Risk factors in the road freight transport industry

LITERATURE REVIEW

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RESEARCH AND EVALUATION

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appendices

1.0 Introduction

IN THIS SECTION:

Work-related vehicle crashes are a major cause of work-related fatalities, injuries, and risk to the safety and health of workers (and the public) both in New Zealand and internationally

Currently, road traffic fatalities are the eighth leading cause of death in the world with around 1.35 million fatalities per year and up to 50 million injuries (see World Health Organization, 2018 for a detailed review).

Work-related vehicle crashes are a major cause of work-related fatalities, injuries, and risk to the safety and health of workers (and the public) both in New Zealand and internationally, so much so that it has been described as:

- involving a multitude of associated risks and underlying factors that impact workers' health, safety, and well-being (New Zealand; George, 2018)
- being 'considered one of the most hazardous operations which is undertaken by workers' (Australia; Rowland, 2018, p. 5)
- being responsible for the highest number of worker fatalities and bystander fatalities in Australia (Safe Work Australia, 2017)
- the most common cause of occupational injury in Australia (Mitchell, Bambach, & Friswell, 2014)
- the largest cause of work-related fatalities in the UK (Clarke, Ward, Bartle, & Truman, 2005)
- making up around 40% of all road fatalities in Europe (this is the number of road deaths that are work-related; Adminaite, Jost, Stipdonk, & Ward, 2017)
- making up a significant part of all work-related fatalities, across several countries (Australia, USA, and New Zealand) (despite differing risk factors) (T. Driscoll et al., 2005)

In New Zealand, 80–90% of the total domestic freight is carried by trucks (George, 2018). Our road freight transport industry employs the highest proportion of the workforce within the transport, postal and warehousing economic sector, with around 30,400 workers (31.60%) (see Appendix 1: The road transport domain for details of this sector). It is considered that, as the New Zealand economy grows, there will be an increase in trucks transporting domestic freight on the road in order to keep up with the predicted demand (Deloitte, 2014; George, 2018; Mackie, Baas, & de Pont, 2007). This indicates that there will likely be an increase in the number of workers in this industry and an increase in exposure to risk.[1]

[1] These projections have not taken into account increased automation and other modes of freight increasingly being used.

1.1 Purpose of this report

Based on currently available data and evidence, vehicles have been shown to be a cause of serious harm and fatalities for workers in Aotearoa New Zealand.[2] WorkSafe New Zealand is establishing a cross-industry Working In and Around Vehicles (WIAV) programme that is tasked with developing effective interventions to reduce harm and fatalities for workers who work in or around vehicles from any industry (road, agriculture, forestry, etc) or economic sector (transport, postal, and warehousing; agriculture, fishery and forestry, etc). This report supports the WIAV programme by specifically focusing on the known potential harm and risk factors in the road freight transport industry for workers. This specific focus is because the road freight transport industry currently employs a substantial number of workers and this is expected to increase, with most (if not all) of these workers working in or around vehicles.

The purpose of this literature review is to identify the risk factors that exist in the road freight transport industry that are associated with increased harm to workers. In order to understand these risk factors, the context of this industry and the harms that exist for these workers were also identified. A literature search of recent and accessible New Zealand and international literature was conducted to inform this work.

1.2 Method

A non-systematic search of available published literature was undertaken. Articles and reports identified were predominately published in the last 10 years, peer reviewed, from relevant conferences and journals, and from organisations/ associations within the road safety field (with some occasional exceptions). Moreover, literature included in this report is predominately from Australia and the United States of America (USA), as these countries are considered to have some similarity, such as by industry and working conditions to New Zealand (T. Driscoll et al., 2005; Feyer et al., 2001). Additionally, in a comparison study, Australia and the USA were found to be similar (Blower & Woodrooffe, 2012). However, it is noted that they are not directly comparable and there are differences in terms of regulation, geography, healthcare systems, worker compensation schemes, and social support systems. For instance, self-employed workers in Australia are not required to pay worker compensation premiums nor are they eligible to claim benefits (Xia, Iles, Newnam, Lubman, & Collie, 2019).

Considerations of risk factors identified. The focus of this literature search was to identify risk factors in the road freight transport and their associated harm for workers. However, determining the relative potential severity and/or probability of occurrence between the different risk factors identified (ie which risk factors are the 'biggest' risks) is a challenging task. The biggest risk factors identified in this literature search tended to be those that appeared to be most published, quantified, and/or argued (by evidence) as being 'key' risk factors. Secondly, other risk factors that were not identified as being 'key' may also have been included in this report, if deemed relevant by the author and/or as requested by internal WorkSafe stakeholders. Thirdly, the risk factors identified in this literature review are by no means exhaustive. There may be additional risk factors that have yet to be identified, studied, and/or published. Lastly, some identified or known risk factors were deemed not to be relevant for inclusion in this report, such as manual handling, slips, trips and falls and, being hit by an object, as they either have been discussed in other reports by WorkSafe's Research and Evaluation and Regulatory Intelligence teams or will be discussed in future reports. In this report, criteria were developed to select the risk factors that are most critical to address (as will be discussed in the summary and discussion section below).

[2] Regulatory Intelligence, WorkSafe, has produced an intelligence report titled 'Vehicles Environmental Scan' (July 2019) to use as an internal reference.

2.0 The road transport industry landscape

IN THIS SECTION:

In New Zealand, 80–90% of the total domestic freight is being carried by trucks (George, 2018). In the National Freight Demand Study, 91% of the freight (in tonnes) transported in New Zealand in 2012 was transported by road, with only 7% and 2% by rail transport and coastal shipping, respectively (Deloitte, 2014).

In particular, the transfer of building materials, logs and timber products, general freight, and manufactured and retail goods accounted for almost three-quarters of freight moved in New Zealand in 2012 (Deloitte, 2014). Domestically, the New Zealand road freight industry generates around NZ$6 billion per year, which is around 1.4% of the national economic activity and around NZ$21 billion from overseas exports per year (Road Transport Forum NZ, 2019).

Classification: It is important to note that there is inconsistency and confusion over the use of the terms 'sector' and 'industry'. Through reviewing published material, it appears that road transport is more commonly referred to as an industry. In the ANZSIC classification system, Division I: Transport, Postal, and Warehousing is classified as an industry and divided into eight areas, one of which is road transport (see below). Road transport is further divided into road freight transport and road passenger transport. To avoid confusion and to keep consistency with published material, in this paper, transport, postal and warehousing is classified as an industry division. Road transport is considered a domain (which is broad) that is further divided into the road freight transport industry and the road passenger transport industry. This report focuses on the road freight transport industry solely.

2.1 Defining work-related driving

The purpose of this report is to identify the risk factors that have associated harms for workers in the road freight transport industry. The primary work activity engaged in by workers in this industry is driving (Hanowski et al., 1999; van der Beek, 2012). Workers who drive for work or drive for work purposes are often referred to in the literature as work-related drivers, professional drivers, commercial drivers, and similar variations. The activity of driving is often referred to as work-related driving or driving for work purposes. All of these terms appear to be used interchangeably in the literature, and this seems to be related to the publishing author(s) and their country. In this report, when referring to a published article, the same terminology is used as that in the article being cited.

In general, work-related driving can include vehicles that may or may not be registered to an organisation, are owner-operated, and/or any vehicle that is used for the purposes of work. The literature differentiates between grey fleets (privately owned vehicles used for the purpose of work) and work fleets (business owned/or managed vehicles) (Grayson & Helman, 2011). This report includes both and does not make special reference to the fleet type, but rather the employment type (ie employee versus owner-operator).

Work-related driving describes the activity of driving for work purposes (Grayson & Helman, 2011). Work-related driving will typically exclude commuting (travelling between home and work) and vehicles used for commuting purposes (ie a private car). This distinction, however, is not the same in all countries. In New Zealand, Australia (Safe Work Australia, 2017) and the UK (Broughton, Baughan, Pearce, Smith, & Buckle, 2003), commuting is not considered to be work-related or included in work-related statistics. However, in some countries, such as France, Switzerland, Spain, Italy and Germany, commuters are included in data of work-related casualties (Adminaite et al., 2017).

In some countries, the vehicle is considered to be the workplace if driven both on the public road (on-road) and businesses worksite (off-road) (European Road Safety Observatory, 2006). In other countries, businesses are responsible for the occupational health and safety of workers only when on the worksite and not

on the public road. Therefore, caution must be taken when comparing data from different data sources and between countries because there is no consensus on the definition of what is work-related driving (ie commuting to/from work) if the vehicle is considered the workplace and is on-road or off-road.

Overall, when we look at drivers who drive for work purposes and, in particular, when comparing datasets or evidence between countries, there are some important differences to be aware of:

- There is variation in how workers who drive for work are referred to, for example work-related drivers, professional drivers, or commercial drivers etc.
- Driving for work is often referred to as work-related driving or driving for work purposes, but other variations exist.
- In New Zealand, Australia, and the UK, commuting to/from work is not considered part of work-related driving, but in several other OECD countries, commuting is included and thus is in their datasets (but not New Zealand datasets).
- In this report, commuting to and from work is not considered to be part of work-related driving.
- The vehicle as a workplace is also not consistently defined in OECD countries. In this report, the vehicle is considered to be a workplace and is still considered a workplace whether it is used for on-road, on-site or off-road work purposes.

2.2 Context within the road freight transport industry

It is important to identify and understand that, within the road freight transport industry, there are various sub-industries that may have their own set of occupational health and safety risk factors and associated harms. Therefore, it is important to note that, while there may be some similarities, research has illustrated that there are important and sometimes significant differences within an industry and between occupation groups.

There are different ways of categorising road freight drivers by:

- distance and destination points, such as short-haul drivers, long-haul drivers, local delivery drivers and drivers who have many different drop -off destinations
- material transferred, such as logs, furniture, earth material, hazardous substances, retail goods, etc
- distribution points, such as warehouses, ports, retail locations, and food locations (Apostolopoulos, Lemke, & Sönmez, 2014; van der Beek, 2012)
- vehicle types, such as heavy vehicles, vans, tractors etc.

Research by Smith and Williams (2014), Hanowski et al. (1999) and Charlton and Baas (2000) has demonstrated significant differences amongst drivers from different industries within the broader road transport industry, such as long-haul, short-haul, logging, refrigeration, waste management etc. In addition, Friswell and colleagues (2006) have demonstrated that fatigue is similarly a problem for both short-haul and long-haul drivers, despite the causes of which being attributed to a range of different work activities and pressures. The experience of fatigue has also been shown to be similar for short-haul drivers across different types of employment contracts (Williamson, Bohle, Quinlan, & Kennedy, 2009). Fatigue is discussed further later in this report.

The risk factors for drivers of different vehicle types, materials, and organisations (and contract types) will be different.

Through analysing work-related injuries data in Washington State from 2005–2010, Smith and Williams (2014) found significant differences in injuries by industry sector and occupation. For instance, drivers in the waste and recycling sub-sector had the lowest overall incident rate, yet the highest overall incidence rate per FTE employment. General freight trucking had the highest overall incidence rate. Consistent with previous research, vehicle crashes were shown to be costly and have longer time loss than other types of injuries (Smith & Williams, 2014).

In a study that examined the accident case files of 2,111 police reports of work-related drivers, the researchers identified the antecedents before the accident (Clarke et al., 2005). Of the vehicle types involved in incidents, 88% were company cars, vans, trucks (large), buses, taxis, and emergency vehicles. Company car drivers were shown to have excessive speed as a causal factor in work-related accidents. Van drivers were more likely to make observational failures (meaning a lack of situational awareness), whereas drivers of large trucks were more likely to have fatigue and vehicle defects as causal factors related to incidents. Drivers of buses, taxis and emergency vehicles, however, were more likely to be involved in incidents due to the fault of other drivers or road users (Clarke et al., 2005).

Work activities and work life for drivers of different vehicle types, occupation groups, and organisations are also different.

Truck drivers are a heterogeneous group, and they can engage in work tasks that vary from driver to driver (Apostolopoulos et al., 2014; van der Beek, 2012). There are different categories of workers within the road transport industry and its various industry sub-sectors who engage in a range of different work activities and responsibilities. Such variances can mean that workers are exposed to different risk factors, experience different harm outcomes and could face different stressors and decisions throughout their workday.

In regards to the work life of a long-haul driver, they are not likely to leave home daily, are likely to be away from home for multiple days and have irregular sleeping patterns and may sleep in the sleeper berth (Apostolopoulos et al., 2014; Belman & Monaco, 2001; George, 2018; Hanowski et al., 1999). Their official work journey would start at the loading environment (outsource post), and they would drive to the destination place and unload (receiving post). They may even pick up another load at the receiving post or along the way so that they are not driving with an empty trailer in order to be efficient and make another drop-off at their outsource post or along the way (George, 2018; Hanowski et al., 1999). Given the opportunity, drivers are more likely to choose local jobs over long-haul jobs, but when they are away from home for long periods of time, they are more likely to keep working (harder and longer hours) and try to earn as much as they can (Apostolopoulos et al., 2014; Belzer & Sedo, 2018).

Short-haul: On a daily basis, short-haul drivers, such as furniture movers and local freight delivery drivers, are likely to make several deliveries in a single trip, engage in manual handling of material, repetitively get in and out of their vehicle (George, 2018), manage the driving schedule, and engage directly with customers (Hanowski et al., 1999). Short-haul drivers are likely to work across various sites and environments (though mostly urban) and typically begin and end their day from their home (George, 2018; Hanowski et al., 1999).

Long-haul: In contrast, long-haul freight drivers are likely to engage in driving as their primary task (George, 2018; Hanowski et al., 1999; Sieber et al., 2014; van der Beek, 2012). Long-haul drivers may or may not be involved in the loading/unloading of material and may have to wait during the loading/unloading phase (George, 2018; Sieber et al., 2014; van der Beek, 2012). Additional activities can involve queuing, vehicle maintenance and checks (Hanowski et al., 1999), and managing on-board technology (George, 2018). Long-haul drivers are likely to be driving over greater distances, manoeuvring and driving heavy vehicles and have their time schedules set by the customers (George, 2018; van der Beek, 2012). Long-haul drivers tend to not be specifically paid based on time spent working (ie they are usually not paid while waiting or queuing), receive few benefits, and experience high levels of turnover (Belman & Monaco, 2001).

3.0 Identified risk factors in the road freight transport industry

IN THIS SECTION:

Workers are exposed to multiple risk factors, some direct and some indirect, that may affect their health, safety, or well-being.

These influencing factors can come from the government (ie legislation), regulators, industry, business and management, the road and environment, or the workers themselves (Bigelow et al., 2014; Edwards, Davey, & Armstrong, 2015; George, 2018).

3.1 Key risk factors identified at the government to management system levels

Policy, deregulation, and globalisation

Policies and the deregulation of the road freight transport industry have contributed to the overall deterioration of working conditions of long-haul freight drivers' working conditions (Apostolopoulos et al., 2014; Belman & Monaco, 2001). In New Zealand and OECD countries, this has allowed the road freight transport industry, in particular, trucking,[3] to become a highly competitive industry. Moreover, with the movement towards globalisation, there was demand to change what were seen as over-rigid regulations in order to compete in the global market (George, 2018). It was the adoption of flexible working arrangements that allowed businesses to overcome market volatility, compete on costs, respond to market changes, and run on a demand basis (George, 2018). Global events, such as the Global Financial Crisis in 2008, also impacted New Zealand freight drivers because it reduced demand for materials (Deloitte, 2014).

In particular, deregulation or a reduction in regulations has led to an increase in outsourcing and the use of contract or fixed-term workers. Outsourcing has been used by businesses across a range of industries to help them increase competitiveness, cut costs, bypass regulations, and gain more flexible employment arrangements (Bensman, 2017; George, 2018; Johnstone, Mayhew, & Quinlan, 2000; Williamson et al., 2009). In addition, while some regulations exist to specifically protect workers, it is often the drivers, rather than employers, who are liable for violating regulations (Belman & Monaco, 2001). Regulations around maximum work hours for instance can be easy to break or work around (Edwards, 2014). For instance, it is considered a cultural norm for truck drivers to have multiple logbooks and inaccurately record hours of work for the regulator authorities (Apostolopoulos et al., 2014; Belzer & Sedo, 2018; Charlton & Baas, 2000; Edwards, 2014; Shattell, Apostolopoulos, Sönmez, & Griffin, 2010).

