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# Safety Science

## Associations of heavy vehicle driver employment type and payment methods with crash involvement in Australia

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| **Corresponding Author:** | Wonmongo Soro<br>Centre for Accident Research and Road Safety—Queensland (CARRS-Q) ,<br>Queensland University of Technology<br>Brisbane, Queensland Australia |
| **First Author:** | Wonmongo Soro |
| **Order of Authors:** | Wonmongo Soro |
| | Narelle Haworth |
| | Jason Edwards |
| | Ashim Kumar Debnath |
| | darren wishart |
| | Mark Stevenson |
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| **Abstract:** | The heavy vehicle industry is characterized by high levels of competition because the relatively ease of entrance into the industry has resulted in the presence of a large number of carriers. Some heavy vehicle companies use third-party drivers to improve profit margins. Previous research has reported mixed findings regarding the relationship between heavy vehicle driver employment type and crash involvement. Moreover, this relationship has been less explored in Australia than in elsewhere. None of these studies included payment methods despite other reports that they influence safety outcomes. The current study assessed the associations of long-distance heavy vehicle driver employment type and payment methods with crash involvement in Australia. It used existing case-control data collected from 1038 long-distance heavy vehicle drivers in New South Wales and Western Australia between November 2008 and November 2011. Cases were 194 drivers who were involved in a police-attended crash during the survey period. Controls were 844 drivers recruited at truck stops, who were not involved in a crash during the previous 12 months. Driver crash involvement was modelled in an unconditional logistic regression framework after adjusting for potential confounding factors. Owner drivers had lower odds of crash involvement than employee drivers. Drivers paid time- or trip-based rates had lower odds of crash involvement than those paid distance-based rates. Payments for loading and unloading times were associated with lower odds of crash involvement than non-payments for these times. Carrying general or dangerous freight was associated with lower odds of crash involvement than driving empty trucks. |
| **Response to Reviewers:** | |

## Highlights

- Owner drivers have lower odds of crash involvement than employee drivers
- Hourly or trip rates are associated with lower odds of crash involvement than distance-based rates
- Paying for the time spent loading and unloading is associated with lower odds of crash involvement than not paying for this time
- Drivers of general or dangerous freight have lower odds of crash involvement than drivers of empty trucks
- The age range 45-64 is associated with lower odds of crash involvement than the age range 24-44

# Associations of heavy vehicle driver employment type and payment methods with crash involvement in Australia

Wonmongo Lacina Soro[a,*], Narelle Haworth[a], Jason Edwards[a], Ashim Kumar Debnath[b], Darren Wishart[c], Mark Stevenson[d]

[a] Queensland University of Technology (QUT), Centre for Accident Research and Road Safety – Queensland (CARRS-Q), 130 Victoria Park Rd, Kelvin Grove, QLD 4059, Australia
Email: w.soro@hdr.qut.edu.au, swlsoro@gmail.com
n.haworth@qut.edu.au
jason.edwards@qut.edu.au

[b] School of Engineering, Faculty of Science, Engineering & Built Environment, Deakin University, Locked Bag 20000, Geelong, VIC 3220, Australia
Email: ashim.debnath@deakin.edu.au

[c] School of Applied Psychology, Griffith University, Mt Gravatt Campus, QLD 4122, Australia
Email: d.wishart@griffith.edu.au

[d] Melbourne School of Design and Melbourne School of Engineering, The University of Melbourne, Melbourne, VIC 3010, Australia
Email: mark.stevenson@unimelb.edu.au

*Corresponding author

# Associations of heavy vehicle driver employment type and payment methods with crash involvement in Australia

**Abstract**

The heavy vehicle industry is characterized by high levels of competition because the relatively ease of entrance into the industry has resulted in the presence of a large number of carriers. Some heavy vehicle companies use third-party drivers to improve profit margins. Previous research has reported mixed findings regarding the relationship between heavy vehicle driver employment type and crash involvement. Moreover, this relationship has been less explored in Australia than in elsewhere. None of these studies included payment methods despite other reports that they influence safety outcomes. The current study assessed the associations of long-distance heavy vehicle driver employment type and payment methods with crash involvement in Australia. It used existing case-control data collected from 1038 long-distance heavy vehicle drivers in New South Wales and Western Australia between November 2008 and November 2011. Cases were 194 drivers who were involved in a police-attended crash during the survey period. Controls were 844 drivers recruited at truck stops, who were not involved in a crash during the previous 12 months. Driver crash involvement was modelled in an unconditional logistic regression framework after adjusting for potential confounding factors. Owner drivers had lower odds of crash involvement than employee drivers. Drivers paid time- or trip-based rates had lower odds of crash involvement than those paid distance-based rates. Payments for loading and unloading times were associated with lower odds of crash involvement than non-payments for these times. Carrying general or dangerous freight was associated with lower odds of crash involvement than driving empty trucks.

