	2-3 crash parties *96% two parties, 4% three*	1 crash party *100% one party (DFW vehicle only)*
Crash severity		Around one third of each severity *38% minor, 31% serious, 32% fatal*	Mostly serious and fatal *18% minor, 46% serious, 36% fatal*	Mostly minor and fatal *40% minor, 23% serious, 38% fatal*
DRIVING FOR WORK USER	**Vehicle type**	Half vans, SUVs, or utes *26% van, 23% SUV/ute, 23% car, 15% bus, 11% light truck, 2% road works/rubbish truck*	One third buses and a quarter vans *32% bus, 24% van, 20% car, 11% SUV/ute, 10% light truck, 4% road works/rubbish truck*	One third vans and a quarter light trucks *33% van, 25% light truck, 18% SUV/ute, 10% bus, 10% car, 5% road works/rubbish truck*
	Occupation group	One third professional drivers *34% machinery operators and drivers, 22% technicians and trades workers, 14% labourers*	Half professional drivers *50% machinery operators and drivers, 18% technicians and trades workers, 22% unknown*	One third labourers *30% labourers, 27% machinery operators and drivers, 18% technicians and trades workers*
	Speed relative to SAAS	Nearly one fifth exceeding SAAS *28% driving 0-0.5x SAAS, 36% 0.5-1x SAAS, 18% exceeding SAAS, 19% unknown*	One third driving less than half the SAAS *36% driving 0-0.5x SAAS, 28% 0.5-1x SAAS, 11% exceeding SAAS, 25% unknown*	Nearly a quarter exceeding the SAAS *10% driving 0-0.5x SAAS, 38% 0.5-1x SAAS, 23% exceeding SAAS, 30% unknown*
	Restraint worn	Mostly wearing seat belt *82% yes, 9% no, 9% uncertain*	One fifth not wearing seat belt *50% yes, 21% no, 29% uncertain*	One quarter not wearing seat belt *63% yes, 25% no, 13% uncertain*

	Evidence of fatigue	Fatigue evident in one in 20 crashes *5% yes, 91% no, 6% unsure*	Fatigue rarely evident *3% yes, 92% no, 6% unsure*	Fatigue in almost one in five crashes *18% yes, 78% no, 5% unsure*
	Injury level	Mostly uninjured or minor injured *54% uninjured, 29% sustained minor injuries, 11% serious, 6% fatal*	Almost entirely uninjured *99% uninjured, 1% sustained minor injuries*	Over half seriously or fatally injured *8% uninjured, 40% sustained minor injuries, 20% serious, 33% fatal*
OTHER USER(S)	Mode and vehicle type	Mostly driving, mostly cars *88% driving (at least one user), 11% motorcycling, 1% cycling* *126 cars, 32 SUVs/utes, 24 motorcycles, 18 road works/rubbish trucks, 15 vans, 4 light trucks, 2 buses, 2 bicycles*	All VRUs, almost all walking or cycling *75% walking/running, 24% cycling, 1% motorcycling* *54 pedestrians, 17 bicycles, 1 motorycle*	N/A
	Alcohol and drug use	Alcohol or drugs present in 20% *7% alcohol or drugs detected, 13% suspected, 66% none, 13% unknown*	Alcohol or drugs recorded in 7% *6% alcohol or drugs detected, 1% suspected, 21% none, 72% unknown*	N/A
	Distraction and inattention	Over a third distracted or inattentive; half not *Distraction or inattention identified in 39% of crashes, 10% unsure, 51% none*	Almost half distracted or inattentive, one third not *Distraction or inattention identified in 47% of crashes, 17% unsure, 36% none*	N/A
	Injury level[11]	Over a third seriously or fatally injured *30% of crashes resulted in no injuries to Other Users, 27% in minor injuries, 23% serious, 20% fatal*	Mostly seriously or fatally injured *3% resulted in no injuries to Other Users, 19% in minor injuries, 42% serious, 36% fatal*	N/A
Land use		Half in rural areas *51% occurred in rural roads, 29% urban, 11% commercial (9% big box/industrial), 10% other*	Mostly in urban and commercial areas *40% occurred in urban areas, 39% commercial (22% strip shopping), 8% rural, 13% other*	Mostly in rural areas *78% rural, 10% urban, 8% commercial (5% strip shopping), 5% other*

[11] Maximum injury level sustained by an Other User (excludes passengers)

Crash impact type	Half side impact, a quarter head on *48% side impact, 27% head on, 21% rear end, 1% hit object, 3% other*	Almost two thirds head on *61% head on, 15% side impact, 6% rear end, 1% hit object, 17% other*	Mostly hit object or rolled over *43% hit object, 40% rollover, 5% side impact, 13% other*

Note user numbers exclude passengers; VRU = vulnerable road user (motorcyclist, cyclist, pedestrian), SAAS = Safe And Appropriate Speed; percentages may not add up to exactly 100% due to rounding.

Cluster 1 summary

Overall, cluster 1, the multiple vehicle crash profile, is defined by a large proportion of vans, utes, and SUVs and a low injury rate for Driving for Work Users. Alcohol or drug use on the part of Other Users likely contributes to a fifth of this type of crash. These crashes occur across all land use types including half in rural areas, and half of them involved a side impact to the driving for work vehicle.

Cluster 2 summary

Cluster 2 was made up of VRU crashes and defined by driving for work vehicles with high, one-box bonnets (especially vans and buses) impacting pedestrians and cyclists head on in urban or commercial shopping areas. Professional drivers such as bus and taxi drivers were the most common driver occupation, and Driving for Work Users were almost entirely uninjured. Other Users, on the other hand, were usually seriously or fatally injured, with distraction or inattention implicated frequently on the part of the Other User.

Cluster 3 summary

Cluster 3, entirely single vehicle crashes, was the smallest cluster, comprising only 13% of crashes, and tended to involve vans and light trucks hitting an object or rolling. The large majority occurred in rural areas. The Driving for Work Users in this cluster were more likely to be labourers, and to be fatigued, to not wear a seatbelt, and to exceed the Safe And Appropriate Speed for the road compared to Driving for Work Users in the other two clusters. This type of crash resulted in the most injury to Driving for Work Users, with over half seriously or fatally injured.

3.6. Discussion

The aim of Phase 2 was to explore the Safe System factors associated with fatal, serious injury, and minor injury crashes occurring in 236 light vehicles and 64 specified service vehicles (55 buses, 7 rubbish trucks, 2 road works trucks) while driving for work. The study examined crash factors across 300 such crashes from 2011 to 2020 to describe common patterns and crash profiles that can be used to better understand and address driving for work safety issues.

The findings reinforce previous Safe System analyses showing that injury crashes often occur in the context of multiple system failures (Hirsch et al., 2018; Hirsch et al., 2017; Mackie et al., 2017; Mackie et al., 2018; Thorne et al., 2020). Similarly, with the inclusion of minor injury crashes, we observed a strong relationship between the number of system pillars implicated and the severity of the crash, suggesting that concentrations of minor injury crashes may be a useful indicator of the potential for more severe crashes to occur (Hydén, 1987), if other system failures are added.

Vehicle, speed, and roads and roadsides factors were also more frequently implicated in more severe crashes. Rural roads, which generally involve higher vehicle speeds than in urban and commercial areas, were the site of almost two thirds of fatal crashes, compared to 44% of total crashes. Further, over half of fatal crashes occurred on undivided roads with 100 km/h speed limits, demonstrating the consequences of not protecting traffic in high speed environments.

Vehicle factors in particular were identified more often than in the Serious Injury Crashes study, with the size or mass of driving for work vehicles playing a major role in determining crash outcomes. Towed trailers or cars also played a role in several crashes, in some cases due to loading or attachment issues. In addition, a quarter of driving for work vehicles had overall safety ratings of two or fewer stars, which were more likely to be implicated in serious and fatal crashes. Technicians and trades workers, along with labourers, were over-represented in low safety-rated vehicles, especially vans.

Higher speeds were also associated with more severe crashes, though to a lesser extent than in the Serious Injury Crashes study (Mackie et al., 2017), with 18% of crashes occurring at driving for work vehicle speeds of 20 km/h or less. This in part reflects the inclusion of pedestrians, cyclists, and motorcyclists in the present study, who are vulnerable to injury when impacted even at relatively low speeds (Hirsch et al., 2018, Thorne et al., 2020). However, as has previously been noted, speed estimates are lacking for a fifth to a quarter of vehicles, and tend to rely on witness estimates, therefore the role of speed is likely underestimated (Boufous & Williamson, 2009). Moreover, a number of crashes where driving for work users were travelling at low speeds involved other users at higher speeds, with some indication that unpredictable manoeuvres such as turning into or out of driveways or pulling into or out of traffic were implicated.

Though user factors were implicated to a similar extent to the earlier Serious Injury Crashes study and other Safe System analyses, extreme or reckless behaviours such as speeding and intoxication were observed less frequently in driving for work crashes. This applies especially to those driving for work, but also to other road users involved. In part, this is likely because people are more likely to be 'on good behaviour' while working as they may feel there is more at stake (e.g. losing job), as well as reflecting the inclusion of people walking and cycling in this study. However, in particular with regard to speeding, it may also be related to the increasing use of telematic software to monitor driver speeds and other behaviours (Pyta, Gupta, Stuttard, Kinnear, & Helman, 2020). Speeding while driving for work that did occur in this study was associated with police, labourer, and tradespeople occupations, including across a range of speed limits and crash types. While police speeding was related to pursuits and call-outs, it may be that work-related factors such as time pressures and fatigue contributed to speeding among labourers and tradespeople, particularly with regard to crashes occurring on bends with low speed advisories relative to the posted speed limit.

Work-related factors were generally difficult to assess based on TCRs alone. While variables such as evidence of fatigue, use of technology, hours driving, and employment details were coded, information on these factors was rarely available. The limited data on fatigue showed that this was a contributing factor for people driving for work in this study, particularly in single vehicle crashes, though likely substantially underestimated (*Boufous & Williamson, 2009*).

Occupation information was, however, available for most drivers, and reflects industry representation in overall occupational safety statistics: drivers were the most commonly represented occupation group (i.e. the transport sector; Driscoll, et al., 2005; Lilley, et al., 2021; Sultana et al., 2007), followed by technicians and tradespeople, and labourers (i.e. the construction industry; Driscoll, et al., 2005). In contrast to the international literature (Boufous & Williamson, 2009; Husain et al., 2019), however, taxi drivers were more frequently represented in minor crashes than more severe ones. This makes sense in the context of lower speed urban environments, but it is unclear why this should be different overseas. Bus drivers, on the other hand, made up the single most common driving for work occupation in the crashes in this study, though they tended not to be attributed fault for the crash by the attending officer, similar to research by Clarke et al. in the UK (2005).

Research into the burden of WR MVTC crashes in Aotearoa New Zealand has found a high proportion of crashes occurring among people driving for work aged 35 and over, with involvement in serious and fatal crashes generally increasing with age *(Lilley et al., 2021; Sultana et al., 2007)*. Similarly, in the present study, driver age was distributed fairly evenly across age groups from 21-70, with serious and fatal crashes increasing with age from around 50 years old. This differs substantially from crashes in the general population, in which younger age groups are more frequently involved, particularly in high severity crashes (Mackie et al., 2017). Women were also much less frequently involved as drivers for work compared to general crashes, which likely reflects lower participation in occupations involving driving for work, but also potentially a bias in the data toward occupations and vehicles which are more easily identified as driving for work, such as tradespeople and vans or trucks, while women are more likely to drive cars for work (Stuckey et al., 2010).

Injuries in the crashes included in this study were most often sustained not by the person identified as driving for work, but by other road users involved in the crash. This was especially the case for fatalities, reflecting literature showing that over half of people killed in WR MVTC in Aotearoa New Zealand are bystanders who were not working at the time of crash (Langley et al., 2006; Lilley et al., 2019). This analysis provides further insight into how and why this is the case. The higher burden of injury to bystanders should taken into account when evaluating driving for work risks, also keeping in mind the likely pyschological impacts that involvement in a serious or fatal crash presents even for those who avoid physical injury.

Vulnerable road users were especially likely to suffer serious or fatal injury in crashes with people driving for work in the current study. In total they made up a quarter of people seriously injured or killed. This reflects in part the generally large or one-box bonnet shaped vehicles frequently used as driving for work vehicles, particularly buses and vans.

A particular strength of this analysis was the inclusion of a wide range of crash types, enabling an understanding of the diverse contexts in which driving for work crashes can occur. While this created a nuanced dataset from which it was difficult to generalise factors across all crashes, it helps to paint a broad picture of driving for work safety issues.

Through conducting a cluster analysis, we were further able to identify three common crash profiles, each of which was associated with different crash factors. The findings showed that driving for work crashes are most strongly defined by road user and vehicle types, with cluster 2 entirely made up of crashes with VRUs. This reinforces a broader trend across the data about vehicle mass and the circumstances in which we allow large work vehicles and VRUs in particular to mix. Also of note is that the third and smallest cluster, made up of single vehicle crashes, demonstrated the most similar pattern of user factors to general crashes in the Serious Injuries study (Mackie et al., 2017), such as fatigue, exceeding safe speeds, and non-seat belt use. It was also most similar to the 'Driving for Work' profile in the Non-seat belt use study (Hirsch et al., 2017), with crashes occuring primarily in rural locations and mostly involving vans and trucks.

Interestingly, no major effects related to COVID-19 spread or restrictions were observed in the data. There was some exacerbation of existing trends, such as high numbers of fatal crashes on rural residential roads, and possibly more speeding or risky driving related to fewer vehicles on the road. Professional drivers also made up a smaller proportion of crashes during/post-COVID restrictions, which likely reflects that only some would have been designated as essential workers, and therefore they travelled fewer kilometres overall.

3.7. Study and data limitations

There are a number of limitations in this study, primarily relating to the accuracy and representativeness of the data. Traffic crash reports (TCRs) recorded in CAS were the primary resource used both to identify relevant crashes and to analyse them. TCRs are generally completed at the scene of the crash (or shortly after) by the attending police officer. They provide a wide range of useful crash information, particularly around roads and roadsides and vehicles, and they are relatively easily accessible. However, as noted in the literature (see APPENDIX B: LITERATURE SCAN REPORT), the accuracy and level of detail included in TCRs is variable and often relies on driver and witness statements, particularly for speed estimates and driver behaviours at the time of the crash. Information relating to work activities is also often absent or sparse, making both identification of driving for work crashes and coding of work-related crash factors difficult.

Of particular concern is the, on average, lower level of detail contained in serious injury and especially fatal crash TCRs. This is in part due to the difficulty/impossibility of obtaining witness statements from people who are seriously or fatally injured in a crash, but also because more severe crashes require Serious Crash Unit investigations to be completed, and the information from these appears to be rarely backfilled into the TCR. As a result, some crash factors, such as speed, driver behaviours, and work activities, are likely to be underreported and therefore underestimated in this study. In addition, the distinction between minor and serious injury crashes can be quite subtle, with the potential for quite a bit of overlap. This could lead to an underestimate of the extent to which the crash factors examined influence crash severity.

Another limitation of the research is that the results cannot be generalised to all injury crashes in which someone was driving a light vehicle or service vehicle for work. Due to the difficulties in identifying work activity in crash records, the sample is unlikely to capture the full range of these types of crashes, though we are confident that it includes a sufficiently useful range of these types of crashes, from which conclusions about common crash factors can be drawn. In addition, the sample is likely to include some crashes in which the identified Driving for Work User was not actually driving for work at the time of the crash. However, we expect this latter proportion to be small.

Moreover, and partially related to the lower level of detail in TCRs for more severe crashes, different sampling processes were used to identify fatal crashes than those for minor and serious driving for work crashes. As such, the fatal crash sample encompasses a longer time period and includes older crashes, and may be more biased toward easily identifiable types of driving for work, for example, bus or taxi driving, than the minor and serious injury crash samples. However, given the smaller overall 'population' of fatal driving for work crashes (compared to lower severity crashes), we expect the sample of fatal crashes included in this study represents a greater proportion of the population of fatal driving for work crashes, which would help with their representativeness. By contrast, representativeness in serious and minor crashes was achieved more so by a randomisation process.

The COVID-19 impact analysis was a brief exercise and did not explore trends beyond 'pre' and 'post' COVID restrictions being introduced. The 'post-COVID' dataset therefore includes periods during which no community spread was occurring and no restrictions were in place. Furthermore, the post-COVID dataset was much smaller than the pre-COVID dataset, particularly for fatal crashes, and these smaller sample sizes mean the results should be interpreted with due caution.

Finally, with regard to the cluster analysis, the internal validity of the identified clusters is governed by the HCPC algorithm. However, we were unable to assess the external validity of those clusters, that is, the extent to which the current clustering results can be generalised to other crash events. Additional data to perform external validity checks on was not available.

4. SOCIO-TECHNICAL ANALYSIS

4.1. Introduction

This study aims to develop and apply two levels of analysis to understand both the immediate and wider contextual factors associated with driving for work crashes. The first level of analysis was designed to understand the immediate context of different types of crashes using the Safe System analysis. The second level of systems analysis, outlined below (and Phase 3 of the study), employs a socio-technical system framework and accompanying pilot AcciMap to capture the direct and indirect contextual factors that led to a crash while driving for work.

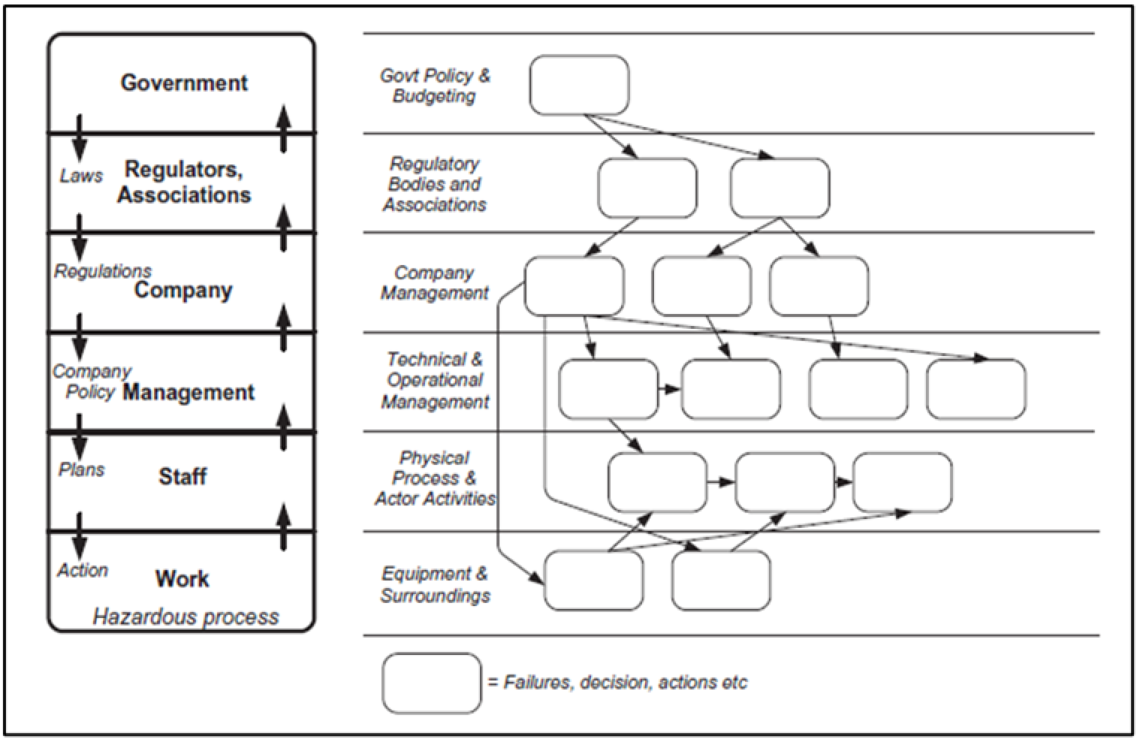
4.2. Socio-technical approach and AcciMap

Rasmussen's socio-technical Risk Management Framework (left side of Figure 42), chosen as the basis for the Phase 3 analysis is made up of a hierarchy of levels, and although not rigidly set, the layers typically comprise the following groups, which make up the system:

- Government
- Regulators/Associations
- Company
- Management
- Staff and
- Work (Salmon et al., 2010).

The premise of the approach is that crashes or harm incidents depend on the contextual mechanisms in place at various system levels. Safety emergent behaviour arises from interactions between the actors and other system artefacts at each level. Vertical integration is an important aspect of the framework; information and influence should transfer downward but should also transfer upward. This means that decisions made at top levels should reflect the work done at lower levels, and the work should also directly inform decisions made above.

