NSW GOVERNMENT

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WorkCover Assist

Applied research project final report

Age Related Safety in Professional Drivers

WORK SAFE HOME SAFE

FOREWORD

WorkCover Assist Applied Research Project Final Report - '*Age Related Safety in Professional Drivers*'.

This research was funded under the WorkCover Assist Applied Research Program. The grantee, the Transport Workers Union (TWU) engaged the University of Newcastle to undertake the study. The conclusions in the final report are those of the authors and any views expressed are not necessarily those of WorkCover NSW.

The purpose of the research was to: compare accident rates of younger and older heavy vehicle drivers relative to middle age drivers using data from the New South Wales Roads and Traffic Authority and the Australian Bureau of Statistics; and, to test for an interaction between vehicle type and controller age group for various other factors which may contribute to accident causation.

The research suggests that the risk for younger drivers was higher than the 30-44 years age group, and that the risk increases after approximately 60 years of age. The researchers were able to separate heavy vehicles into rigid and articulated trucks and noted that the risk for these two vehicle types differs. Most notable is the difference in risk rates for articulated trucks and rigid trucks in the age groups under 35 years - for the rigid trucks the lower risk is significantly different. Younger drivers of rigid trucks are less likely to be involved in an accident than drivers of passenger vehicles and articulated trucks.

The researchers concluded that for a number of important accident factors the age of the driver alone does not significantly affect accident causation. These factors include: time, weather, and road condition factors. The probability of being involved in a fatality is unaffected by age. However, the risk increases by type of vehicle driven.

The analysis of accident factors showed a statistically significant interaction of vehicle type and controller age group for the following factors: mileage travelled, severity of accident, time of accident, urbanisation, road classification, speed limit at location, hazardous feature at location, road user movement, age of vehicle and controller speeding.

Study of Age Related Safety in Professional Drivers

Project Report

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Executive Summary

Background: With Australia facing a looming shortage of heavy vehicle drivers the question is raised as to whether it is desirable or prudent to encourage older professional heavy vehicle drivers to remain in the transport sector for longer, particularly those of heavy vehicles or recruit drivers of a younger age. The objectives of this study are to: compare accident rates of younger and older heavy vehicle drivers relative to middle age drivers using data from the New South Wales Roads and Traffic Authority and the Australian Bureau of Statistics and to test for an interaction between vehicle type and controller age group for various other factors which may contribute to accident causation.

Methods: This study utilised a retrospective cohort study design to analyse all accidents involving a heavy vehicles reported in the New South Wales Roads and Traffic Authority Accident Database between 1999 and 2006. Observations were excluded where missing data existed, accident involved stolen vehicle, and accident factor was identified as relating to a pedestrian, animal or object thrown at vehicle. To calculate the rate of accident involvement the numerator was involvement in an accident and the denominator was the number of kilometres travelled each year as estimated by the Australian Bureau of Statistics Survey of Motor Vehicle Use. The following statistical analysis was undertaken: 1) A descriptive analysis was undertaken tabulating number of events by key vehicle type and controller age group; 2) Annual accident incidence rates were modelled using Poisson regression with the explanatory variables of vehicle type and age group of the controller. The interaction of these two variables was included to allow the model to estimate the accident rate for each age and vehicle type combination. In addition mileage travelled was used as the exposure variable; and 3) Accident factors were modelled using linear, logistic, or multinomial logistic regression containing the interaction term for vehicle type and controller age group to test whether the interaction is significantly at the 0.05 level.

Results: A total of 26,146 accidents occurred in New South Wales in the observation period involving a total of 54,191 traffic units. A total of 13,451 observations did not meet the inclusion criteria for the study and were excluded from the analysis leaving 40,740 observations representing 20,401 accidents.

The accident incident rate ratio analysis showed: 1) For accidents involving the controllers of passenger and light commercial vehicles only, 18 – 20 year old vehicle controllers of any vehicle type are almost eight times more likely and 21 – 25 year olds three times more likely to be involved in an accident which involved a heavy vehicle than 35 – 44 year old controllers. Vehicle controllers aged more that 64 years were 1.6

times more likely to be involved in an accident with involved a heavy vehicle than 35 – 44 year old controllers. All associations are statistically significant at the 0.05 level. 2) For accidents involving the controllers of rigid trucks only, 18 – 20 year old vehicle controllers of any vehicle type are 3.4 times more likely, 21 – 25 year olds twice as likely and 26 – 34 year olds are 1.6 times more likely to be involved in an accident which involved a heavy vehicle than 35 – 44 year old controllers. Vehicle controllers aged more that 64 years are almost less likely to be involved in an accident with involved a heavy vehicle than 35 – 44 year old controllers. All associations are statistically significant at the 0.05 level. 3) for accidents involving the controllers of articulated trucks only, 18 – 20 year old vehicle controllers of any vehicle type are thirteen times more likely and 21 – 25 year olds 3.2 times as likely to be involved in an accident which involved a heavy vehicle than 35 – 44 year old controllers. Vehicle controllers aged more that 64 years are no more likely to be involved in an accident with involved a heavy vehicle than 35 – 44 year old controllers. In interpreting this rate ratios care is required as most of the confidence intervals overlap, indicating that there is little difference between the vehicle types.