**Keywords:** Crash involvement; Employment type; Heavy vehicle; Payment methods.

# 1. Introduction

## *1.1. Background*

The heavy vehicle industry is a highly competitive sector due to the relative ease of entrance into the industry and the presence of a large number of carriers. Some carriers outsource the driving task to improve profit margins (Belcourt, 2006; Corsi, Fanara, & Jarrell, 1988; Monaco & Redmon, 2012; Quinlan, Johnstone, & Mayhew, 2006; Quinlan & Wright, 2008b). Other reasons that companies use third-party drivers include: (1) to create and expand services in order to meet customer demand without hiring new drivers (Cantor, Celebi, Corsi, & Grimm, 2013; George, et al., 2015; Houtman, Klein Hesselink, van den Bossche, Berg, & Heuvel, 2004; Mayhew & Quinlan,1997) ; (2) to alleviate the complexities of handling many of the processes associated with managing drivers throughout a geographically-dispersed supply chain (Cantor, 2016); (3) to have their cargo carried with a specialised technology that the companies do not possess (Belcourt, 2006; Cantor, 2016); (4) to mitigate exposure to safety risks (Cantor, 2016); and (5) to protect themselves against the uncertainty related to insurance and fuel costs (Belcourt, 2006).

Nevertheless, the use of third-party drivers may have negative outcomes for the outsourcing companies (Mayhew & Quinlan, 1997) and the drivers themselves (Quinlan, 2001). The subcontracted drivers are often paid based on distance driven or the number of trips completed, and due to competition for work, they may underbid which, combined with performance pay, may divert attention from safety and encourage risky driving behaviours (Hensher & Battellino, 1990; Hensher, Battellino, Gee, & Daniels, 1991; Quinlan & Wright, 2008b). Furthermore, the driving task is often subcontracted to smaller operating units with a lower financial capacity (Quinlan & Wright, 2008a) which perform the task outside of the control of the subcontracting company (Miller, Golicic, & Fugate, 2018; Nickerson & Silverman, 2003). Uncertainty in costs is often detrimental to the subcontracted drivers because it may deflate the already set rates or drivers may misprice their services if they do not possess accurate cost information (Peoples & Peteraf, 1995). The presence of many subcontractors may create a more segmented and complex work environment that is not easy to manage, and the outsourcing companies may not consider the consequences of their decisions on safety outcomes (Cantor, 2016). Thus, the cargo may be carried in a supply chain composed of several subcontracting parties. At each level of this chain, the involved party takes part of the profit margins and passes on the tight contract to the next level. At the end of the chain is the least powerful party composed of owner drivers who undergo the adverse effects of the profit dilution in the supply chain (Quinlan, 2001).

Heavy vehicle drivers in Australia are generally classified as employee drivers, owner drivers and subcontractor drivers (National Transportation Commission, 2012). Employee drivers, as the name indicates, are employed by companies which provide vehicles and support the costs related to their operations. Owner drivers are self-employed businesspersons who possess their own vehicles, fully support the costs of their equipment and fuel and carry freight on a contractual basis either with companies or directly with clients. Subcontractor drivers do not possess any heavy vehicles and are hired by heavy vehicle companies or owner drivers for specific tasks or periods.

Mooren, et al. (2014) compared Australian logistics and transport companies with low and high insurance claims. They found that the previous crash history of drivers at the time they were recruited differentiated among these companies. They concluded that examining previous crash histories when recruiting drivers could help improve the safety of operations. Accordingly, there is a need for research to provide strong arguments to managers seeking to understand which type of driver is the safest. Theoretical predictions assert that owner drivers are prone to drive more safely than employee drivers because risky behaviours will put their capital at risk (Nickerson & Silverman, 2003). Conversely, they are under financial pressure to cover both the fixed and variables costs of their activities (Cantor, Celebi, Corsi, & Grimm, 2013; National Truck Insurance, 2016) and may be tempted to engage in hazardous practices.

*1.2. Previous research*

The contradictory theoretical predictions mentioned earlier have triggered empirical examinations of crash involvement for the different driver employment types. A summary of these studies is provided in Table 1. Among those studies that examined the relationship between the proportion of owner drivers and the company's crash involvement, Corsi, et al. (1988) and Britto, Corsi, and Grimm (2010) found a positive relationship, while Dammen (2005) and Cantor (2014) found a negative relationship and Bruning (1989) did not find any significant association. Another study which focused on the safety of employee drivers (Cantor, 2016) concluded that employee drivers had poorer safety performance. Those studies which compared the safety of owner and employee drivers within the same company reported mixed results, some finding that owner drivers are safer than employee drivers (Hunter & Mangum, 1995) while others found the reverse (Cantor, et al., 2013; Monaco & Redmon, 2012). Regarding the specific case of Australia, Mayhew and Quinlan (2006) reported mixed safety outcomes from comparisons between employee and owner drivers.