Figure 42: Rasmussen's Risk Management Framework and accompanying AcciMap diagram



4.2.1. Socio-technical applications

Various frameworks exist for the analysis of systems. One method stands out in particular because it is theoretically driven and provides a structured methodology for analysing incidents – namely the AcciMap (right side of Figure 42). It is based on Rasmussens (1997) model of socio-technical complex system by identifying the contributing factors to an incident. The method can be used to map system elements (actors, procedures), failures, decisions, and actions that link together to explain incident causation. It is a useful method because of its generality and flexibility to assess different work systems (Hulme et al., 2021). Hulme et al's earlier work identified 20 AcciMaps that were successfully applied in different contexts including public health, aerospace, led outdoor recreation, emergency response, transport, and civil engineering (Hulme et al. 2019). In New Zealand, AcciMaps were also used in an earlier study of cycling fatalities (Mackie et al. 2016).

The socio-technical approach and AcciMaps were applied to transport, postal, warehousing and manufacturing in a recent WorkSafe project (Tedestedt George et al., 2021). The project sought to capture contextual factors from throughout the supply chain which were contributing to harm in and around vehicles in New Zealand. Data was collected from across the supply chain and the system. The AcciMaps produced during this project visually showed that undesirable outcomes resulted from decisions and actions made throughout the system. Importantly, they also showed that no one individual or organisation was at fault, and that any improvements must be made collaboratively at various system levels.

The AcciMap was chosen for Phase 3 of this project to further understand the utility of this method within the context of driving for work crashes. The following section outlines the recommended method for creating an AcciMap and the process we undertook, included to show how this method can be applied in a driving for work context. A pilot AcciMap is then included, showing the contextual factors that led to the death of a taxi driver and injury to the six passengers.

4.2.2. AcciMap method

Creating an AcciMap involves the construction of a multi-layered diagram in which various causes of an incident are arranged according to their causal remoteness to the incident (Branford, Naikar & Hopkins, 2019). The first column in Table 4 below shows the recommended steps for creating an AcciMap (Branford et al., 2019), and the second column explains how we carried out these steps.

Table 4: AcciMap method

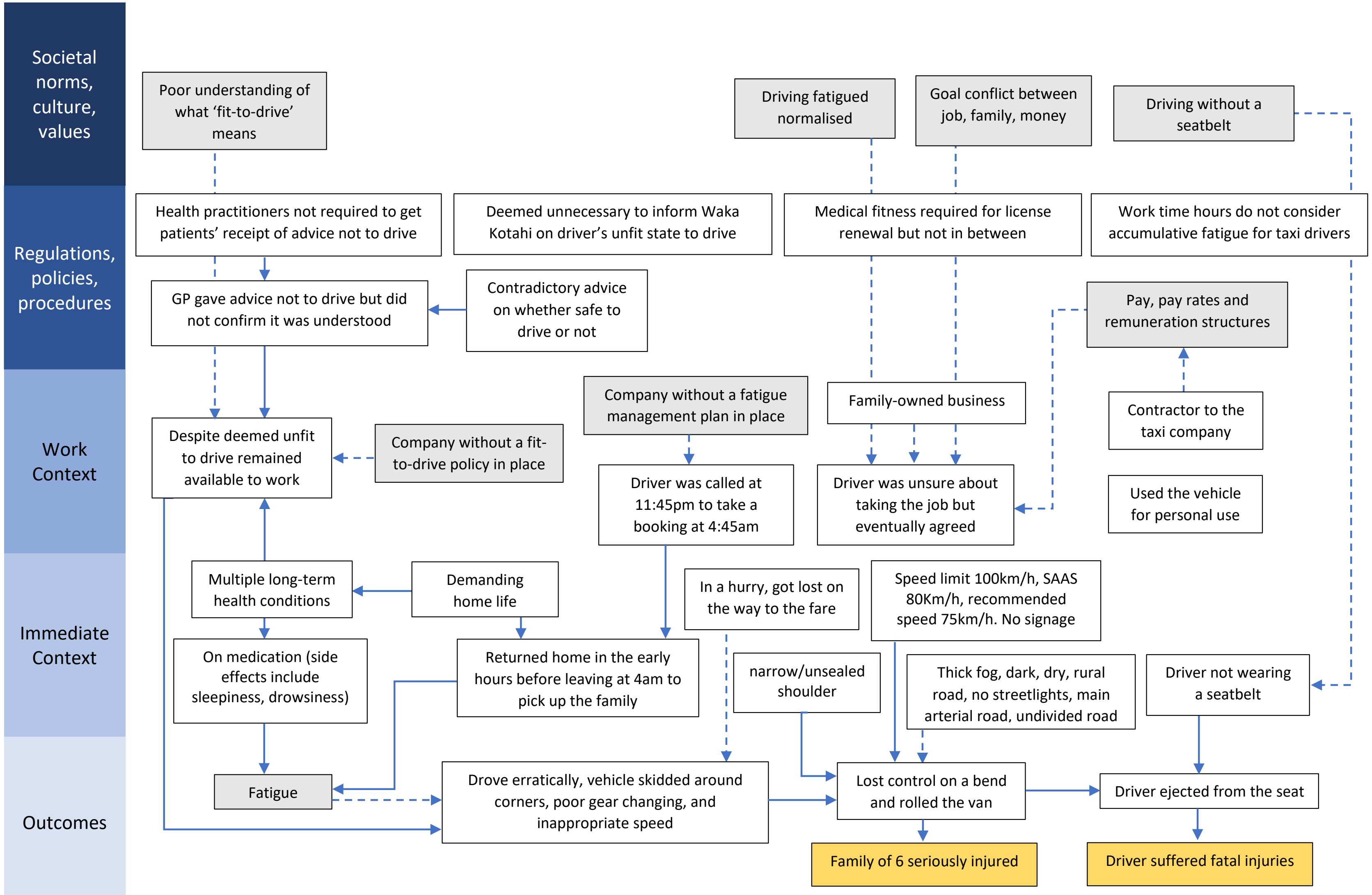
Recommended steps for AcciMaps	How we carried out the steps
1. Select a case to map and collect available data from a wide variety of sources.	Using investigation records, WorkSafe provided a list of 20 work-related road fatalities from between 2013 and 2020. Ease case was discussed to determine the suitability of for this project and for mapping. The list was narrowed to four possible cases. Traffic Crash Reports (TCR) were sourced for three out of the four cases. Applications were made for Coroner's reports; three of the four were available. Information provided by the Coroner's office included Police reports, expert analyses, witness statements, medical information (sensitive information redacted), and other supporting information used to make conclusions on the case. The final case selected based on the availability of data.
2. Create a blank AcciMap format guided by the Risk Management Framework and identify the negative outcome(s) of the case. From the data collected identify all the causes in the incident data. The causal factors are only included if their occurrence contributed to the incident. There could be a great number of causes for any incident, therefore it is necessary to draw boundaries around what will be included and what will not. It is suggested that only causes of practical significance be considered (Branford et al 2019). These are causes that something could conceivably be done about. For example, causes such as "had the driver taken a different route" will not be included because they are not of significance as no action can be taken to address this.	The data for that case was read through, and an initial list of causal factors was created. The outcome was the fatality of the driver and injuries to the six other passengers. A list of causal factors was created. Factors included inappropriate speed, distraction, driver fatigue as well as inconsistent medical advice, driving while on medication, challenging family life, and inadequate notice of the job from the employer. These factors were triangulated as much as possible (though this was not possible for all factors) by cross checking information across the various documents.
3. Place each of the causes at an AcciMap level, review the level titles as	As the data was reviewed and causal factors begun emerging, it was apparent that to understand this case

	appropriate. Determine what information is missing and how to go about collecting it.	more fully, the suggested AcciMap levels needed to be renamed for example, we added in "Societal norms, culture, values" as a level in the map to include causes such as normalising driving while fatigued as a factor. Each of the causal factors were placed at an AcciMap level. This was an iterative process in which the levels were refined and causal factors grouped. Further information was sought from government websites to help fill in upper levels.
4.	Arrange the causes in the AcciMap so that the causes lie directly above their effects (whether the effects are in the same level or in the level(s) below). Check the causal logic and determine whether if it had not occurred that the incident itself may not have occurred.	As suggested, the causes were placed above their effects and causal logic was indicated by arrows. This was also and iterative process requiring many attempts and a discussion among the research team. An example of this is the driver not wearing a seatbelt led to them being ejected from the seat and through the windscreen. Another example is the driver receiving conflicting advice about fitness to drive and the driver remaining available to work (drive).
5.	Address any gaps in information. The process will result in the contributing upper-level system failures being identified from the causal pathway diagrams, which can then be linked to the lower-level factors determined from the crash reports.	Further information was sought from policy documents, government reports and websites, and media to shed light on higher levels such as regulations, policies and procedures.
6.	Discuss any findings to ensure all causal pathways make sense and allow the input of content experts.	It is recommended that as this project concludes, a stakeholder group of experts in the field be brought together to discuss the map, the causes, and in particular the causal pathways between each cause. The discussion with these stakeholders could include how this method could be used more broadly in the driving for work context and limitations including access to data (discussed below) can be overcome.

4.2.3. Pilot AcciMap

Below is the pilot AcciMap (Figure 43) that resulted from the method outlined above. Following the map, is an accompanying description of the case.

Figure 43: Pilot AcciMap of fatal crash case



ACCIMAP KEY

White box = causal factors

Yellow box = outcome of the incident / injuries sustained

Grey box = causal factors assumed from the evidence but not confirmed

Solid arrow = relationship between factors found in evidence

Dashed arrow = relationship assumed from evidence but not confirmed

Description of the case

A taxi driver was rung by their employer just before midnight and asked to pick up a family before 5:00am the following morning. The driver reluctantly took the job and left home for the fare just before 4:00am. The trip should have taken roughly 25 minutes, however the driver got lost and needed to be redirected to the correct address arriving 15 minutes late. Presenting as stressed and out of breath, one of the passengers helped the driver load the van. They later commented that the driver drove inappropriately for the conditions down their driveway.

During the time leading up to the crash, the driver was reportedly riding the clutch and not taking corners appropriately, at times skidding on the road. The full beams were left on throughout the trip despite the presence of oncoming traffic.

In the years prior to the crash, the driver had had their license cancelled after presenting unwell and consequently deemed unfit to drive. The license had been reissued a short time later after seeing an appropriate medical practitioner. Also during the previous years, the driver had fallen asleep at the wheel and had been involved in a crash where they were hit by another car. This left the driver with injuries that hindered full-time work.

Roughly a week before the crash, the driver presented to their GP with dizzy spells and had also been unwell requiring an overnight stay in hospital the week before that. They were offered time off work by the GP though refused. The GP prescribed medication of which has side effects including sleepiness and drowsiness. While on this medication, patients are advised against driving. It is noteworthy to mention that the advice from the GP was deemed contradictory by the coroner because in some places they were advised against driving and in other places “the affected person has to be careful with driving”. Even though advised against it, the driver remained available to work according to employer records.

In addition to the ill health and injury, the driver appeared to have a demanding home life, which, on this night prior to the crash meant they had slept in the vehicle rather than returning home to sleep.

At roughly 5:25am the driver failed to turn at a right bend, travelled straight onto soft gravel on the left side of the road, and overcorrected which caused the van to roll several times and then rotate around. The driver was not wearing a seatbelt and was ejected from the vehicle and died at the scene of the incident.

Environmental factors played a role. The road is undivided and the speed limit 100km/h. The safe and appropriate speed is 80km/h and TCR records recommend a speed limit of 75km/h, however there is no signage to indicate this, just arrows. This road is in the top 10 percent priority for speed management. The shoulder was narrow, unsealed and running into a ditch.

This incident occurred partly because the driver was unfit to drive – a symptom of a series of interrelated contextual factors. They were given contradictory medical advice, allocated the work only four hours prior to beginning, and remained available to drive despite being fatigued and under the influence of medication. Waka Kotahi were approached by the coroner, as was the GP, each with reasons for not suspending the license or taking further intervening action. There was agreement that although license suspension was not possible in this case, there is scope for improvements in the current guidelines.

4.2.4. Data availability and access

The AcciMap analysis was developed to a point, but given project constraints was not able to be fully pursued to include a deeper understanding of the contextual factors surrounding the crash. Using this method at scale will require greater and easier access to relevant data sources. It will also require the creation of data sets that more easily allows for the identification of 'upstream' contributing factors to crashes. It was challenging to obtain the information required for this one case and yet there is a strong need to carry out more 'system' focussed analyses of crashes.

It is acknowledged that data of this nature contains senstive information and respect needs to be given to individuals involved. However, if crashes while driving for work are to be reduced, then broader systemic trends must be identified via methods such as AcciMaps. The benefits of using AcciMaps are particularly evident when a maps can be created from clusters of similar cases, allowing trends to emerge. Interventions can then be designed to address causes at higher system levels with the aim of preventing crashes at a larger scale.

4.3. Conclusions

Socio-technical analyses such as AcciMaps show promise in developing a more contextual understanding of the conditions associated with driving for work crashes. However, collaborative effort across the system is needed to improve access to data so that socio-technical analyses of crashes and groups of crashes can be carried out. New arrangements for data collection and amalgamation of current data sets are needed however, and it is currently very difficult to obtain the relevant data (which mostly exists in various places) to effectively carry out these analyses. Work in other areas such as the Led Outdoor Activity sector (see the work of Goode, Salmon, Lenné, Finch, & Cassell, 2012) sector have shown that some of the factors that contribute to minor incidents are the same as those leading to those of a more serious and fatal nature. This means that by understanding and acting on contributing factors to even minor incidents can help improve the design of the system. However, this requires greater access to work-related data from across the system and an ongoing commitment to the analysis of contextual factors when a crash for work occurs.

5. KEY LESSONS AND IMPLICATIONS FOR POLICY AND PRACTICE

5.1. Key lessons for policy and practice

This study has utilised two different system methods to examine the characteristics of driving for work crashes. The analysis has highlighted some key trends and these are summarised below:

- Failure across a greater number of Safe System components is associated with higher crash severity
- The burden of injury from driving for work crashes is largely borne by other users, particularly by other drivers and vulnerable road users
- There is often a large difference in mass and level of protection between road users, such as in crashes involving a bus or light/medium truck and a pedestrian
- As in previous studies, most severe crashes occurred on rural roads, particularly undivided roads with 100 km/h speed limits – though severe crashes involving vulnerable road users were more common in urban areas
- Speed factors were strongly linked to crash severity – however severe crashes also occurred at very low driving for work travel speeds, particularly where vulnerable road users were involved (e.g. pedestrian and rubbish truck) or another driver was travelling much faster
- Driving for work vehicles often had quite low safety ratings, especially vans, and especially for technician and trades worker and labourer type occupations
- Reckless or extreme behaviours were less common in driving for work crashes, particularly among those driving for work
- There are broader, systemic factors that contribute to driving for work crashes. Trends among systemic causal factors can be identified using methods such as AcciMaps. Benefits of the method are evident when maps can be created from clusters of similar cases which allow trends to emerge
- Collecting data on contextual factors that contribute to driving for work crashes will mean interventions can be designed to address causes at higher levels, preventing crashes on a larger scale.

The cluster analysis has shown that driving for work cases are often associated with three crash context types:

Multiple vehicle crashes (n=188), often involving work vans, utes, and SUVs in side impact crashes, occurring across all land use types, and typically resulting in injury to non-driving for work drivers.

Vulnerable road user crashes (n=72), often involving professional drivers in vans or buses colliding head on with a pedestrian in an urban or commercial shopping area.

Single vehicle crashes (n=40) involving people driving vans or light trucks for work losing control on rural roads and hitting an object or rolling, with fatigue, non-seat belt use, and speed often implicated, and resulting in high worker injury rates.

5.2. A need for better data and access

A theme of data limitations existing across both system analysis methods. For the Safe System analysis variations and limitations in CAS data were identified, possibly relating to the adjoining SCU report for any case. However, SCU reports are generally unavailable for analysis purposes despite the rich array of contextual information they likely contain. Likewise, for both analyses ACC and WorkSafe data was deemed too difficult to obtain within the parameters of this study, and yet these combined data sets may be valuable in understanding work related road safety trends and cases.

If more system focussed analysis of road safety issues are deemed useful, then it is suggested that agreed pathways for data use and access are determined, so that approved researchers and/or studies can access necessary data safety, without undue difficulty. Significant effort and resources are used to collect and store this data, and hence while there is an ethical obligation to ensure individual data is protected, there is also an obligation to ensure the usefulness of the data is maximised.

5.3. Recommendations for future research

Based on the study findings, we propose the following actions:

- Develop a deeper understanding of the context around examples from the crash clusters, so that advocacy and policy responses can be accurately targeted.
- Use minor crash frequency as a potential indicator of more severe crash risk in work and other settings
- Improve CAS data quality by ensuring relevant information from SCU reports is backfilled into TCRs, or that CAS reports are adequately completed in any case.
- Establish data access procedures, across various data sets, for valid crash analysis purposes
- Examine how common work-related factors such as fatigue, time pressures, and work stress can be better recorded in TCRs
- Explore the different crash clusters identified in more detail to further understand the crash factors associated with each
- Further develop socio-technical methods and data collection/analysis procedures for different crash types to identify and address contextual trends present at higher system levels.

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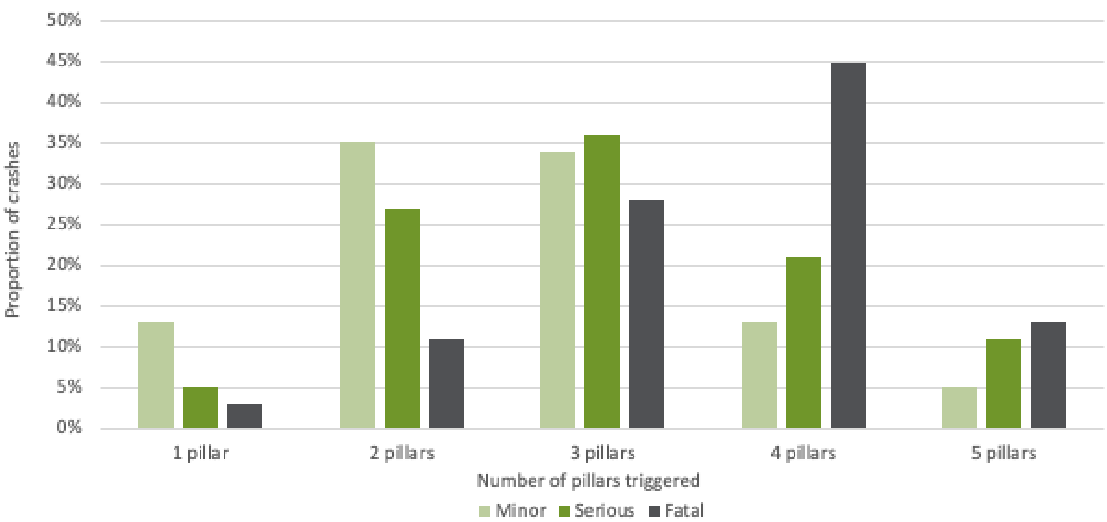
APPENDIX A: SUPPLEMENTARY TABLES AND GRAPHS

Table 5: Number of crashes in each region of New Zealand by severity

	Minor	Serious	Fatal	Total
Northland	2	3	7	12
Auckland	31	33	29	93
Waikato	18	14	16	48
Bay of Plenty	2	1	3	6
Gisborne	2	0	2	4
Hawkes Bay	3	2	3	8
Taranaki	2	6	3	11
Manawatū-Whanganui	6	7	8	21
Wellington	14	9	5	28
Tasman	0	0	0	0
Nelson	1	0	0	1
Marlborough	1	2	1	4
West Coast	0	0	2	2
Canterbury	7	15	13	35
Otago	9	4	6	19
Southland	2	4	2	8
Total	**100**	**100**	**100**	**300**

Figure 44: Proportion of crashes triggering multiple Safe System pillars by crash severity – with User pillar separated into DFW driver and Other user pillars



APPENDIX B: LITERATURE SCAN REPORT

Introduction

Background

Work-related road safety is a strategic priority in the new road safety strategy Road to Zero and is of strategic interest across a number of government agencies (e.g., MOT, Waka Kotahi, WorkSafe, ACC). It has been identified that the prevalence of work-related fatal injuries which were road traffic fatalities make up 30% of all worker fatalities (McNoe, Langley, & Feyer, 2005) and between 22%-36% of the national road toll (including workers, bystanders, and commuters) (Lilley, et al., 2019). While definitions of driving for work vary internationally, overseas studies have similarly shown that work-related motor vehicle traffic crashes (WR MVTC) are the greatest cause of occupational injury and fatalities in Australia (Mitchell, Bambach, & Friswell, 2014; Safe Work Australia, 2017) and the UK (Clarke, Ward, Bartle, & Truman, 2005), and that they are responsible for 40% of road fatalities in Europe (Adminaite, Jost, Stipdonk, & Ward, 2017).