The analysis of accident factors showed a statistically significant interaction of vehicle type and controller age group for the following factors: mileage travelled, severity of accident, time of accident, urbanisation, road classification, speed limit at location, hazardous feature at location, road user movement, age of vehicle and controller speeding.

This study has strengths and limitation. These strengths are: large sample size of all accidents, not just fatal accidents; and the use of total kilometres travelled by vehicle type, age and gender of the vehicle controller in the statistical modelling. A limitation of the study are the low number of observations and mileages for females and the younger age groups in heavy vehicles. This caused wide confidence intervals which made interpretation of results difficult.

<u>Conclusion</u>: Following this thorough analysis of all motor vehicle accidents where a vehicle was towed away, an injury or fatality occurred we conclude that the Australian Government initiative to diversify the working population to include older workers (> 65 years) is appropriate to the Australian transport industry, particularly heavy vehicle drivers following appropriate health surveillance. However this analysis has demonstrated that encouraging younger drivers (< 26 years), particularly to drive rigid trucks is also appropriate without this endangering workplace and road safety. We have demonstrated that for a number of important accident factors the age of the driver does not affect accident causation. This practice, with appropriate mentoring and training would lead to the creation of a more professional and skilled workforce.

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1 Introduction

In 2005 the Australian Government launched the report "Workforce Tomorrow: Adapting to a more diverse Australian labour market."(1) Due to Australia's ageing population and declining birth rate the publication emphasised the challenges of these issues in order to stay competitive and economically viable in the future, and aimed to inform employers and industry of the recruitment challenges they are likely to face in the near future across all industries.

Of particular interest to the Transport Workers Union of NSW and the Australian transport industry in general were the predictions of skills shortage in the transport/storage sector. The modelling shows that employment in every industry is forecast to be adversely affected by population ageing over the next five years (see Figure 1). At a national level, it is forecast that in the subdivision within Wholesale Trade, Transport and Storage is forecast to be more affected than average at the national level.

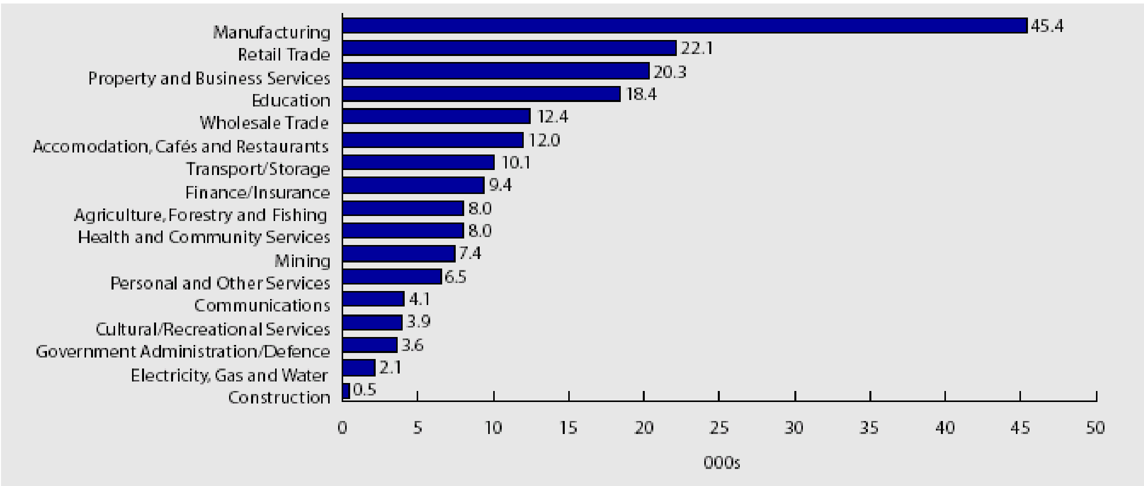


Figure 1: Forecast Reduction in Employment Levels ('000) due to Population Ageing by Industry, 2004-05 to 2009-10. (1)

Further, it is suggested that semi-skilled and unskilled occupations will be most greatly affected by this labour shortage and that NSW will be the state bearing the largest impact.(1)

All major occupational groups are forecast to be adversely affected by population age (as illustrated in Figure 2). In terms of skill levels, it appears that semi-skilled and unskilled occupations such as transport workers will be most greatly affected.