**Table 1**

Previous studies relating heavy vehicle driver employment type and crash involvement

| Author(s) | Key variables<br>SP: Safety performance<br>ET: Employment type | Sample | Findings |
|---|---|---|---|
| Corsi, et al. (1988) | *SP:* Number of crashes per vehicle mile<br>*ET*: Owner driver proxied by the percentage of miles rented | Two-non overlapping US cross-sectional data sets for 998 heavy vehicle (HV) companies in 1977 and 770 HV companies in 1984 | The use of owner drivers is associated with higher crash rates |
| Bruning (1989) | *SP:* Number of crashes per mile driven<br>*ET*: Owner driver proxied by the ratio of the rented power units to the total number of power units | Cross-sectional data for 468 US HV companies on profitability for 1980, 1982 and 1984, and crash rates, employment type and other variables for 1984 | No significant relationship between the use of owner drivers and crash rates |

| | | | |
|---|---|---|---|
| Hunter and Mangum (1995) | *SP:* Number of fatal and injury crashes per million miles<br>*ET*: Owner operated companies, union companies, non-union companies | Two US non-overlapping cross-sectional data sets for 117 HV companies in 1976 and their 1975 financial information, and 235 HV companies in 1986 and their 1985 financial information | Owner operated companies have higher crash rates than non-union companies for the 1975-1976 data<br>No relationship exists for the 1985-1986 data |
| Monaco and Williams (2000) | *SP:* Dummy variable for crash involvement, moving violation, logbook violation over the past 12 months<br>*ET*: Binary indicator taking 1 for owner drivers and 0 for employee drivers | 1997 cross-sectional survey data from 573 US HV drivers | No difference in terms of crash involvement and logbook violations<br>Owner drivers have more moving violations than employee drivers |
| Dammen (2005) | *SP:* Crash rate, injury rate<br>*ET*: Owner driver proxied by the ratio of the rented distance to the total distance | 516 US HV companies in 1996 | The use of owner drivers is associated with lower crash and injury rates |
| Mayhew and Quinlan (2006) | *SP:* Number of crashes, hours of work<br>*ET*: Self-report of whether the driver is an employee or owner-driver | 2000 survey data from 300 long-haul HV drivers in New South Wales, Australia | Mixed results for major crashes<br>Owner drivers have the lowest crash counts over the past 12 months and the highest over the past 5 years<br>Owner drivers drive longer hours than employee drivers |
| Britto, et al. (2010) | *SP:* Number of crashes, driver safety assessment score index; vehicle safety assessment score index<br>*ET*: Percentage of the owned fleet | Cross-sectional data for 657 US HV companies in 2003 and their 2002 net profit margins | Fleet ownership increases the number of crashes, but improves vehicle safety and does not affect driver safety |
| Monaco and Redmon (2012) | *SP:* Number of crashes, injuries, and fatalities<br>*ET*: Owner driver proxied by companies having one truck and one driver, and for multiple truck companies by the percentage of the fleet that is trip or term leased | 2009 data on 295,814 US HV companies | Companies using owner drivers have fewer crashes, injuries and fatalities than those using employee drivers<br>Mixed results for severe and fatal crashes |
| Cantor, et al. (2013) | *SP:* Number of crashes, driver and vehicle out-of-service violation rates<br>*ET*: Dummy variable equals 1 for employee drivers and 0 for owner drivers | 599,758 US HV drivers having had at least three roadside inspections over 2008-2011 | Owner drivers are less involved in crashes but have higher driver- and vehicle out-of-service violation rates than employee drivers |
| Cantor (2014) | *SP:* Number of crashes, driver and vehicle out-of-service violation rates<br>*ET*: Owner driver proxied by the percentage of the owned fleet | 1,380,764 US HV companies | Fleet ownership decreases the number of crashes but increases driver- and vehicle out-of-service violation rates |
| Cantor (2016) | *SP:* Number of crashes, proportions of driver and vehicle out-of-service rates | 108,780 US HV Companies | The use of employee drivers is associated with poor safety performance |

|  | |
|---|---|
|  | *ET*: Employee drivers proxied by the ratio of owned tractors to the total number of owned and leased tractors |

Most of these empirical studies were conducted at the company level. Company-level data provide evidence of the aggregate safety performance of companies but not of the individual safety performance of drivers. Monaco and Redmon (2012) claim that this type of data cannot provide conclusive evidence that employment type influences safety at the individual level. Importantly, none of the previous studies examined the influence of the payment method despite reports that this affects driver behaviours (Belzer & Sedo, 2018; Mooren, Williamson, & Grzebieta, 2015; O'Neill & Thornthwaite, 2016). Due to the budgetary constraints and reduced profit margins in the subcontracting chain, companies generally transfer their financial risks to drivers through payments based on the number of trips completed or the distance travelled (Mooren, et al., 2015; Quinlan & Wright, 2008b). Thus, drivers in the quest for an acceptable net income are stimulated to engage in risky behaviours such as speeding, drug use to stay awake and hours-of-service violations. The current study was designed to assess the associations of both employment type and payment methods with long-distance heavy vehicle driver crash involvement in Australia.