The competitive nature of the road transport industry has flow-on effects to both workers and managers/supervisors. Research has shown that the pressure that is placed on businesses to remain price competitive has influenced managers, who

[3] 'Trucking' is a colloquial term that refers to the sector in which freight is moved by trucks.

are then likely to create poor working conditions for their workers (employees or contractors), such as tight timeframes, unrealistic contracts and low pay (Apostolopoulos et al., 2014; Belman & Monaco, 2001; Deighton-Smith, 2014; George, 2018; Mooren, Williamson, & Grzebieta, 2015; Rodriguez, Targa, & Belzer, 2006). Managers or supervisors in businesses, who are responsible for both the health and safety of their workers (or contractors) and the financial solvency of the firm, are left to take shortcuts, cut pay rates, and increase the workload of drivers (George, 2018). Thereby, the occupational health and safety of the workers (and indirectly the public) ends up not being prioritised or taken seriously enough. This pressure results in workers needing to work longer hours, cut corners and engage in behaviours and practices that can play a detrimental role in their own occupational health, safety, and well-being (Apostolopoulos et al., 2014; George, 2018). Lastly, a literature review about truck drivers highlighted the conflict that government, industry and healthcare providers experience in which they must keep the transport system profitable while taking care of drivers' health and safety and the safety of the public (Garbarino, Guglielmi, Sannita, Magnavita, & Lanteri, 2018).

In summary, there is evidence that shows that changes in policy, deregulation or a reduction in regulations, globalisation and a global market have resulted in negative outcomes for workers in general but particularly in the road transport industry. Such changes, it has been argued, have seen outcomes of:

- outsourcing of risk
- increased use of contract and fixed-term workers
- a highly competitive industry
- a profit over safety dilemma that managers/supervisors face
- negative flow-on effects to the workers
- increased pressures on workers who in turn will cut corners and violate health and safety regulations in order to make a living
- degradation in working conditions (discussed below)
- low pay and inequalities between unionised and non-unionised workers (discussed below)
- a remuneration structure based on output-based models (discussed below).

Remuneration

As discussed above, in the industrialised global world, such as New Zealand, Australia, and the USA, road transport industries are highly competitive and businesses need to be price competitive. In particular, deregulation or a reduction in regulations on the industry has also played a part in a decline in workers' wages. For instance, deregulation in the trucking industry in the USA in 1979 is considered to be responsible for one-third of the resulting decline in drivers' wages, which particularly disadvantaged non-unionised members, who earned 18–21% less than unionised members (Belman & Monaco, 2001). Following industry deregulation or a reduction in regulations in New Zealand, practices of flexible work occurred as well as an increase in individual bargaining for contracts (compared with collective bargaining). This was particularly compounded by the Employment Contracts Act 1991, which limited the strength of unions to bargain on workers' behalf (George, 2018).

There are multiple remuneration schemes that exist, including by the kilometre, hourly, by the load or delivery output (Apostolopoulos et al., 2014; Mooren et al., 2015; Quinlan & Wright, 2008) or as a percentage of income (Apostolopoulos et al., 2014).

It has been argued that pay systems that are based on output production may incentivise drivers to speed (Edwards et al., 2015), finish as quickly as possible, take on extra trips and violate health and safety regulations, such as exceeding maximum working hours and skipping rest periods (Nævestad, Phillips, & Elvebakk, 2015; Thornthwaite & O'Neill, 2017). Output-based remuneration is also unlikely to include payment for time that drivers spend on non-driving activities, such as loading/unloading or queuing/waiting (Mooren et al., 2015). Long-haul drivers are also likely to try to make up for low pay by working more hours and violating maximum working hours regulations rules, falsifying logbooks, skipping rest periods and driving while tired or drowsy (Apostolopoulos et al., 2014; Belman & Monaco, 2001). In contrast, drivers who are being paid by the hour are likely to work longer hours in order to earn more (Thornthwaite & O'Neill, 2017).

In a study that examined the reasons why truck drivers worked extremely long hours,[4] the researchers identified that the remuneration system influenced the number of hours that drivers worked (Belzer & Sedo, 2018). Drivers who were on low pay were far more likely to increase their work hours, accept more trips and drive for longer periods of time and over longer distances in order to earn what they needed. It is with the increase of work and poor working conditions that the accident risk rate for drivers increases. In contrast, drivers who were paid well were likely to drive shorter distances, worked fewer hours, were less likely to change jobs and were less likely to be involved in a collision (Belzer & Sedo, 2018).

A recent longitudinal study that looked at the link between freight drivers' remuneration and safety performance found a strong link whereby low pay was linked with poorer safety performance (Miller & Saldanha, 2016). A review by Quinlan and Wright (2008) concluded that there is a link between low pay and poor safety performance in the road transport industry. In a North American study, crash incident rates were observed to decrease when drivers' pay was increased (from the previous low-pay period that followed deregulation). The authors concluded that this was likely because of lower separation from the business, higher motivation and the retention of older and more experienced drivers (Rodriguez et al., 2006).

In summary, research has shown links between the remuneration system and driver behaviour, decisions, and negative outcomes. Drivers are likely to work harder and longer in order to make a living, which results in higher job strain, stress and negative health outcomes (Apostolopoulos et al., 2014). Overall, how drivers are paid in this industry has impacts on health outcomes, fatalities and injuries, and general safety performance.

Employment status

Closely related to the different remuneration systems that exist, researchers have identified differences between employment groups or employment contract types. The main groups are referred to as company drivers or employed drivers, owner-drivers or owner-operators, and independent contractors (Apostolopoulos et al., 2014). However, there are also subcontractors (Quinlan & Wright, 2008), employees on fixed-term contracts and employees with multiple contracts with multiple companies at a time.

As discussed above, there has been a push over recent years to move towards the owner-driver business model and a global trend of increasing the use of contractors. This shift from employee to contractor has seen wages and conditions being set by the hiring party (Quinlan & Wright, 2008) and a lack of control and uncertainty from workers' perspectives, which has resulted in reduced regard for

[4] The authors derived a labour supply curve from the UMTIP Driver Survey Data.

workers' health, safety and well-being (George, 2018; Quinlan & Wright, 2008). As a result, these unstable and precarious working conditions have become ubiquitous in the road freight transport industry (George, 2018).

In an interview (n=77) and survey (n=217) study of short-haul truck drivers in New South Wales, working conditions, attitudes, and outcomes for drivers were examined for permanent (69%) and contract (14.3%) employees and self-employed owner-drivers (16.7%) (Williamson et al., 2009). Numerous differences were seen, and of particular interest, results revealed that:

- compared to permanent employees, contractors were less likely to have set shifts and tended to work on rotation and with irregular shifts
- permanent drivers were more likely to belong to a union than the other two groups, whereas owner-drivers were slightly more likely to be in an employer association
- owner-drivers drove longer distances and had longer working days, on average, with less weekend work than permanent and contract workers
- owner-drivers typically experienced the most negative consequences from the working conditions.

In a survey of 559 heavy vehicle truck drivers across Australia, perceptions and experience of health and safety regulations and how these affect their work and work environments was investigated. This study identified an entrenched retribution culture that resulted in drivers being reluctant to complain even if their (or others') health and safety was at risk (Thornthwaite & O'Neill, 2017). In the review by Quinlan and Wright (2008), drivers expressed fear of not accepting contracts, as this could result in them not being offered work in the future and the need to compete with others. That being said, some drivers expressed that they had chosen to decline contracts due to past negative experiences with a particular contracting/hiring party.

In a study that looked at crash risk of owner-drivers and employee drivers, owner-drivers were found to have more driver and out-of-service violations[5] but were involved in fewer crashes (Cantor, Celebi, Corsi, & Grimm, 2013). This study used crash report and commercial vehicle drivers' database information. Moreover, the more businesses the driver worked for, the worse their safety performance was – as shown by an increase in associated driver and vehicle out-of-service violations and crashes. More specifically, owner-drivers who worked for only one company averaged 0.12 crashes, whereas those who worked for four and nine companies averaged 0.32 and 0.57 crashes, respectively (Cantor et al., 2013).

In summary, there is some evidence that shows strong links between employment status and contract types with the health, safety and well-being of truck drivers, safety risk factors and outcomes (Cantor et al., 2013; Deighton-Smith, 2014; Mooren et al., 2015; Olson, Hanowski, Hickman, & Bocanegra, 2009; Williamson et al., 2009). It is often argued and evidenced that self-employed drivers or owner-drivers cannot afford to prioritise their health and safety and therefore they are unlikely to take it seriously. As a consequence, self-employed drivers or owner-drivers are more likely to experience ill health, stress, increased crashes and injuries compared with employed drivers from small and large organisations (George, 2018; Mooren et al., 2015). Overall, employment status has been shown to affect the occupational health and safety of truck drivers in New Zealand (George, 2018), Australia (Mooren et al., 2015; Olson et al., 2009; Williamson et al., 2009) and the USA (Apostolopoulos et al., 2014).

[5] This mean not keeping their vehicles maintained when out-of-service warnings appear.

Safety culture and norms

Safety culture and safety climate[6] are important factors that can affect the health, safety and well-being of workers both positively and negatively. Furthermore, safety culture can be developed and/or influenced by the government (ie legislation), regulation, industry, businesses and/or workers (George, 2018; Rowland, 2018).

Management commitment and support has been shown to be a critical factor in safety culture, with managers who are committed to the safety of their workers being less likely to place unrealistic work pressures on their staff (Rowland, 2018). Good management commitment, safety training and scheduling and journey planning have been shown to be the most significant predictors of safety outcomes (Mooren, Grzebieta, Williamson, Olivier, & Friswell, 2014). However, in the road freight transport industry, decisions are not only made by business management but are also influenced by industry demands and external clients (George, 2018).

Furthermore, as road freight transport drivers often work across a range of different work environments and spend a lot of time out of their depot and within the wider industry, their health, safety and well-being is also influenced by the industry culture, norms, practices, and working conditions (Edwards et al., 2015; George, 2018). As a driver enters different worksites, they will also likely be influenced by the health and safety practices and safety culture of such.

In the road freight transport industry, there is also a culture of there being someone else who will do the job for a lower price. This culture allows hiring parties or businesses to place extra pressure on drivers, who in turn feel that they have to take contracts or assignments with tight time margins and poor working conditions (George, 2018; Nævestad et al., 2015; Quinlan & Wright, 2008). It is considered that this may lead to an increase in migrant workers being employed at lower pay rates (George, 2018), further placing pressure on the drivers to take the contract/assignment otherwise they will not gain the contract/assignment.

The actions and beliefs that organisations and management have towards health and safety can influence how workers perceive health and safety. Lack of management commitment and support for driver health and safety has been shown to influence drivers' attitudes, with drivers displaying a 'do not care' attitude as a consequence (AUS; Rowland, 2018). Safety culture can have associations with safety performance and perceptions of safety. A study has shown that drivers who rated their businesses safety climate as poor were at an increased risk of experiencing a distraction-related crash or near-crash (Swedler, Pollack, & Agnew, 2015).

New Zealand: The New Zealand trucking industry has norms that are themselves a barrier to positive change and result in drivers working under suboptimal conditions (George, 2018). Combined with industry norms and employment conditions, research is revealing that truck drivers are becoming powerless and losing their autonomy, which negatively impacts their occupational health, safety, and well-being (George, 2018). For instance, New Zealand research has shown that some managers are using monitoring and surveillance equipment to monitor and control drivers, with the drivers being unaware (George, 2018).

In a study of New Zealand log truck drivers, industry factors were reported as being serious concerns for the safety and well-being of truckers, such as time pressure, work hours, and work-life balance (Mackie & Moore, 2009). In an earlier New Zealand study of truck drivers, safety climate was shown to have an indirect

[6] Some authors use 'safety climate' and 'safety culture' interchangeably, and some make clear distinctions. This distinction is not made in this report, and it is out of scope for this report to define the terms.

(but not significant) relationship with crash risk whereby safety climate was related to the involvement drivers had in risky driving behaviours – a low safety climate meant more risky driving behaviours (Sullman, Pajo, & Meadows, 2003).

Australia: In a PhD thesis, Edwards (2014) investigated the safety culture within the Australian heavy vehicle industry. Edwards identified a large number of factors and interrelated factors that influenced the occupational health and safety of workers. For instance, speeding was influenced by a broad range of cultural and contextual factors, such as time – because time is money in this industry. Another example was fatigue, which was influenced by a culture of hard work. Drivers' perceptions of fatigue led them to hold inaccurate beliefs, such as drivers believing they could work 10 hours straight without becoming fatigued, and therefore they would not take breaks. Moreover, when drivers worked long hours, the consumption of stimulants was ubiquitous, as drivers believed that it would keep them alert. Overall, this study identified an interplay between many cultural and industry norms that existed with risk factors, beliefs, and behaviours, illustrating the complexity of safety culture in the heavy vehicle industry (see Edwards, 2014 for a detailed review).

In another Australian PhD thesis, Rowland (2018) investigated work-related road safety from a holistic perspective using a theoretical concept of safety culture. This study of drivers and managers/supervisors of light vehicle fleet businesses identified a lack of management commitment and support. Furthermore, managers/supervisors believed that vehicle incidents and adverse driver behaviours were the responsibility of the driver, not the business, and that the drivers were responsible. Rowland claimed that the current approach to responsibility and accountability for work-related road safety was obstructing the effectiveness of safety interventions and that future success in this area will need to address the needs and complexities between the workers, job design, businesses, and the industry – thus taking a holistic approach.

Lastly, in a survey of 559 heavy vehicle truck drivers in Australia, drivers' perceptions and experiences of health and safety regulations and how these factors affect their work and work environments were investigated. This study identified an entrenched retribution culture, which resulted in drivers being reluctant to complain even if their (or others') health and safety was at risk (Thornthwaite & O'Neill, 2017).

In summary, safety culture is influenced by a number of different factors, and these factors are interrelated. Not only is safety culture influenced by government, regulation, industry and businesses, it is also influenced by external factors outside of the control of the industry, such as economic conditions. Safety culture is also heavily influenced by management and workers' perceptions, attitudes and beliefs. There are industry norms and practices that are ubiquitous and entrenched (ie fear of punishment, fear of missing contracts). The complexity of safety culture is such that a single intervention focusing on one part of the picture is very likely to be ineffective. For instance, as mentioned above, falsifying logbooks has been identified as an industry-wide practice that undermines current fatigue management systems and regulations of work hours, which were designed to improve the health and safety of workers. Despite its complexity, safety culture is an important area to address, as it has been shown in the literature to be strongly associated with workers' health, safety, and well-being, with positive safety culture being associated with positive worker health, safety, and well-being and negative (or a lack of) safety culture being associated with negative worker health, safety, and well-being.

Supply chain

The supply chain[7] of material transfer is complex and touches on or weaves through many other sectors, such as warehousing and storage, ports, forestry, agriculture, construction, and manufacturing. The road freight industry is woven throughout many other industries and sectors and is not a static workplace (George, 2018).

As has been discussed previously, differences exist within the road freight transport industry, and this includes differences in the supply chain. For instance, freight drivers who transfer material to a port are given timeframes that are dictated by the delivery schedules of such businesses (George, 2018). Short-haul drivers who are transferring material within urban settings or over short trips are more likely to have more regular contact with dispatchers and/or clients (Hanowski et al., 1999), which means they are likely more involved in the organisation of the supply chain but not necessarily in a position of decision making.

Supply chains are often complex and can affect the health, safety, and well-being of workers in a multitude of ways. Supply chains can also have a significant impact on the safety of the public and other workers who receive or provide the freight material, such as shippers or consignees (George, 2018; Miller & Saldanha, 2016). It is considered that actors in the supply chain, such as transport buyers,[8] forwarding agents[9] and loading agents,[10] place pressures on drivers, such as setting the schedules of the delivery of freight, thereby setting the drivers' schedule (which drivers have no control over). Such pressure can result in the drivers experiencing stress and making decisions that likely compromise health and safety practices (Nævestad et al., 2015; Quinlan & Wright, 2008).