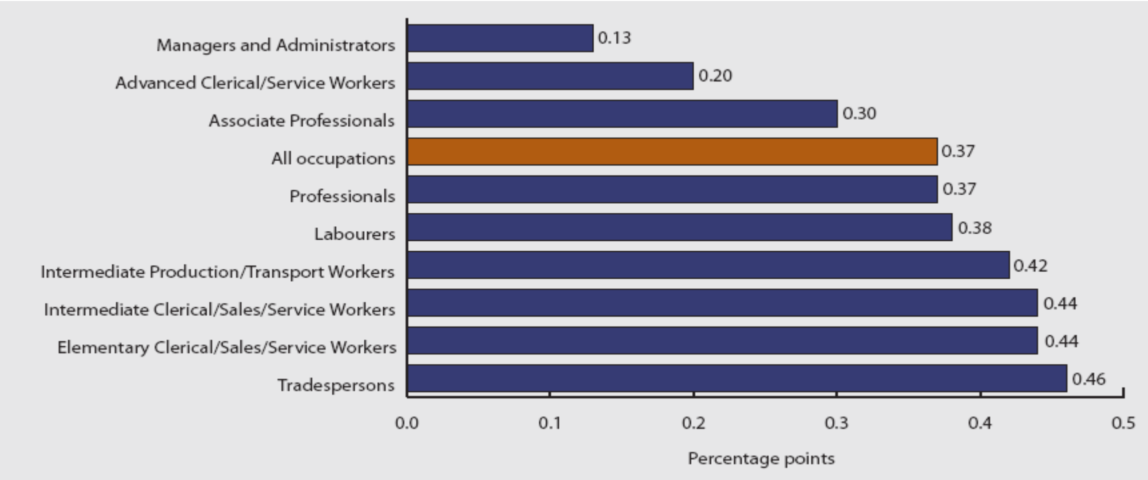


Figure 2: Forecast Reduction in Average Annual Employment Growth (Percentage Points) due to Population Ageing, by Occupation, 2004-05 to 2009-10.[1]

The solution to this shortage as proposed by the Department of Employment and Workplace Relations is that "the workforce of the future will be more diverse; it will consist of more older workers, more parents, more people with disabilities and more people wanting to work part-time"[1].

The Australian Trucking Association is also concerned about a lack of skilled drivers. In a press release on a nation-wide truck driver campaign to boost skills, the association Chief Executive, stated:

"..what is looming to be a national crisis as the demand for skilled drivers continues to increase amidst a doubling of the road freight task".[2]

1.1 Ageing professional heavy vehicle drivers

The natural process of ageing bring with it physical and cognitive differences which perhaps do not equate to the desirability of encouraging older workers to continue their employment as professional heavy vehicle drivers. While there are many individual differences in the ageing process, even relatively healthy older adults are likely to experience some level of functional decline in sensory, physical and cognitive areas.[3] These changes would intuitively be expected to affect driving and lead to an over-involvement in crashes as a consequence. Some principal associations between age-related impairments and driving difficulties are listed in Table 1. However, current evidence of causal relationships between declines in specific abilities and reduced driving performance or increased crash risk is limited.[4]

Table 1: Age-related impairments and associated driving problems

(Adapted from Suen and Mitchell)[5]

Age-related impairments	Driving Problems
Increased reaction time. Difficulty dividing attention between tasks	Difficulty driving in unfamiliar or congested areas
Deteriorating vision, particularly at night	Difficulty seeing pedestrians and other objects at night, reading signs Difficulty with wet weather driving
Difficulty judging speed and distance	Failure to perceive conflicting vehicles. Accidents at intersections
Difficulty perceiving and analysing situations	Failure to comply with Give Way signs, traffic signals and railway crossing signs. Slow to appreciate hazards
Difficulty turning head, reduced peripheral vision	Failure to notice obstacle while manoeuvring. Failure to observe traffic behind when merging and changing lanes
More prone to fatigue	Get tired on long journeys, run-off road single vehicle crashes
General affects of ageing	Worries over inability to cope with a breakdown, driving to unfamiliar places, at night, in heavy traffic
Some impairments vary in severity from day to day. Tiredness, symptoms of dementia	Concern over fitness to drive

1.2 Young professional heavy vehicle drivers

Perhaps a more feasible solution to the predicted skills shortage in the transport industry is to recruit drivers of a younger age; however this may not be a palatable solution with the public, regulators and insurance companies. Given the extensive media focus recently on the driving skills and attitudes of young drivers, particularly P-platers any organisation suggesting the encouraging younger drivers into the transport industry needs to be sure that this is a viable solution and does not present a risk to public safety and occupational health and safety.