## 2. Materials and methods

### *2.1. Study design and participants*

This study used existing case-control data collected within the framework of an Australian Research Council Linkage Project in the Australian States of New South Wales (NSW) and Western Australia (WA) between November 2008 and November 2011. The project aimed to identify the factors that affect crash involvement for heavy vehicles. The participants were long-distance (≥ 200 kilometres from the base) drivers of heavy vehicles (weight ≥ 12 tonnes) (Stevenson, et al., 2010). Cases were drivers involved in a crash during the survey period while controls were drivers not involved in a crash during the past 12 months. The response rates were 59% for cases and 58% for controls (Sharwood, et al., 2013; Stevenson, et al., 2014) . Each participant was provided with a $50 retail voucher for the time spent in the survey.

Data from this case-control study have previously been used to examine the prevalence of sleepiness and sleep disorders among heavy vehicle drivers in NSW and WA (Sharwood, et al., 2012; Stevenson, et al., 2014), to evaluate the link between the intake of caffeinated substances and crash risk in NSW and WA (Sharwood, et al., 2013), the relationship between sleepiness and sleep disorders and crash risk in NSW and WA (Stevenson, et al., 2014), the connection to driver payment methods and to heavy vehicle driver fatigue and sleepiness (Thompson & Stevenson, 2014), and the assessment of sleep disorders and health factors with crash risk (Meuleners, Fraser, Govorko, & Stevenson, 2015a), and the association between a driver's work environment factors and heavy vehicle crash risk in WA (Meuleners, Fraser, Govorko, & Stevenson, 2015b).

*2.2. Cases*

Cases were drivers involved in police-attended crashes during the study period. They were identified at the end of each week from police-reported data. Drivers were excluded if they were seriously injured in the crash or if any fatalities resulted from the crash because it was deemed that the survey would be stressful for these drivers. Seriously injured persons were those hospitalised for at least two weeks or who were in a state of unconsciousness due to the crash (Stevenson, et al., 2014).

The research team retrieved contact information (telephone number, mail address) for case drivers from the police records and sent them invitation letters to participate in the study. The letters informed drivers that the research team would contact them by telephone, and that participation was optional and could be declined. The letter identified the study purpose as "*studying the numerous factors related to heavy vehicle crashes*" to *"identify appropriate ways to manage heavy vehicle safety in Australia"*.

Two weeks after sending the letters, drivers were contacted by telephone, and a 40-minute interview was conducted to complete the survey after a verbal agreement. The unwilling drivers declined their participation by mail or on the phone at the time the research team contacted them. A total of 194 drivers were interviewed in the case group.

### *2.3. Controls*

Controls were selected by approaching drivers, often during meal or refuelling time, at truck stops in NSW and WA distributed across the routes most frequented by long-distance truck drivers. The purpose of the study was introduced as "*studying truck crashes aiming to identify strategies to improve safety in your industry*".

Drivers who consented to participate in the survey provided written agreement, and a face-to-face interview was immediately conducted over the next 30 minutes. Drivers willing to participate in the interview but could not stay for 30 minutes due to job constraints were asked to provide contact details, including telephone numbers. A telephone interview was then scheduled within the following two days. The interviews were conducted between 6 am and midnight and spread over different times, days, weeks and months to capture various travel patterns. A total of 844 drivers were interviewed in the control group.

Both case and control interviews were conducted by the same researchers who were trained based on a standardised protocol. The questionnaire included questions on driver demographics, crash involvement history, schedules and work patterns, payment methods, and types of vehicles and loads. Both samples had the same questionnaire except the number of crashes, which was not included for the controls. The participants were informed that the results of the survey would be confidential.

*2.4. Data description*

The study included many variables described and summarised in Table 2 among which were driver employment type, payment method for driving time, payment for the time related to non-driving tasks such as loading and unloading, and truck type.

Employment type had four categories: employee drivers, owner drivers, subcontractor drivers and other. Employee drivers are full-time company-employed drivers, owner drivers are self-employed business operators, while subcontractor drivers are drivers contracted to work for companies or owner drivers for specific tasks or periods.

With regard to payment methods, drivers can be paid per unit of time (hour, day or week) worked which may be supplemented by an overtime pay for any extra hours or days worked when drivers are paid a fixed salary for working a specified number of hours per day or days per week. Alternatively, drivers can be paid based on the amount of work performed (piecework or performance-based payment), for instance, by the number of trips completed between a given origin and destination or the distance driven in kilometres. Performance-based payments, unlike time-based payments, by connecting drivers' earnings to their output encourage unsafe behaviours such as drug use and noncompliance with speed and hour-of-service regulations (Belzer & Sedo, 2018; O'Neill & Thornthwaite, 2016). Payment method in this study had two time-based categories: time-based (flat) rates and single-time pay plus overtime, and two performance-based categories: trip rates and distance-based rates, as well as final category of other. Single-time pay plus overtime is the term used to describe the situation in which drivers are paid a fixed salary for working a specified number of hours per day or days per week, and then receive additional payment for any extra hours or days worked.