Definitions of driving for work vary from country to country in terms of what counts as driving to work; for example, in some European countries, commuting to and from work is included while in most English-speaking countries it is not, and in some places the vehicle is only considered to be a workplace when used on worksites (Mathern, 2019). Within this, existing studies focus on different types of driving for work, for example, heavy freight drivers, light truck and short-haul vehicle (up to 12 tonnes) drivers, and company fleet drivers. Business-owned or managed vehicles (work or company fleets) are also often differentiated from privately-owned vehicles used for work (grey fleets), or employees from owner-operators (Mathern, 2019). Lilley et al. (2019) use a broad definition of driving for work in their study, which includes volunteer work and activities occurring during a non-work period but to which work contributed.

For the purposes of this study, driving for work is defined as all on-road driving for the purposes of work, excluding commuting. In addition, because relatively more research has focussed on truck drivers and less is known about other kinds of work-related trips, we are focused on driving for work in light vehicles, especially cars, but also including light trucks, and buses.

Beyond understanding the overall burden of WR MVTC, and in order to address some of their underlying causes, we need to develop a better understand of the factors contributing to their occurrence. Recent research into the factors associated with WR MVTC in New Zealand has identified a range of government policy, organisational, and worker level risk factors associated with heavy freight driving (Mathern, 2019; Tedestedt George, 2018), and how upstream factors linked to supply chain pressures can be addressed (Tedestedt George, et al., 2021). However, comparatively little research has been done into the contextual factors associated with WR MVTC in light vehicles such as cars and small trucks.

This study seeks to address this knowledge gap by examining the factors associated with WR MVTC using three methods:

- A brief scan of key literature on WR MVTC that occurred in light vehicles (as part of Study Phase 1)

- An analysis of the Safe System factors associated with WR MVTC that occurred in light vehicles in New Zealand in recent years (Phase 2)
- A socio-technical systems analysis of the upstream factors associated with WR MVTC occurring in light vehicles in New Zealand (Phase 3).

This report summarises the findings of the first of these methods, the literature scan.

Scope

The scope of this brief scan of literature is to help to identify methodologies, key themes, and to position this project. The literature scan will inform the next phases of this project. Note that this was not a comprehensive review of literature, but rather a scan of key methodologies and themes to inform our study.

As above, driving for work is defined for the purposes of this literature scan as all driving for the purposes of work, excluding commuting and off-road (e.g., worksite) driving. However, studies that include commuting and off-road driving will also be considered where relevant. Likewise, the literature scan focuses on driving for work in light vehicles, but due to the limited evidence available specific to light vehicles, literature on driving for work in heavy vehicles, or a mix of both, is included where relevant.

Method

An initial step was to review academic and non-academic literature related to driving for work crashes. A literature search was conducted using the databases Science Direct and Google Scholar. Key words in the search terms began with "driving for work", "crash", "work-related", "fatality", "occupational", "injury", with "contributing factors", "system influences" and "light vehicles" as examples of secondary search terms where appropriate. The majority of initial literature found was related to heavy truck-driving, which is not the focus of this project, so "light vehicle" became a key area of focus as the search focus progressed. Literature was selected based on methodologies that seemed relevant to our work and with findings that revealed common characteristics of driving for work crashes.

Research methodologies used to better understand driving for work crashes

Research to understand the nature of driving for work crashes have employed many different methods depending on the study objective. These methods and objectives are summarised in Table 1 below. This review of methods will assist in the coding protocols we will use for our analysis based on variables found to be relevant in other studies, while also informing areas of focus for further phases of our study.

Table 1: Methods researchers have used to understand driving for work crashes.

Method	Primary Objective	References
Coronial data (provides accurate injury and demographic information)	To determine burden of driving for work related fatal injuries and provide demographic and other context	Driscoll, et al. (2005); Lilley, et al. (2019); Lilley, et al. (2021); McNoe, Langley, & Feyer (2005)

Injury claims (typically easily filterable and pre-selected for work-related incidents)	To determine incidence rates and associated costs of work-related injury claims	Boufous & Williamson (2009); Copsey, et al. (2010); McNoe, Langley, & Feyer (2005); Sultana, Robb, Ameratunga, & Jackson (2007)
Police reports and crash records (recording and reporting of this data has variable accuracy)	To identify work-related traffic incidents and provide demographic, roading environment, and crash context	Boufous & Williamson (2009); Clarke, Ward, Bartle, & Truman (2005); McNoe, Langley, & Feyer (2005); Rowland, Wishart, & Davey (2005); Stuckey, Glass, LaMontagne, Wolfe, & Sim (2010); Ward, Christie, & Walton (2020); Wishart, Rowland, Freeman, & Davey (2011)
Vehicle-use registration data	To cross-reference and identify specific vehicle types e.g., occupational light vehicles or load-shaped vehicles	Stuckey, LaMontagne, Glass, & Sim (2010); Stuckey, Glass, LaMontagne, Wolfe, & Sim (2010)
Stakeholder interviews and focus groups	Gaining driver or organisational stakeholders' perspective on specific contributing factors e.g., fatigue or safety culture	Husain, Mohamad, & Idris (2019); Ward, Christie, & Walton (2020); Rowland (2018); Rowland, Wishart, & Davey (2005); Tedestedt George (2018); Wishart, Rowland, Freeman, & Davey (2011)
Diary studies	Tracking changes among drivers in an identified variable e.g., fatigue or perceptions of job strain and determining its relationship with poor driving safety	Anderson, et al., (2018); Husain, Mohamad, & Idris (2019)
Surveys and questionnaires	Gaining further perspective and understanding on any number of contributing factors e.g., fatigue, speeding, safety culture, or work demands	Freeman, Wishart, Davey, & Rowland (2008); Friswell, Williamson, & Dunn (2006); Husain, Mohamad, & Idris (2019); Marcus & Loughlin (1996); Montoro, Useche, Alonso, & Cendales (2018); Newnam, Watson, & Murray (2004); Newnam, Griffin, & Mason (2008); Rowden, Matthews, Watson, & Biggs (2011); Rowland, Wishart, & Davey (2005); Rowland (2018); Useche, Cendales, Alonso, & Orozco-Fontalvo (2020); Williamson, Friswell, & Dunn (2006); Wills, Watson, & Biggs (2009); Wishart, Somoray, & Evenhuis (2017)

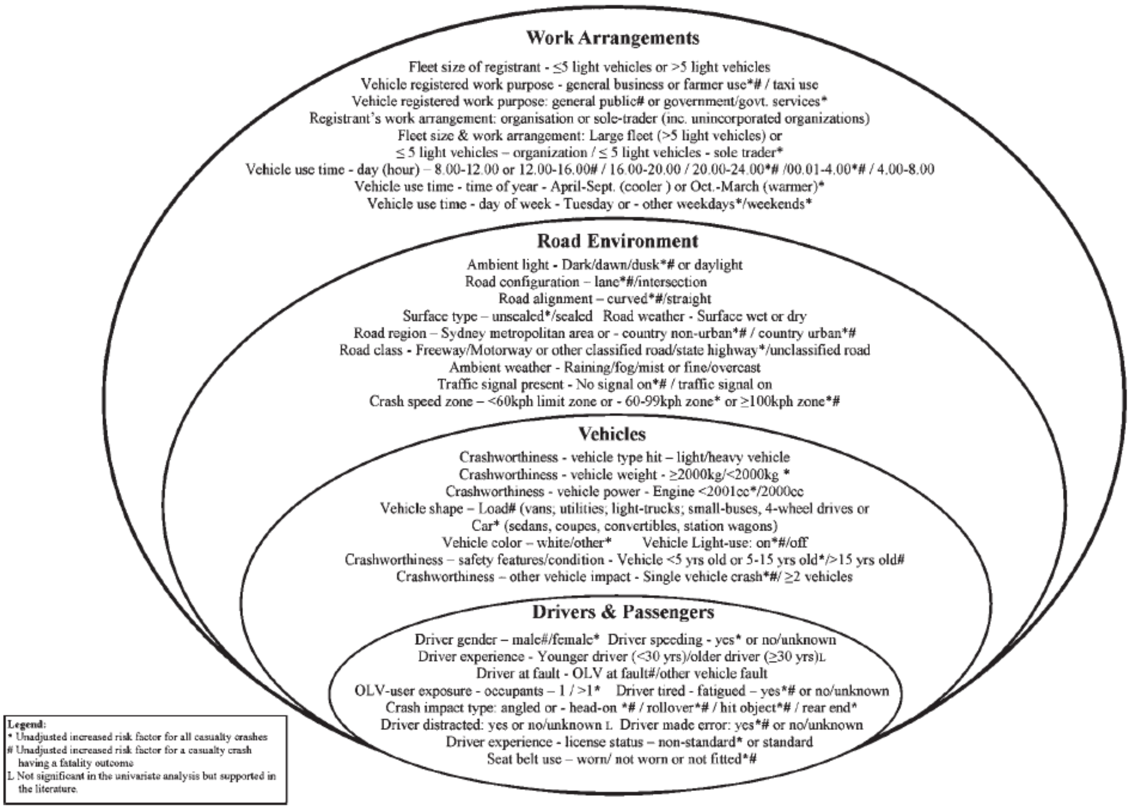
Literature review	To identify current knowledge base of driving for work crashes and identifying potential gaps e.g., socio-technical approach in intervention design	Newnam & Watson (2011); Salmon & Lenné (2015); Stuckey, LaMontagne, & Sim (2007)
Thematic analysis of case studies and safety policies	Broader review of general themes commonly found in organisational safety policy, safety interventions, and crashes	Copsey, et al. (2010); Copsey, et al. (2011); Wishart, Rowland, Freeman, & Davey (2011)

Analysis considerations

The methods used in the literature above have highlighted some potentially useful elements that could be incorporated into the coding protocol for the current study. These include:

- Include pedestrians and/or bystanders during the analysis of driving for work crashes to properly represent the burden of work-related fatal injuries (Lilley, et al., 2019; McNoe, Langley, & Feyer, 2005; Sultana, Robb, Ameratunga, & Jackson, 2007).
- Consider drivers participating in the gig economy e.g., ridesharing and food delivery, and grey fleet e.g., driving personal car for work purposes, in analysis. This is important as this is a large sector and has not received adequate attention in the literature (Ward, Christie, & Walton, 2020)
- Include 'work activity', defined as "working for pay, profit or payment in kind, assisting with work in an unpaid capacity, or being engaged in work-related activities even when on a break or away from the workplace, for example, rest stops taken during work-related travel" (Lilley, et al., 2021, pp. 124-125)
- Consider "blameworthiness" ratio – "drivers could be either 'to blame', 'at least partly to blame', or 'not to blame' in any given incident". This coding allows for an analysis of "blameworthiness" by other variables e.g., vehicle type and severity of injury (Clarke, Ward, Bartle, & Truman, 2005, p. 14). Note that taking a more systemic view of crashes is the goal of this and other more contemporary road safety research, rather than focussing on blame. However, it is still important to understand the contributing factors to crashes across the system areas of driver, roads, vehicles, and speed.
- Code for fatigue and speeding, in the absence of police identification of these conditions, by identifying characteristics of driving behaviour that indicate fatigue (e.g., travelling on incorrect side of road for single vehicle crashes, running off road with no evidence of speeding) or speeding (e.g., losing control on a curve) (Boufous & Williamson, 2009, p. 468).
- Code a wide range of variables as limited coding can potentially significantly misrepresent the impact and effects of driving for work crashes (McNoe, Langley, & Feyer, 2005; Ward, Christie, & Walton, 2020).
- Code vehicle, road environment, and work factors as well as those related to drivers and passengers (Stuckey, Glass, LaMontagne, Wolfe, & Sim, 2010) – see example of coding protocol in Figure 1 below.

Figure 1: Occupational Light Vehicle (OLV)-use systems model with potential crash determinants at each level (Stuckey, Glass, LaMontagne, Wolfe, & Sim, 2010)



Analysis limitations

It is widely understood that the accuracy of such analyses is dependent on the availability of data and accuracy of recording at time of the crash, usually by police officers. Inconsistent reporting of whether the driver was participating in a work activity, severity of injury or other important standard contextual factors can lead to incomplete and often inaccurate databases which under-report the severity of the issue (Clarke, Ward, Bartle, & Truman, 2005; McNoe, Langley, & Feyer, 2005; Ward, Christie, & Walton, 2020). It is also important to recognise the limitations of ethnicity coding if the person identifies with multiple ethnicities and only one is recorded at time of crash (Sultana, Robb, Ameratunga, & Jackson, 2007).

Further, data sourced from insurance claims or worker compensation claims are limited by accurate self-reporting within organizations, drivers' willingness to lodge a claim, or unclear knowledge of claim eligibility, particularly for self-employed or grey fleet drivers (Boufous & Williamson, 2009; Sultana, Robb, Ameratunga, & Jackson, 2007; Ward, Christie, & Walton, 2020).

Driver demographics in work related crashes – key trends

There are clear trends in the literature around how work-related driving injury and fatality affect people of different ages and genders, and a small amount on ethnicity. These trends are summarised in this section.

Age

The rate of fatal injuries or permanent disability after a work-related crash generally increases with age, with the highest fatality rate occurring among those aged 65 years and older (Boufous & Williamson, 2009; Driscoll, et al., 2005; Lilley, et al., 2021; McNoe, Langley, & Feyer, 2005;). This age effect was attributed to the age profile of driving occupations and the increased risk of fatal injury due to the physical effects of aging. Studies differed in their findings of which New Zealand age group bore the highest burden in absolute numbers, but all fell between 35-54 years old (Lilley, et al., 2021; Sultana, Robb, Ameratunga, & Jackson, 2007).

Gender

Males are significantly over-represented in work-related fatal and non-fatal injury statistics internationally and in New Zealand (Boufous & Williamson, 2009; Driscoll, et al., 2005; Lilley, et al., 2021; McNoe, Langley, & Feyer, 2005; Sultana, Robb, Ameratunga, & Jackson, 2007), though females may be more prominently featured in 'company car' crashes compared to other vehicle types (Clarke, Ward, Bartle, & Truman, 2005). Furthermore, in an Australian study specific to occupational light vehicles (OLV), the authors found that females had an increased risk of injury, but not fatality, in OLV crashes. This was in part attributed to females being less likely to drive load-shape occupational vehicles and instead more likely to drive car-shaped vehicles which have a better chance of safety features and airbag deployment, which may increase the risk of trauma, but protect from fatal injury (Stuckey, Glass, LaMontagne, Wolfe, & Sim, 2010).

Ethnicity

This demographic statistic was not reported often across the different studies, however Lilley, et al. (2021) reported that the rate of work-traffic fatalities for Māori workers was almost three times higher than other ethnic groups in New Zealand.

Factors involved in work-related crashes

Contextual factors involved in work-related crashes identified in the literature tended to focus on factors related to the driver and to their organisation. Where vehicle and environmental factors were discussed, it was mainly in relation to freight and road haulage (Clarke, Ward, Bartle, & Truman, 2005; Copsey, et al., 2010). In addition, Australian working drivers were found to report that external factors were not as important as organisational or personal ones (Rowland, 2018).

The key findings related to driver and organisational factors reported in the literature are summarised below. Note that all findings are for work-related driving.

Driver factors

Fatigue

Fatigue has been identified as a common experience amongst drivers for work across multiple industries (Anderson, et al., 2018; Friswell, Williamson, & Dunn, 2006; Husain, Mohamad, & Idris, 2019; Marcus & Loughlin, 1996) and a significant factor in increasing the risk of severe and fatal injuries (Boufous & Williamson, 2009; Clarke, Ward, Bartle, & Truman, 2005; Stuckey, Glass, LaMontagne, Wolfe, & Sim, 2010). Further, it is noted that the effects and scale of fatigue amongst professional drivers is at risk of being severely underreported due to issues in collection of contextual crash information, manifestation of fatigue in different crash factors such as driver distraction or swerving, and reluctance of drivers to self-report fatigue (Clarke, Ward, Bartle, & Truman, 2005; Friswell, Williamson, & Dunn, 2006).

Speeding

Speeding was also found to be a significant and common issue among work-drivers (Freeman, Wishart, Davey, & Rowland, 2008; Hirsch, et al., 2017) and a risk factor which increases the likelihood of severe and fatal injuries in driving for work crashes ((Boufous & Williamson, 2009; Stuckey, Glass, LaMontagne, Wolfe, & Sim, 2010; Clarke, Ward, Bartle, & Truman, 2005; Wishart, Somoray, & Evenhuis, 2017). While speeding was found to be the most common driving violation incurred by working drivers, drivers report it to be their least problematic driving behaviour (Freeman, Wishart, Davey, & Rowland, 2008; Newnam, Watson, & Murray, 2004). Further, Wishart, Somoray, & Evenhuis (2017) found that drivers who report thrill-seeking and adventurous behaviour are more likely to display risky work driving such as speeding. This behaviour also seems to be regulated by the safety climate of the organisation.

Other driver factors associated with work-related traffic crashes

- Not wearing a seatbelt, illness or other impairment (Copsey, et al., 2010; Hirsch, et al., 2017; Lilley, et al., 2019)
- Driver distractions, such as mobile phones, maps, in-vehicle technology (Rowland, 2018; Salmon & Lenné, 2015)
- 'Reckless and Careless', 'Anxious', and 'Angry and Hostile' driving styles can exacerbate work stress and job strain, which are positively associated with increasing work traffic crashes (Useche, Cendales, Alonso, & Orozco-Fontalvo, 2020)
- Employment and vehicle type: Workers driving company cars, vans/pickups, and large goods vehicles in the UK were more likely to be deemed at fault than the other parties they were involved in crashes with, for reasons of excess speed, observational failures, and fatigue or vehicle defects respectively. In contrast, workers driving buses, taxis, and emergency vehicles were more likely to be deemed victims of the road behaviour of other parties (Clarke, Ward, Bartle, & Truman, 2005).

Organisational factors

Industries

People driving for work in the transport sector (including postal, warehousing, public utilities, storage and communication) were found to be the most frequent victims of driving for work fatalities and injuries in New Zealand (Driscoll, et al., 2005; Lilley, et al., 2021; Sultana, Robb, Ameratunga, & Jackson, 2007). Interestingly, the construction industry in New Zealand was found to have higher driving for work fatality rates than Australia and the USA (Driscoll, et al., 2005).

Some studies also highlighted the varying needs and challenges of different driving for work industries. For example, gig economy and grey fleet workers (e.g., Uber drivers) in the UK face challenges related to blurring of the lines between self-employment and being part of an organisation (Ward, Christie, & Walton, 2020). Taxi drivers in Australia and Malaysia have also been found to experience high levels of both work stress and serious crash risk (Boufous & Williamson, 2009; Husain, Mohamad, & Idris, 2019).

Time pressure/Work demands

Risky and unsafe driving behaviour is found to be linked to the time pressure and stressful work demands placed on work-drivers, with "productivity [taking] precedence over safety" (Rowland, 2018, p. 205). In transport and delivery industries, this time pressure can also be exerted by customer and client stakeholders (Copsey, et al., 2011). Consistent work demands can also lead to increasing effects of fatigue and reducing motivation to follow safe-driving behaviour (Husain, Mohamad, & Idris, 2019).

Safety culture

A strong and defined safety culture within a driving for work organisation is found to strongly influence organisational safety behaviour and reduce driving errors (Copsey, et al., 2010; Wills, Watson, & Biggs, 2009; Wishart, Somoray, & Evenhuis, 2017). The importance of an organisational understanding – from the drivers to the fleet managers, to organisational safety policies – is also highlighted (Newnam, Griffin, & Mason, 2008). Moreover, safety culture in driving for work organisations may be particularly difficult to implement because many drivers work independently and are away from a fixed base of operations (Ward, Christie, & Walton, 2020).

Towards systems analyses for driving for work

As demonstrated by the findings above, while some influences on driving for work safety seem clear, there is still a significant knowledge gap in understanding the range of contextual factors influencing injury and fatality occurring while driving light vehicles for work. In particular, while there is a large amount of information on driver factors, it is highly variable and not necessarily relevant to the New Zealand context, and there is very little on vehicle, environmental, and wider contextual factors. Similarly, though a number of organisational factors are identified, our understanding of the upstream causes is limited beyond some key recent studies. A holistic and comprehensive systems approach is therefore required to understand the range of influences on work-related road safety and to design appropriate interventions (Rowland, 2018).