There is however a glass floor in place restricting younger drivers entering the industry for two reasons:

1. Reluctance of some transport companies to employ young drivers

2. Reluctance of insurance companies to insure drivers under the age of 26 years

We believe that these policies are based on accident statistics of young recreational drivers and not younger professional heavy vehicle drivers.

2 Literature Review

A large volume of literature is available on fatality and/or crash involvement of commercial vehicle drivers; however a limited number of studies reported outcomes in relation to age for heavy vehicle drivers, and importantly reported on outcomes for young drivers (less than 27 years of age) and older age groups. This review will present findings where age effects could be determined and results will be presented in four parts. Part 1) will focus on papers for which heavy vehicle age-related crash results were available, with Part 2) presenting papers for which fatigue and crash risk in heavy vehicles was the primary focus with age-related results reported. Part 3) will discuss other contributing factors (e.g. heavy vehicle configuration, time of day etc) that affect crash rates; and Part 4) will discuss age specific associations and crashes in motor vehicle crashes for the general population.

2.1 Association between age and fatality and/or crash rates in commercial heavy vehicle drivers

To assess age related accident involvement for younger heavy vehicle drivers in USA, Campbell [6] analysed data from the constructed Heavy vehicles Involved in Fatal Accidents (TIFA) database. The TIFA combined data from the National Highway Traffic Safety Administration (NHTSA) Fatal Accident Reporting System (FARS) and accident data from the MCS 50-T report (submitted to FHWA Office of Motor Carriers by interstate carriers). Data were also used from the National Truck Trip Information Survey (NTTIS) to estimate vehicle miles driven. All heavy vehicles with a gross vehicle weight rating greater than 10,000 pounds were included in the study. In 1991 in USA the minimum age for drivers of commercial vehicles engaged in interstate commerce was 21 years, and consideration was being given to lowering this age to 19. The focus of this study was to examine age in relation to accident rate, as well as to other factors associated with increased accident risk (such as time of day, type of heavy vehicle). The results demonstrated that risk estimates of percent accident involvement per percent of travel for drivers of large heavy vehicles continue to be over-involved until the age of 27 years, when the risk generally decreased until the age of 63, after which increases was observed.

When examining fatal accident involvement rates by heavy vehicle driver age groups for days versus night: for driver age group 21-24 years for daytime, Relative Risk (RR) was 1.52, which declined for age 25-29 years (RR: 0.96), a trend which continued till age over 64 years. For night-time driving a "U" shaped association between risk and age was evident where all the reported RRs were greater than 1, however, were highest for 21-24 years (RR: 4.00), 25-29 years (RR: 3.09) and 30-34 years (RR: 2.36); all other reported RRs for older age categories were below RR of 2 until over 64 years (RR: 2.92). The findings of this study support an elevated risk of fatal involvement for younger drivers of large heavy vehicles.

Increased risk associated with accidents/fatalities for younger drivers of heavy vehicles was also supported by McCall [(7)], Häkkänen and Summala [(8)], Braver [(9)], Stein [(10)] and Hamelin [(11)]. Analysing workers compensation data in Oregon, USA for truck accidents between 1990 and 1997, McCall [(7)] found an over-representation of claims related to accidents for heavy vehicle drivers' ≤ 25 years of age: 19.5% of claims for ≤ 25 years while for the same period heavy vehicle drivers 25 years or younger represented only 8.5% of heavy vehicle drivers in Oregon. The majority of claimants were for heavy vehicle drivers' ≤ 35 years of age (51.4%) and had less than one year of job tenure (51%).

In the Finnish study of 1357 multiple vehicle accidents where at least one occupant had died (from the Traffic Safety Committee of Insurance Companies data base*)* Häkkänen and Summala [(8)] found that trailer-truck drivers were principally responsible for 16% of all accidents, and compared to drivers over the age of 50 years, the risk of being responsible for an accident increased by a factor of 3.5 for drivers younger than 30 years of age (OR, p-value: 3.45, 0.04). Likewise, Summala and Mikkola [(12)] using in-depth studies of accidents where at least one occupant had died (586 single vehicles; 1357 multiple vehicles) in Finland among car and truck drivers, found that excluding alcohol, trailer-truck drivers who either fell asleep or were tired to the extent that contributed to the accident were younger than those involved in other types of fatalities (31.9 versus 35.7 years; p=0.043, Mann Whitney U test, p=0.043). This result is further supported by survey (n=1000) findings by Hamelin [(11)] of French lorry drivers' time habits in work and their involvement in traffic accidents. The relative contribution to the global accident risk was higher for "younger drivers" (18-29 years) than "senior drivers" (≥30years). Risk rates reported: for "all hours" for < 30 years: 1.97, ≥3 0years 1.32; for work span duration <11 hours: < 30 years: 1.88, ≥30years: 1.24; for work span duration ≥ 11 hours: 30 years: 2.47,≥30years: 1.76. The higher accident risk rate of younger drivers was thought to reflect lack of driving experience.