Payment method for the time related to non-driving tasks had four categories for loading time and unloading time: not paid, same as for driving time, a flat amount and an hourly rate. Nevertheless, the questionnaire did not specify the difference between *same as for driving time* and *hourly rates.* These categories overlap for drivers paid hourly for driving time. Thus, following Kudo and Belzer (2019), the payment for the time related to these non-driving tasks was turned to a binary variable equalling 1 if both loading and unloading times are paid and 0 otherwise.

Driver's age as a continuous variable was turned to a 3-category variable (24-44; 45-64 and 65 and more), following the cut-off values of the World Health Organisation, to test whether the relationship between crash involvement and age is non-linear.

Figure 1 (Austroads, 2019) shows the truck configurations in Australia. In this study, the trucks were categorised as rigid trucks (Classes 3 to 5), semitrailers (Classes 6 to 9), B-doubles (Class 10) and road trains (Classes 11 and 12).

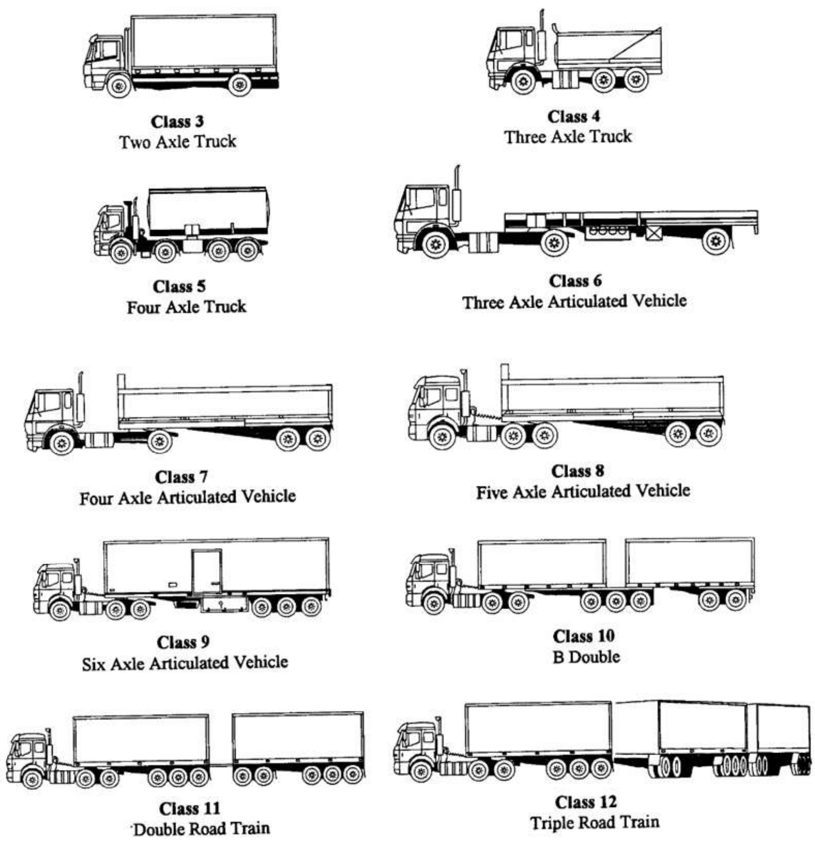


Figure 1. Australian truck configurations

(Source: Austroads, 2019)

Among the variables included in the regression estimation, the case group had 35 (18.0%) missing values distributed among employment type (2.1%), payment methods (4.6%), payment for both loading time and unloading time (11.3%) while the controls had 75 (8.9%) missing values distributed among load type (0.2%), driving experience (0.2%), payment methods (1.4%), payment for both loading time and unloading time (7.0%). The missing values were included in the regression using the multiple imputations method, the state-of-the-art technique to handle missing data (Enders, 2010). It uses the distribution of the observed data to estimate a set of plausible values for the missing observations. The logistic regression was estimated using the multiple imputations by chained equations function (White, Royston, & Wood, 2011) in Stata 15.0.

Ethics exemption to use the data in this study was obtained from the Queensland University of Technology Human Research Ethics Committee in September 2018 (Approval number 1800000975). Ethics approval for the original data collection was obtained from the University of Sydney Human Research Ethics Committee in January 2008.

*2.5. Statistical analysis*

Descriptive statistics were calculated for the cases and controls. An unconditional logistic regression then assessed the associations of driver employment type and payment methods with crash involvement while controlling for other confounding factors such as load type.

Crash involvement as the dependent variable was represented by a binary variable equalling 1 for cases and 0 for controls. The explanatory variables retained for modelling were those related to the dependent variable in a chi-square test with a P-value $<0.2$ following the practice adopted by Stevenson, et al. (2010) and Thiese, et al. (2015) in their studies of the factors that affect heavy vehicle crashes in Australia and the United States, respectively.