One way of considering the different levels at which we can seek to understand the influence of different factors on WR MVTC is shown in Figure 2.

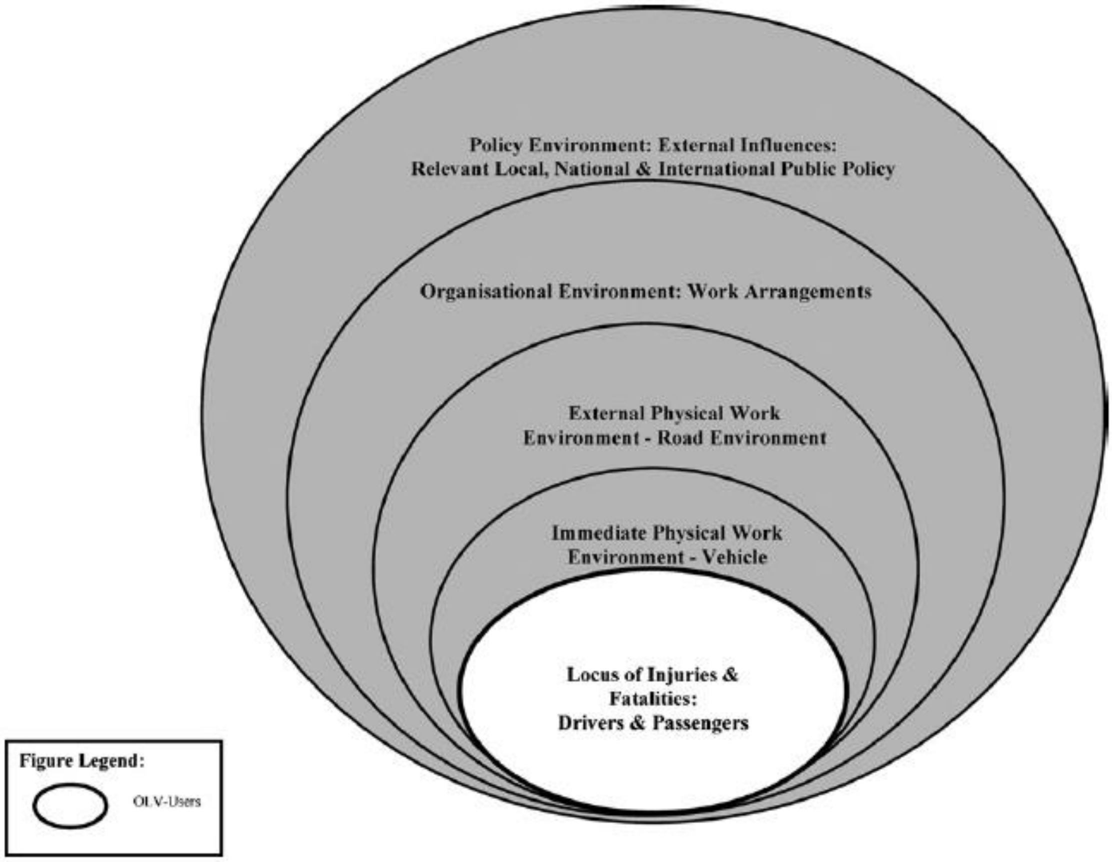
Figure 2: Levels of analysis of factors contributing to vehicle crashes

One model that has been used to understand the immediate context of different types of crashes is the Safe System analysis framework used to examine Safe System factors in studies of vehicle occupants not wearing seatbelts, pedestrian crashes, and differences between crashes causing serious injury and those causing fatality (Hirsch, Mackie, Scott, & Thorne, 2018; Hirsch, et al., 2017; Mackie, et al., 2017; Thorne, Hirsch, Blewden, & Mackie, 2020). These studies have facilitated an understanding of the types of environmental, vehicle, and road user factors associated with injury and fatal crashes, and how multiple system factors come together in crashes.

Taking the system approach a step further is research into the wider and upstream factors influencing road safety, such as organisational arrangements and government policies (Salmon & Lenné, 2015; Salmon, 2020). Taking socio-technical and socio-ecological approaches, these kinds of analyses have recently been carried out for workplace safety related to people driving heavy vehicles for work in New Zealand (Tedestedt George, 2018; Tedestedt George, et al., 2021).

An example of a systems approach applied specifically to light vehicles used for work purposes is the Occupational Light Vehicle (OLV)-use systems model (Figure 3) developed by Stuckey, LaMontagne, & Sim (2007). This model offers a framework by which the range of research needs and policy and practice interventions can be determined, and looks at both the immediate crash context and upstream factors. It attempts to simplify the complexities of and recognises the relationship between the different spheres of influence on driving for work safety - Drivers & Passengers; Vehicle; Road environment; Work arrangements; Local, National, International, Public policy (Wishart, 2015).

Figure 3: Occupational Light Vehicle OLV)-use systems model (Stuckey, LaMontagne, & Sim, 2007)



The application of a systems analysis on driving for work research is supported by a recognition in the literature of the value it provides to fully understand the scale of the issue and the range of interventions at different scales needed to make an impact on safety (Copsey, et al., 2011; Newnam & Watson, 2011; Useche, Cendales, Alonso, & Orozco-Fontalvo, 2020). Further, Tedestedt George et al. (2021) recommend that methods for monitoring and mapping risk and harm related to driving for work are improved, and that ways of sharing data are established to leverage existing data from outside government and across government departments

The current research project seeks to develop and apply two levels of systems analysis to better understand the immediate and wider contextual factors associated with crashes while driving for work in light vehicles. This deeper understanding of factors within the light vehicle driving for work context will fill this knowledge gap and facilitate decision-making around how best to reduce harm related to driving for work.

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APPENDIX C: CLUSTER ANALYSIS

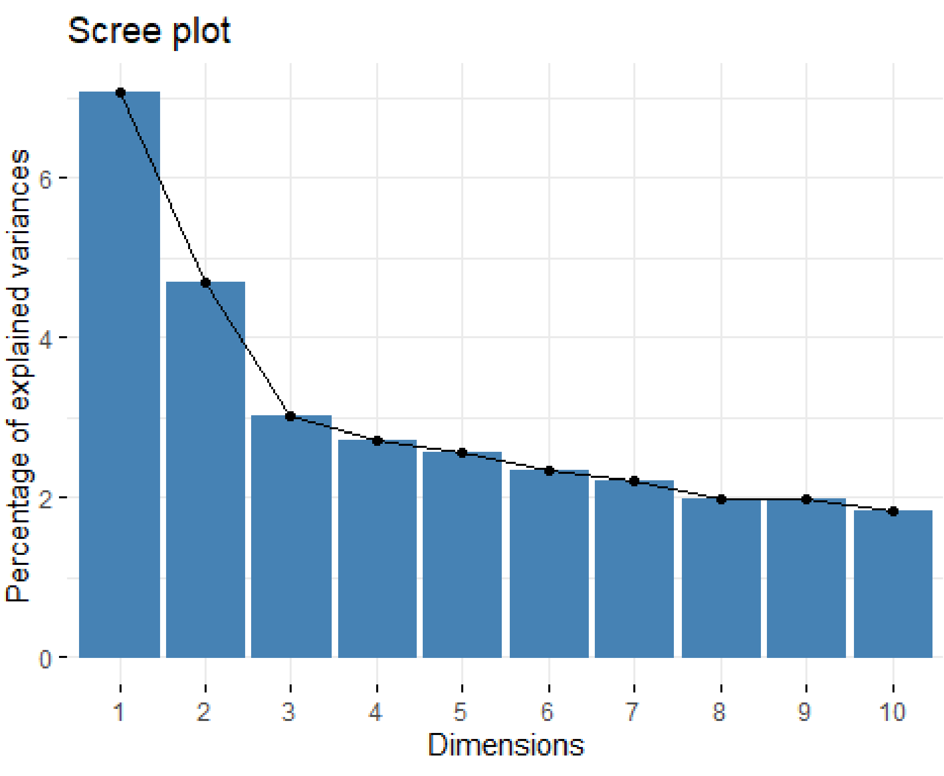
DFW ANALYSIS

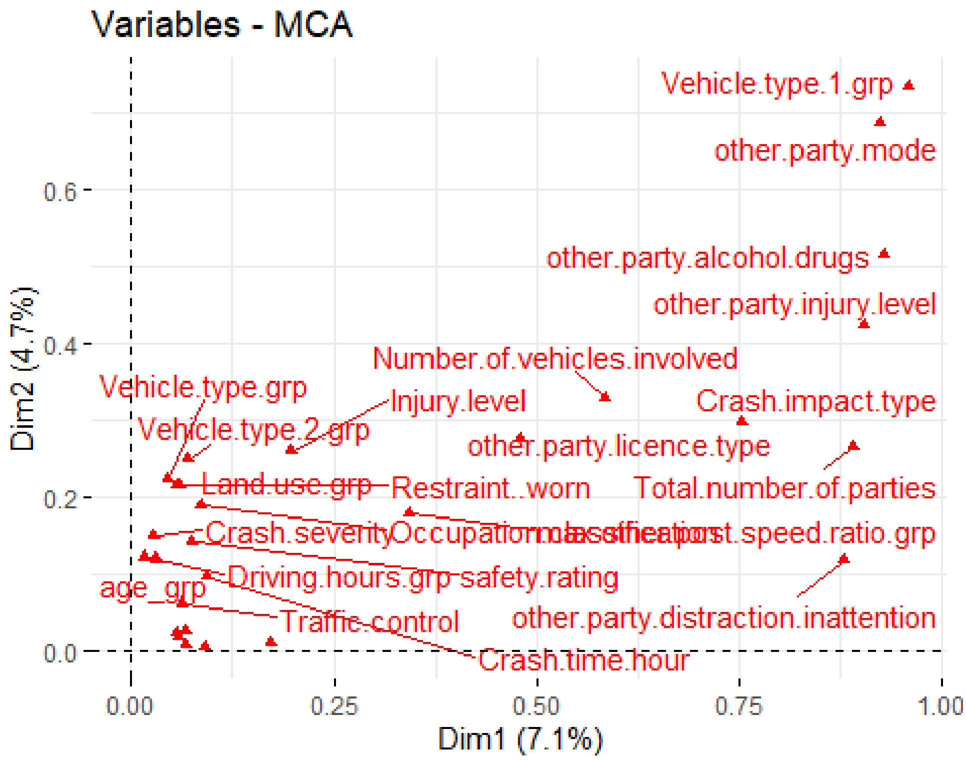
Eileen Li

Jan 2022

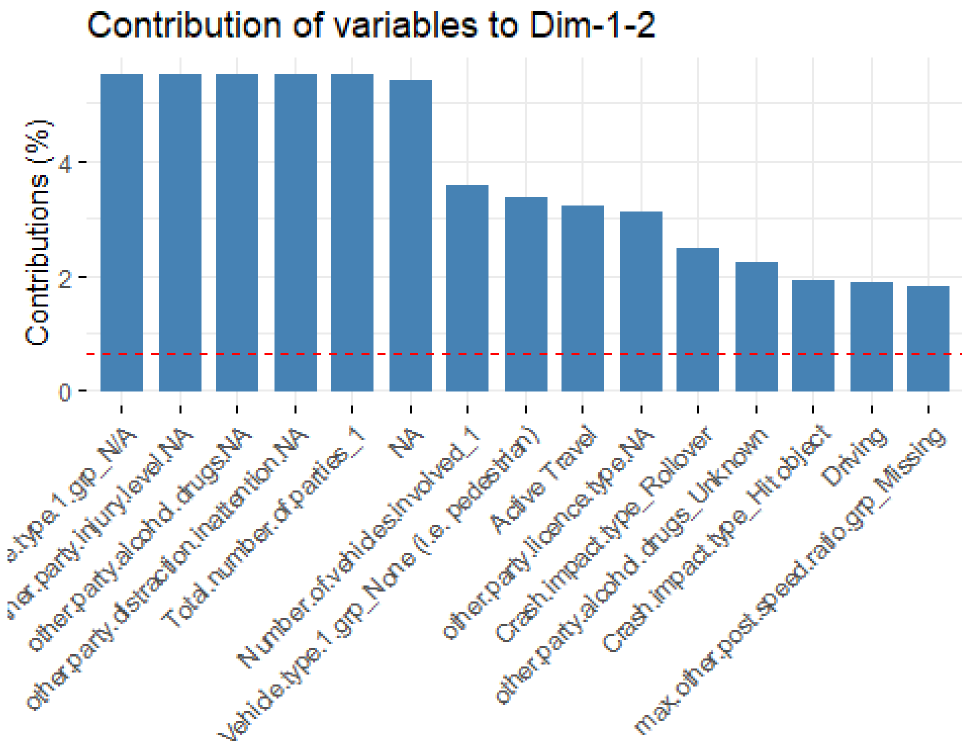
Multiple Correspondence Analysis

Multiple correspondence analysis was applied to level 1 priority variables - that is, applying numerical transformation on categorical variables: age group, occupation classification, land use, crash impact type, crash severity, vehicle type, etc.



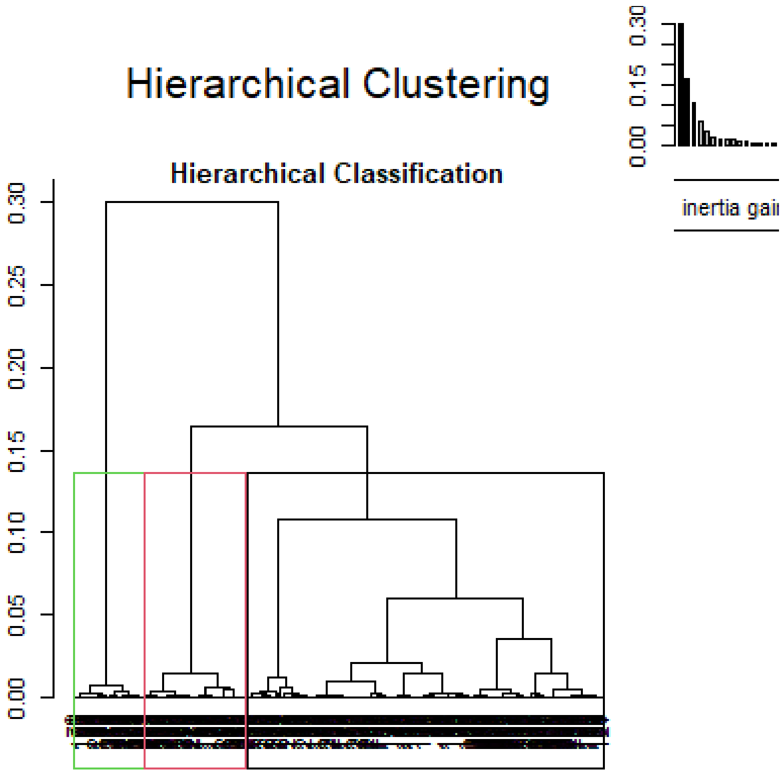


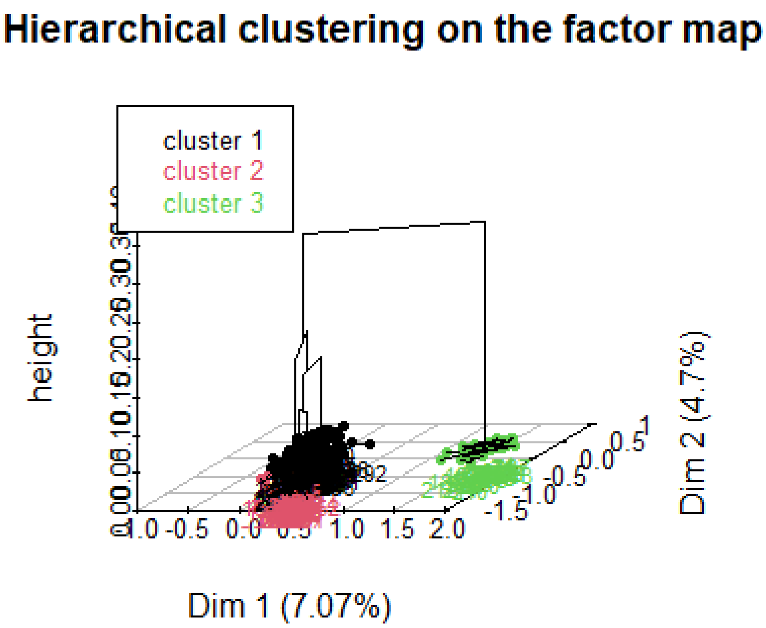
Variables - MCA
Vehicle.type.1.grp
other.party.mode
other.party.alcohol.drugs
other.party.injury.level
Number.of.vehicles.involved
Vehicle.type.grp
Injury.level
Crash.impact.type
Vehicle.type.2.grp
other.party.licence.type
Land.use.grp
Restraint..worn
Total.number.of.parties
Crash.severity
Driving.hours.grp
safety.rating
age_grp
Traffic.control
other.party.distraction.inattention
Crash.time.hour
Dim2 (4.7%)
Dim1 (7.1%)
0.0
0.2
0.4
0.6
0.00
0.25
0.50
0.75
1.00

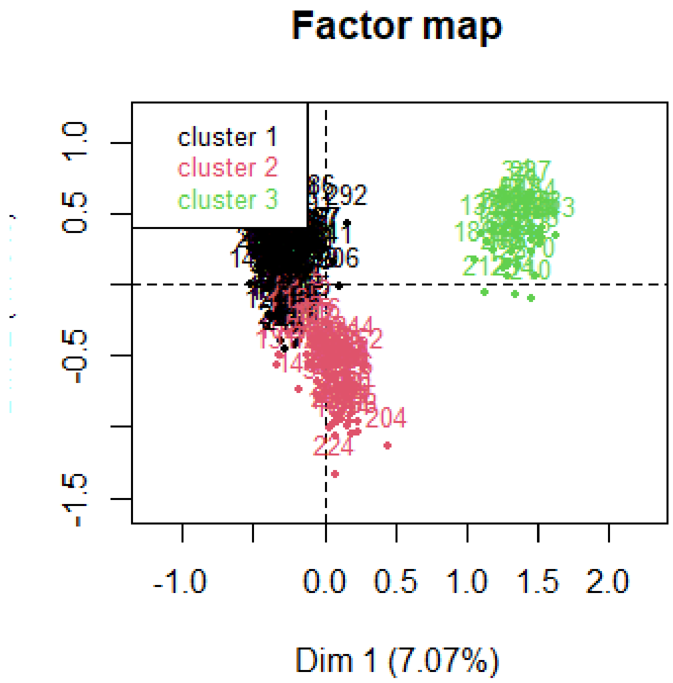


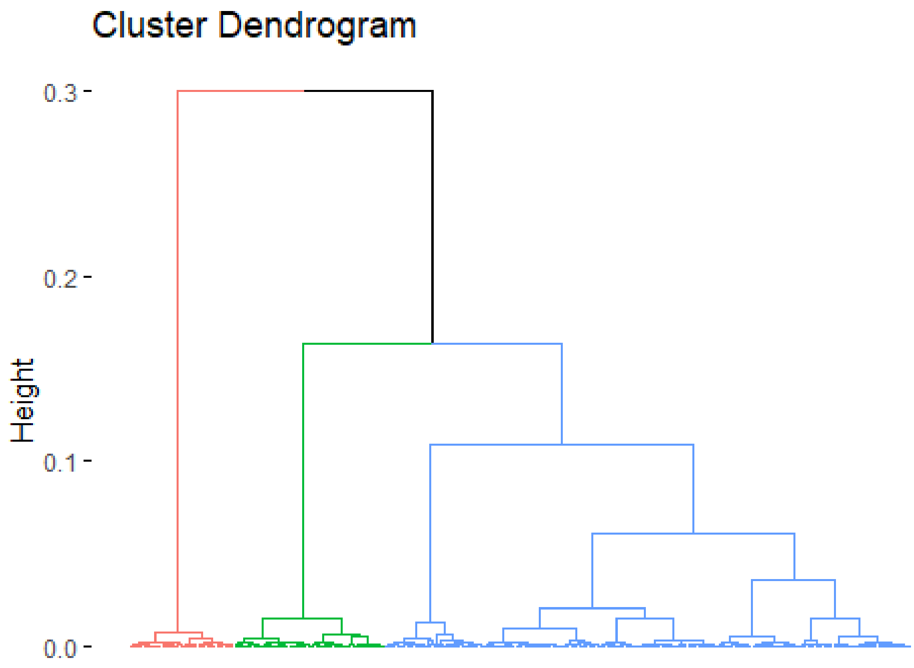
Contribution of variables to Dim-1-2
Contributions (%)
0
2
4
other.party.alcohol.drugs.NA
other.party.distraction.inattention.NA
Total.number.of.parties_1
NA
Number.of.vehicles.involved_1
Vehicle.type.1.grp_None (i.e. pedestrian)
Active Travel
other.party.licence.type.NA
Crash.impact.type_Rollover
other.party.alcohol.drugs_Unknown
Crash.impact.type_Hit.object
Driving
max.other.post.speed.ratio.grp_Missing