In particular, owner-drivers and contract drivers (usually from small businesses) are often accepting pay conditions and schedules that have been set by the forwarding agent who has negotiated a contract rate with the client or transport operator. The forwarding agent who has negotiated this will then subcontract this work to the owner-driver or contract driver. This owner-driver or contractor is unlikely to have any say or negotiation power (especially if they belong to a small business) in setting this rate and then feel pressured into accepting the contract (George, 2018; Quinlan & Wright, 2008). Also identified in this review is the practice of recipient-generated invoicing whereby other trucking operations (in the case of subcontracting) would accept a verbal contract offer from the client and then generate a different invoice with different terms and conditions to the owner-driver or driver from a small organisation (Quinlan & Wright, 2008).

As mentioned above, as drivers are not typically paid for time spent waiting, queuing, or loading/unloading, many hours are not accounted for, and this puts additional pressures on drivers. This unaccounted for time (which is not regulated) has also been shown to lead to driver fatigue (Thornthwaite & O'Neill, 2017; Williamson & Friswell, 2013). Moreover, owner-drivers have expressed concerns and experienced stress about the penalties or risk of losing a contract for a late delivery and about being unpaid during the loading/unloading waiting time (Quinlan & Wright, 2008).

[7] Definition of supply chain: channel of distribution beginning with the supplier of materials through to the distributor to the end-consumer www.dictionary.com/browse/supply-chain

[8] A transport buyer is typically the hiring party – the person or organisation that buys the services of the freight organisation or owner-driver to transfer their material.

[9] A freight forwarder or forwarding agent arranges the shipment/road transport of materials.

[10] This refers to workers who are responsible for loading and unloading the material, for instance, from the truck to the shipping container.

In summary, supply chains in the road freight transport – short-haul and long-haul – are complex and predominately have tight scheduling and delivery pressures that are exerted by others, such as subcontractors, loading agents, transport buyers, and/or forwarding agents. Lastly, as discussed above, most workers are working on output-based remuneration schemes and have little, if any, control over the organisation of the supply chain or contract conditions. All of these practices place pressures on drivers who end up having to work longer, compromise on their health, safety, and well-being, and engage in risky behaviours in order to deliver material on time and to earn a living (Apostolopoulos et al., 2014; George, 2018).

Work demands and time pressures

With the highly competitive industry and complex supply chains that exist within the road freight transport industry, businesses, managers, and workers have to adapt and change their processes, practices and employment conditions in order to compete in the global market, continue to make profit and employ staff or gain contracts. Despite industry demands having a direct influence on how businesses run, work demands and time pressures are typically considered to be a business issue as opposed to an industry one (Rowland, 2018).

Work demands and time pressure have been shown to increase the likelihood that drivers will engage in risky driving behaviours. Truck drivers, in particular, have expressed that they engage in risky driving behaviours because they were frustrated by the need to mitigate business productivity demands or pressure from clients (George, 2018; Rowland, 2018). Such behaviours include aggressive driving, close following, risky overtaking (Rowland, 2018), speeding (Edwards, 2014; Rowland, 2018; Sullman, Meadows, & Pajo, 2002), working more than the legally allowed hours (Apostolopoulos et al., 2014; Belzer & Sedo, 2018; Charlton & Baas, 2000), and consuming stimulants (Davey, Richards, & Freeman, 2007; Edwards, 2014; Girotto, Mesas, de Andrade, & Birolim, 2014).

Research has also identified clear links between work pressures and demands with work-related illnesses, diseases, and health conditions including (but not limited to) obesity, diabetes, cardiovascular disease, cancers, musculoskeletal disorders, arthritis, chronic back pain, heart disease, lung disease, depression, mental health issues and stress (Apostolopoulos et al., 2014; Mooren et al., 2015; Rowland, 2018; Thornthwaite & O'Neill, 2017). In particular, many truck drivers experience issues such as chronic sleep deprivation, fatigue, and sleep apnoea (Apostolopoulos et al., 2014; Belman & Monaco, 2001; Crizzle et al., 2017). Related to work hours, fatigue and time pressures, truck drivers are also more likely to take driving risks and not conduct preventive truck maintenance (Mooren et al., 2015). Road freight drivers are also more likely to develop diseases that are related to exposures to hazards such as vibration, airborne hazards, hazardous substances, and the sun (Apostolopoulos et al., 2014; Thornthwaite & O'Neill, 2017).

New Zealand and Australian road freight drivers often work under conditions of shift work, night work and long work hours, which have all been shown to increase the risk of work-related vehicle crashes/incidents (George, 2018; Rowland, 2018). In a New Zealand study, log truck drivers identified time pressure, work hours and work-life balance as being serious concerns to their safety and well-being (Mackie & Moore, 2009).

In an UK study, researchers examined the link between work pressure, kilometres driven and accident risk (Broughton et al., 2003). Findings revealed that the pressure that drivers were placed under appeared to explain the increase in accident risk for drivers who drove high kilometres rather than being due to behaviours or individual factors. Here, drivers who were driving long distances were found to be working under conditions of fatigue and time pressure and were distracted by in-vehicle tasks, all which have been shown to be risk factors of incidents (Broughton et al., 2003).

By reviewing working conditions of truck drivers involved in a serious collision, a study found those driving more than 12 hours since the last sleep period had an 86% crash risk increase compared to those driving fewer than 8 hours (USA; Teoh, Carter, Smith, & McCartt, 2017). These collisions mostly occurred on weekdays during daylight hours on major roadways, and involved another vehicle (Teoh et al., 2017). In another study, interviewed truckers expressed that they felt immense pressure to deliver loads on time and felt powerless and that they had no control over delivering schedules – this was a predominant stressor experienced by truck drivers (Shattell et al., 2010). Lastly, long-haul truck drivers (LHTDs), especially in the USA, who drive long distances and across multiple worksites may even have the truck cab as their sole residence because it does not make financial sense to pay for a fixed residence as they are away from 'home' for extended periods of time (Apostolopoulos et al., 2014).

In summary, drivers are typically working long hours, driving over long distances and working irregular hours (including shift work) and are away from home for long periods of time (especially LHTDs). In addition, they work under immense pressure to deliver freight on time and must adhere to schedules that they have little (if any) control over – leaving them feeling stressed and powerless. With the health conditions of drivers being degraded and drivers engaging in risky behaviours, this also has a flow-on effect and raises concerns for the safety of the public. The high work demands and time pressures placed on drivers have been shown, to:

- result in drivers having to accept poor working conditions and working longer hours, take on shift work and skip/avoid breaks or rests
- incentivise drivers to engage in risky behaviours
- increase the risk of being involved in a fatal, serious injury or injury incident – long hours, night work and shift work have been shown to increase crash risk, and work pressure can also explain an increased crash risk for drivers who drive greater distances (related to hours of work and fatigue)
- be linked with a range of different work-related illness, diseases, and health conditions
- negatively impact the work-life balance of workers – personal relationships can become strained as drivers (especially LHTDs) spend a lot of time on the road.

3.2 Key risk factors identified at the worker system level

This section looks at key risk factors that are predominately at the worker or individual level. They may be immediate and/or contextual, direct or indirect, and can be managed or influenced by other variables. This section presents the key risk factors that were identified from the literature. However, as previously mentioned, this does not mean that these are the key risk factors in this sector but rather they are the ones that appeared to be more prominent in published literature. Lastly and most importantly when looking at risk factors at the worker level, it is important to remember that a risk factor can increase the likelihood of harm and that harm itself can also be a risk factor. One of the best examples of this is fatigue, which is discussed in this section.

Driver distraction

Driver distraction or diverted attention is when the attention of a driver is diverted towards a competing activity that takes away attention from critical tasks for safe driving (Regan, Hallett, & Gordon, 2011). This competing activity could be external to the vehicle (ie billboards, other road users), internal to the vehicle (ie a map, GPS, cell phone, passenger) or be in the mind (ie daydreaming, thinking) – anything that takes attention away from driving safely. Drivers may engage in these activities voluntarily or involuntarily and they may engage in activities for a range of reasons, such as to help fight off boredom or fatigue, answering a call or rumination of thoughts.

In a 2016 study in New Zealand, driver distraction was identified as a contributing factor in 11% of all vehicle crashes (n=1,097), of which 17 (1.5%) were fatal, 172 (15.7%) were serious injury crashes and 908 (82.8%) were minor (Ministry of Transport, 2017b). The cost of driver distraction was estimated at NZ$333 million, which is around eight percent of the social cost associated with all vehicle crashes. For truck drivers, from 2014 to 2016, driver distraction was involved in four percent of fatal and serious injury crashes (Ministry of Transport, 2017). Current statistics from the NZ Transport Agency report that, in 2017, there were 36 fatal road crashes in which driver distraction was recorded as a contributing factor, with another 192 serious injury crashes (New Zealand Transport Agency, 2019). In an Australian study, driver distraction was shown to negatively impact work-related road safety and driver behaviours (Rowland, 2018). Driver distraction was also associated with speeding and aggressive behaviour, because drivers were under stress and time pressure so they engaged in practices like eating while driving, speeding and aggressive driving (Rowland, 2018).

Research has shown a strong positive correlation between total hours of driving and level of distraction (Craft & Preslopsky, 2009). In a naturalistic driving study,[11] long-haul trucks drivers were studied and visually demanding tasks were shown to have the highest level of risk for distraction-related critical incidents (Hanowski, Perez, & Dingus, 2005). In an interview study of long-haul and short-haul drivers, driver distraction was the third ranked safety issue reported by drivers (Hanowski et al., 1999). A study has shown that drivers who rated their organisation's safety climate as poor were at an increased risk of experiencing a distraction-related crash or near crash (Swedler et al., 2015). Lastly, driver distraction can be caused by fatigue and work pressure for truck drivers (Craft & Preslopsky, 2009).

There is a large amount of research on driver distraction in private vehicles (non-work-related drivers), and the research in work-related driving is increasing. To date, research shows that driver distraction occurs and manifests itself differently between private and work-related drivers. For instance, one of the most common distractions behind the wheel – using a cell phone – has been shown to increase the risk of being involved in a vehicle crash from four to nine times for private vehicles (McEvoy et al., 2005; Redelmeier & Tibshirani, 1997; Violanti, 1998; Violanti & Marshall, 1996). However, as research expands in the area of commercial motor vehicle drivers (in this study, truck drivers), it appears that talking into a hands-free cell phone unit is not a risk factor (Olson et al., 2009). Instead, engagement in a cell phone conversation has actually been shown to provide a protective effect because this activity keeps truck drivers alert and awake (Olson et al., 2009).

[11] A naturalistic driving study is similar to an observational study. However, in these studies, cameras and devices are used to monitor and track drivers' behaviours, such as head and eye movements, braking and acceleration movements and force etc.

In summary, driver distraction is regarded by some researchers as one of the most significant influences on work-related road safety outcomes (Rowland, 2018), as there is overwhelming evidence that driver distraction is a leading cause of vehicle casualties for private and commercial vehicles (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006; Olson et al., 2009; Regan et al., 2011). It is also likely to be under-reported and under-estimated as it is a difficult area to report and monitor. Driver distraction is complex and is linked with other factors such as fatigue, monotony of driving, driving alone, and business practices.

Fatigue

Fatigue is both a risk factor and harm. Fatigue is a complex phenomenon, and it is difficult to identify as being a causal factor in vehicle crashes and workplace injuries. It is also likely that the role of fatigue is under-represented in current road crash, injury and fatality reporting and recording systems. While keeping this in mind, the statistics that are available show that fatigue is a significant contributing factor in road fatalities and injuries, and worker illnesses, diseases, and health conditions in New Zealand and internationally.

In a cross-country literature review study, driver fatigue was identified as a significant safety issue in Brazil, China, Australia and the USA (Blower & Woodrooffe, 2012). Seeing a similar pattern across these countries indicates that fatigue is a significant factor that can affect drivers regardless of the industry, population, and working conditions. In these four countries, the competitiveness of the industry, time-constrained working conditions, and work hours (hours of service) were all related to fatigue (Blower & Woodrooffe, 2012).

Both long-haul and short-haul drivers experience fatigue though for different reasons (Friswell et al., 2006). Long-haul drivers are shown to experience fatigue as a result of the monotony of long hours and engagement in limited other activities while driving. In contrast, short-haul drivers experience fatigue due to the pressure of having to carry out a large amount of driving and delivery work during daytime hours (Friswell et al., 2006). In another study comparing long-haul and short-haul drivers, there was a correlation between hours of sleep at night and the likelihood of drivers citing fatigue as a safety concern, with long-haul drivers expressing more concern about fatigue than short-haul drivers (Hanowski et al., 1999).

New Zealand: In the period 2014–2016, driver fatigue was an associated factor in 12 percent of fatal crashes, six percent of serious injury crashes and six percent of all minor injury crashes (Ministry of Transport, 2017c). From the 2002–2006 period to the 2014–2016 period, fatigue has remained a significant a factor in road collisions, in particular, fatal road crashes. Overall, it has been estimated that this has incurred a total social cost of NZ$291 million or 7% of all injury crashes12 in 2016 (Ministry of Transport, 2017c).

Fatal crashes that involve fatigue as a key contributing factor are usually of a head-on or loss-of-control/off-road nature (Ministry of Transport, 2017c). Often it is the driver who was fatigued who died in such crashes. Moreover, fatigue in combination with alcohol/drugs and/or speed significantly increases the risk of a crash occurring (Ministry of Transport, 2017c; National Road Safety Committee, 2010). Despite alcohol/drugs and speed playing a higher role in the number of fatal crashes (43%), the Ministry of Transport consider that 'the more serious a crash, the more likely it is that driver fatigue is a factor contributing to the crash' (Ministry of Transport, 2017c, p. 5). In regards to vehicle type and fatalities, fatigue has been a contributing factor for 10% of car/van drivers, five percent of truck drivers, and two percent of motorcyclists (Ministry of Transport, 2017c).

[12] This is less than the impact of driver distraction on New Zealand road crashes, which was NZ$333 million and 8% of the total social cost.

In a New Zealand survey, log truck drivers reported six hours of sleep per night, and one-quarter of the drivers achieved fewer than six hours of sleep (Mackie & Moore, 2009). Out of this population, 10–20% of log truck drivers reported sleep problems, sleepiness, or experiencing fatigue. There was also a correlation between hours of work, the time of day of work and fatigue, with log truck drivers experiencing fatigue at the end of a 70-hour week and those who exceeded 12 hours of duty being less able to cope with fatigue and tiredness (Mackie & Moore, 2009).

Australia: Even though policy changes have seen a reduction in fatigue-related accidents, fatigue remains a critical issue for the road freight transport industry in Australia (Deighton-Smith, 2014). Fatigue is shown to impact drivers of both short-haul and long-haul freight transport and has been shown to affect driving performance and fatigue-related accidents (Friswell et al., 2006; Williamson et al., 2009). Long-haul drivers in particular experienced degraded handling skills of their vehicles whereas short-haul drivers struggled to keep situational awareness and vigilance (Friswell et al., 2006). Each employment group – permanent, contract and owner-drivers – experienced fatigue around the same number of hours at work and at about the same time of the day (Williamson et al., 2009).

United States: The Large Truck Crash Causation Study (LTCCS) dataset (2001–2003) revealed that falling asleep at the wheel was found in 13% of the single-vehicle truck crashes and was the most significant factor in this crash type (Starnes, 2006). Fatigue is predominately associated with single-vehicle truck crashes, with extreme fatigue (ie head bobbing) being noted in the long-haul trucking industry and more often among single-vehicle truck drivers (Dingus, Neale, Klauer, Petersen, & Carroll, 2006). In an analysis of the USA Bureau of Labor Statistics Census of fatal occupational injuries database (2003–2008), drivers of heavy vehicles were predominately involved in single-vehicle crashes, for which fatigue and drowsiness are considered to be associated risk factors (Chen, Amandus, & Wu, 2014). Lastly, in a case-control study of 231 crashes and 462 non-crashes (controls) of three nationwide truck companies, the researchers found that crash risk increases with each hour of driving. The crash risk exponentially increases after the 11th hour, and at the 11th hour, the crash risk is three times that of the first hour (Jovanis, Park, Chen, & Gross, 2005). In addition to crash risk, working long hours and being fatigued increases the odds of LHTDs experiencing elevated cardiovascular health risks (Lemke, Apostolopoulos, Hege, Wideman, & Sönmez, 2017).

In a cross-sectional survey study with the Truck Sleep Disorders Survey being interviewer-administrated at truck stops in central North Carolina, researchers collected data from 260 LHTDs (Hege, Lemke, Apostolopoulos, Whitaker, & Sönmez, 2019). Drivers were asked about the characteristics of their work (work organisation), sleep, physical and mental health, and work-life balance. Poor sleep was shown to have negative impact on drivers' work-life balance, work and non-work performance, mood, and mental and physical health. These negative impacts were more noticeable on workdays compared with non-workdays (Hege et al., 2019).