In a case-control study of drivers of large heavy vehicles on an interstate system in Washington State USA and crash involvement, data were collected by Commercial Vehicle Enforcement Section (CVES) of the Washington State Patrol [(13)]. Authors reported that when compared to older drivers, younger drivers of large heavy vehicles were over involved in crashes, independent of heavy vehicle configuration, with an adjusted Odds Ratio (OR) and 95% confidence interval (95%CI) for crash involvement for "all truck crashes" for younger drivers≤ 30 years of age of 1.51 (1.20, 1.92) when compared to reference group over drivers over the age of 30 years. An increased risk was also found for "all hours" of driving and younger lorry drivers (< 30 years) of 1.97 compared to lorry drivers 30 years or older with relative risk of 1.32. Braver et al [9] in a cross-sectional study of tractor-trailer drivers (n=1249) in the US found that drivers 33 years or younger had a higher risk of violation of "hours of service" and therefore associated higher risk of accident involvement than older drivers; the risk of being an "hours of service" violator decreased with increasing age.

Using fatality data (N=521 Australia 1989-92; N=210 in New Zealand (NZ) 1985-98; N=4322 in USA 1989-92) Driscoll [14] examined general work-related motor vehicle traffic incidents and fatalities. Drivers of heavy vehicle drivers represented 49% of work-related motor vehicle traffic fatalities in Australia and 37% for NZ and US. Whilst the results pertained to more general work-related traffic fatalities (rate/100,000 person years), the rates for younger workers for 20-24 years and 25-34 years were 1.8 and 2.1, respectively. These rates decreased slightly for ages 35 to 64 years between 1.1 and 1.7, after which age, the rate increased to 3.3 for 65-69 years and for≥ 70 years, to rate of 6/100, 000 person years.

These studies have used accident reports such as accident, fatality or insurance claims data and results support the trend that younger drivers are over-involved in accidents. Kaneko [15] in a study of driving patterns and motor carrier accident risk reported that driver age did not affect accident risk significantly, however drivers with more than ten years experience driving with a firm were significantly safer than drivers who had less driving experience. This suggests that number of years of experience driving trucks is the strong predictor with increasing years of experience associated with decrease in accident risk which is also supported by Hamelin [11].

2.2 Heavy vehicle drivers, fatigue and accidents

Driver fatigue has been identified as a leading contributor to roadway crashes among workers as well as the general population. Fatigue affects driving performance by impairing information processing, attention, and at times reaction times; it may also cause a driver to fall asleep. Time of day, duration of wakefulness, inadequate sleep, sleep disorders, and prolonged work hours have all been identified as major causes of fatigue [16]. A wide range of estimates of the proportions of crashes attributable to fatigue exist in the literature and is related to the varied spectrum of definitions of fatigue and to the different study methodologies used. Despite these variations, driver drowsiness or fatigue has been implicated in fatal crashes: in USA in 2000, 3.1% of crashes were attributable to fatigue or driver sleepiness. However, fatigue was reported for 7.4% of drivers of large heavy vehicles involved in single-vehicle crashes and implicated in only 1.0% of large-heavy vehicle drivers involved in fatal, multiple-vehicle crashes [(17)].

Kanazawa et al., [(18)] Howard[(19)], Maycock [(20)] and Summala and Mikkola [(12)] have found that being a younger driver of a heavy commercial vehicle is associated with a higher risk of excessive sleepiness at work with an expected higher risk of accident involvement. Kanazawa [(18)] conducted a cross-sectional study of commercial long-haul heavy vehicle drivers in Japan (N=1005) assessed burden of driver characteristics (e.g. age) and work factors (e.g. night shifts) on excessive sleepiness at work and sleep quality disturbance and found that compared to 18-29 year olds, with increasing age there was a decrease risk of excessive sleepiness at work and lower associated risk of accidents; with the reference age group18-29 years, OR (95%CI) were 0.9 (0.5-1.6), 0.6 (0.3-0.9) and 0.3 (0.2-0.5) for age groups 30-39, 40-40, ≥ 50 years, respectively. This trend is further supported by results of an interview study of 996 heavy goods vehicle drivers in the UK, which included administration of the Epworth Sleepiness Scale (ESS) and self-report of accident history [(20)] that found the accident frequency was highest for the youngest group of 17 to 29 years and the accident frequency decreased to less than one third of this for drivers over 55 years of age; this result was considered to be the combined effects of age and driving experience. Likewise, in an Australian survey of commercial drivers (N=1687) aged between 16 to 71 years, of sleepiness and self-reported accidents, Howard [(19)] found age to be a strong predictor of accident risk (in the last three years) with increase in age associated with a decrease in risk (OR: 0.86, p=0.03). Results of Summala and Mikkola [(12)] research in Finland using in-depth studies of accidents where at least one occupant had died (N=586 single vehicle; 1357 multiple vehicle) among car and truck drivers found trailer-truck drivers for whom fatigue contributed to the accident were younger than those involved in other types of fatalities (31.9 versus 35.7 years; p=0.043, Mann Whitney U test, p=0.043).