Driving experience and driver age (under its continuous form) were not included in the same model because they were highly and significantly correlated (Pearson correlation coefficient r= 0.68) at the 95% confidence level. The model including age is presented in the study because it has the smallest average relative variance increase. The average relative variance increase in estimations using multiple imputations represents the effects of the loss of information due to missing data on the variance of the model. The lower the average relative variance increase, the less are the effects of missing data on the variance of the model (White, et al., 2011). Truck type was removed from the analysis because there were so few rigid trucks among the cases that it prevented testing other more relevant variables.

## 3. Results

All cases and 94.4% (N=841) of controls were men. Cases and controls did not differ statistically in terms of age (cases: 44.5 years, SD=10.4; controls: 45.3 years, SD=10.5), driving experience (cases: 16.9 years, SD=11.4; controls: 17.7 years, SD=12.3, N=842), or distance driven during the past week (cases: 3,771 kms, SD=1,667.2, N=191; controls: 3,774 kms, SD=1,773.6, N=836). Table 2 presents the descriptive statistics for cases and controls for truck type and the variables included in the logistic regression.

**Table 2**

Descriptive statistics of truck type and the variables included in the logistic regression

| Variable | Cases (N=194) | Controls (N=844) |
|---|---|---|
| | (%) | (%) |
| Employment type in past week | | |
| Employee driver | 138 (71.1) | 593 (70.2) |
| Owner driver | 20 (10.3) | 108 (12.8) |
| Subcontractor driver | 32 (16.5) | 115 (13.6) |
| Other | 00 (0.0) | 28 (3.4) |
| Missing values | 4 (2.1) | 00 (0.0) |
| | | |
| Payment method in past week | | |
| Time-based rate | 51 (26.3) | 224 (26.6) |
| Single-time pay plus overtime | 5 (2.6) | 35 (4.1) |

| | | |
|---|---|---|
| Trip rate | 50 (25.8) | 221 (26.2) |
| Distance-based rate | 79 (40.7) | 298 (35.3) |
| Other | 00 (0.0) | 54 (6.4) |
| Missing values | 9 (4.6) | 12 (1.4) |
| | | |
| Payment for time spent loading and unloading in past week | | |
| Yes | 96 (49.5) | 466 (55.2) |
| No | 76 (39.2) | 319 (37.8) |
| Missing values | 22 (11.3) | 59 (7.0) |
| | | |
| Truck type on the current trip | | |
| Rigid truck | 10 (5.1) | 67 (7.9) |
| Semitrailer | 87 (44.9) | 371 (44.0) |
| Road train | 17 (8.8) | 116 (13.7) |
| B-double | 80 (41.2) | 290 (34.4) |
| | | |
| Load type on the current trip | | |
| General freight or mixed freight | 61 (31.4) | 292 (34.6) |
| Livestock and dangerous goods | 9 (4.6) | 58 (6.9) |
| Other Goods | 38 (19.6) | 109 (12.9) |
| Empty | 86 (44.4) | 383 (45.4) |
| Missing values | 00 (0.0) | 2 (0.2) |
| | | |
| Driver age (years) | | |
| 24-44 | 99 (51.0) | 412 (48.8) |
| 45-64 | 90 (46.4) | 406 (48.1) |
| 65 and more | 5 (2.6) | 26 (3.1) |

The logistic regression estimates are presented in Table 3. The unspecified drivers and payment methods were only in controls. Thus, these categories were not included in the regression. The distance-based rate was considered as the reference category because research mostly reported it as the most associated with drivers' poor safety performance (O'Neill & Thornthwaite, 2016; Quinlan & Wright, 2008a). The F-test for the overall model provided a statistic of 24.85 with an associated P-value<0.0001, implying that the models is globally significant at the 99% confidence level.

**Table 3**

Estimates from the logistic regression of crash involvement

| Variable | Odds ratio | P-value | 95% CI[×] |
|---|---|---|---|
| Employment type in past week | | | |
| Employee driver | 1.00 | - | - |
| Owner driver | 0.50** | 0.008 | 0.30 to 0.83 |
| Subcontractor driver | 0.82 | 0.37 | 0.54 to 1.26 |
| Pay method in past week | | | |
| Time-based rate | 0.67* | 0.04 | 0.46 to 0.99 |
| Single-time pay plus overtime | 0.44 | 0.10 | 0.16 to 1.18 |
| Trip rate | 0.56** | 0.002 | 0.39 to 0.80 |
| Distance-based rate | 1.00 | - | - |
| Payment for time spent loading and unloading in past week | | | |
| Yes | 0.50** | <0.001 | 0.36 to 0.68 |
| No | 1.00 | - | - |
| Load type on the current trip | | | |
| General freight or mixed freight | 0.59** | 0.002 | 0.42 to 0.82 |
| Livestock and dangerous goods | 0.45* | 0.03 | 0.21 to 0.95 |
| Other Goods | 1.13 | 0.56 | 0.73 to 1.75 |
| Empty | 1.00 | - | - |
| Driver age | | | |
| 24-44 | 1.00 | - | - |
| 45-64 | 0.55** | <0.001 | 0.42 to 0.73 |
| 65 and more | 0.46 | 0.12 | 0.17 to 1.24 |

**p<0.01, *p<0.05, [×]CI= confidence interval

Owner drivers had lower odds of crash involvement than employee drivers. Crash involvement was associated with the payment method; however, with distance-based rates being associated with higher odds of crash involvement than other payment methods, with the exception of single-time pay plus overtime. Drivers who were paid for the time spent loading and unloading had lower odds of crash involvement than those not paid for this time.