Lastly, numerous studies have shown that long-haul drivers spend most of their time on the road, away from home (Apostolopoulos et al., 2014; Hege et al., 2019; Lemke et al., 2017; Shattell et al., 2010; Sieber et al., 2014). In one study of long-haul and short-haul drivers, drivers mostly spent more than 21 days on the road per month (57%), followed by 17–21 days per month (28.8%), working an average of 61 hours per week. As a result, nearly one-fifth of drivers reported experiencing chronic fatigue or low energy, and within the last week, 67.4% were tired or low in energy and 39.3% had problems sleeping (Shattell, Apostolopoulos, Collins, Sönmez, & Fehrenbacher, 2012). Additionally, studies have also shown that long-haul drivers, in particular, have more sleep and better-quality sleep during their non-workdays (Hege et al., 2019; Lemke et al., 2017).

Research has shown that driving fatigued is comparable to driving while intoxicated (Williamson & Feyer, 2000), and being fatigued produces performance decrements similar to being intoxicated (Dawson & Reid, 1997; Lamond & Dawson, 1999). Driver fatigue has also been shown to be a major causal factor in long-haul truck crashes (Dingus, Neale, et al., 2006; Hanowski et al., 1999). Fatigue also increases the likelihood of developing work-related illness, diseases and health conditions (Lemke et al., 2017), and engaging in poor practices such as the use of stimulants (Davey et al., 2007; Edwards, 2014; Gates, 2011; Mooren et al., 2015). However, there are many challenges in estimating the true cost and role that fatigue has in workplace injuries, fatalities, illness, and diseases in the road transport industry, making it hard to appropriately eliminate or mitigate.

In summary, fatigue is often cited as one of the key safety concerns – by both workers and businesses (Edwards, 2014; George, 2018; Hanowski et al., 1999; Mackie & Moore, 2009; Rowland, 2018). Fatigue is a complex phenomenon that interacts with several factors that need to be considered. Studies on fatigue in the road transport industry have shown that:

- the true costs and involvement of fatigue in poor outcomes for workers and the public are likely to be underestimated and not truly understood
- being fatigued increases the risk of workers experiencing poor health outcomes and work-related illness and disease
- being fatigued significantly increases the risk of workers experiencing vehicle crashes and fatal road crashes
- long-haul and short-haul freight drivers experience fatigue but for different reasons
- long work hours, shift work and working hours have all been shown to be associated with an increase in experiencing fatigue or chronic fatigue
- fatigue impacts driving performance and safety practices
- fatigue impacts work-life balance, home life, drivers' mood and sleep quality.

Physical health

The organisation of work in the long-haul trucking industry is considered to cause harm to the physical health of workers, lower their quality of life and reduce their lifespans, which has wider implications for the industry, health system, and general public (Lemke et al., 2017). Truck drivers experience an increased risk for a number of chronic diseases and health conditions such as heart disease, diabetes, hypertension, obesity, high cholesterol, arthritis, lung disease, and sleep disorders (for instance, Apostolopoulos et al., 2014; Edwards, Davey, & Armstrong, 2014; Lemke et al., 2017; Shattell et al., 2012; Sieber et al., 2014; Thornthwaite & O'Neill, 2017). Moreover, due to prolonged sitting and long work schedules combined with cab design and ergonomics, loading/unloading of goods, whole-body vibration, personal fitness and stress, truck drivers often experience musculoskeletal disorders (Apostolopoulos et al., 2014; Smith & Williams, 2014; Thornthwaite & O'Neill, 2017).

New Zealand: Comparing the findings to the general population, log truck drivers were found to be more overweight and obese than New Zealand males of a similar age and have a similar incidence of mental illness to the same demographic group, and hearing problems were found to be commonplace (Mackie & Moore, 2009). Interviews from New Zealand truck drivers illustrated that drivers will typically 'push through' illness and injury and are not likely to take holidays or sick leave to recover, mostly due to financial pressure (George, 2018). Furthermore, these drivers showed awareness that they engage in practices that are not good for their health, such as smoking, consuming alcohol and eating unhealthy food, but they claimed to do so in order to cope with or adapt to the pressures they faced at work (George, 2018).

Australia: In Australia, poor occupational health and safety outcomes are common for short-haul truck drivers, such as work-related chronic illnesses and injuries. In particular, the inability to manage a good work-life balance was the main predictor of negative occupational health and safety outcomes, injury, and illness (Williamson et al., 2009).

Australian workers in the transport and warehousing sector, in particular, freight drivers, have poorer health than the average working population (Bennetts, 2012). In particular, there is a higher prevalence of health risk behaviours that lead to chronic disease. Such behaviours include smoking (28.5%), lack of physical activity (79.8%), being overweight or obese (82.5%), inadequate fruit and vegetable intake (57.3%) and unhealthy alcohol consumption (31.2%). The author argues that little has been done to create innovative solutions to address transport workers' health challenges. This is compounded by the fact that the boundary between work and non-work-related illness and disease is not clear. Poor health in drivers is likely to cost employers through absenteeism, lower productivity, more sick leave taken, higher injury and crash rates, and so forth (Bennetts, 2012).

USA: In one study, working and sleep conditions and cholesterol levels of 262 LHTDs was conducted by taking biometric data (ie blood samples to determine cholesterol levels), and survey and interview data at truck stops (Lemke et al., 2017). Overall, the cholesterol profile of the sampled group was poor, and sleep (quality, duration) was found to be a strong predictor of cholesterol levels (HDL and LDL and total cholesterol). Lastly, in an interview study of LHTDs, 76.3% reported at least one physical health problem, namely musculoskeletal disorders (16.9%), hypertension (16.9%), diabetes (10.2%) and complaints about being overweight or obese (8.2%) (Shattell et al., 2010).

By analysing the National Survey of USA Long-Haul Truck Driver Health and Injury (LHTDS)[13] database, the researchers concluded that the working conditions in this industry sector play a significant role in creating barriers to particular healthy behaviours, and thus, interventions should be focused at the industry and business level and not the worker level (Birdsey et al., 2015).

A systematic literature review from 33 published articles and nine reports (grey literature) of the health and wellness of LHTDs identified multiple risk factors that can lead to a range of medical conditions and adverse events (Crizzle et al., 2017). This review supports the findings discussed throughout this report – the work environment and conditions of LHTDs involve a multitude of risk factors that are clearly associated with numerous health conditions and poor health outcomes. These risk factors are also associated with an increase in adverse events, such as crashes, worker compensation claims and healthcare costs (Crizzle et al., 2017).

Obesity: An area of physical health that is predominant in published studies is obesity amongst truck drivers. Studies have identified that obesity and poor nutrition is common for truck drivers (Canada; Bigelow et al., 2014). Obesity amongst truck drivers was associated with higher crash rates than for non-obese truck drivers (USA; Anderson et al., 2012). In one study, over half of truck drivers surveyed had a BMI over 30, which is considered obese, 30% were overweight (but not obese) and 16.7% were had a BMI less than 25 (USA; Shattell et al., 2012). A total of 1,670 drivers (44% response rate) were surveyed using the National Survey of US Long-Haul Truck Driver Health and Injury. Over two-thirds of drivers were found to be obese and 17% morbidly obese, which is higher than the general working population (USA; Sieber et al., 2014). Obesity has been shown

[13] The survey was conducted by the National Institute for Occupational Safety and Health. It collected occupational health and safety information from a representative nationwide population of 1,265 long-haul drivers in America across 32 truck stops and in 48 states in the USA.

to be associated with numerous medical factors or conditions including cardiovascular conditions, diabetes, sleep disorders, spinal injuries, spinal disease, lung disease and breathing, vision and digestive problems (USA; Thiese et al., 2015). Lastly, in a crash causation analysis, an increase in drivers' BMI was associated with poor safety performance (USA; Cantor, Corsi, Grimm, & Özpolat, 2010).

Overall, it has been demonstrated that the road freight transport industry is associated with causing poor physical health outcomes for workers and fostering poor behaviour choices by workers. There is a significant body of published literature that has examined the physical health of workers in the road freight transport industry. However, as it is challenging to separate the worker (professional life) from the person (personal life and lifestyle decisions), it is difficult to determine whether poor health is a result of work-related factors or of workers' personal life (ie family and relationships), personal lifestyle decisions (such as smoking and unhealthy eating), and health predispositions. The above research highlighted the following:

- The physical health of truck drivers is generally worse than that of the general population.
- Industry and business-level factors are considered to be barriers that prevent or make it much harder for drivers to maintain a healthy lifestyle and to engage in healthy behaviours, therefore interventions should not only be targeted at the worker level.
- Truck drivers are very likely to be overweight or obese –one area of physical health that is highly studied. Obesity is associated with higher accident rates.
- Truck drivers, especially long-haul drivers, are likely to be at an increased risk of experiencing work-related illness, disease, or health conditions such as diabetes, hypertension, obesity, high cholesterol, stress, musculoskeletal disorders, heart disease and sleep disorders or sleep apnoea.
- Engagement in poor lifestyle behaviours, such as smoking and eating junk food, and irregular eating routines.
- Many of these work-related illnesses, diseases or health conditions can be related to one another, caused by one another and may have some connection with the drivers' mental health and well-being.
- Poor physical health of workers impacts the business, the wider industry, the health system, and the general population (such as other road users in truck-car collisions).
- Overall, poor physical health of drivers in the road freight transport industry is common and has been shown to be associated with a range of harms.

Psychological health and stress

The psychological health and stress of workers is a complex topic to understand, discuss, and illustrate. In this section, research that examines the impact of work on workers' psychological health, stress levels, well-being, and the factors that contribute to these conditions is presented. In particular, this section includes research that looks at workplace violence, alcohol, stress, stimulant misuse (due to stress), and mental health and mental illnesses.

New Zealand: Mackie and Moore (2009) surveyed 225 log truck drivers and conducted 14 in-depth interviews. They asked the drivers a series of questions about their health status, work-life balance, and factors of the industry that they believe may affect this. Around 37% of log truck drivers reported difficulties in managing a good work-life balance, which was considered to play a role in

relationships failing and isolation from family. The biggest concern that drivers expressed was the conflict between work and families. They found it hard to have a healthy home life and having to deal with relationship stress (Mackie & Moore, 2009).

Australia: Around one in three drivers in Australia experienced work-related violence in the past year, with other drivers typically being the main source of violence (Williamson et al., 2009). Casual employees experienced more assaults and being held up (27.3%) compared with the two other employment status groups – permanent employees and contractors (Williamson et al., 2009). In a cross-sectional self-report survey[14] of 91 male truck drivers in Melbourne, researchers examined the drivers' presence/absence of depression and the level of depression (if applicable) and related symptoms. A total of 20 participants (21.97%) were considered to meet the clinical criteria for major depression disorder (Rice, Aucote, Eleftheriadis, & Möller-Leimkühler, 2018).

United States. In an interview study of long-haul and short-haul truck drivers, stress due to time pressures was considered to be the second-biggest issue raised by drivers (Hanowski et al., 1999). Stress was shown to be a critical factor, with drivers experiencing higher rates of psychological distress than the general working population (Hanowski et al., 1999).

A survey study of 316 truck drivers examined whether there was a link between the transportation environment and mental health and illness (Shattell et al., 2012). Even though drivers reported their general mental health to be 'good' to 'very good' (65.6%) or excellent (23.2%), when probed further, drivers reported a number of mental health issues and anxiety symptoms. In particular, loneliness (27.9%), depression (26.9%), and chronic sleep problems (20.6%) were reported. Additionally, when looking at anxiety-related issues, almost half of the participants reported feeling agitated in the past week, 41.8% found it hard to wind down, and 37.5% found it difficult to relax (Shattell et al., 2012).

In a study looking at the impact of work-life conflict on sleep and stress, sleep duration and sleep quality were found to be significant predictors of stress (Hege et al., 2019). In particular, inadequate sleep duration and poor-quality sleep affected almost two-thirds of long-haul drivers' social and leisure activities (58.6%) and family and home responsibilities (59.1%). This also had an impact on drivers' intimate and sexual relationships, with 48.1% reporting that it had 'at least some' impact. Furthermore, participants reported that poor sleep and duration had 'at least some' impact on their mood (82%) and mental health (63%). Lastly, when asked to rate their levels of stress, 62.6% of participant drivers felt that their stress levels were moderate or high (Hege et al., 2019).

Other countries: In a study of 2,445 Colombian work-related drivers, researchers examined the prevalence of regular alcohol consumption and cigarette smoke and its relationship to work-related stress and road safety outcomes – 28% of participants reported that they had experienced job stress, 20.3% regularly smoked and 27.9% consumed alcohol. Job stress was positively associated with both regular smoking and alcohol consumption behaviours (Useche, Serge, Alonso, & Esteban, 2017). A group of researchers led by the same author as the previous study combined the data from five studies on Colombian work-related drivers in order to describe their working conditions and health status with associated health and safety outcomes (Useche, Cendales, Montoro, & Esteban, 2018). Overall, the researchers were able to conclude that 'work-related stress is consistently associated with mental health and safety outcomes' (p. 13). However, this same consistency across the studies was not as strong with physical or behavioural health-related outcomes (ie smoking, obesity, diabetes, and hypertension).

[14] This was a convenience sample of drivers from one multinational transport deport, which was part of a wider employer-sponsored health check for diabetes and sleep apnoea and funded by various parties.

In Israel, researchers examined alcohol misuse and associations with stress, drinking norms, alcohol policy and supervisory behaviours towards the misuse via a self-report survey of commercial drivers from eight transport companies (Bamberger & Cohen, 2015). This study revealed a low prevalence of alcohol misuse (3.3%) and that alcohol misuse was associated with increased role conflict,[15] supervisory abuse and a drinking culture (by colleagues). Supervisory abuse was seen to increase the stress of workers, who were more likely to misuse alcohol as a way to cope with the situation. However, good supervisory monitoring was a protective factor, even when colleagues displayed a poor culture of drinking norms (Bamberger & Cohen, 2015).

In a study of 800 bus and truck drivers[16] in Tehran, Iran, researchers explored whether there was a relationship between mental health disorders, personality traits and road crash risk (Alavi et al., 2017). All three levels of depression (minor, mild, major) were revealed to increase the odds of a road crash occurring 2.4-fold. Obsessive compulsive disorder (OCD) was revealed to have the highest correlation with road risk (2.7-fold), which the authors consider to be related to anxiety (as it is an anxiety disorder). On the other hand, post-traumatic stress disorder (PTSD) and driving behaviour were not found to increase crash risk significantly. The only personality disorder with an increased crash risk was neuroticism (1.1-fold) (Alavi et al., 2017).

Lastly, in a literature review, Garbarino et al. (2018) examined the relationship between sleep and mental health and the impact this has on truck drivers. Firstly, this revealed that there are a small number of published research articles in this area, and literature reviews that exist are mostly non-systematic. Secondly, the findings revealed that truck drivers around the world work in a highly stressful work environment, and this was shown to significantly negatively influence their physical and mental health and well-being. Thirdly, truck drivers were shown to be susceptible to a range of health risks such as obesity, sleep disorders, mental illness (ie depression, anxiety) and mental health-related problems (ie loneliness, substance abuse). The authors concluded by emphasising the importance of more research (related to interventions) needing to be done in this area, especially when looking at the relationship between sleep problems, mental health, obesity, substance abuse and road collisions (Garbarino et al., 2018).

In summary, there are few high-quality research studies in relation to psychological health and stress among road transport drivers, especially systematic reviews. In part, this is due to psychological health and stress being one of the hardest areas to measure, understand, and describe, and yet it could be argued to be one of the most important areas to investigate and develop interventions. As the impact of stress on driving has been shown to predict unsafe driving behaviours and to negatively affect driving performance, it is important that more high-quality research is conducted.

The limited range of research presented above has, however, identified some key findings:

- Truck drivers work under stressful working conditions that are likely to induce or exacerbate mental health disorders, poor health, and unhealthy lifestyles.
- Poor-quality sleep and inadequate duration of sleep are predictors of stress.
- Freight drivers, in particular, long-haul freight drivers, are highly stressed and excessively fatigued, which exacerbates health conditions.