Clusters Analysis






Factor map
cluster 1
cluster 2
cluster 3
-1.5
-0.5
0.5
1.0
-1.0
0.0
0.5
1.0
1.5
2.0
Dim 1 (7.07%)


Cluster Dendrogram
Height
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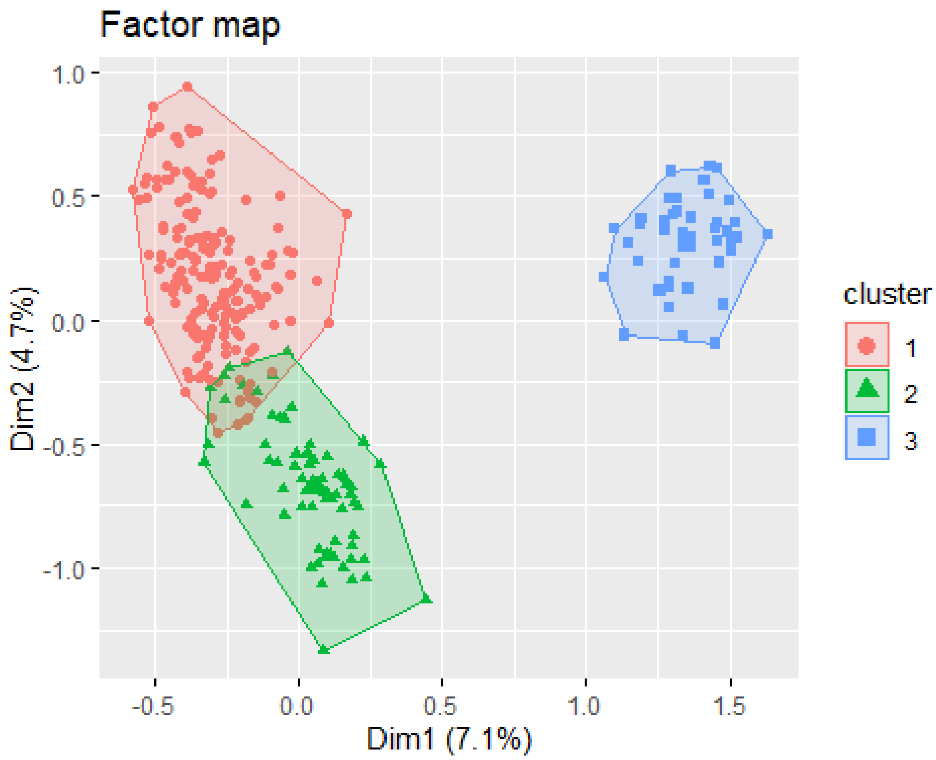
0.2
0.1
0.0

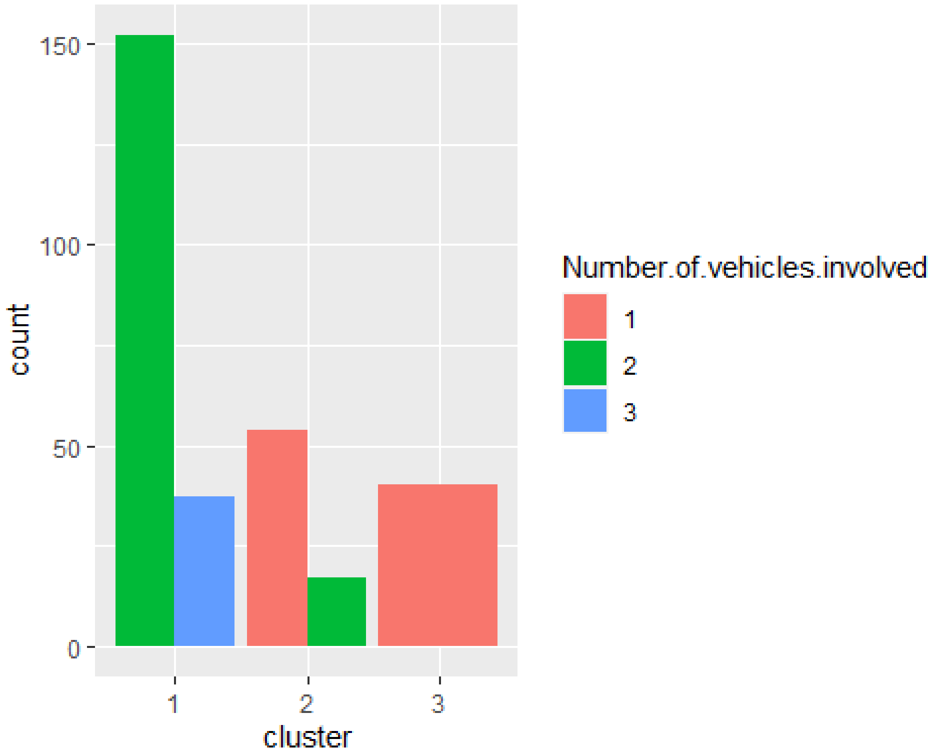


Cluster Summary

- Number of vehicles involved:
  - Cluster 1: two and more vehicles. 80% of crash cases in Cluster 1 involved 2 vehicles, and 20% involved 3 vehicles.
  - Cluster 2: two and less vehicles. 75% of crash cases in Cluster 2 involved only 1 vehilce, and 25% involved 2 vehicles.
  - Cluster 3: purely 1 vehicle crashes.
- Occupation:
  - A third of Cluster 1 is made up of Machinery operators and drivers (Level 7), followed by Technicians and trades workers (Level 3, 22%) then Unknown occupations (14%).
  - Half of Cluster 2 is made of Machinery operators and drivers (Level 7), then Unknown (23%) and Level 3 Technicians and trades workers (17%).
  - Nearly a third of Cluster 3 is made up of Labourers (Level 8), followed by Machinery operators and drivers (Level 7, 28%) then Technicians and trades workers (Level 3, 18%).
- Age group:
  - A quarter of Cluster 1 DFW drivers are aged between 25-34, followed by 55-64 (23%) then 45-54 (16%) and 35-44 (15%). The average age for this cluster is 44.

  - A quarter of Cluster 2 DFW drivers are aged between 55-64, followed by 45-54 (23%), then 25-34 (17%) and 35-44 (17%). The average age for this cluster is 48.
  - Cluster 3 has less DFW drivers aged between 35-44 (10%), 23% are aged 25-34 and another 23% are aged 45-54. The average age for this cluster is 44.
- Other party vehicle type:
  - Cluster 1: 54% cars, 15% SUV or ute, 12% motorcycles. For the third party involved in crash, most are cars.
  - Cluster 2: 76% pedestrians, 23% bicycles and 1% motorcycles.
  - Cluster 3: none, since this cluster doesn't not involve any other party.
- Other party mode:
  - Cluster 1: 86% driving and 11% motorcycling.
  - Cluster 2: 99% active traveling and 1% motorcycling.
  - Cluster 3: mostly NA, 1 driving.
- Other party presence of alcohol or drugs:
  - Cluster 1: majority no (67%), 13% unknown and 13% suspected, 7% yes.
  - Cluster 2: majority unknown (73%), 20% no and 6 % yes.
  - Cluster 3: NA, since no other party involved.
- Other party injury level:
  - Cluster 1: relatively evenly distributed, more than 50% minor injured or not injured.
  - Cluster 2: mostly seriously injured or fatal (79%).
  - Cluster 3: NA, no other party involved.
- Other party distraction or inattention:
  - Cluster 1: No (51%) vs. Yes (39%).
  - Cluster 2: No (35%) vs. Yes (48%).
  - Cluster 3: NA, no other party involved.
- Injury level (DFW driver):
  - Cluster 1: more than half (54%) no injury, 29% minor injury.
  - Cluster 2: 99% no injury.
  - Cluster 3: more than half (53%) seriously injured or fatal.
- Land use group:
  - Cluster 1: 50% rural, 29% urban.
  - Cluster 2: 41% urban, 23% commercial strip shopping and 15% commercial big box / industrial.
  - Cluster 3: 78% rural then 10% urban.
- Vehicle type group:
  - Cluster 1: dominant vehicle types: van (26%), car (23%) and SUV or ute (23%).
  - Cluster 2: dominant vehicle types: bus (32%) and Van (23%).
  - Cluster 3: dominant vehicle types: van (33%) and light truck (25%).

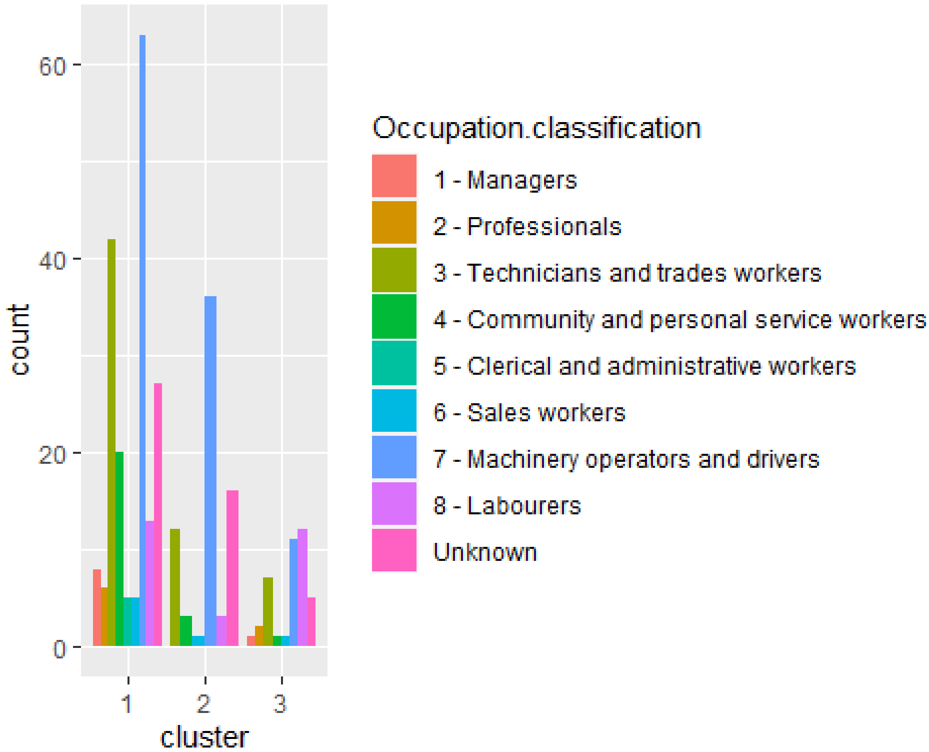
Number of Vehicles Involved



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
1	0	54	40	0.00	57.45	42.55
2	152	17	0	89.94	10.06	0.00
3	37	0	0	100.00	0.00	0.00

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
1	0	54	40	0.00	76.06	100
2	152	17	0	80.42	23.94	0
3	37	0	0	19.58	0.00	0

Occupation Classification

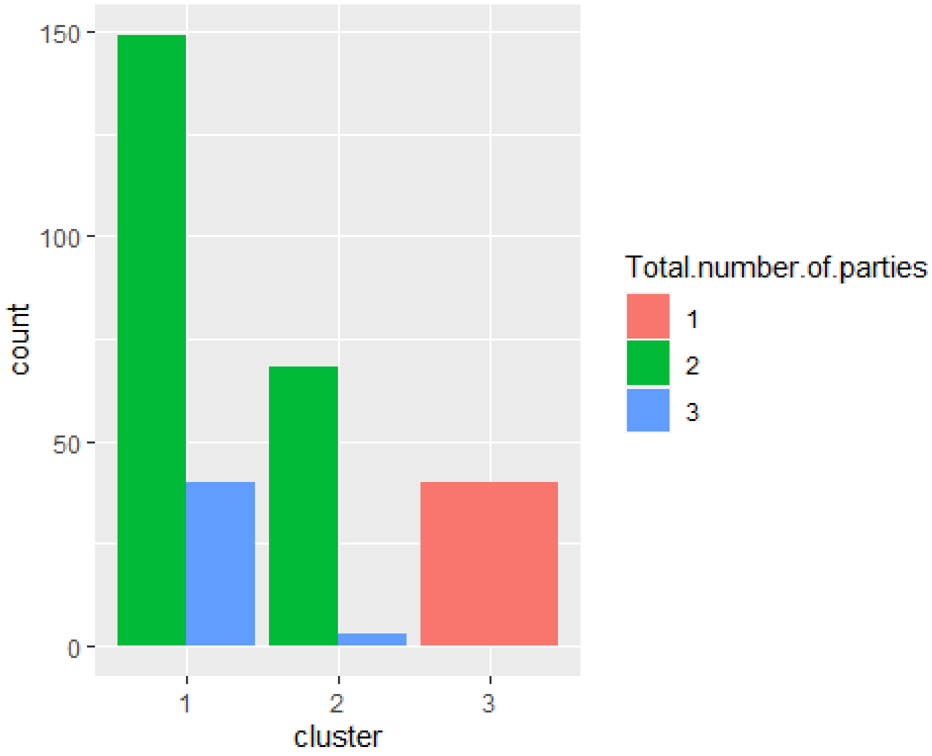


myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
1 - Managers	8	0	1	88.89	0.00	11.11
2 - Professionals	6	0	2	75.00	0.00	25.00
3 - Technicians and trades workers	42	12	7	68.85	19.67	11.48
4 - Community and personal service workers	20	3	1	83.33	12.50	4.17
5 - Clerical and administrative workers	5	0	0	100.00	0.00	0.00
6 - Sales workers	5	1	1	71.43	14.29	14.29
7 - Machinery operators and drivers	63	36	11	57.27	32.73	10.00
8 - Labourers	13	3	12	46.43	10.71	42.86
Unknown	27	16	5	56.25	33.33	10.42

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
1 - Managers	8	0	1	4.23	0.00	2.5
2 - Professionals	6	0	2	3.17	0.00	5.0
3 - Technicians and trades workers	42	12	7	22.22	16.90	17.5

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
4 - Community and personal service workers	20	3	1	10.58	4.23	2.5
5 - Clerical and administrative workers	5	0	0	2.65	0.00	0.0
6 - Sales workers	5	1	1	2.65	1.41	2.5
7 - Machinery operators and drivers	63	36	11	33.33	50.70	27.5
8 - Labourers	13	3	12	6.88	4.23	30.0
Unknown	27	16	5	14.29	22.54	12.5

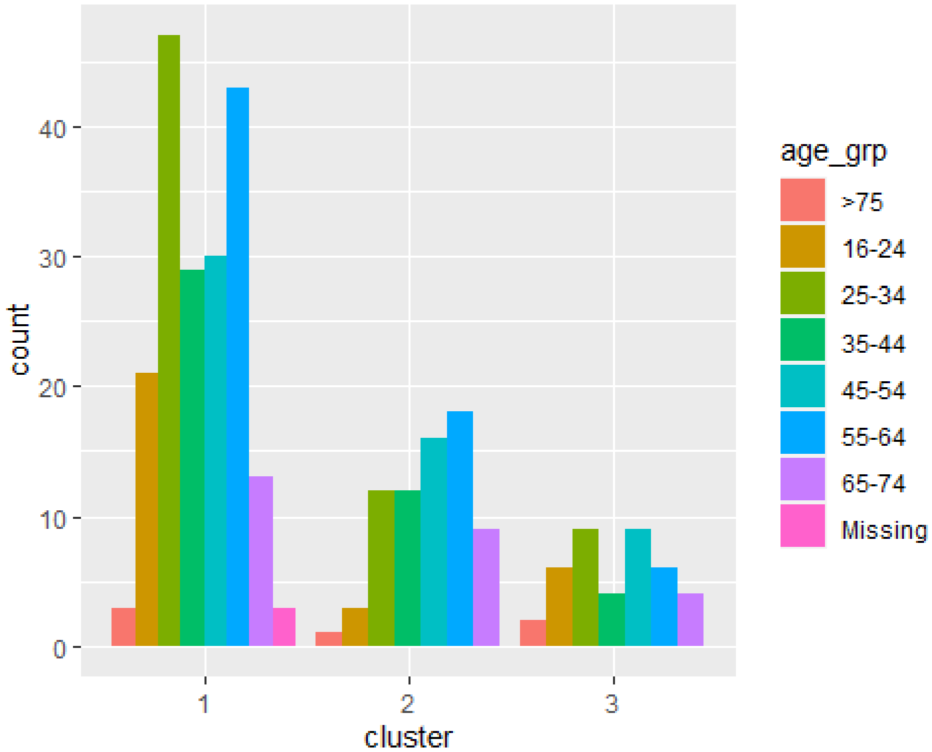
Total number of parties



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
1	0	0	40	0.00	0.00	100
2	149	68	0	68.66	31.34	0
3	40	3	0	93.02	6.98	0

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
1	0	0	40	0.00	0.00	100
2	149	68	0	78.84	95.77	0
3	40	3	0	21.16	4.23	0

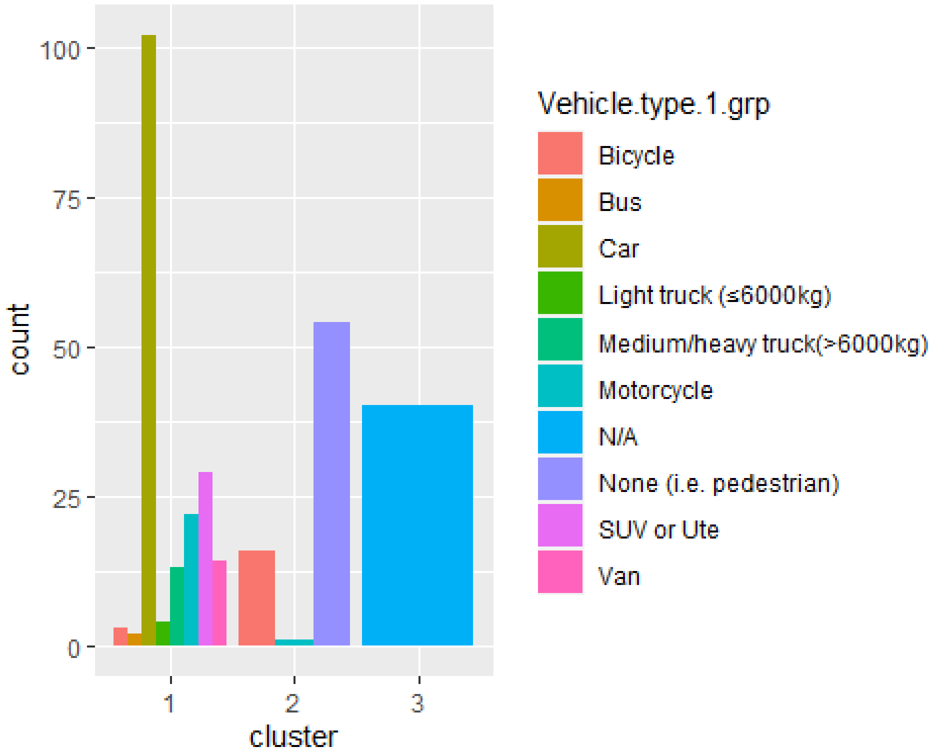
Age Group



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
>75	3	1	2	50.00	16.67	33.33
16-24	21	3	6	70.00	10.00	20.00
25-34	47	12	9	69.12	17.65	13.24
35-44	29	12	4	64.44	26.67	8.89
45-54	30	16	9	54.55	29.09	16.36
55-64	43	18	6	64.18	26.87	8.96
65-74	13	9	4	50.00	34.62	15.38
Missing	3	0	0	100.00	0.00	0.00

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
>75	3	1	2	1.59	1.41	5.0
16-24	21	3	6	11.11	4.23	15.0
25-34	47	12	9	24.87	16.90	22.5
35-44	29	12	4	15.34	16.90	10.0
45-54	30	16	9	15.87	22.54	22.5
55-64	43	18	6	22.75	25.35	15.0
65-74	13	9	4	6.88	12.68	10.0
Missing	3	0	0	1.59	0.00	0.0