## 4. Discussion

Previous research has produced mixed evidence regarding the influence of heavy vehicle driver employment type on crash involvement. This study examined this influence along with that of payment method using Australian data. The findings suggest that payment method and employment type are associated with crash involvement.

The lower odds of crash involvement for owner drivers than employee drivers is consistent with the findings of Dammen (2005) and Cantor (2014). Owner drivers, as self-business persons, face financial pressure to cover their costs. Nevertheless, they acknowledge that a crash may necessitate the repair of vehicles with significant cost repercussions and time delays (Nickerson & Silverman, 2003). Moreover, the time devoted to repairing vehicles is seen as a loss of money due to the loss of other job opportunities (Cantor, et al., 2013). Thus, they may be less likely to be involved in crashes than employee drivers. Furthermore, employee drivers may be more likely to be involved in crashes than owner drivers if the employing company allocates fewer resources to equipment maintenance and/or stimulates them to drive faster and longer through distance-based payments (Cantor, 2016). The company may also not be able to provide the appropriate equipment needed to carry the cargo safely.

The results of this study showed evidence of an association between payment method and crash involvement. Drivers paid time-based rates, trip-based rates or unspecified rates had lower odds of crash involvement than those paid distance-based rates. While time-based payments may be associated with driving longer than advisable, distance-based rates incentivise both faster and longer driving (Quinlan & Wright, 2008a). The lower is the uncertainty of earnings; the lower is the likelihood of crash involvement (Hensher, et al., 1991). This uncertainty is likely to be lower for trip-based rates than distance-based rates. While both types of rates are related to the number of kilometres driven, trip-related earnings appear to be the most predictable because trips are defined between specified origins and destinations. These findings are consistent with previous studies connecting payment methods to crash involvement and other safety outcomes (Belzer & Sedo, 2018; Mooren, et al., 2015; Stevenson, et al., 2014; Viscelli, 2016). In another Australian study, logistics and transport companies with good safety records mostly paid their drivers time-based rates (hourly or weekly) or fixed salaries while companies with poorer safety records mostly paid drivers based on loads carried (Mooren, et al., 2014). The majority of Australian heavy vehicle drivers surveyed between September 2015 and August 2016 strongly believed that payments based on distance travelled implicitly encourage unsafe behaviours (O'Neill & Thornthwaite, 2016). As explained by Williamson and Friswell (2013), drivers work more hours than those simply required to drive non-stop from origin to destination and the total hours worked is influenced by operational factors. Incentive payments (distance-based or trip-based rates) encourage longer hours of working than time-based payment where drivers are paid for all of the hours they work (including the time spent waiting for loading and unloading to occur). In addition, drivers operating under distance-based payments are effectively penalised for taking breaks because these are unpaid time (Belzer & Sedo, 2018). Driving without taking breaks makes drivers vulnerable to fatigue and crash involvement (Chen & Xie, 2014; Chen, Fang, Guo, & Hanowski, 2016; Lenné & Jacobs, 2016). Moreover, distance-based payments can encourage drivers to speed, violate hours-of-service regulations and take drugs to stay awake and drive for longer hours, making them further vulnerable to fatigue and crash risk (Quinlan & Wright, 2008a; Williamson, 2007; Williamson, Cooley, Hayes, & O'Neill, 2006; Williamson & Friswell, 2013).

The drivers paid for the time associated with the non-driving tasks such as loading and unloading had lower odds of crash involvement than those not paid for this time. Drivers in the current study, as shown in Table 2**,** were mostly paid distance-based rates (40.7% of cases and 35.3% of controls) implying that they only make money when driving. In such situations, the time related to non-driving duties if not paid becomes an opportunity cost because it decreases driving time resulting in lower income for drivers. Drivers are accordingly motivated to drive faster and longer than legally required increasing the risk of fatigued driving and crash risk (Kudo & Belzer, 2019; Office of the Inspector General, 2018; Quinlan & Wright, 2008b).

Drivers carrying general or mixed freight, or livestock and dangerous goods had lower odds of crash involvement compared to drivers driving empty trucks. It is more likely that drivers operate vehicles more attentively when transporting freight that requires particular precautions (Cantor, Corsi, Grimm, & Özpolat, 2010). The findings may reflect the need for drivers with empty load vehicles to travel to destinations quickly and consequently speed in order to secure another load. It may also be related to the handling issues of empty trucks like trailer sway, which may increase the risk of rollover crash (Blower, Campbell, & Green, 1993).