However, studies by McCartt et al. [(21)], Bunn et al. [(22)] and Häkkänen and Summala [(23)] reported older and longer-time drivers to be at higher risk of a fatigue related accident, while Stoohs et al. [(24)] and Adams-Guppy and Guppy [(25)] reported no statistically significant association with age. McCartt et al.[(21)] interviewed long-distance truck drivers using New York state's interstate roadways with ages 21 to 71 years (N=1005) to identify factors associated with falling asleep while driving. Of the six factors identified tendency toward daytime sleepiness, arduous work schedule and being an older, long-time driver were most highly predictive of falling asleep at the wheel. This result was supported by results of a case-control study by Bunn et al. [22] comparing commercial motor vehicle collision (CVC) data for drivers who died (cases), with CVC drivers who survived from state police accident electronic files from 1998-2002. Results showed that with 18-32 years age group as reference, a significant association was found only for those over the age of 51 years (OR, 95%CI: 2.94, 1.08-7.99). In this study sleepiness and fatigue were assessed by the accident investigating officer. However, this study was based on a small number of cases (n=68) although matched to controls 1:4. Häkkänen and Summala [23] surveyed long haul (N=184) and short-haul (N=133) truck drivers in Finland to assess self-reported sleep related problems and "near misses"; 11% reported that they had dozed off at least once in their lifetime and had an accident while working as a result. These were more often long-haul drivers ($p<0.05$), somewhat older ($t_{304}=2.96$, $p<0.01$) and had more professional driving experience ($t_{258}=3.62$, $p<0.001$); no statistical significant model was able to be built due to small number of accident cases reported.

Stoohs et al. [24] investigated possible independent sleep-related breathing disorders on traffic accidents in long haul commercial drivers in the US (N=90) of ages 20 to 64 years. Drivers completed self-report information on demographics, number of accidents over the previous five years and daytime sleepiness, with accident information also obtained from company records; drivers also underwent sleep monitoring during sleep. No statistically significant result for age was found between those drivers with and without reported accidents (37.0 ±8.8 years versus 36.2 ± 8.8 years), rather results showed that drivers who were obese and those with sleep-disordered breathing had two fold higher accident rates than drivers without these factors. Adams-Guppy and Guppy [25] in a multi-centre safety study, surveyed commercial goods drivers (N=640, response rate 53%) and their managers (116, response rate 27%) within a series of related companies across 17 countries. The study used self reported data on driver characteristics, fatigue and near miss and accident experience; no statistically significant association was found for age of driver and experience of fatigue.

Experimental studies using simulated driving tests to assess effects of sleep found that: younger drivers were more likely to decrease alertness level during the period of driving and, found it more difficult to drive in low traffic conditions than middle-aged drivers [26]. When deprived of sleep, the younger were more likely to have increased or slowed reaction times; older drivers already had slower reaction times at baseline, and these remained relatively unchanged (Philip et al., 2004). Other research has been conducted to identify factors implicated in fatigue-related accidents, for which age-related effects have not been reported, such as obesity [24, 27], inadequate sleep prior to driving schedule and sleep debt [28-31] and balance of work and rest at appropriate times [32]. The majority of cross-sectional studies discussed used self-report measures of sleepiness, fatigue and accidents to predict expected accident risk, with only two studies using accident databases to identify accidents. Whilst an abundance of literature is available on fatigue and accident risk, limited research is available that reports strong evidence of age-related fatigue and accident risk in heavy truck drivers.