Vehicle Type Other Party 1

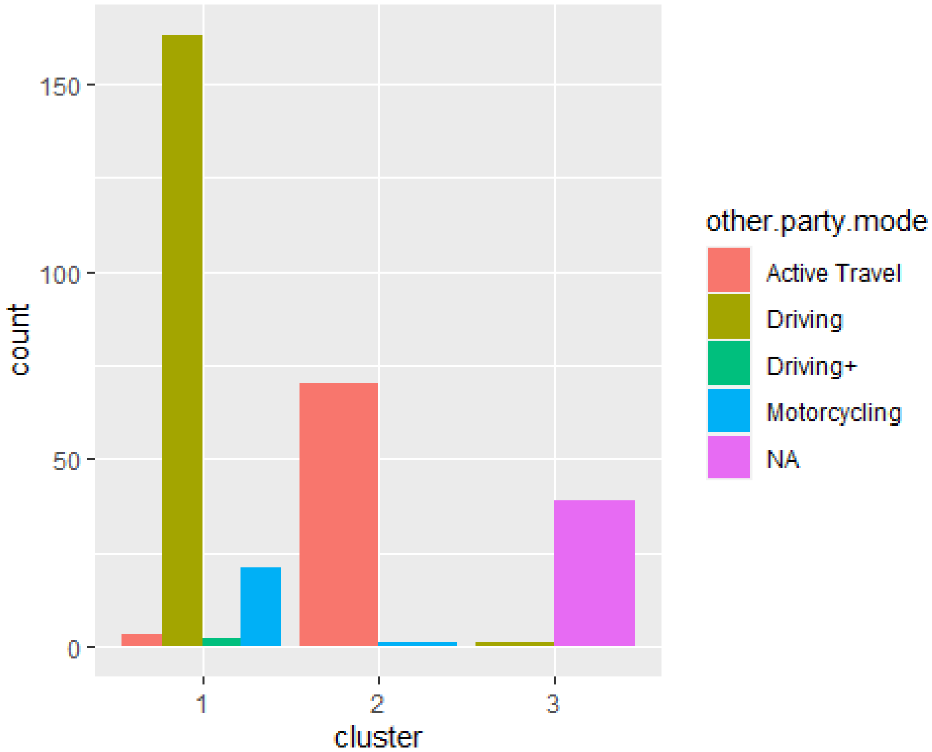


myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Bicycle	3	16	0	15.79	84.21	0
Bus	2	0	0	100.00	0.00	0
Car	102	0	0	100.00	0.00	0
Light truck (=6000kg)	4	0	0	100.00	0.00	0
Medium/heavy truck(>6000kg)	13	0	0	100.00	0.00	0
Motorcycle	22	1	0	95.65	4.35	0
N/A	0	0	40	0.00	0.00	100
None (i.e. pedestrian)	0	54	0	0.00	100.00	0
SUV or Ute	29	0	0	100.00	0.00	0
Van	14	0	0	100.00	0.00	0

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Bicycle	3	16	0	1.59	22.54	0
Bus	2	0	0	1.06	0.00	0
Car	102	0	0	53.97	0.00	0
Light truck (=6000kg)	4	0	0	2.12	0.00	0

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Medium/heavy truck(>6000kg)	13	0	0	6.88	0.00	0
Motorcycle	22	1	0	11.64	1.41	0
N/A	0	0	40	0.00	0.00	100
None (i.e. pedestrian)	0	54	0	0.00	76.06	0
SUV or Ute	29	0	0	15.34	0.00	0
Van	14	0	0	7.41	0.00	0

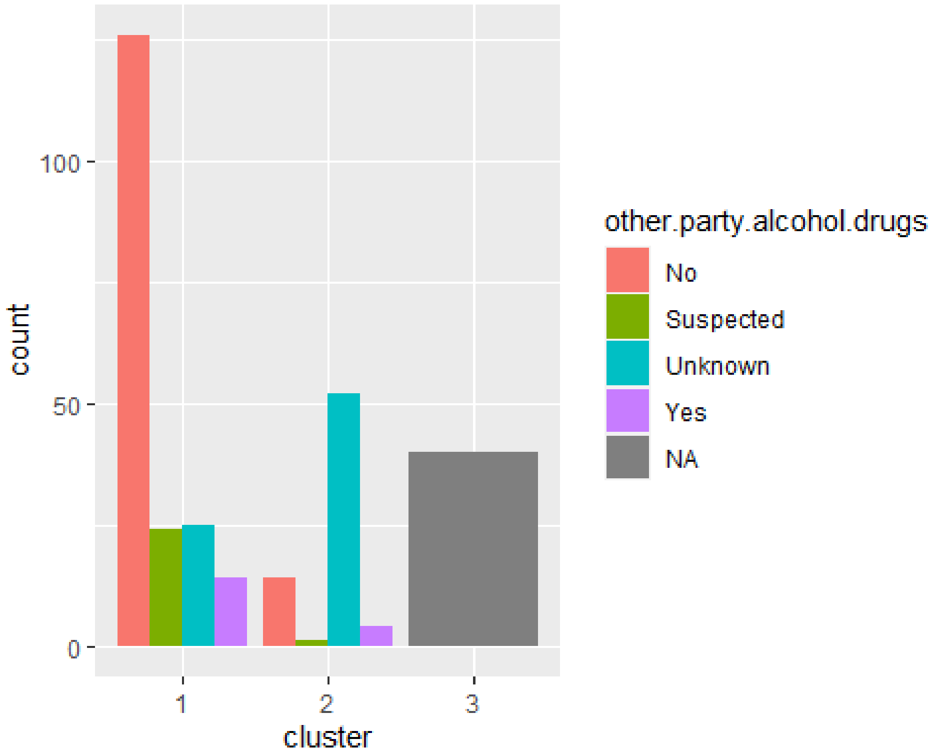
Other Party Mode



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Active Travel	3	70	0	4.11	95.89	0.00
Driving	163	0	1	99.39	0.00	0.61
Driving+	2	0	0	100.00	0.00	0.00
Motorcycling	21	1	0	95.45	4.55	0.00
NA	0	0	39	0.00	0.00	100.00

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Active Travel	3	70	0	1.59	98.59	0.0
Driving	163	0	1	86.24	0.00	2.5
Driving+	2	0	0	1.06	0.00	0.0
Motorcycling	21	1	0	11.11	1.41	0.0
NA	0	0	39	0.00	0.00	97.5

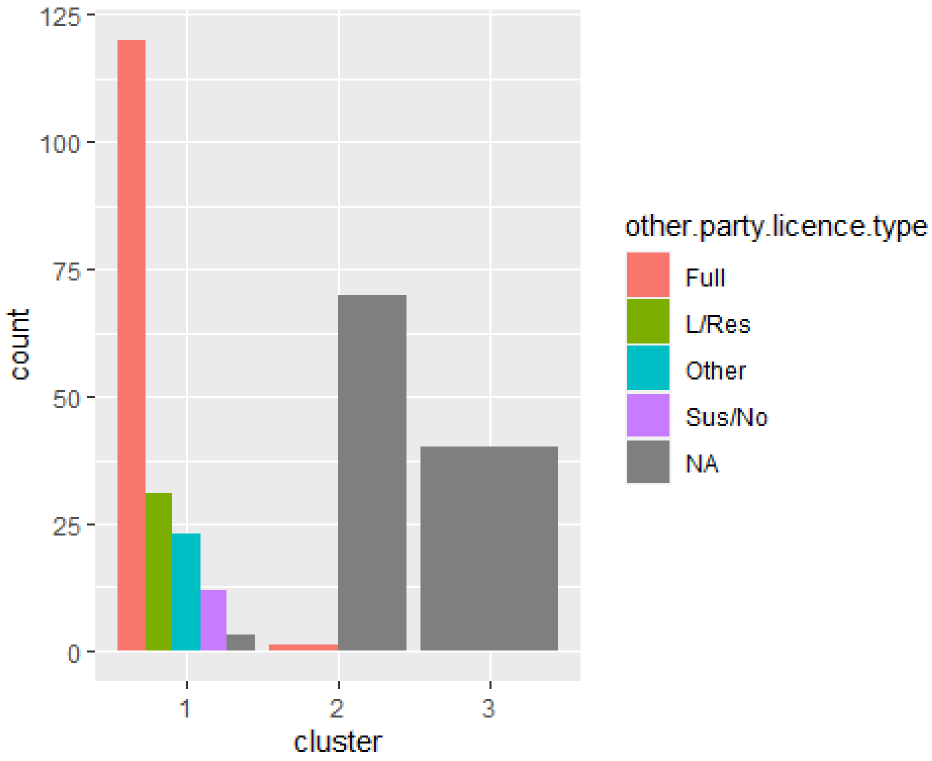
Other Party Presence of Alcohol or Drugs



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
No	126	14	0	90.00	10.00	0
Suspected	24	1	0	96.00	4.00	0
Unknown	25	52	0	32.47	67.53	0
Yes	14	4	0	77.78	22.22	0

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
No	126	14	0	66.67	19.72	NaN
Suspected	24	1	0	12.70	1.41	NaN
Unknown	25	52	0	13.23	73.24	NaN
Yes	14	4	0	7.41	5.63	NaN

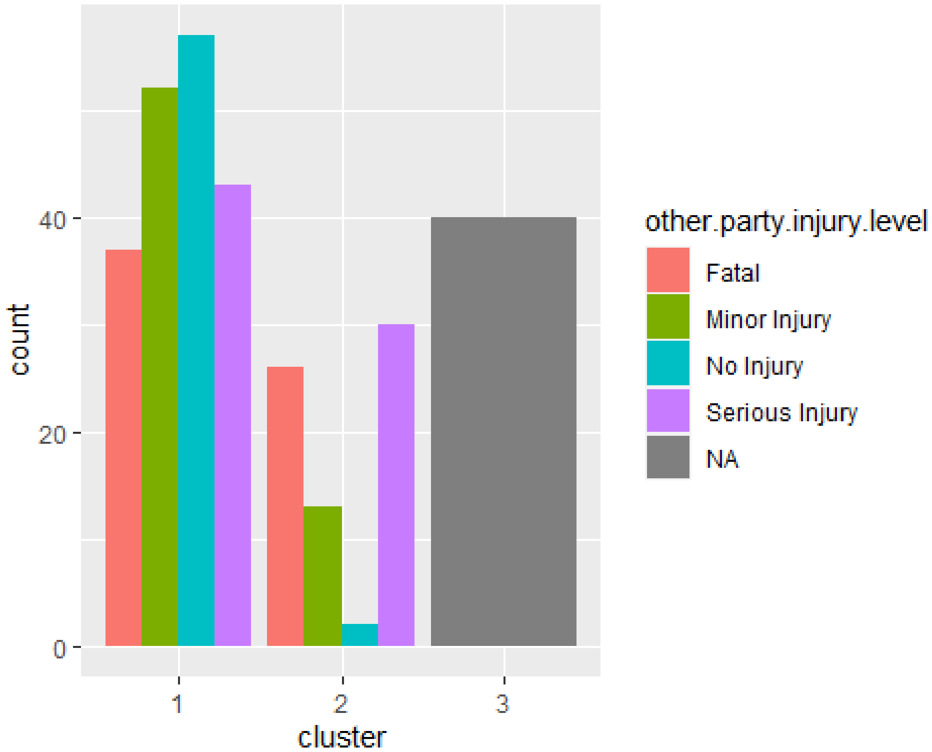
Other Party Driver Licence



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Full	120	1	0	99.17	0.83	0
L/Res	31	0	0	100.00	0.00	0
Other	23	0	0	100.00	0.00	0
Sus/No	12	0	0	100.00	0.00	0

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Full	120	1	0	64.52	100	NaN
L/Res	31	0	0	16.67	0	NaN
Other	23	0	0	12.37	0	NaN
Sus/No	12	0	0	6.45	0	NaN

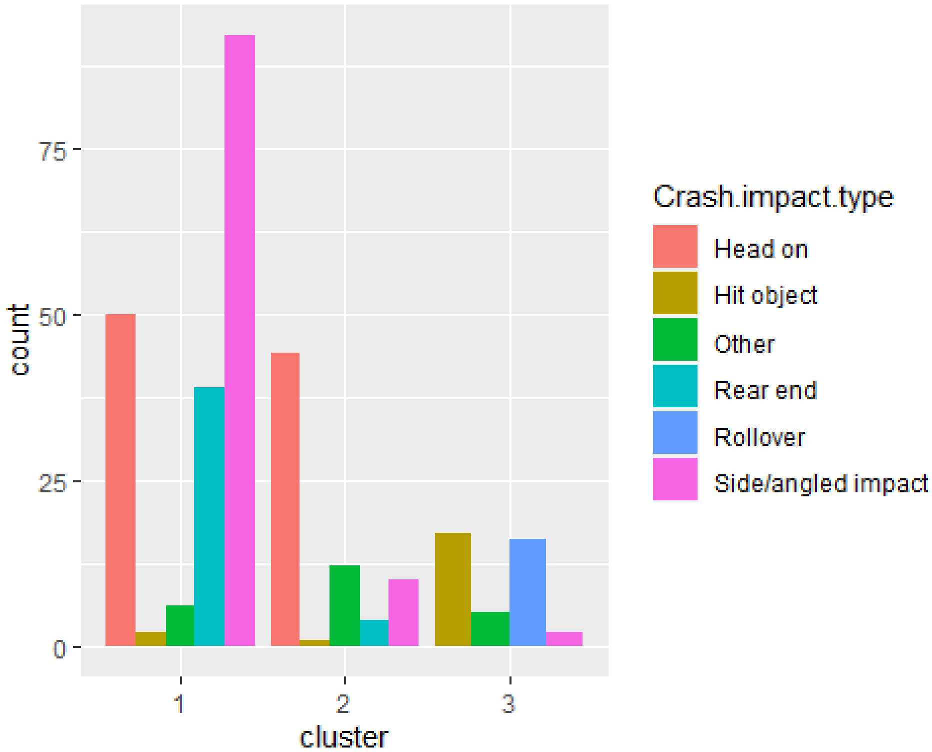
Other Party Injury Level



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Fatal	37	26	0	58.73	41.27	0
Minor Injury	52	13	0	80.00	20.00	0
No Injury	57	2	0	96.61	3.39	0
Serious Injury	43	30	0	58.90	41.10	0

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Fatal	37	26	0	19.58	36.62	NaN
Minor Injury	52	13	0	27.51	18.31	NaN
No Injury	57	2	0	30.16	2.82	NaN
Serious Injury	43	30	0	22.75	42.25	NaN

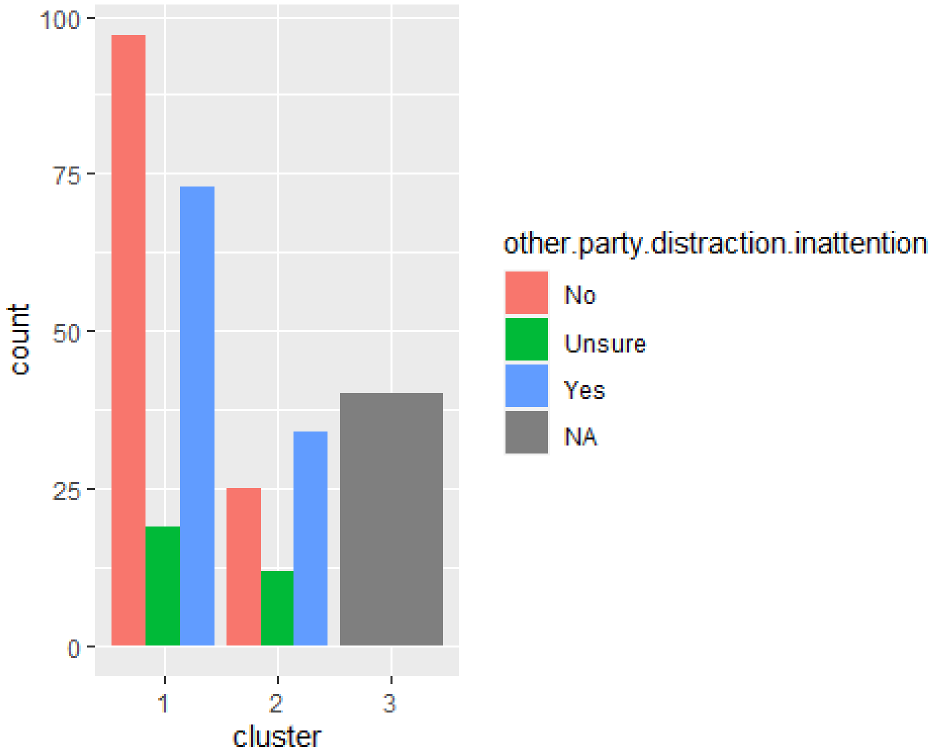
Crash Impact Type



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Head on	50	44	0	53.19	46.81	0.00
Hit object	2	1	17	10.00	5.00	85.00
Other	6	12	5	26.09	52.17	21.74
Rear end	39	4	0	90.70	9.30	0.00
Rollover	0	0	16	0.00	0.00	100.00
Side/angled impact	92	10	2	88.46	9.62	1.92

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Head on	50	44	0	26.46	61.97	0.0
Hit object	2	1	17	1.06	1.41	42.5
Other	6	12	5	3.17	16.90	12.5
Rear end	39	4	0	20.63	5.63	0.0
Rollover	0	0	16	0.00	0.00	40.0
Side/angled impact	92	10	2	48.68	14.08	5.0

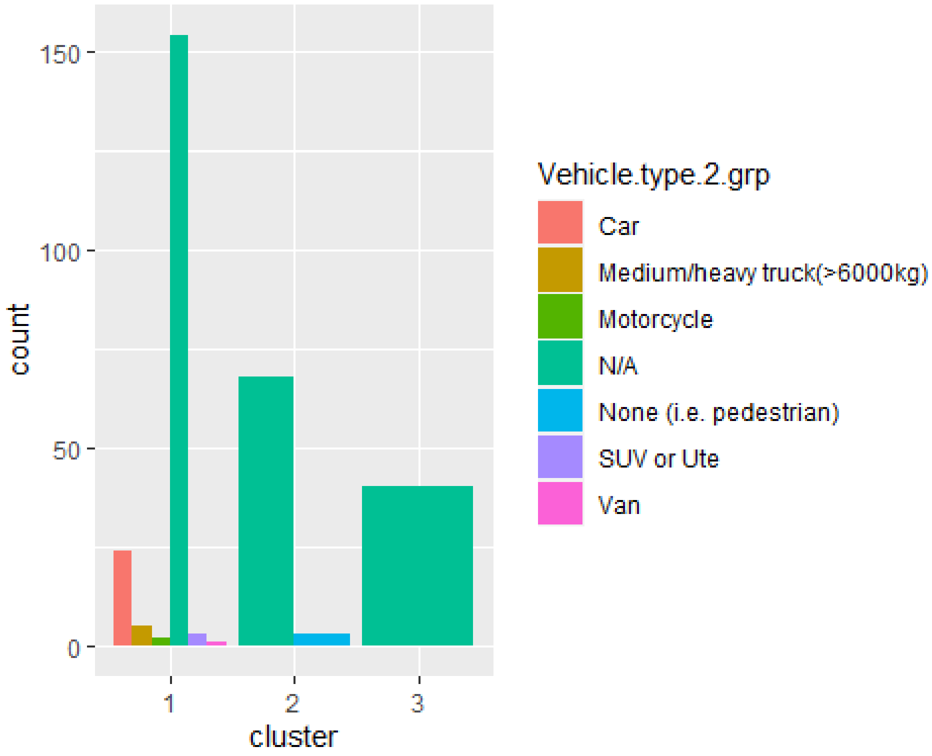
Other Party Evidence of Distraction Inattention



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
No	97	25	0	79.51	20.49	0
Unsure	19	12	0	61.29	38.71	0
Yes	73	34	0	68.22	31.78	0

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
No	97	25	0	51.32	35.21	NaN
Unsure	19	12	0	10.05	16.90	NaN
Yes	73	34	0	38.62	47.89	NaN