[15] Role conflict means when someone has conflicting work demands, for instance, they are instructed to or should do something but consider that it should be done differently or not at all. This conflict has been shown to be a reliable source of stress.

[16] Drivers were recruited from the hospital as they needed to complete a drug test there in order to renew their driver's licence. Interviewers were present to encourage the participants to fill out the survey, which was then followed by semi-structured interviews conducted by a clinical psychologist who was able to diagnose any mental disorders. This was a study where the drivers were followed up two years after the initial recruitment to identify accidents that occurred in that two-year period.

- Truck drivers are at an increased risk of poor mental and physical health outcomes, stress, and substance use.
- Work-related violence is likely to be a significant source of stress for truck drivers.
- Psychological health and mental health are usually associated with physical health and well-being.
- Drivers' mental health and associated physical conditions (obesity, diabetes etc) are often worse than those of the general population (especially for long-haul drivers).

Safety belt use

In New Zealand, legislation requiring the use of a safety belt while driving an on-road vehicle was introduced in 1978, and since this time, it has been one of the key driver behaviour measures targeted by New Zealand regulators and relevant agencies in order to reduce on-road fatalities and serious injuries occurring from vehicle crashes (Begg & Langley, 2000). While New Zealand has a high overall rate of safety belt use, non-safety belt fatalities accounted for around 19–30% of all road deaths between 2006 and 2016 (Hirsch, Waters, Scott, Mackie, & de Pont, 2017). Failing to wear a safety belt while driving significantly increases the risk of death or serious injury occurring when in a vehicle crash (Hirsch et al., 2017). Wearing a safety belt is also considered to be one of the most effective ways of reducing and preventing fatal and non-fatal injuries in motor vehicle crashes (Dinh-Zarr et al., 2001; Hirsch et al., 2017).

Research conducted in OECD countries indicates that the most effective interventions in heavy vehicle safety are those that can be applied to all vehicle types of which the most effective intervention is increasing safety belt usage (Deighton-Smith, 2014; OECD, 2011). However, the use of safety belts is often considered to be a concern of the individual drivers and not the responsibility of the business (Edwards, 2014; Nævestad et al., 2015), therefore little effort is taken by businesses or hiring parties to ensure drivers wear a safety belt. In an OECD report (2011) on improving safety in road freight transport, there was a low rate of truck drivers wearing a safety belt, and for collisions, not wearing a safety belt was identified as one of the strongest associated factors in the likelihood of heavy vehicle occupants dying in such collisions. In Australia, around 80% of truck occupants killed in vehicle crashes were not wearing safety belts at the time of the collision (Deighton-Smith, 2014). In an analysis of accident data of work-related vehicle fatalities in Norway from 2005–2011, failure to use a safety belt was one of the top three risk factors identified (Nævestad et al., 2015).

New Zealand: In an analysis of 200 fatal crashes in which the driver was not wearing a safety belt, fatigue was identified as a possible factor in 36.5% of the cases and alcohol was involved in 53.5% (Hirsch et al., 2017). Of the 200 fatalities, there were 20 work-related drivers: nine truck drivers, four trade workers, four agriculture workers and three service workers. These deceased workers were most likely to have worked in the agriculture, forestry or fishery sectors (18.5%). In terms of occupation, truck drivers were represented in 4% of the 20 fatal crashes without a safety belt despite only making up 1.2% of the working population. Out of these 20 fatal crashes, 18 were in rural settings, nine were in a truck, six were in a van and 18 out of 20 were driving within the speed limit, indicating that, out of 200 fatal crashes where a safety belt was not worn, work-related drivers made up 10% and these drivers were mostly driving within the speed limit and had a fatal crash in a rural setting (Hirsch et al., 2017).

Australia: In Victoria, around 41% of truck drivers were recorded as wearing a safety belt at the time of the fatal crash (Brodie, Lyndal, & Elias, 2009). In New South Wales, the rate of wearing a safety belt for truck drivers is estimated to be around 75%, which is lower than 90% of the general population (Mooren & Williamson, 2013). In another study, work-related drivers (cars, not trucks) were slightly more likely to wear a safety belt compared with non-work-related drivers (93.4% versus 89.3%, respectively) (Mitchell et al., 2014). This indicates that safety belt usage in Australia is higher for drivers of cars (both work-related and non-work-related) than for truck drivers, and truck drivers wear their safety belts less than the general population.

United States: In a national survey of LHTDs, a total of 1,086 drivers (86.1%) reported that they 'often' wear a safety belt, 7.8% (n=99) 'sometimes' wore a safety belt, and 6.0% never wore one (n=76) (Chen, Sieber, et al., 2015). In a further study, the same group of researchers explored the associated factors with non-safety belt use (Chen, Collins, et al., 2015). Through using multiple logistic regression (adjusted odds ratio, AOR) non-safety belt use was associated with:

- often driving over the speed limit (by 10mph or more) (AOR=2.9)
- having no written safety policy or programme in the business (AOR=2.8)
- being female (AOR=2.3)
- receiving two or more moving violation tickets in the last year (AOR=2.2)
- living in a state that does not have a primary safety belt law (AOR=2.1).

In contrast, non-safety belt use was not significantly associated with BMI, smoking, recorded crashes or (perceived) tight delivery schedules (Chen, Collins, et al., 2015).

Reasons for drivers of heavy vehicles wearing or not wearing safety belts are based on their beliefs, past experiences, stories they have heard from other drivers (others' experiences), financial incentives (ie to avoid fines) and comfort (Apostolopoulos et al., 2014; Edwards, 2014; Mooren & Williamson, 2013). Some drivers believe that safety belts are dangerous to wear, for instance, finding it difficult to get out of the vehicle when in an accident (Edwards, 2014). In contrast, some drivers wear a safety belt because they believe that it will protect them during a vehicle accident and increase the chances of them staying within the truck cab (Edwards, 2014). Reasons for not wearing a safety belt include inconvenience when performing work activities, restricting the use of side mirrors, perceptions around drivers' ability to move or escape if necessary (Mooren & Williamson, 2013) and comfort – as the seat moves, this makes the safety belt uncomfortable to wear (Apostolopoulos et al., 2014; Mooren & Williamson, 2013).

In summary, ensuring that businesses take responsibility for the use of safety belts by their workers or contractors appears to be a necessary shift in order to reduce the harm that occurs in crashes when the driver is not wearing a safety belt. Work is needed in order to change the design and ergonomics of truck cabs to ensure the safety belts are comfortable and practical to wear while working and completing work activities. Combined with this, dispelling myths about wearing a safety belt not being safe when in a crash also needs to be challenged.

Speed

Most research on speeding, meaning speed violations or inappropriate speed for the circumstances, focuses on private vehicles, and there is sparse academic research involving drivers of heavy vehicles (Tseng, Yeh, Tseng, Liu, & Lee, 2016). That being said, research identified in this literature review indicates that, despite not being a behaviour that is frequently engaged in, it is a significant risk factor.

In Norway, speed is one of the top three important risk factors identified in fatal incidents that involved work-related drivers, and it is considered to be an organisational issue as opposed to an individual one (Nævestad et al., 2015). In a UK study, company car drivers were shown to have excessive speed as a causal factor in work-related collisions, whereas van and truck drivers did not display this behaviour (Clarke et al., 2005). In an earlier New Zealand survey study of 378 truck drivers,[17] speeding was the most commonly reported violation behaviour (one out of 12 violation behaviours) (Sullman et al., 2002). In a national survey study of LHTDs in the USA, the majority of participants (69%; n=871) reported that they did not drive 10 miles per hour or more (16+ kmph) over the speed limit (Chen, Sieber, et al., 2015). Additionally, there were 26% (n=328) who reported 'sometimes' driving over 10mph and 4.5% (n=57) who said that they 'often' drove 10mph over the speed limit.

New Zealand: During the period 2014–2016, driver speed was a factor in 30% of fatal crashes, 21% of serious injury crashes and 16% of minor injury crashes (Ministry of Transport, 2017d). Out of these, half of the time alcohol or drugs were also involved. Speeding is more than twice as likely to occur in open-road environments, than urban settings. When looking at fatal crashes by vehicle type, truck drivers were not often recorded as having speed as a contributing factor – only five percent of truck vehicle fatalities involved speed. In terms of types of crashes involved in fatalities where speed was a factor, lost control/off road was the most common followed by head-on collisions (Ministry of Transport, 2017d), which is similar to fatigue-related crashes. It is estimated that the total social cost for speed-related collisions in 2016 was NZ$879 million, which is around 22% of the social cost associated with all road injury crashes (Ministry of Transport, 2017d). This is much higher than driver distraction or fatigue, making it the most significant recorded risk factor in fatal crashes in New Zealand.

Australia: Despite some improvements that have been attributed to policy changes (Deighton-Smith, 2014), excessive and inappropriate speed remains a serious concern in the heavy vehicle industry in Australia, and it is a significant factor in the cause of crashes (Deighton-Smith, 2014; Edwards et al., 2015). In one study, work-related drivers were less likely to speed compared with non-working (car) drivers (Mitchell et al., 2014). In a study of 461 heavy vehicle crashes, 25.4% of these had inappropriate speed as the contributing factor (O. P. Driscoll, 2013). In a study of fatalities of drivers of heavy vehicles from 1997–2007, speed was associated in 36% of crashes in which the driver was killed (Brodie et al., 2009).

Taiwan: In a national survey of 2,101 drivers of heavy vehicles in Taiwan in 2012, around 12% of drivers reported having at least one speeding offence in the past year. Factors that influenced this behaviour were related to the driver's profile, the amount and quality of sleep gained and how many hours and the time of day that they were driving (Tseng et al., 2016).

Sweden: Regulatory and cultural/industry norms appear to play an influential part in speeding by commercial vehicle drivers. In Sweden – the EU's road safety champion – private cars (62%) were less likely to comply with speed limits than truck and bus drivers (72%) and trucks with loads (84%) (Swedish Transport Administration, 2015). The Vision Zero approach changed the way people look at road traffic safety, and speeding enforcement is a key focus (Swedish Transport Administration, 2015).

[17] A total of 1,065 surveys were sent to truck drivers from 48 different transport companies from the logging, petroleum and dairy sectors.

In summary, speed is interrelated with a number of other risk factors, associated outcomes, and exacerbating factors. Speeding is related to a number of factors at the industry and worker levels and to cultural factors, including drivers' attitudes (Edwards, 2014; Edwards et al., 2015; Young, Newstead, Fridman, & Truong, 2014). Truck drivers report speeding due to a range of time-related reasons, such as remuneration methods, making up for delays, completing their delivery on time, wanting to sleep or going home earlier and other road users tailgating or trying to overtake them (Edwards, 2014; George, 2018; Sullman et al., 2002; Tseng et al., 2016; Young et al., 2014). This being said, research has shown that speeding is not a common behaviour engaged in by truck drivers (Chen, Sieber, et al., 2015; Clarke et al., 2005; Hirsch et al., 2017; Ministry of Transport, 2017d; Mitchell et al., 2014), despite speeding being a key contributing factor to crashes.

Stimulant consumption

This section includes research of work-related drivers who consume stimulants, alcohol and/or drugs[18] (illicit and licit) during work hours, when it remains in their 'system' (ie body) during work hours, or drivers consuming stimulants for work-related reasons. Data presented here includes the reasons and prevalence of stimulant use as gathered from self-report data and from crash causation studies (mostly fatal crashes).

In general, the consumption of drugs[19] impairs driving performance (Drummer et al., 2004) and very likely increases crash risk (Gates, 2011; Longo, Hunter, Lokan, White, & White, 2000). Some studies have shown that drug stimulant use is also positively associated with culpability of a vehicle crash[20] (Drummer et al., 2004).

That being said, the use of certain drugs has been shown to make some improvements in driving-related cognitive functions such as attention, vigilance, psychomotor functioning, and other visuospatial and visuomotor abilities (Gates, 2011). Interviews and surveys of drivers have shown that they may consciously engage in drug use because they believe it improves their driving and/or keeps them awake and more alert, or helps them to combat fatigue (Birdsey et al., 2015; Davey et al., 2007).

Being under the influence of alcohol while driving has been associated with an increase in unsafe driving and behaviours and a decrease in information processing, situational awareness, and driving performance (Howat, Sleet, & Smith, 1991; Martin et al., 2013; Williamson & Feyer, 2000) – all of which can increase crash risk (Drummer et al., 2004). Reducing the blood alcohol concentration (BAC) limit has been shown to reduce the rate of fatalities resulting from vehicle crashes (Fell & Voas, 2006; Howat et al., 1991), or as the BAC increases, so too does the culpability of vehicle crashes (Drummer et al., 2004; Longo et al., 2000). Furthermore, drugs and alcohol consumption combined has been shown to increase the culpability of drivers in crashes (Drummer et al., 2004; Longo et al., 2000).

New Zealand: In 2016, there were 80 fatal crashes, which led to 89 deaths related to alcohol/drug[21] consumption on New Zealand roads for all drivers (27.21% out of 327 fatalities). In addition, alcohol/drugs contributed to 144 serious injury crashes (leading to 189 serious injuries) and 479 minor injury crashes (leading to 674 minor injuries). This means a total of 6.9% of injuries occurred with alcohol/drugs

[18] In this report, alcohol and drugs fall under the term 'stimulant'; however, attention has been given to make sure that they are described accurately to avoid confusion and they have not been combined. For instance, a drug stimulant or drug does not refer to alcohol (even though it is in some publications).

[19] As the term 'drugs' contains a number of different drugs and classes of drugs, there is variance between the type of drug (class) and the effects it may have.

[20] In particular, in the study by Drummer et al. (2004), tetrahydrocannabinol (THC) had a higher level of culpability in crashes than other classes of drugs.

[21] These two stimulants could not be separated in the statistics provided.

as a contributing factor and a result of 863 people experiencing an injury. It is estimated that the social cost of these fatalities and injuries was $564 million[22] – 14% of the social cost associated with all injury crashes (Adminaite et al., 2017; Ministry of Transport, 2017a).

More specifically, five percent of truck drivers were involved in fatal crashes in which consumption of alcohol/drugs was identified as an associated factor (it does not say if they were at fault). Drivers with full licences were the least likely to be involved in a fatal crash with alcohol/drug consumption – it would be presumed that all work-related drivers would have licences. The statistics also showed a correlation between alcohol use and safety belt use, with drivers who had alcohol in their system being less likely to be wearing a safety belt at the time of the crash (Ministry of Transport, 2017a). In a survey study of New Zealand work-related drivers, driving while over the alcohol limit was the second-least reported violation behaviour out of 12 violation behaviours (Sullman et al., 2002).

Australia: In Victoria, one in six (16.7%) fatal crashes involved the presence of stimulants or cannabis in the driver (Brodie et al., 2009). In a case-control study of 3,400 fatally injured drivers in Victoria, New South Wales and Western Australia), 23% of truck drivers had stimulants in their system and there was a strong association of stimulant use and culpability (Drummer et al., 2004). In this study, drugs investigated were alcohol, drugs of abuse (ie cannabinoids, amphetamines), and psychotropic drugs.

One-third of Queensland workers in the transport and warehousing sector self-reported unhealthy alcohol consumption (31.2%) (Bennetts, 2012). An interview study of Queensland truck drivers (n=35) identified that there is high usage of illicit drugs (57% – 20 out of 35) (Davey et al., 2007). Amphetamine (speed) was the most commonly used drug (20 overall and nine currently using). Fatigue, peer pressure, fitting in, relaxation and addiction were the main reasons given for using such drugs. Fatigue in particular was seen to be a strong reason for stimulant use, and some drivers reported taking the drugs before driving in order to counter fatigue (Davey et al., 2007).

United States: In a sample of 316 truck drivers, alcohol was consumed more commonly than other substances (Shattell et al., 2012). In this study, 33.5% of drivers used alcohol once a month or less, and 20.6% 2–4 times a month (consumption does not appear to be while driving). There were 5.7% and 2.2% of drivers who used alcohol 2–3 times or 4+ times a week, respectively. Cannabis was consumed by 3.4% of truck drivers in the last month, followed by opioids (2.5%) and cocaine (2.2%). In terms of substance use, this affected 4% of drivers in terms of emotional effects and 2.8% had a strong urge to continue using (Shattell et al., 2012).