2.3 Other contributing factors

Safety practices

There is consensus in the literature that fatigue experienced while driving is a common determinant of 'near misses' and crashes. Driver fatigue is in turn considered to be a result of a broad spectrum of factors, including some inherent to the function of driving work and others more related to company safety practices. Supportive safety policies in the heavy vehicle industry are needed to ensure the safety of heavy vehicle drivers. Such policies would include limiting unsafe driver behaviour like driving at night, especially between midnight and 6am, minimising fatigue inducing activities such as loading and unloading, and setting reasonable expected delivery times, reducing 'late' penalties and providing reasonable pay for duty [33].

There are often strong economic pressures to minimise the time allotted to loading and unloading heavy vehicles by shippers and receivers. Often drivers will feel an incentive to assist with these duties if it is perceived that they will get back on the road faster. The effects of driver involvement in loading/unloading are mixed: initially alertness may be improved but these effects wear of quickly and contribute to a decreased driving performance, especially after 12 hours on duty [34]. Studies have shown that it is difficult to estimate the extent to which drivers are likely to experience work overload because many drivers frequently exceed the legal driving limits [9]. Drivers who drive more miles are more likely to violate regulations, drive while drowsy [21], and have an increased risk of crashing [35].

Morrow and Crum [34] surveyed commercial heavy vehicle drivers across 116 trucking firms (N=116 drivers) to explore the relationship between fatigue inducing factors and company safety practices with 'near misses' and crashes. Their findings indicated that the development of a strong company safety culture, company assistance with fatigue-inducing activities such as loading/unloading, had considerable potential to offset fatigue-inducing factors associated with heavy vehicle driving work. Naveh and Marcus

[36] similarly in a study of all U.S. motor carriers with large heavy vehicles to assess safety performance at the system or management level and accidents of large heavy vehicles found that safety performance of certified carriers was significantly better after certification than before, and it also was significantly better that that of non-certified carriers.

Heavy vehicle configuration

Heavy vehicles with multiple trailer combinations have demonstrated certain handling problems more commonly than single-trailer combinations. These handling problems include trailer sway (tendency of the trailers to sway sideways by 4-6 inches or more), rearward amplification (tendency of rapid steering movements to be heightened toward the rear of the vehicle, which can increase risk of roll-over or lane encroachment), off-tracking (movement out of lane of travel that occurs when the rear trailer wheels do not follow the path of the tractor front wheels), and slowed acceleration on grades [37, 38].

In a case-control conducted by Stein and Jones [13] in the US, double trailer-heavy vehicles were found to be over-involved in crashes regardless of driver age, hours of driving, cargo weight, or type of fleet. The study was conducted over a two-year period and investigated heavy vehicles, greater than 10,000 pounds weight, involved in crashes occurring on interstate road systems. Heavy vehicle configurations included were: rigid truck, tractor only (bob-tail), tractor with trailer, rigid truck with trailer, heavy vehicle-trailer, Western Double (tractor pulling two 28 foot trailers) and Rocky Mountain double (tractor pulling a 48 foot or longer trailer as well as a 28 foot trailer). While double combinations were over-involved in all crashes, empty doubles were more involved than partially or fully loaded doubles. When examining the effect of daytime/night-time crashes as a function of vehicle configuration, doubles were over-involved in crashes compared to tractor-trailers, however for all configurations, night-time involvement ratios were generally lower than daytime ratios.

In a study of heavy vehicle with trailers in Michigan, USA, by Blower et al. [39], accident rates for three tractor configurations were examined: a tractor with no trailer, a tractor with a single trailer and a tractor with two trailers (doubles). The accident data were drawn from Michigan State Police accident files and were not limited to interstate system crashes as in the study by Stein [13]. Results of this study found that doubles posed an approximate 10% increased risk than singles for a casualty accident. Using a log-linear model, Blower et al., concluded that after adjusting for type of road, doubles had no increased risk of involvement in injury and property damage. However, doubles driving on non-major roads had an injury risk ratio of 1.32 relative to single-trailer configuration. Neither type of carrier, driver variables, weather, nor road surface condition was adjusted for in the analysis. The tractor configuration for which there were substantial differences in relative risk was the bob-tail; the bob-tail configuration was found to be much less safe than singles or doubles. Using similar methodology, Campbell et al. [10] estimated relative risks for fatal crashes of multiple-trailer heavy vehicles using two University of Michigan Transportation Research Unit databases: Trucks involved in Fatal Accidents (TIFA) and the National Truck Trip Information Survey (NTTIS). After adjusting for type of roadway, time of day, and urban/rural location, the fatal crash rates of multiple-trailer configurations during the period 1980-1984 were only 1.1 times those of single-trailer heavy vehicles. The authors expressed a limitation of their study was that fatal crash rates of doubles during 1980-1984 may have been underestimated by using 1985-1986 travel data because miles travelled by doubles increased rapidly after 1982.