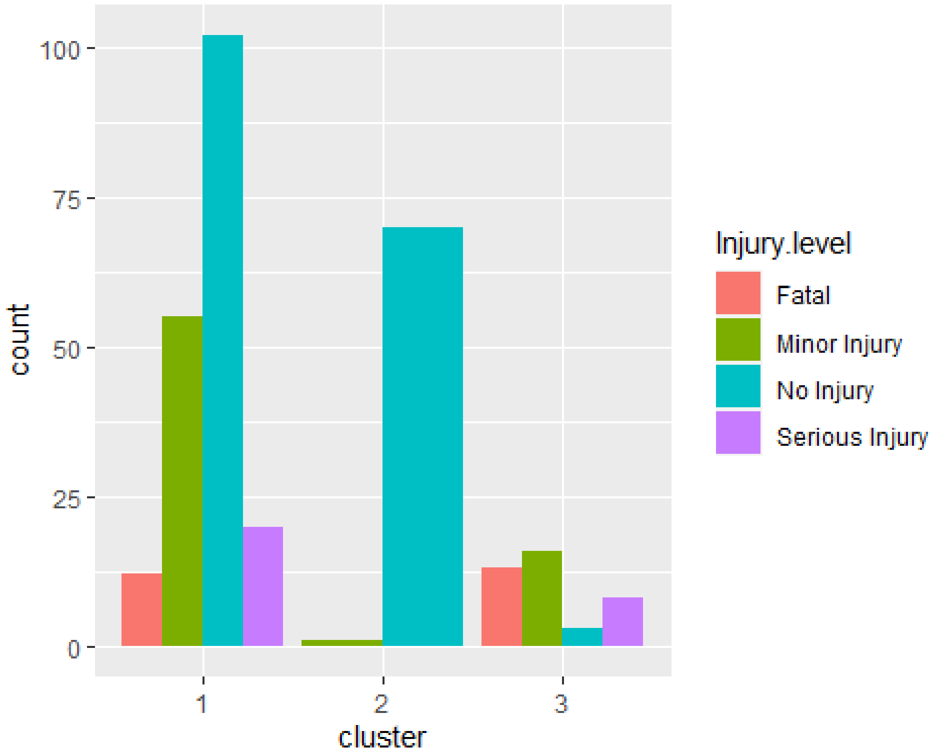
Vehicle Type Other Party 2



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Car	24	0	0	100.00	0.00	0.00
Medium/heavy truck(>6000kg)	5	0	0	100.00	0.00	0.00
Motorcycle	2	0	0	100.00	0.00	0.00
N/A	154	68	40	58.78	25.95	15.27
None (i.e. pedestrian)	0	3	0	0.00	100.00	0.00
SUV or Ute	3	0	0	100.00	0.00	0.00
Van	1	0	0	100.00	0.00	0.00

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Car	24	0	0	12.70	0.00	0
Medium/heavy truck(>6000kg)	5	0	0	2.65	0.00	0
Motorcycle	2	0	0	1.06	0.00	0
N/A	154	68	40	81.48	95.77	100
None (i.e. pedestrian)	0	3	0	0.00	4.23	0
SUV or Ute	3	0	0	1.59	0.00	0
Van	1	0	0	0.53	0.00	0

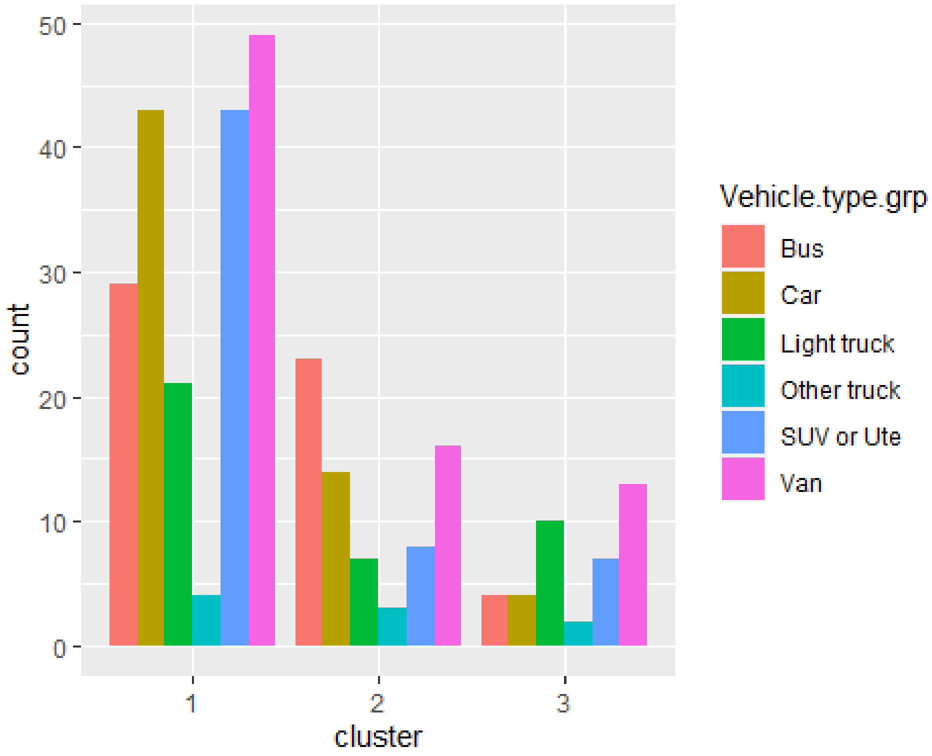
Injury Level



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Fatal	12	0	13	48.00	0.00	52.00
Minor Injury	55	1	16	76.39	1.39	22.22
No Injury	102	70	3	58.29	40.00	1.71
Serious Injury	20	0	8	71.43	0.00	28.57

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Fatal	12	0	13	6.35	0.00	32.5
Minor Injury	55	1	16	29.10	1.41	40.0
No Injury	102	70	3	53.97	98.59	7.5
Serious Injury	20	0	8	10.58	0.00	20.0

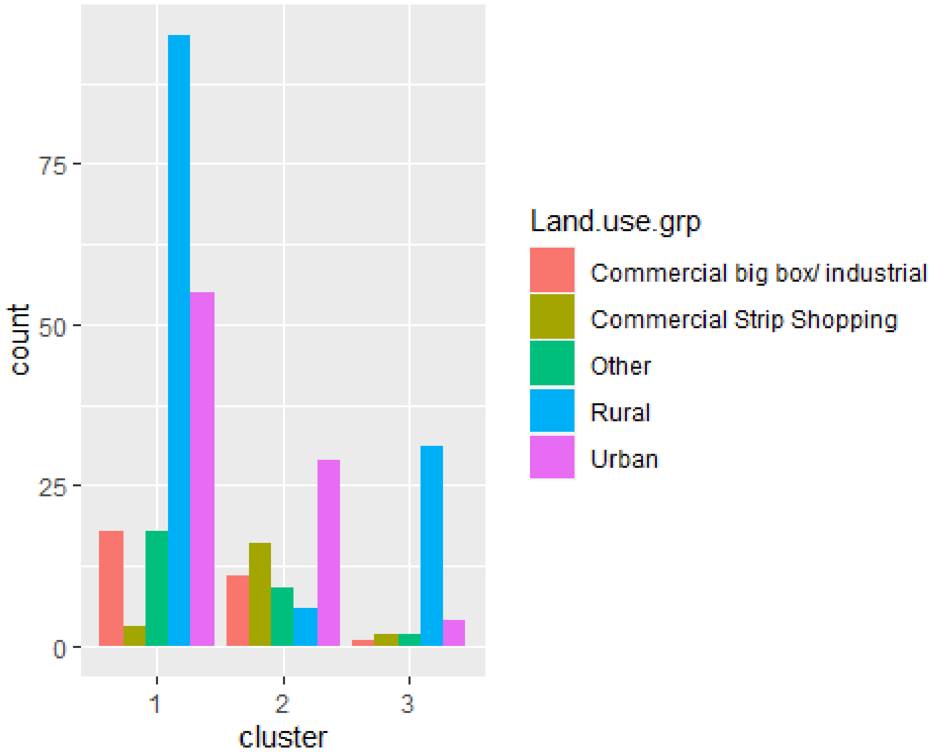
Vehicle Type Group



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Bus	29	23	4	51.79	41.07	7.14
Car	43	14	4	70.49	22.95	6.56
Light truck	21	7	10	55.26	18.42	26.32
Other truck	4	3	2	44.44	33.33	22.22
SUV or Ute	43	8	7	74.14	13.79	12.07
Van	49	16	13	62.82	20.51	16.67

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Bus	29	23	4	15.34	32.39	10.0
Car	43	14	4	22.75	19.72	10.0
Light truck	21	7	10	11.11	9.86	25.0
Other truck	4	3	2	2.12	4.23	5.0
SUV or Ute	43	8	7	22.75	11.27	17.5
Van	49	16	13	25.93	22.54	32.5

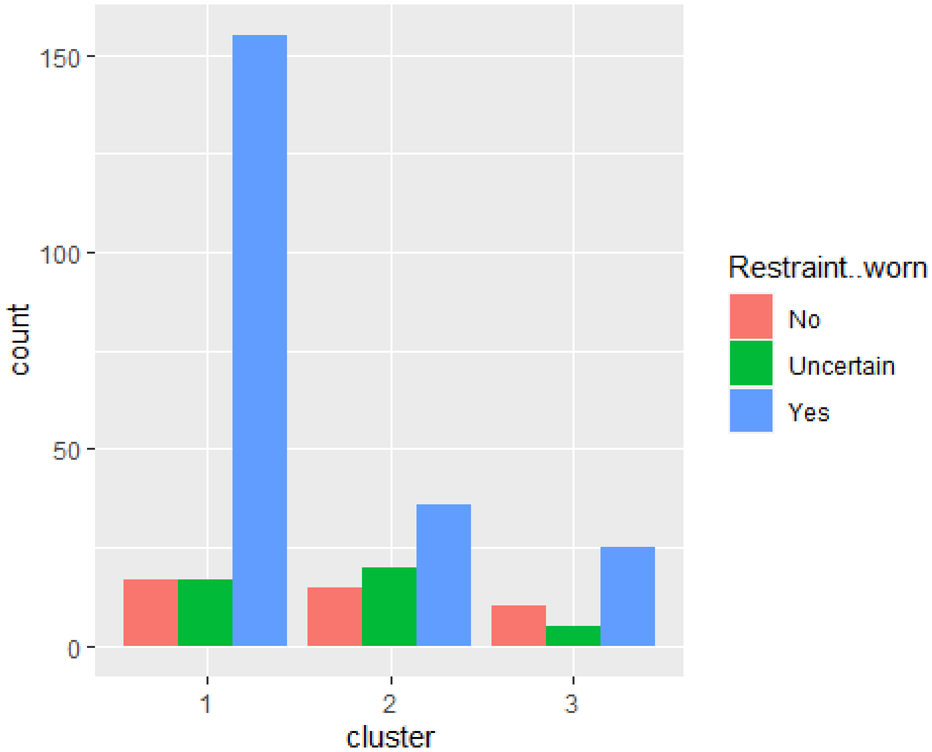
Land Use Group



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Commercial big box/ industrial	18	11	1	60.00	36.67	3.33
Commercial Strip Shopping	3	16	2	14.29	76.19	9.52
Other	18	9	2	62.07	31.03	6.90
Rural	95	6	31	71.97	4.55	23.48
Urban	55	29	4	62.50	32.95	4.55

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Commercial big box/ industrial	18	11	1	9.52	15.49	2.5
Commercial Strip Shopping	3	16	2	1.59	22.54	5.0
Other	18	9	2	9.52	12.68	5.0
Rural	95	6	31	50.26	8.45	77.5
Urban	55	29	4	29.10	40.85	10.0

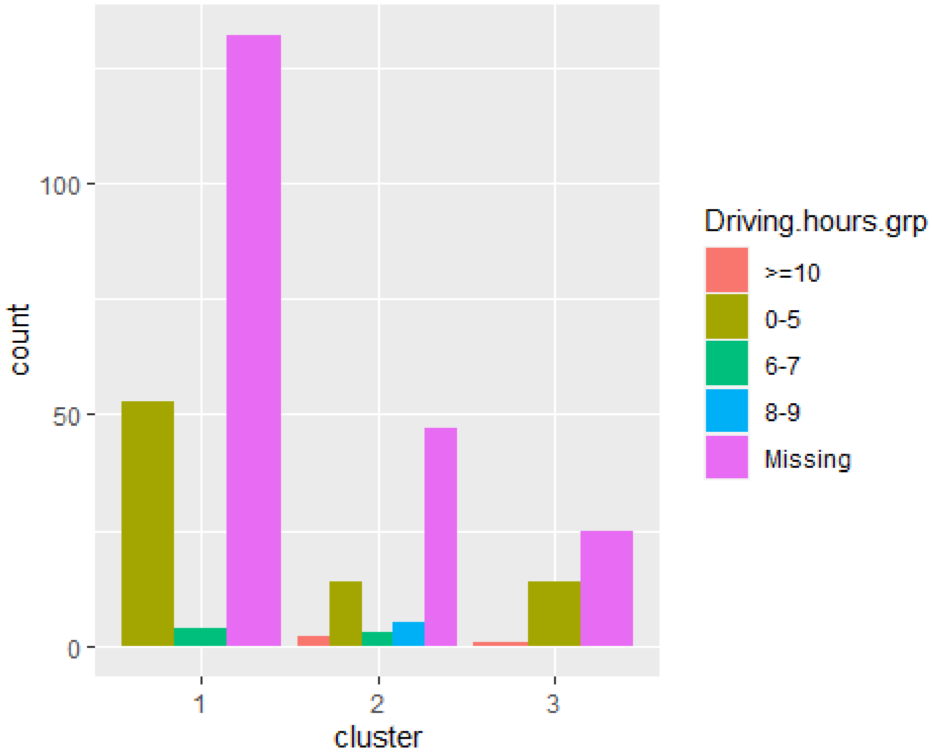
Restraint Worn



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
No	17	15	10	40.48	35.71	23.81
Uncertain	17	20	5	40.48	47.62	11.90
Yes	155	36	25	71.76	16.67	11.57

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
No	17	15	10	8.99	21.13	25.0
Uncertain	17	20	5	8.99	28.17	12.5
Yes	155	36	25	82.01	50.70	62.5

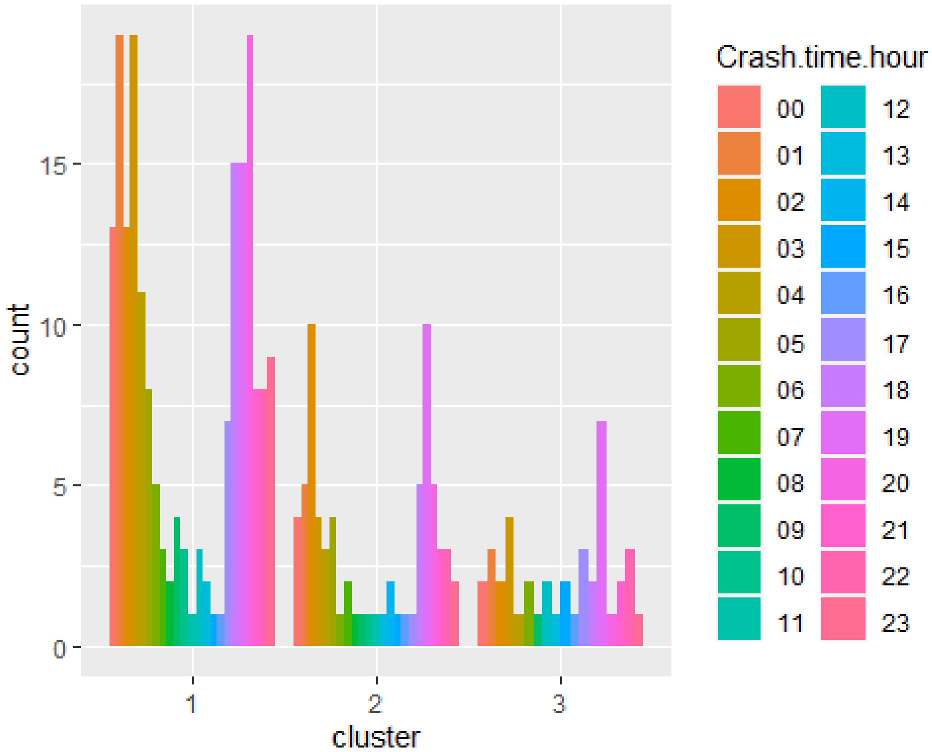
Driving Hours Group



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
>=10	0	2	1	0.00	66.67	33.33
0-5	53	14	14	65.43	17.28	17.28
6-7	4	3	0	57.14	42.86	0.00
8-9	0	5	0	0.00	100.00	0.00
Missing	132	47	25	64.71	23.04	12.25

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
>=10	0	2	1	0.00	2.82	2.5
0-5	53	14	14	28.04	19.72	35.0
6-7	4	3	0	2.12	4.23	0.0
8-9	0	5	0	0.00	7.04	0.0
Missing	132	47	25	69.84	66.20	62.5

Crash Time Hour

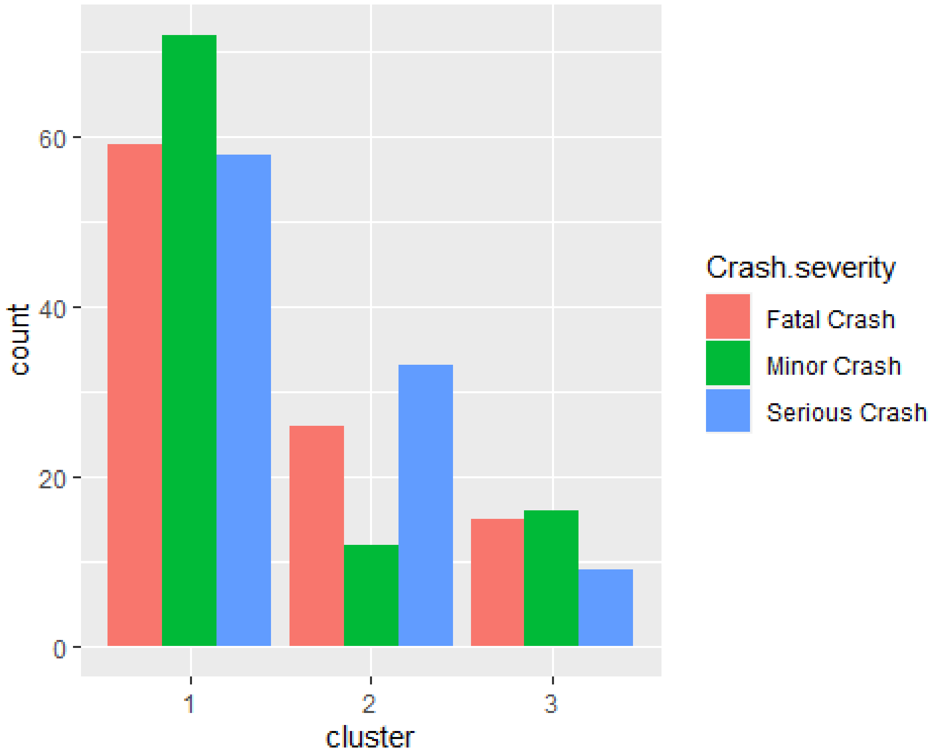


myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
00	13	4	2	68.42	21.05	10.53
01	19	5	3	70.37	18.52	11.11
02	13	10	2	52.00	40.00	8.00
03	19	4	4	70.37	14.81	14.81
04	11	3	1	73.33	20.00	6.67
05	8	4	0	66.67	33.33	0.00
06	5	1	2	62.50	12.50	25.00
07	3	2	0	60.00	40.00	0.00
08	2	1	0	66.67	33.33	0.00
09	4	1	1	66.67	16.67	16.67
10	3	1	0	75.00	25.00	0.00
11	1	1	0	50.00	50.00	0.00
12	3	0	2	60.00	0.00	40.00
13	2	1	1	50.00	25.00	25.00
14	0	2	0	0.00	100.00	0.00
15	1	1	2	25.00	25.00	50.00
16	1	1	1	33.33	33.33	33.33
17	7	1	3	63.64	9.09	27.27

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
18	15	5	2	68.18	22.73	9.09
19	15	10	7	46.88	31.25	21.88
20	19	5	1	76.00	20.00	4.00
21	8	3	2	61.54	23.08	15.38
22	8	3	3	57.14	21.43	21.43
23	9	2	1	75.00	16.67	8.33