The lower odds of crash involvement for drivers aged between 45 and 64 years old compared to drivers aged between 24 and 44 years old could be the result of the risk-taking behaviours such as speeding of drivers aged between 24 and 44 years old and their relatively low driving experience compared to others (Cantor, et al., 2010).

*4.1. Study limitations and future research*

This research has some limitations. It only looked at factors associated with moderate severity crashes because drivers involved in fatal crashes and drivers who were severely injured were excluded. Self-reported data may contain some errors and potential sampling bias. Drivers under time constraints may not have agreed to participate or could have been more preoccupied with finishing the interview rather than by giving candid answers. Controls were selected by approaching drivers at truck stops during mealtimes. This selection process could omit those of them who did not often use truck stops for their meals. Nevertheless, the survey was spread over different times, days, weeks and months to capture various travel patterns.

While the payment for the time related to the loading and unloading tasks is connected with lower odds of crash involvement, it is not known whether drivers themselves performed these tasks. The loading and unloading tasks, when performed by the drivers, may constitute a significant source of fatigue irrespective of whether they are paid or not (Williamson, Friswell, & Sadural, 2001).

The use of crash involvement as a measure of safety performance has been criticised on the ground that it does not reveal the actual safety performance of a logistics and transport company because the driver may not be at-fault (Beard, 1992; Savage, 1999). The research team did not collect information from police records regarding whether case drivers were at-fault in the crash. Thus, it may be more appropriate to use safety behaviour variables, such as hours-of-service compliance, speeding and vehicle maintenance, because they reflect the efforts of companies more than crash involvement (Miller, et al., 2018; Miller & Saldanha, 2016). Case-control studies could be used to examine these behaviours based on driver employment type (Cantor, 2016). Researchers could also explore whether the different types of drivers perceive different advantages for diverse safety violations given the various job constraints they face (Miller, et al., 2018).

Other authors have claimed that it is the pay level per se, rather than payment method, which encourages undesired safety behaviours because drivers are in the quest for an acceptable net income (Hensher & Battellino, 1990; Hensher, et al., 1991). A safe payment system should consider the pay level, payment method and other elements, such as the payment for non-driving time (Quinlan & Wright, 2008b). While the influences of payment method and the payment for non-driving time on safety have been analysed in Australia, studies about pay level are missing, despite drivers reporting that low pay rates are a key threat to safety in

Australia (O'Neill & Thornthwaite, 2016; Williamson, et al., 2001). Higher pay rates have been reported to improve safety performance in the United States (Belzer, Rodriguez, & Sedo, 2002; Belzer & Sedo, 2018; Britto, et al., 2010; Kraas, 1993; Monaco & Williams, 2000; Rodríguez, Rocha, Khattak, & Belzer, 2003; Rodriguez, Targa, & Belzer, 2006). One US study based on data collected in 1997-1998 showed that drivers were more likely to reduce the amount of driving time when the distance-based pay rate increased (Belzer & Sedo, 2018). The authors concluded that drivers have a target level of earnings, and greater compensation can lead them to be more mindful of safety and drivers who cannot obtain their target revenue without breaching safety regulations will be tempted to do so.

There is a need to explore driver pay level and safety outcomes in the Australian heavy vehicle industry to help identify the pay rate levels that are conducive to safety. This could be achieved by examining the factors that affect pay satisfaction. Studies in the heavy vehicle industry mostly identified pay level as among the top factors that affect heavy vehicle driver job satisfaction (Humphreys, 2016; Sersland & Nataraajan, 2015), but pay satisfaction itself is still to be explored. For instance, one of the important, influential factors of pay satisfaction is the gap between the perceived and the actually received amounts (Miceli & Lane, 1990). Drivers who are satisfied with their payment level may be more willing to comply with safety regulations (Fehr & Schmidt, 2000; Milgrom & Roberts, 2002).

## 5. Conclusions

Due to the high level of competition in the heavy vehicle industry, logistics and transport companies often use drivers other than their employed drivers to increase flexibility and stay competitive. It is, therefore, necessary for company managers to have thorough knowledge about the safety performance of the different types of drivers. Nevertheless, research is inconclusive about the relationship between driver employment type and crash involvement in the industry. Moreover, this issue has been relatively less explored in Australia compared to the United States, and no past studies included payment methods as well, despite reports that they influence safety outcomes.

This study used existing Australian case-control data to explore the association of both long-distance heavy vehicle driver employment type and payment methods with crash involvement. The results from an unconditional logistic regression suggested that owner drivers had lower odds of crash involvement than employee drivers. Likewise, drivers receiving hourly or trip rates had lower odds of crash involvement than those paid on distance travelled. Drivers paid for time spent loading and unloading had lower odds of crash involvement than those not paid for this time. Drivers carrying general freight or mixed freight, or livestock and dangerous goods had lower odds of crash involvement than drivers driving empty trucks. Driver's age was also a significant crash influential factor involvement with lower crash involvement for drivers aged between 45 and 64 years old compared to those aged between 24 and 44 years old.

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**Declarations of interest**

None.

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