In another study, a total of 52 interviewed LHTDs self-reported using drugs (88.1% out of 59). Of those, 22.1% reported either daily or every other day use, 35.6% used drugs several times per week and 18.6% used drugs once per month (Shattell et al., 2010). The top three drugs used were crack cocaine (81.6%), marijuana (20.3%), and cocaine (17%). Looking at alcohol consumption, 23.7% reported that they never consumed alcohol and 32.2% reported occasionally consuming alcohol (totalling 55.9% out of 59 drivers). Eight LHTDs (n=59; 13.6%) reported consuming alcohol on a daily basis, another 23.7% reported weekly consumption and 5% did not provide information on frequency of consumption (Shattell et al., 2010). Lastly, in a large study of LHTDs (n=1,265), 2.4% of male drivers reported using a drug stimulant in order to stay awake (Birdsey et al., 2015).

By analysing data from a vehicle fatal collision database,[23] Gates examined truck drivers with unsafe driving behaviours across drivers who had drug stimulants in

[22] This is higher than fatigue and driver distraction-related crashes but less than speed -related crashes.

[23] From the National Center for Statistics and Analysis of the National Highway Traffic Safety Administration in the United States.

their system and those without (USA; Gates, 2011). Drivers who had committed unsafe driving behaviours were more likely to be drug stimulant positive by an odds ratio of 2.29. However, it is important to note that only 0.58% of the truck drivers in this database tested positive for drug stimulants in the first instance (Gates, 2011).

In summary, research has shown that the prevalence and frequency of drug and alcohol use by truck drivers varies considerably. As one literature review on this topic noted, while drug and alcohol use appears to be relatively frequent, reported studies reveal that the frequency and prevalence varies considerably across countries and study methodology (Girotto et al., 2014). The prevalence of alcohol and/or drugs found in the driver's body at the time of a collision (through crash causation studies) ranged from 1.2% to 23%. Self-reported use of alcohol and/or drug stimulants ranged from 2.2% to 88.1%.

Research has identified that stimulant use is related to poor working conditions (Davey et al., 2007; Girotto et al., 2014), as a way for truck drivers to combat the effects of fatigue (Davey et al., 2007; Gates, 2011) or to stay awake (Birdsey et al., 2015), addiction (Davey et al., 2007; Shattell et al., 2012), peer pressure, fitting in, and relaxation (Davey et al., 2007).

In conclusion, as most studies look at the presence of stimulants in drivers in fatal collisions, these deceased sample populations are likely biasing findings by inflating the rate of drug and alcohol use (as noted by Gates, 2011; Longo et al., 2000). Studies of fatal collisions tend to find a high-level of culpability of drivers who have stimulant use (ie Brodie et al., 2009; Drummer et al., 2004). However, in one of the few studies that looked at the role of drugs in non-fatally injured drivers, analysis identified that 52.8% of drug-free drivers were deemed culpable for the crash and only 0.8% of truck drivers tested positive for drugs (Longo et al., 2000). This means that we lack data on the rate of drug and alcohol use by drivers in the wider professional driver population and in non-fatal collisions. Combined with data showing wide variation in the use of stimulants, it appears that more work is needed to collect more representative and conclusive data.

3.3 Risk factors identified in the work process system level

Work processes or the work environment can cause harm, indirectly or directly, to workers. For drivers in the road freight transport industry, these are factors that involve the work environment, such as other road users, road conditions, weather conditions and condition of the vehicle. This section provides findings from the literature search of identified risk factors that were deemed to be at the work processes level.

Diesel exhaust

The exhaust produced by diesel fuel used in most mobile plant and machinery was recognised as a Class 1 human carcinogen in 2012 (International Agency for Research on Cancer, 2012). Exposure to diesel exhaust may cause lung cancer (Peters et al., 2017) and prostate cancer (Seidler, Heiskel, Bickeboller, & Elsner, 1998), with long-term exposure resulting in a higher likelihood of developing cancer. Diesel exhaust emissions are one the most common toxicants that drivers are exposed to through both driving and engine idling practices (Apostolopoulos et al., 2014). In New Zealand, particulate matter PM_{10} (from diesel exhaust) in particular is considered to be a serious concern. It is associated with severe health effects and often breaches national and international standards/guidelines.[24]

[24] www.mfe.govt.nz/more/environmental-reporting/air/air-domain-report-2014/state-new-zealands-air/pm10

In the road freight transport industry, drivers typically leave the truck idling in order to power cab accessories for their comfort. However, with more recent vehicles and technological solutions, this practice is decreasing, which in turns decreases the time drivers are exposed to diesel exhaust emissions and the amount (Apostolopoulos et al., 2014). In the truck freight industry, cumulative exposure to elemental carbon (used as a surrogate for engine exhaust) has been shown to increase the mortality rate from lung cancer (USA, Garshick et al., 2012). This included mechanics and workers who were drivers and/or loading and unloading goods in the dock environment.

Other road users

This literature search identified other road users as one of the most predominant risk factors for workers in the road freight transport industry, with a particularly strong association of harm. In this section, other road users refers to drivers who were not driving for the purposes of work, also called public drivers (meaning non-work-related drivers or from the general public). Research has consistently revealed that it is not common for work-related drivers to be at fault or blameworthy in fatal and serious-injury crashes. The blameworthiness ratio for work-related drivers is low because it is usually other road users who are the primary cause of the collision.

New Zealand: Data from the Ministry of Transport in 2016 looking at road fatalities that involve trucks shows there were 620 injury-related and 60 fatal-injury crashes.[25] There were 75 casualties – 10 truck drivers and 65 public drivers – which represents 22.9% of the total road toll. The majority of fatalities (87% in 2016, 83% in 2015) were occupants of non-work-related vehicles or other road users – not truck drivers. When looking at who was primarily at fault in fatal collisions, truck drivers were recorded as being primarily responsible for 34% of fatal crashes and were deemed partially responsible in 4% of fatal crashes in 2011–2015. Lastly, data shows that the more serious the crash, the less likely the truck driver had primary responsibility (Ministry of Transport, 2016).

In one New Zealand study, truck drivers reported directing aggressive or hostile behaviours towards other road users, with sounding their horn to express annoyance and indicating their hostility towards other road users being the second and third most commonly reported negative behaviours (Sullman et al., 2002). This is because other road users were reported as engaging in behaviours that negatively affected the truck drivers or could have increased perceived crash risk. For log truck drivers in New Zealand, other road users and their driving behaviours were identified as significant stress factors (Mackie & Moore, 2009).

Australia: When looking at heavy vehicles that are involved in fatal accidents, there is a significant proportion of accidents that are caused by other road users (Deighton-Smith, 2014). In one study, other road users were typically considered to be the biggest risk to a heavy vehicle organisation. This is because the private vehicle driver was usually at fault, and it was usually the non-work-related driver and/or passengers who ended up deceased when involved in a truck-car collision (Edwards et al., 2015). Additionally, from data of fatalities over ten years at Toll Group Australia, passengers in private vehicles (light vehicles; non-work-related) were the deceased party in 37% of all truck-car collisions and were more likely to be culpable of causing this collision (Jones, 2019).

USA: When looking at fatalities data, the main risk factor related to truck-car collisions and fatal truck-car collisions is overwhelmingly other road users, in particular, drivers of light motor vehicles (ie cars), and it is these drivers or their passengers that are more likely to be the deceased party (Blower & Woodrooffe,

[25] www.transport.govt.nz/mot-resources/road-safety-resources/roadcrashstatistics

2012). Moreover, other road users and their driving behaviours have been identified as a significant stressor for a large number of interviewed LHTDs (Shattell et al., 2010). In a national survey of LHTDs, more than half of drivers (54%) reported that they were 'sometimes' frustrated by other road users, 36% were 'often' frustrated and 10% were never frustrated (Chen, Sieber, et al., 2015). Moreover, traffic delays were 'sometimes' (61%) delaying delivery by a significant amount (17% often and 22% never) (Chen, Sieber, et al., 2015).

In summary, other road users are both a risk factor and the party that suffers the most serious consequences when involved a truck-car collision. Other road users are overwhelmingly likely to be culpable in truck-car collisions and fatal collisions, and they are more likely to be the deceased party. Other road users are also major stressors for truck drivers.

Road conditions and design

Road conditions and road design were not found in this literature search to be significant risk factors associated with increased harm for drivers in the road transport industry. This is partly because there does not appear to be a lot of published literature (especially in high-income OCED countries) and what has been published was far less in volume than studies focusing on driver behaviour and individual (worker) factors. That being said, some studies do exist showing that road conditions and design and weather conditions can play a role in increasing the likelihood of a crash occurring or the severity of injury when a crash occurs.

The road environment, including other road users, environmental and road conditions and design, can influence worker safety (Edwards, 2014). Perceptions of safety and stress of the road environment can also influence worker safety (Mackie & Moore, 2009). Road design factors can all have an impact on heavy vehicle safety, for instance, height clearances, horizontal alignment, signage, lane size, speed zones, length of on/off-ramps, shoulder sealing and pavement quality (Edwards, 2014).

In a New Zealand study of log truck drivers, the poor condition of the roads was identified as a significant stress factor (Mackie & Moore, 2009). In addition to this was the conditions of the environment around the truck itself – skid sites in particular were identified as perceived risk factors for drivers (Mackie & Moore, 2009). The roads in Australia, especially in the remote areas, are not built to high standards or necessarily paved, and around 60% of truck fatalities have been estimated to occur in rural and remote parts (Blower & Woodrooffe, 2012). In an American study that asked short-haul and long-haul drivers about their perception of risks while driving, roadway or dock design was the fourth-highest ranked concern and was mentioned in over half of the focus groups (Hanowski et al., 1999). In particular, drivers were concerned about roads having short merge lanes, narrow roads, and short on/off-ramps. Lastly, in a survey of 1,265 American LHTDs, 24% of participants reported that they 'often' or 'sometimes' (49%) continued to drive in order to meet a delivery time despite the fact that they might be fatigued, the weather was bad or they were in heavy traffic (Chen, Sieber, et al., 2015).

Vehicle condition and design

This section presents identified research on the condition and design of the vehicle and the relationship with the responsibility of ensuring that the vehicle condition is up to regulation standard. Vehicle condition and design were not identified as being key risk factors and were identified as being influenced by both business and individual worker factors, such as failure to comply with safety requirements and not maintaining the vehicle due to fatigue, long work hours, and time pressure.

Condition of vehicle: Even though vehicle (truck) conditions are generally improving over time and related violations are decreasing in the USA, it still remains a significant concern for crash risk (Teoh et al., 2017). Vehicle condition has consistently shown to have a relationship with safety outcomes (Mooren et al., 2014), with poor conditions correlated with increased crash risk. Moreover, in Australia, even though truck vehicles are fairly modern, the maintenance of the trucks has been identified as one of the key areas to focus on for safety improvement (Blower & Woodrooffe, 2012).

In the USA, data on the mechanical condition of trucks is not complete because police officers do not often complete detailed vehicle inspections following truck collisions (Blower & Woodrooffe, 2012). Other data and studies that exist, for instance, from the Federal Motor Carrier Safety Administration, have shown that a large number of trucks have serious defects, in particular, brakes (Blower & Woodrooffe, 2012).

In a study that analysed the Large Truck Crash Causation Study, a relationship between the mechanical condition of heavy trucks and crash involvement was identified (USA; Blower, Green, & Matteson, 2010). Around 55% of vehicles involved in crashes had at least one mechanical violation, and 30% had at least one out-of-service condition.[26] More than 36% of the vehicles had a violation related to the brake system, and around 20% had an out-of-service condition in the brake system. In particular, the brake out-of-service condition was shown to increase the risk of a truck contributing to crashes by 1.8 times. Moreover, violations by drivers, particularly working more than they are allowed by regulation, and log violations[27] were also shown to increase crash risk by 2.0 and 2.2 times, respectively (Blower et al., 2010).

In a paired case-control study of large trucks that had been involved in serious crashes and those that had not been involved (the control group), researchers examined the factors that were associated with increased crash risk (USA; Teoh et al., 2017) – 73% of serious collisions of trucks had at least one vehicle defect identified, and this had a statistically significant association of a three-fold crash risk. More specifically, brake violations were identified in 42% of the collisions, and this was associated with a 45% increased crash risk. Out-of-service violations were present for 54% of trucks involved in a serious collision and 30% of trucks not involved in a collision (the control group). Overall, the authors calculated that having any type of out-of-service violation was associated with a 362% increased crash risk and a 900% increased crash risk in scenarios where the crash involved multiple vehicles and the truck was the striking vehicle (Teoh et al., 2017).

Design of vehicle: Vehicle design is an important factor because of the significant negative impact heavy vehicles have on the light vehicle passengers in a truck-car collision (Blower & Woodrooffe, 2012). The design of the vehicle has been identified as an important area to focus on to make areas of safety improvement, in particular, to prevent heavy truck rollover and serious impact on passengers in light motor vehicles (Blower & Woodrooffe, 2012). While of interest, this topic is out of the scope of this literature search, with the exception being safety belt use, which has been discussed above.

Responsibility of vehicle condition: Related to vehicle condition and design, there are two key points to consider. Firstly, who is able to modify or change the vehicle condition and design? Secondly, who is responsible for making necessary changes or alterations for the purposes of health and safety? These points include vehicle maintenance and complying with health and safety regulations. Predominately, it is the drivers who are responsible for modifying the vehicle condition or design to

[26] Out of service is related to compliance inspections and the out-of-service criteria, whereby determined physical conditions of the commercial vehicle are assessed. Out of service means that the physical condition inspected does not meet this criteria.

[27] Log violations include instances where the driver may have been providing false reports, no record or no current duty of status data.

ensure it is safe for them and on the road, even though the condition of the vehicle has been shown to be impacted by the business and worker (Mooren et al., 2014). As has been discussed previously, when a driver is also the owner, there may be financial and time constraints that mean the vehicle is not maintained adequately or as well as would be the case in a heavy vehicle fleet organisation.

Even though the USA and Australia have inspections and enforcement of the mechanical conditions of trucks, this is still identified as a risk factor, in particular, around the brakes (Blower & Woodrooffe, 2012). Moreover, out-of-service violation rates have been shown to be strong predictors of future safety performance (Cantor et al., 2010). Failure to comply with vehicle condition health and safety regulations could be related to the fact that, as research has shown, drivers are unlikely to be able to conduct preventive truck maintenance due to factors such as work hours, fatigue and time (Mooren et al., 2015).

Vibration exposure

Whole-body vibration and vibration exposure was not identified as a key risk factor for drivers of vehicles in this literature search. Nevertheless, it is a known risk factor that influences the physical health of drivers. Exposure to whole-body vibration and vibration in general (including, arms, hands etc) will likely be further researched in upcoming review reports by WorkSafe's Research and Evaluation team and has been previously identified in WorkSafe's construction and manufacturing research reports (Barton, 2018b; Daubé & Barton, 2018).

Exposure to prolonged whole-body vibration is recognised as a risk factor associated with vibration-induced spinal disorders, musculoskeletal disorders, muscle fatigue, sprains and strains (Apostolopoulos et al., 2014; Birlik, 2009; Vanerkar, Kulkarni, Zade, & Kamavisdar, 2008). Whole-body vibration is also likely more hazardous for seated workers, such as machine operators (Shinozaki, Yano, & Murata, 2001), truck drivers (Apostolopoulos et al., 2014) and train drivers (Birlik, 2009).

Combining long work hours, postural fatigue, poor ergonomic design of seats and cabs with whole-body vibration has been shown to increase the risk of truck (and also bus) drivers experiencing vibration-induced spinal disorders and musculoskeletal disorders (Apostolopoulos et al., 2014; Bigelow et al., 2014). Exposure to prolonged whole-body vibration in professional drivers is a common cause of lower-back pain, which has been shown to negatively impact sleep quality and duration with an association with affecting drivers' vigilance while driving (Du et al., 2018).

Lastly, the type of seat that a driver sits on can also contribute to different levels of discomfort, likelihood of experiencing lower-back pain and difficulty in maintaining vigilance (Du et al., 2018) and can impact the vibration exposure and potential development of pain and musculoskeletal disorders (Tiemessen, Hulshof, & Frings-Dresen, 2007). In an experiment study, truck drivers using active seats had better levels of vigilance than truck drivers who were using traditional passive seats (Du et al., 2018). Seat design combined with vibration has been identified as a reason why drivers are less likely to wear a safety belt compared to the general population, as discussed in Safety belt use.