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
00	13	4	2	6.88	5.63	5.0
01	19	5	3	10.05	7.04	7.5
02	13	10	2	6.88	14.08	5.0
03	19	4	4	10.05	5.63	10.0
04	11	3	1	5.82	4.23	2.5
05	8	4	0	4.23	5.63	0.0
06	5	1	2	2.65	1.41	5.0
07	3	2	0	1.59	2.82	0.0
08	2	1	0	1.06	1.41	0.0
09	4	1	1	2.12	1.41	2.5
10	3	1	0	1.59	1.41	0.0
11	1	1	0	0.53	1.41	0.0
12	3	0	2	1.59	0.00	5.0
13	2	1	1	1.06	1.41	2.5
14	0	2	0	0.00	2.82	0.0
15	1	1	2	0.53	1.41	5.0
16	1	1	1	0.53	1.41	2.5
17	7	1	3	3.70	1.41	7.5
18	15	5	2	7.94	7.04	5.0
19	15	10	7	7.94	14.08	17.5
20	19	5	1	10.05	7.04	2.5
21	8	3	2	4.23	4.23	5.0
22	8	3	3	4.23	4.23	7.5
23	9	2	1	4.76	2.82	2.5

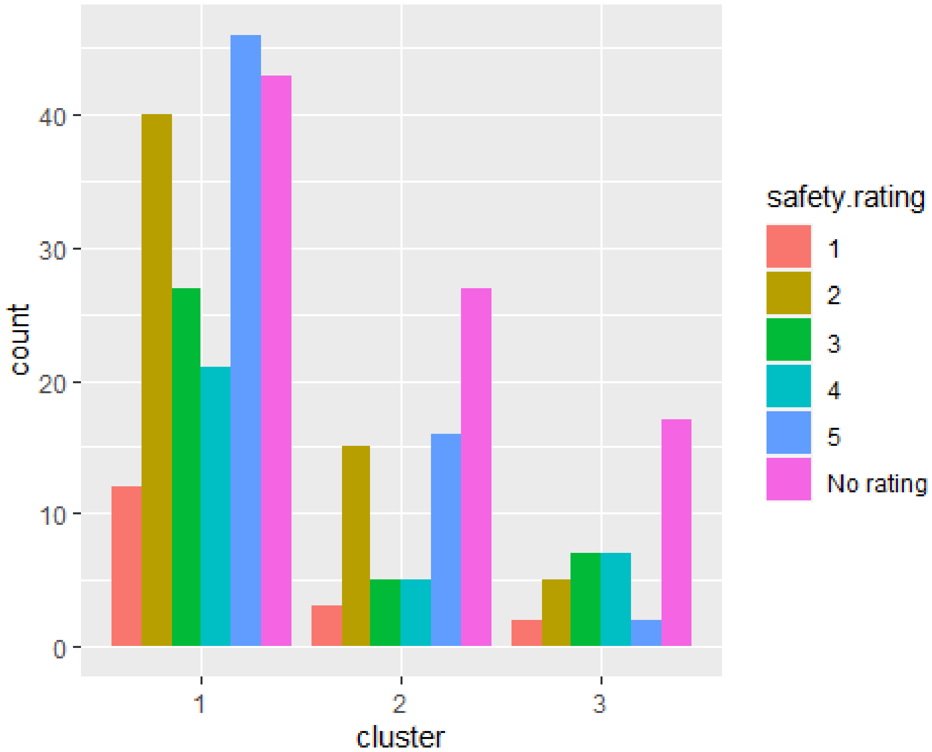
Crash Severity



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Fatal Crash	59	26	15	59	26	15
Minor Crash	72	12	16	72	12	16
Serious Crash	58	33	9	58	33	9

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Fatal Crash	59	26	15	31.22	36.62	37.5
Minor Crash	72	12	16	38.10	16.90	40.0
Serious Crash	58	33	9	30.69	46.48	22.5

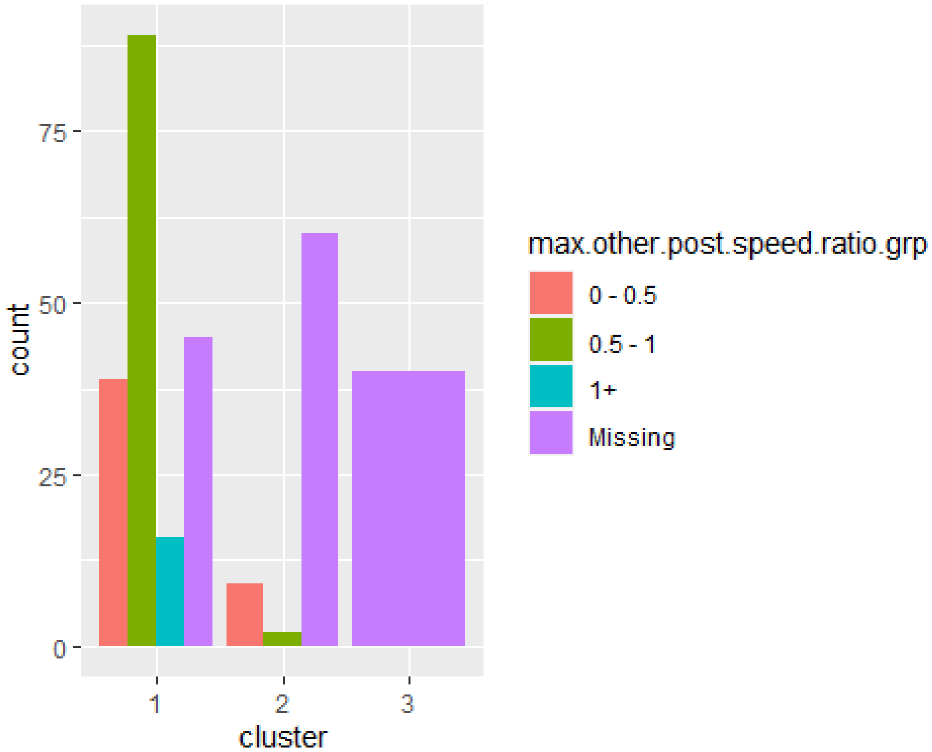
Safety Rating



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
1	12	3	2	70.59	17.65	11.76
2	40	15	5	66.67	25.00	8.33
3	27	5	7	69.23	12.82	17.95
4	21	5	7	63.64	15.15	21.21
5	46	16	2	71.88	25.00	3.12
No rating	43	27	17	49.43	31.03	19.54

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
1	12	3	2	6.35	4.23	5.0
2	40	15	5	21.16	21.13	12.5
3	27	5	7	14.29	7.04	17.5
4	21	5	7	11.11	7.04	17.5
5	46	16	2	24.34	22.54	5.0
No rating	43	27	17	22.75	38.03	42.5

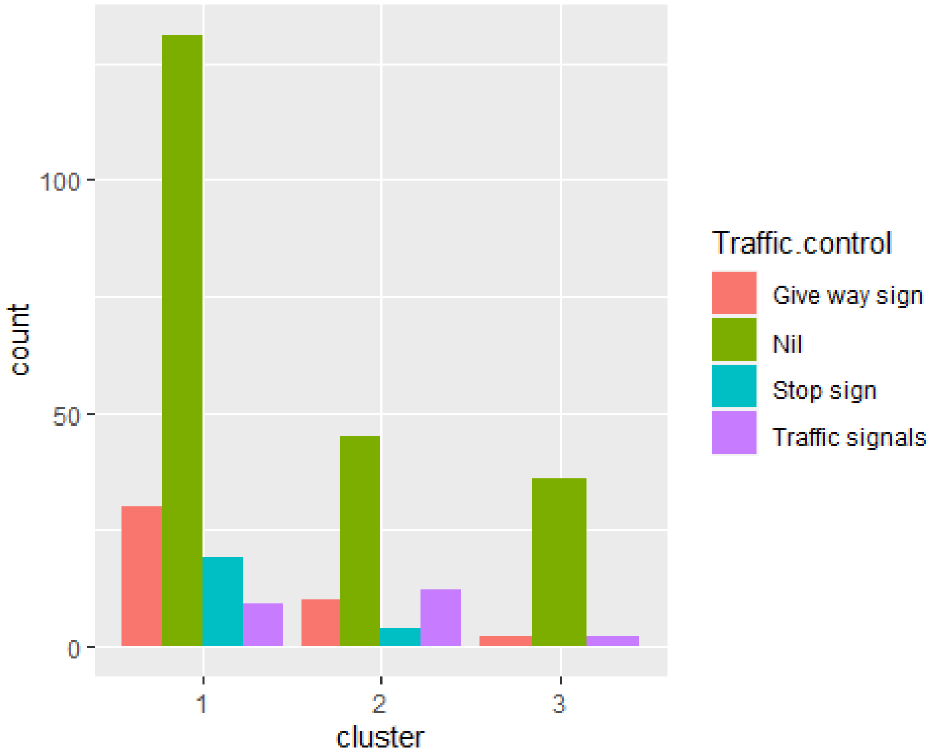
Max Other Party Post Speed Ratio Group



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
0 - 0.5	39	9	0	81.25	18.75	0.00
0.5 - 1	89	2	0	97.80	2.20	0.00
1+	16	0	0	100.00	0.00	0.00
Missing	45	60	40	31.03	41.38	27.59

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
0 - 0.5	39	9	0	20.63	12.68	0
0.5 - 1	89	2	0	47.09	2.82	0
1+	16	0	0	8.47	0.00	0
Missing	45	60	40	23.81	84.51	100

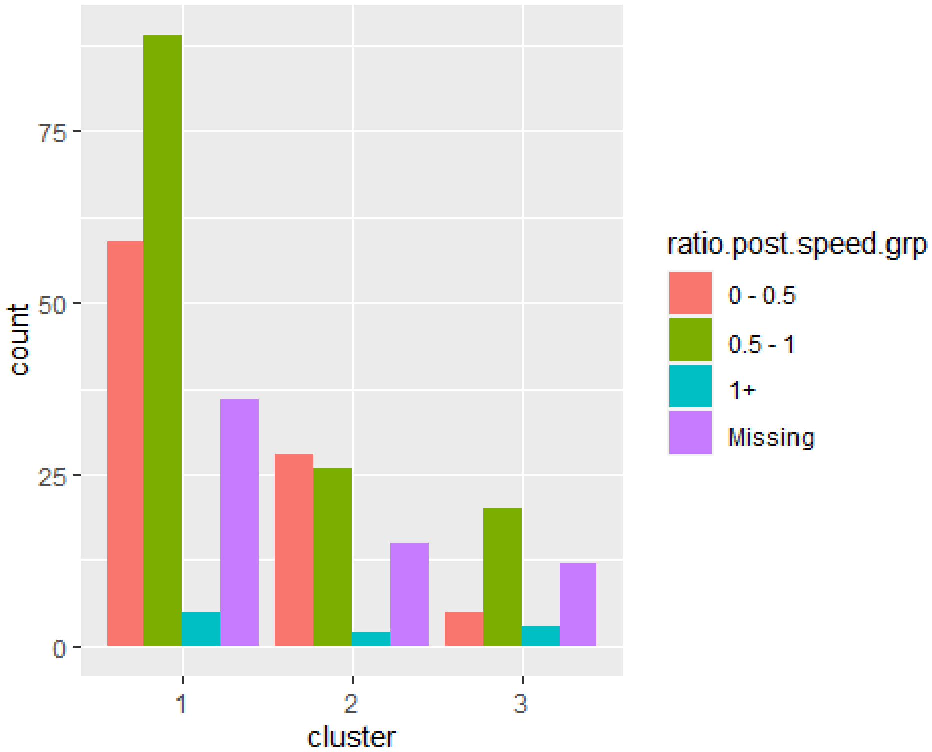
Traffic Control



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Give way sign	30	10	2	71.43	23.81	4.76
Nil	131	45	36	61.79	21.23	16.98
Stop sign	19	4	0	82.61	17.39	0.00
Traffic signals	9	12	2	39.13	52.17	8.70

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
Give way sign	30	10	2	15.87	14.08	5
Nil	131	45	36	69.31	63.38	90
Stop sign	19	4	0	10.05	5.63	0
Traffic signals	9	12	2	4.76	16.90	5

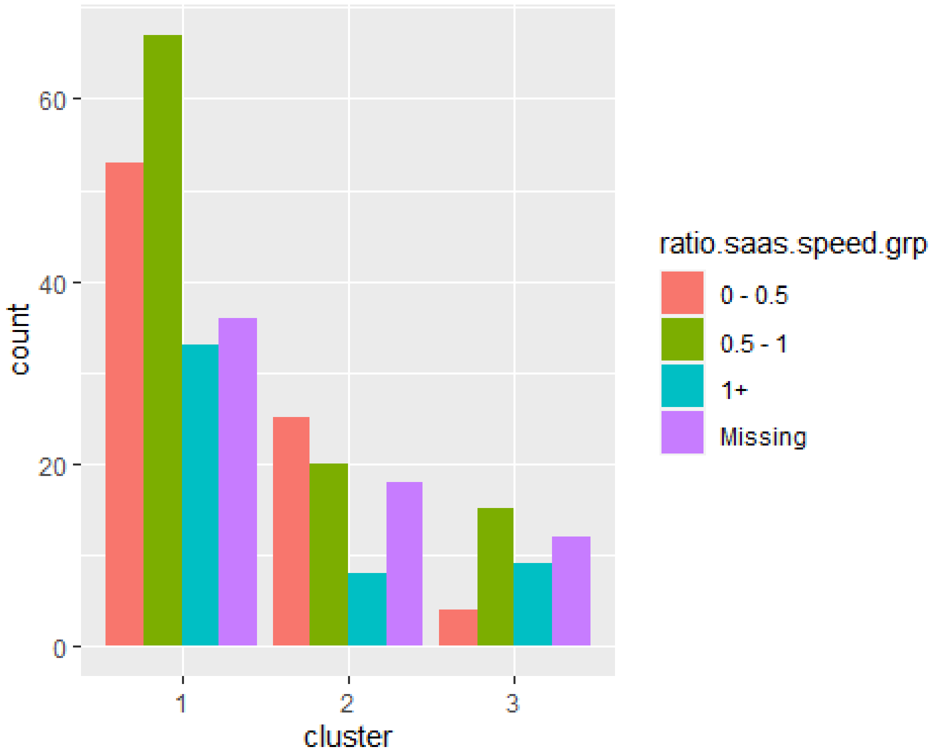
Ratio Post Speed Group



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
0 - 0.5	59	28	5	64.13	30.43	5.43
0.5 - 1	89	26	20	65.93	19.26	14.81
1+	5	2	3	50.00	20.00	30.00
Missing	36	15	12	57.14	23.81	19.05

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
0 - 0.5	59	28	5	31.22	39.44	12.5
0.5 - 1	89	26	20	47.09	36.62	50.0
1+	5	2	3	2.65	2.82	7.5
Missing	36	15	12	19.05	21.13	30.0

Ratio SAAS Speed Group



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
0 - 0.5	53	25	4	64.63	30.49	4.88
0.5 - 1	67	20	15	65.69	19.61	14.71
1+	33	8	9	66.00	16.00	18.00
Missing	36	18	12	54.55	27.27	18.18

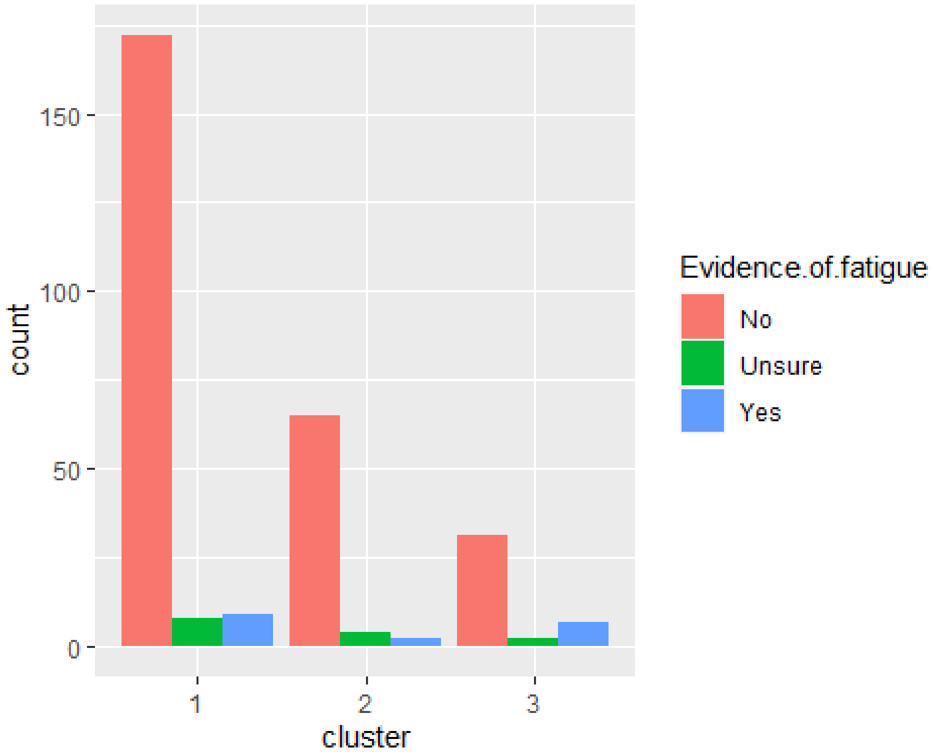
myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
0 - 0.5	53	25	4	28.04	35.21	10.0
0.5 - 1	67	20	15	35.45	28.17	37.5
1+	33	8	9	17.46	11.27	22.5
Missing	36	18	12	19.05	25.35	30.0

Presence of Alcohol or Drugs

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
No	155	60	25	64.58	25.00	10.42
Suspected	14	5	4	60.87	21.74	17.39
Unknown	14	6	8	50.00	21.43	28.57
Yes	6	0	3	66.67	0.00	33.33

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
No	155	60	25	82.01	84.51	62.5
Suspected	14	5	4	7.41	7.04	10.0
Unknown	14	6	8	7.41	8.45	20.0
Yes	6	0	3	3.17	0.00	7.5

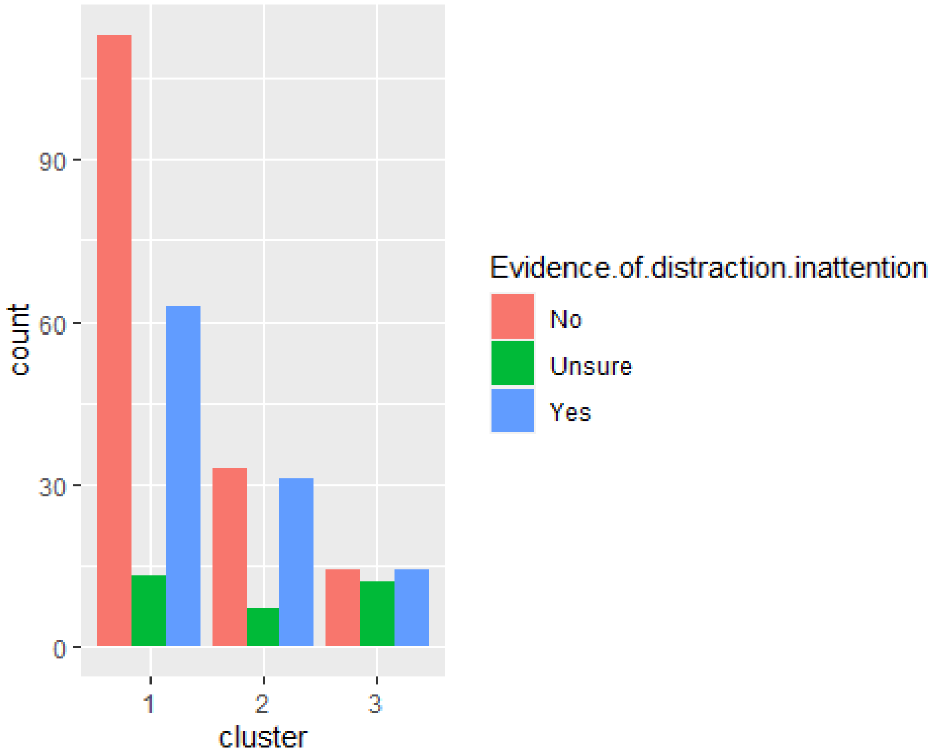
Evidence of Fatigue



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
No	172	65	31	64.18	24.25	11.57
Unsure	8	4	2	57.14	28.57	14.29
Yes	9	2	7	50.00	11.11	38.89

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
No	172	65	31	91.01	91.55	77.5
Unsure	8	4	2	4.23	5.63	5.0
Yes	9	2	7	4.76	2.82	17.5

DFW evidence of distration or inattention



myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
No	113	33	14	70.62	20.62	8.75
Unsure	13	7	12	40.62	21.88	37.50
Yes	63	31	14	58.33	28.70	12.96

myvar	Freq_1	Freq_2	Freq_3	Perc_1	Perc_2	Perc_3
No	113	33	14	59.79	46.48	35
Unsure	13	7	12	6.88	9.86	30
Yes	63	31	14	33.33	43.66	35