3.4 Other identified risk factors

This section presents other risk factors that were identified in the literature search but did not appear to be key risk factors. A non-key risk factor means that it was not shown to have a high, strong, or causative link with harm for workers in this industry. Reasons for this could have been that evidence was weak or

inconclusive or the risk factor may not have been widely studied or published (either at all or as much as other risk factors); however, these risk factors have still been shown to have some link or association to harm and are briefly mentioned in this section.

Age

In a literature review examining age-related accident risk for drivers of heavy vehicles, Duke and colleagues (2010) found that younger drivers and older drivers have an increased risk of being involved in a crash (like a U-shaped curve). However, correlations with hours of work and time of day were also shown to have an impact (Duke et al., 2010). Some research studies have supported this finding of a U-shaped curve with age as a risk factor and others have not, as is presented here.

Risk increases with age: In a study examining highway fatalities for drivers of heavy vehicles, age was identified as a risk factor; however, unlike the study by Duke et al., (2010) risk increased with age (USA; Chen et al., 2014). In a study of Australian truck drivers' worker compensation claims, a correlation between the drivers' age and compensation claims was present (Newnam, Xia, Koppel, & Collie, 2019). As the age of the driver increases, the relative risk of claims also increases and older drivers were also shown to take longer recovery periods than their younger counterparts. In another Australian study related to age, drivers having more years of professional driving experience was shown to be a significant predictor of workers' experience of chronic injury (Williamson et al., 2009). Lastly, in a comparison study of fatalities across Australia, New Zealand and the USA, as the age of workers increased, so too did the rate of work-related fatalities (Feyer et al., 2001).

Risk decreases with age: In an Iranian study of truck and bus drivers, age was revealed to reduce the risk of accident occurrence. With each year of age increasing, the rate of an accident occurring decreased by 0.01-fold (Alavi et al., 2017). The authors considered this was because older drivers have more driving experience, are more cautious, and are less likely to engage in risky driving practices.

Risk is higher for younger drivers compared with older drivers: In a case study of truck drivers involved in serious collisions, an associated increased crash risk was identified for younger (<30) and older (60+) drivers, although this was only statistically significant for older drivers (USA; Teoh et al., 2017). In a crash causation analysis study, drivers 24 years or younger were found to have an associated increased crash risk compared with their older counterparts (USA; Cantor et al., 2010). Lastly, in one New Zealand study, younger drivers[28] were shown to have been involved in a higher number of crashes in the past three years (Sullman et al., 2002).

In summary, research in the road transport industry looking at the age of the driver and the association with work-related crashes and injuries is mixed. Therefore, we cannot say with certainty that age by itself is a risk factor.

Distance driven

Some research studies have looked at the link between distance driven and crash and/or negative health outcomes. Some studies have shown that the more distance one drives, the greater the risk of being involved in a crash. Thus, as work-related drivers in the road transport industry tend to drive more than average, it would presume that they would be at a greater risk of being involved in a vehicle

[28] The cut-off for 'young' was not described.

crash. In contrast, a few studies have not shown an association with distance driven and crash risk. Since hours driven can be used as a proxy for distance driven, some of the following studies refer to hours driven instead.

More distance driven, more risk: In a large cross-sectional study of 37,570 drivers in Australia, long hours of driving (meaning more distance travelled) for both professional and private vehicle drivers has been associated with poorer physical and mental health, shorter sleep duration and unhealthy lifestyles and behaviours (ie alcohol consumption and smoking) (Ding, Gebel, Phongsavan, Bauman, & Merom, 2014).

In a study of work-related driving in the UK, a link was revealed between collisions and drivers who drive more distance (as measured by kilometres) than other drivers, but this link was less profound than other studies that have shown the same effect (Broughton et al., 2003). This study took into account the effect of total kilometres driven in comparing work-related driving and non-work-related driving. Driving for work across long distances was associated with an increase in driving under time pressure, using a hands-free cell phone, eating and drinking while driving and having to commute a long distance after a full day of work (Broughton et al., 2003).

No association between kilometres driven and risk: In a New Zealand study, the amount of distance (by kilometres) driven was not shown to be associated with crash risk (Sullman et al., 2002). Reasons given for this were related to truck drivers having a similar level of annual mileage than the general public and the possibility that there is a point at which no further exposure would increase the crash risk.

Fewer kilometres driven, more risk: One study comparing crash risk of drivers who drive fewer than 60,000 miles per year (short-haul) with those who drove 100,000 miles[29] or more (long-haul) revealed that driving fewer miles was associated with a statistically significant increased crash risk – a 383% increase (almost four-fold; USA; Teoh et al., 2017). The reasons for this were considered by the authors to be because short-haul drivers in USA operate under a short-haul exemption (ie they are not required to maintain a logbook) and are less likely to have their vehicle inspected (less regulation) and they are more likely to be owner-operator drivers.

Driving alone

While there is not a lot of research in this area, what has been studied has shown that truck drivers driving alone were involved in more crashes than paired or team truck drivers (Dingus, Klauer, et al., 2006; Duke et al., 2010; Hanowski et al., 2005). In particular, in the Hanowski et al. (2005) naturalistic driving study, truck drivers driving alone were involved in more than 60% of critical events recorded compared with team drivers. Further, in the 100-car naturalistic driving study, truck drivers driving alone experienced worse episodes of fatigue and had the most severe critical incidents, compared with team drivers (Dingus, Klauer, et al., 2006). In one study of USA LHTDs, 78.2% of drivers reported driving alone, and 21.8% were driving with others (Sieber et al., 2014). Lastly, in another America study, only 6.05% of drivers worked in a driver team (ie did not drive alone) (Anderson et al., 2012).

Manual handling

Manual handling of material is typically an activity that takes place at the loading dock or in a loading/unloading environment (outsource or receiving post). As discussed above, it is not common for truck drivers to be involved in the loading/unloading of material. For instance, in a national study of LHTDs, the

[29] 60,000 miles equals 96,560 kilometres, and 100,000 miles equals 160,934 kilometres.

majority of participants (67%; n=846) reported 'never' loading and unloading goods from their truck at work and 17% often engaged in these activities (USA; Chen, Sieber, et al., 2015). Therefore, a discussion of associated harm and risk factors with manual handling of material is not discussed here. That being said, while not specifically searching for manual handling as a risk factor, this literature search did capture some relevant information that is presented here.

The road freight and warehousing industry has a high injury incidence rate, particularly related to activities such as working at height and manual handling (Day, 2017), and research in the area of truck drivers experiencing non-road workplace injuries appears to be increasing (Shibuya, Cleal, & Kines, 2010). Truck drivers may engage in a number of work activities outside of driving, in particular, the handling of material and multiple-site delivery. When there are multiple delivery sites, there is also a higher frequency of exposure to work activities such as manual handling of goods (loading/unloading), getting in and out of the vehicle and different environmental conditions (Day, 2017). With multiple delivery sites, an item that is securely fastened in the initial site may become unstable or shift between delivery sites, with such poorly secured loads being a risk on the road and to the driver who must refasten the item(s) (Day, 2017). One study has shown that activities that require ascending to and descending from the cabin have the highest injury rates amongst truck drivers (Shibuya et al., 2010). Lastly, in a study of Australian drivers who filed worker compensation claims (which was considered to be a 'low' amount), most work-related injuries occurred during loading/unloading activities and involved musculoskeletal disorders as a consequence (Williamson et al., 2009).

In a recent Australian study, researchers compared work-related injuries, diseases, time away from work and compensation claims with other Australian workers (Xia et al., 2019). Over 509,571 accepted worker compensation claims were included in the analysis. Truck drivers had the most accepted claims (n=120,742). Delivery drivers (n=21,479), rail drivers (n=12,280) and automobile drivers (n=5,485; i.e., taxi drivers) followed. For truck drivers, musculoskeletal disorders (59.5%) were the most common injury type, followed by body stressing (36%), 'being hit by or hitting objects' (29%) and other traumatic injury (23.6%). In regards to mechanism of injury, 'body stressing' (36%), was the highest followed by 'being hit or hitting objects' (29%) and slips, trips and falls (18.6%). Regarding the number of claims made per rate of 1,000 workers, truck drivers made the most claims for musculoskeletal disorders (n=71,811; rate=41.79) followed by other traumatic injury (n=28,478; rate=16.57) then fractures (n=10,849; rate=6.31) (Xia et al., 2019).

Slips, trips, falls and being hit by objects

A brief mention of the risk factor categories slips, trips and falls and 'being hit by objects' is presented here. However, as such incidents are most likely to occur during the loading/unloading stage of material transfer or moving in and around the vehicle, evidence of these risk factors and associated harm is discussed in greater detail in other reports or articles. For these two risk factors in particular, there is quite a bit of generalisation that can be made, and overlap exists across industry sectors.

In particular, manual handling, slips, trips and falls and being hit by objects have been shown to be risk factors mostly in warehouses or ports where material gets loaded and unloaded as opposed to on the road.

In New Zealand, around one-third of log truck drivers visited an emergency room or hospital due to a workplace accident. Slips, trips and falls around the truck (17%) were the most common cause of injury, with the most common injury type being musculoskeletal (Mackie & Moore, 2009). In Australia, slips, trips and falls were the third highest mechanism of injury of accepted worker compensation claims, as mentioned in the previous section (Xia et al., 2019).

Thornthwaite and O'Neill (2017) conducted a survey of 559 heavy vehicle truck drivers in Australia to understand their work environment and how that impacts them. Self-reports from the drivers identified that 52% had fallen or slipped out of the truck cabin, 45% had fallen off the cab, trailer, or loading dock and 42% had driven into a stationary object, a moving vehicle (27%) or a stationary vehicle (20%). Furthermore, participants reported walking into things (37%) and being hit by falling objects (32%) or a moving vehicle (15%). This study also revealed that there is likely an underreporting of risks and near-misses that truck drivers' experience. Injuries and incidents for truck drivers resulted not only from road crashes but also from moving in or out of the cabin, moving the truck, falling from height, loading/unloading goods, slips, trips and falls and being hit by moving vehicles and objects (Thornthwaite & O'Neill, 2017).

Researchers in Denmark conducted interviews and field observations to determine the hazard scenarios that truck drivers experience during loading and unloading activities (Shibuya et al., 2010). Falls from heights were the most prevalent accident that truck drivers experienced while working in and around trucks during the loading and unloading process. Here, the main cause of falls involved stepping off the edge of a back-hatch lift, wrong footing and loss of balance, or control of cargo wagons. When looking at accidents in general in or around the truck, it was caused by slip/trips and defect/malfunction (Shibuya et al., 2010).

4.0 Summary and discussion

IN THIS SECTION:

Evidence we have to date revealed that vehicles are a significant cause of serious harm, injuries and fatalities for workers in Aotearoa New Zealand and internationally. WorkSafe is establishing a cross-sector Working In and Around Vehicles (WIAV) programme that is tasked with developing effective interventions to reduce harm, injuries, and fatalities for workers who work in or around vehicles. This report focuses on the various harms and risk factors that exist in the road freight transport industry. This industry employs the highest number of workers within the transport, postal, and warehousing industry division, and as trucks are the predominant 'tool' used to transfer freight, the numbers of employed workers are expected to increase in the future.

The purpose of this literature review was to identify risk factors that are associated with increased fatality rates and harms to the health and safety of workers in the road freight transport industry. A secondary purpose was to understand the context of the road freight transport industry, particularly how it relates to workers and human factors. This review focused on work-related drivers, or workers who drive for work purposes, who transport freight within the road system. A non-systematic literature search of recent New Zealand and international literature was conducted.

New Zealand and international research revealed that work-related vehicle crashes are a major cause of work-related fatalities and injuries. Moreover, there is a range of risk factors in the road freight transport industry that contribute to workers experiencing a wide range of illnesses, diseases, and poor health outcomes. Lastly, to a certain extent, the risk factors identified in this review also pose a risk to the general road population, particularly in terms of road collisions.

In regards to context within the road freight transport industry, there are several sub-industries and occupation groups that can experience different occupational health and safety risk factors and associated harms. There are also different ways of categorising road freight drivers, such as by distance (short-haul and long-haul), items of freight (logs, furniture, hazardous substances), drop-off or pick-up locations (warehouses, ports, retail locations) and vehicle types (heavy vehicles, vans, trailer-trucks). Each occupation group and/or sub-industry can have different risk factor profiles, work activities, or working conditions. Therefore, it is not possible to make generalisations within the road freight transport industry as a whole.

4.1 Summary of identified risk factors

The road freight transport industry internationally and in New Zealand is considered highly competitive, with tight scheduling, high demands and delivery pressures placed on businesses and workers. Drivers are predominately remunerated by distance-based or production-output-based schemes (Apostolopoulos et al., 2014; George, 2018; Hege et al., 2019). In the USA and Australia, the industry is also considered to be one of the worst for occupational health, safety and well-being of workers (George, 2018; Quinlan & Wright, 2008; Thornthwaite & O'Neill, 2017), especially for LHTDs (Apostolopoulos et al., 2014; Rowland, 2018). These harms place a burden on the healthcare system, the wider industry, government, workers and the general population (Apostolopoulos et al., 2014).

The identified risk factors have been grouped into four sections:

- 2A) Government to Management system levels
- 2B) Individual or worker system level
- 2C) Work process or work environment system level
- 2D) Other risk factors.

The structure and inclusion of risk factors of sections 2A, 2B, and 2C have been influenced by the system-level approach to workplace safety, as proposed by the works of Rasmussen (1997), Leveson (2011) and the sociotechnical system

(Carayon et al., 2015). The levels in the sociotechnical system are (from top to bottom) government, regulations and associations, business or company, management, staff (or worker) and work processes. Numerous papers cited in this report have referred to the different levels of the sociotechnical system. While the system-level approach has not been discussed in detail in this paper as it is out of scope, a summary of these works and the theories behind the system-level approach can be found in Barton (2018a).

Within the government to management range of system levels, the key risk factors identified included:

- policy, deregulation and globalisation
- remuneration systems or schemes
- employment status
- safety culture and norms
- supply chain
- work demands and time pressures.

The key risk factors identified at the individual or worker system level, included:

- driver distraction
- fatigue
- physical health (of the driver)
- psychological health and stress (of the driver)
- safety belt use
- speed
- stimulant (alcohol and drug) consumption.

Identified key risk factors that can be deemed to occur due to work processes or the work environment include:

- diesel exhaust
- other road users
- road conditions and design
- vehicle condition and design
- vibration exposure.

There were other risk factors identified in the search that did not appear to be key risk factors, meaning that they were not well evidenced, studied or published or their links with harm appear to be inconclusive, namely:

- age
- distance driven
- driving alone
- manual handling
- slips, trips and falls and being hit by objects.

These other risk factors have not been grouped into a specific system level. Certain other risk factors, such as gender, years of working experience, ethnicity, marital status, and level of education, and their possible association with harm were weak in evidence and thus were not included in this report. In particular, gender, as a risk factor has purposely not been discussed in this report because the road freight transport industry is male-dominated, and there is little research and supporting evidence to conclude conclusively whether or not gender is a risk factor. This being said, however, female drivers do face different barriers, have different health needs and experience numerous chronic health conditions and seek different treatment solutions (Apostolopoulos et al., 2014).

4.2 Determining relative risk

When looking at the multitude of risk factors that were identified during this literature review, some risk factors were considered to be a greater risk to worker health and safety relative to other risk factors. However, comparing risks relative to one another is a difficult exercise. Firstly, some risk factors have been studied and published more than others, which may reflect biases in people's topic of interest, beliefs of what is a key risk factor and personal experiences, which can influence what is studied and published. Funding can also play an influencing factor in what is studied, and the peer-review process can also determine which articles are published in top journals and thus are more likely to be cited.

Secondly, some risk factors are much harder to identify, observe, and/or measure. The lack of visibility of a risk factor and the difficulty in measuring it can also influence whether or not it is studied and reported. For instance, driver distraction, in particular, cognitive and visual distraction, has been shown to negatively impair driving performance; however, it is very difficult to identify, observe, measure and therefore show an association with driving performance. Furthermore, the flow-on effects, such as poor decisions, lack of situational awareness and visual interference that can result from driver distraction, are even more complex to identify, measure and report on (see Engström, Johansson, & Östlund, 2005; Strayer et al., 2015 for instance).

Challenges in determining relative risk

Related to determining relative risk, there are some limitations of this literature review to mention. Firstly, the limited access to published articles meant that there may have been relevant articles that could not be accessed (due to paywalls). Articles behind paywalls were not included in this review, as the author could not verify whether they were relevant and of high quality and thus necessary to be purchased. Secondly, identifying which risk factor is of greater risk relative to other risk factors is very challenging. As an organisation with limited resources, it is important for WorkSafe to carefully consider how to allocate resources and to identify in which area within the system levels it will be the most effective to intervene. While keeping these challenges in mind, the next section identifies the top three key areas, as considered by the author, for WorkSafe to consider addressing.

4.3 Top three risk factors

The top three risk factors that stood out to the author in the literature as warranting the most attention and as having the biggest impact on the health and safety of workers in the road freight transport industry are presented in this section. The selection of these risk factors was made based on following criteria. The risk factor:

- is a systemic issue
- has a relatively large association with increased crash risk
- and, is associated with a negative impact on drivers' health and safety.

Based on these criteria, the top three risk factors that merit attention are:

- business and industry practices
- fatigue
- other road users.

Business and industry practices

Firstly, business and industry practices and resulting poor working conditions have a major influence on harms for workers. Business and industry practices are likely the most important area to address because it is a systemic issue, is associated with increased crash risk and is significantly associated with negative impacts on drivers' health, safety, and well-being.

Poor working conditions, in particular, low-pay rates, remuneration schemes, employment contracts, work pressures, time demands, safety culture and the supply chain, have all been shown to be associated with increased harms for workers. In particular, these have been affected by deregulation or a reduction in regulations, policy decisions, globalisation and economic factors, including the Global Financial Crisis. Such conditions result in truck drivers and road freight businesses having to cut corners in order to be financially viable, and these cut corners usually are related to health and safety practices or initiatives

Strongly related to this is the organisation of the road transport industry, which has been shown to have a strong link with poor occupational health and safety experienced by workers (George, 2018; Rowland, 2018). Despite this, existing interventions have predominately been aimed at the worker level (ie towards individuals and their behaviours). Industry and business factors have been shown to undermine these interventions by the competing pressures from upstream risk factors (Thornthwaite & O'Neill, 2017). Businesses further compound this issue by failing to take a comprehensive or holistic approach to applying intervention strategies that are aimed at reducing the risk of work-related vehicle incidents (George, 2018; Rowland, 2018).

Fatigue

Another important risk factor that warrants attention is fatigue. Fatigue is a complex phenomenon, and in the context of this review, it is presented as both a risk factor and a type of harm. Fatigue is influenced by all levels of the system – government, regulation, industry, business, management, worker, work processes and the work environment – as well as by external factors. Therefore, fatigue is extremely complex to resolve for workers in this industry, and interventions to address fatigue will need to be holistic and consider every level of the system, such as changes to legislation and related regulations, working conditions, contracts, the supply chain, work environment, worker behaviours and personal lifestyle decisions.

External factors, such as the global economy, have resulted in an extremely competitive industry that incentivises businesses to compete in order to gain contracts. In order to compete with other businesses on the global scale, there is pressure for businesses to be competitive in how they operate and what they prioritise. The constant pressure that businesses experience has flow-on effects to workers who are pressured to accept poor working conditions and to adapt their work practices and work-life balance. The prioritisation of financial factors rather than organisational safety culture has been shown to lead to poor decisions being made by businesses, owner-operators, and employed drivers.

Furthermore, fatigue does not occur in isolation. It is interrelated to several factors. Research has identified that fatigue can have a two-way circular relationship, with certain risk factors contributing to fatigue and fatigue contributing to certain risk factors. For instance, factors such as stress, time pressures, long working hours, short or skipped breaks, eating food of poor nutritional value and being away from home for extended periods of time can contribute to drivers experiencing fatigue. Fatigue can also contribute to drivers experiencing stress, making poor decisions (lifestyle, maintaining their vehicle, skipping breaks, etc) and engaging in risky driving behaviours (speeding, engaging in distracting activities, driving while fatigued, etc). Moreover, fatigue

combined with other risk factors can compound the risk of harm. For instance, driving while fatigued and consuming a stimulant (or simulants) increases the risk of a crash, more than with either risk factor alone. In another example, driver distraction by itself is not necessarily a significant risk factor for LHTDs, but if combined with fatigue, it can become a significant safety concern.

Overall, fatigue is influenced by all levels in the system. It is systemic, increases crash risk and is associated with increased harm to workers' health, safety, and well-being. Currently, fatigue management systems and interventions are aimed at the worker level, such as changing driver behaviours; however, it is the upstream factors higher up in the system that place downward pressures on workers that need to be addressed, as fatigue is the symptom of factors that are mostly out of the direct control of drivers.

Other road users

Lastly, other road users were identified as being a major risk factor for drivers in the road freight transport industry. Other road users have been shown to engage in poor driving behaviours around trucks, such as speeding past trucks only to slow down once in front, cutting in front of them, causing trucks to change gears and brake, and blocking lanes. As truck drivers follow tight delivery schedules and must deliver on time, the actions of other road users can make achieving this much harder. Other road users cause stress and difficulties to truck drivers, leading them to be more hostile towards road users and engage in risky driving behaviours (ie speeding to make up time that other road users made them lose) or having to skip rest breaks (also to make up for lost time).

Furthermore, the poor driving behaviours around trucks by other road users has been shown as a culpable factor in most truck-car collisions, adding further pressure and stress on drivers if not direct harm, such as injury or fatality. Statistics from the Ministry of Transport indicate that trucks contribute to one-fifth of fatalities on New Zealand roads. Trucks are overrepresented in serious crashes and fatal crashes, making up approximately 19% of the road toll despite only travelling 6% of the total distance travelled on New Zealand roads (Ministry of Transport, 2016). However, truck drivers have low blameworthiness, and it is predominately other road users who have been identified as primarily responsible for the fatal crash and who suffer the greater consequences.

While it is not the mandate of WorkSafe to focus on other road users, it is useful as an organisation to be aware of this and explore opportunities to work with other agencies, industry leads, and associations. Other road users are considered a systemic issue because road freight drivers drive on public roads – in a wider road system – and are constrained and impacted by road conditions and the behaviours of other road users. Overall, other road users:

- increase the risk of truck-car collisions
- can alter the time schedules of drivers (causing them to skip breaks and become fatigued)
- impact business operations and the bottom line
- increase stress levels of drivers
- are implicated in collisions that have a wider cost to society.

Exclusion of other risk factors from the top three

In conclusion, most of the risk factors that were identified in this review appear to be symptomatic of the top three identified risk factors.

Speeding and driver distraction are two risk factors that have a large impact on crash risk; however, they are not considered to be systemic issues or to have a direct association with negatively affecting driver health, safety, and well-being.

Rather, speeding is considered to be a symptom of industry practices or norms, remuneration methods and tight schedules, worker factors (such as attitudes) and the need to adapt to the behaviour of other road users. Furthermore, speeding was not identified as being a behaviour that is commonly engaged in by truck drivers.

Driver distraction is a significant factor for crash risk, and it is likely underreported and underestimated. However, current research on driver distraction in naturalistic driving studies of truck drivers shows that engaging in distracting activities, such as talking on a cell phone, can, in fact, be a protective factor as it keeps drivers alert and vigilant when on long-haul drives. Secondly, driver distraction is considered to be a symptom of various factors in the drivers' environment and mind, such as fatigue, monotony of driving, driving alone and business practices. For instance, it may be common for management or administrative staff to have regular contact with their truck drivers while they are on the road, and there is the expectation that they will respond in real time.

Lack of using a safety belt was not considered to be a risk factor as it is not a systemic issue, has not been shown to increase the chances of a crash occurring and does not directly negatively impact drivers' health, safety, and well-being. Rather, the lack of wearing a safety belt is likely to increase the risk of death or serious injury occurring when the driver is in a vehicle crash, making it a safety issue for individual drivers in particular circumstances. Reasons for not wearing a safety belt can be considered to be a symptom of business practices, safety culture, personal beliefs, and the ergonomic design of truck cabs. In regards to business practices or culture, research indicates that it is typically individual drivers who are considered to be responsible for wearing a safety belt. This indicates that it is not standard practice for businesses to take responsibility for ensuring that their workers wear a safety belt at all (reasonable) times.

Lastly, poor physical health and psychological health are risk factors and harms; however, they are considered to be the symptom of a combination of business and industry practices (ie poor working conditions), fatigue and stress, worker behaviours and environmental conditions (ie lack of rest stops, food of low nutritional value at the rest stops etc). Fatigue, in particular, appears to be both a risk factor and a consequence of poor working conditions. Stimulant use appears to be the consequence of being fatigued and tired while driving, trying to make up for lost time, and making deadlines.

4.4 Interventions at the right system level

As previously mentioned, workers are exposed to a multitude of risk factors and harms that may affect their health, safety, or well-being. These risk factors can come from influencing factors from the government (ie legislation), regulators, industry, business and management, the road and environment, or workers (Bigelow et al., 2014; Edwards et al., 2015; George, 2018). As previously mentioned, these influencing factors fall into system levels or levels within the sociotechnical system, namely government, regulators and associations, business or company, management, worker and work processes (Rasmussen, 1997). The activities and actions that occur predominately within particular system levels interact with or influence each other. Activities and actions are also influenced by external factors such as environmental conditions, political climate, economy, and technological change. In order to develop interventions that will have a high likelihood of reducing harm for workers in the road freight transport industry, it is pivotal that efforts are focused at the right level of the system.

Traditionally, interventions to improve the health, safety, and well-being of workers have been targeted at the worker level towards individuals and their behaviours, such as speeding, drink-driving, and safety belt use (Rowland, 2018). However, as more research is done in this area, the evidence is clear that organisational practices of the industry, businesses and other factors, such as regulations and legislation (the upper system levels), have a strong link with poor occupational health and safety outcomes for workers in this sector. Effort is therefore needed to address the interconnectedness between the organisation of the road freight transport industry and occupational health and safety of workers. It is necessary to focus on the government to management system levels, as interventions at these levels will likely have the greatest impact and flow-on effects for workers. Interventions will also require a comprehensive and holistic approach in applying intervention strategies that are aimed at reducing the risk of work-related vehicle incidents and poor health and safety outcomes for workers (George, 2018; Rowland, 2018).

The most important implication from understanding the system-level approach to workplace safety is that interventions to improve health outcomes for truck drivers should not be focused solely at the worker level, such as approaches to influence behaviours, because they fail to address the complex interplay between the driver and their workplace and environment (Crizzle et al., 2017). Worker-level targeted interventions are also not considered to be sustainable and have been shown to not be sufficient to improve truck drivers' health and wellness (Crizzle et al., 2017; Lemke et al., 2017). For instance, in order to seriously address the complex causes of medical comorbidities (physical and psychological health) in truck drivers, it has been highly recommended to adopt a system-based approach (Apostolopoulos, Lemke, Sönmez, & Hege, 2016; Carayon et al., 2015; Crizzle et al., 2017) and to develop multifaceted interventions that address the aspects of the business organisation that are barriers to the good health and well-being of drivers (Apostolopoulos et al., 2016).

Furthermore, one of the top three risk factors determined in this review is other road users. In order to reduce truck-car collisions, for instance, it is important that interventions are put in place to address road safety at a global level to include all road users rather than focus solely on truck drivers within the road freight transport industry. This suggests opportunities for collaboration with other agencies and associations that are best placed to affect factors extrinsic to the workplace health and safety system.

In conclusion, this review has determined that unsafe driving behaviours and attitudes, poor driving performance and driver health and well-being cannot be effectively regulated with interventions aimed solely at the worker level. Rather, there are deeper contextual and systemic issues that exist in the road freight transport industry, and it is important to move away from focusing on the resulting symptoms. This review has demonstrated that symptoms that are regularly noted and managed occur due to a multitude of interrelated factors. These factors in turn place pressure on workers, and there are notable flow-on effects or symptoms that workers experience and exhibit. Therefore, a top-down approach from the higher levels of the system, namely government and industry, would appear to be the most effective and efficient areas to focus on to achieve sustainable and positive improvements to the health, safety, and well-being of workers in the road freight transport industry.

Appendices

IN THIS SECTION:

Appendix 1: The road transport domain

The Australian and New Zealand Standard Industrial Classification (ANZSIC) Division I: Transport, Postal and Warehousing industry division includes the road transport sector (referred to as the road transport domain in this report). A high-level overview of Division I: Transport, Postal and Warehousing, as per the Australian and New Zealand Standard Industrial Classification (ANZSIC) classification system 2006, is presented in the table below (Trewin & Pink, 2006).

Road transport	– Road freight transport – Road passenger transport
Rail transport	– Rail freight transport – Rail passenger transport
Water transport	– Water freight transport – Water passenger transport
Air and space transport	– Air and space transport
Other transport	– Scenic and sightseeing transport – Pipeline and other transport
Postal and courier pick-up and delivery services	– Postal and courier pick-up and delivery services
Transport support services	– Water transport support services – Airport operations and other air transport support services
Warehousing and storage services	– Warehousing and storage services

The road transport domain is comprised of the road freight transport and road passenger transport industries. In the road freight transport industry, the primary activities include furniture removal services, log haulage, road freight transport services, road vehicle towing services and taxi truck and truck hire services (with a driver). In the road passenger transport industry, the primary activities include bus services (including charter, urban, rural and intercity), car hire, and taxi services.

ROAD FREIGHT TRANSPORT	
	Primary activities – Furniture removal service – Log haulage service (road) – Road freight transport service – Road vehicle towing – Taxi truck service (with driver) – Truck hire service (with driver)

ROAD PASSENGER TRANSPORT	
Interurban and rural bus transport	*Primary activities* – Bus transport service, outside metropolitan area – Charter bus service, outside metropolitan area – Interurban bus service – Rural bus service
Urban bus transport (including tramway)	*Primary activities* – Airport bus service – Metropolitan bus service – Metropolitan charter bus service – School bus service – Tramway passenger transport service – Urban bus service
Taxi and other road transport	*Primary activities* – Hire car service (with driver) – Road passenger transport n.e.c. – Taxi cab management service (ie operation on behalf of owner) – Taxi service
RAIL TRANSPORT	
Rail freight transport	*Primary activities* – Rail freight transport service – Suburban rail freight service
Rail passenger transport	*Primary activities* – Commuter rail passenger service – Metropolitan rail passenger service – Monorail operation – Rail passenger transport service

Appendix 2: Transport, postal and warehousing workforce, New Zealand

As of February 2018, Statistics New Zealand recorded 96,200 workers in the transport, postal, and warehousing industry division. This is around 4.3% of the total New Zealand workforce, which has 2,238,900 workers in total (all sectors). Within the transport, postal, and warehousing industry division, the road freight transport industry employs the highest proportion of the workforce, with 31.60% (n=30,400). This is followed by the air and space transport industry with 11% (n=14,900).

Dataset: Enterprises by industry 2018[30]	ANZSIC06	
Measure	**Enterprise Count**	**Employee Count**
I461000 Road Freight Transport	4608	28900
I490000 Air and Space Transport	357	14900
I462200 Urban Bus Transport (Including Tramway)	252	7600
I529200 Freight Forwarding Services	411	6500
I510100 Postal Services	585	5600
I530900 Other Warehousing and Storage Services	561	4900
I510200 Courier Pick-up and Delivery Services	2883	4100
I522000 Airport Operations and Other Air Transport Support Services	87	3600
I521200 Port and Water Transport Terminal Operations	66	3200
I471000 Rail Freight Transport	0	2800
I501000 Scenic and Sightseeing Transport	642	2450
I529900 Other Transport Support Services n.e.c.	351	2200
I521100 Stevedoring Services	18	2000
I462100 Interurban and Rural Bus Transport	183	1750
I462300 Taxi and Other Road Transport	4089	1300
I472000 Rail Passenger Transport	0	930
I521900 Other Water Transport Support Services	228	910
I481000 Water Freight Transport	102	820
I482000 Water Passenger Transport	69	700
I529100 Customs Agency Services	345	620
I502900 Other Transport n.e.c.	411	560
I530100 Grain Storage Services	3	15
I502100 Pipeline Transport	6	12
TOTAL	**16257**	**96367**

[30] Data extracted on 20 Mar 2019 03:27 UTC (GMT) from NZ.Stat.

Appendix 3: References

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Appendix 4: Index

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