Braver et al. [37] using a case control design, investigated the role of heavy vehicle configuration in tractor-trailer crashes in Indiana, USA. This study investigated tractor-trailer crashes on interstate highways for the period 1989 to 1991, using methods similar to that used by Stein (1988). Controls were obtained for 25% of the crash sites and were all tractor-trailers passing the respective crash sites one to four weeks following the crash on the same day of the week, within 30 minutes at the same time of day. For all crashes combined, no increased crash risk was observed for doubles however over-involvement was reported for crashes on roads with conditions of snow, ice or slush. The mean age of drivers of tractor-trailers involved in crashes was significantly higher for double-trailers compared with single-trailer heavy vehicles: 45 versus 39 years; incomplete data for age was obtained for control drivers. In this study 1% of double-trailer drivers and 12% of single trailer drivers in crashes were under the age of 27. Compared with single-trailer drivers, double-trailer drivers were significantly less likely to be given a traffic citation related to the crash (OR: 0.29, 95%CI: 0.11, 0.81). Dissimilarity between this study and that of Stein (1988) was that the median and mean age of drivers of double-trailers and single-trailer heavy vehicles in Washington crashes were much closer together than that observed in this study. Amongst drivers in crashes, the proportions under 27 years were 15% of Washington double-trailer drivers, 1% of Indiana double-trailer drivers, and 12% of both Washington and Indiana single-trailer drivers. Drivers of doubles in crashes in Washington had the same likelihood as drivers of single-trailer heavy vehicles in crashes of being given a traffic citation for the particular crash. This contrasted the result found by Braver [37] in Indiana where drivers of single-trailer heavy vehicles were more than three times as likely to be cited for the crash as double-trailer drivers. Importantly, the majority of double-trailer heavy vehicles in crashes were from carriers with fleets greater than 250 in number, the fleet size group that had the lowest risk for crashing in the Washington state study [13]. Carriers with fleets greater than 250 tend to have better safety practices [37].

Other than the results found in the Stein (1988) study, results would tend to suggest no significant increased risk of multiple trailer heavy vehicles in crashes in USA. Interstate highways are usually road systems of better design. The literature suggests a disproportionate number of tractor-trailer crashes occur on entrances and exits to highways/freeways [40]. Longer heavy vehicle configurations may be at higher risk of crash involvement than single-trailer heavy vehicles when merging into traffic at entrance ramps or when steering to turn onto exit ramps [38]. The type and condition of the roads and road systems used are significant factors in accident risk of drivers of heavy trucks. Age is associated with truck configuration: younger drivers tend to drive single-trailer heavy vehicles rather than multiple trailer heavy vehicles [37]. In Australia, a driver does not qualify for a licence to drive multiple trailer combinations until he has held a single trailer licence for at least one year. To qualify for a single trailer licence a driver must have had a drivers licence for at least three years.

Rural or urban routes

Authors of studies of heavy vehicle involvement in crashes conducted in the USA have clearly stated that interstate roadways are safer and better designed road systems [37, 39]: two lane, dual carriage road systems, no cross-road intersections. Analyses of traffic accident data from these types of road systems reflect lower accident risk than other intrastate road systems. As stated by Summala and Mikkola [12], the main highway road systems in Finland have sections where cross-road intersections exist, similar to Australian interstate highway road systems. Urban areas have higher traffic densities, but they generally have lower operating speeds; lower speeds doubtlessly contribute to a lower probability of injury or death given an accident. Urban areas have lower accident rates than rural areas [39]. The lower speeds may also contribute to fewer accidents overall. Blower et al. [39] found that the casualty accident risk for heavy vehicle-tractors in rural areas was 1.6 times that of urban areas.

Mitchell, Driscoll and Healey [41] analysing data from the Australian Transport Safety Bureau (ATSB) for 543 workers fatally injured in work-related road fatality incidents for the period 1989-1992, found that fatal incidents occurred on all road types, with smaller roads in urban and rural areas, national highways in rural areas and state highways having the largest numbers of deaths. Prime movers were the most common vehicle involved in work-related fatal deaths on both national (56.7%) and state highways (40.6%) and other rural roads (35.6%). Rigid heavy vehicles were found to be almost equally involved in either non-vehicular collisions on a curve in the roadway (21.3%), crashes with vehicles from an opposing direction (19.7%), or non-vehicular collisions on a straight stretch of road (18.0%). Prime movers were commonly involved in non-vehicular collisions on a curve in the roadway (28.8%), in crashes with vehicle from an opposing direction (20.1%) and in non-vehicular collisions on a straight stretch of roadway (16.8%).

Analysing 4-year accident data in California, USA, Khorashadi et al. [(42)] accidents involving heavy vehicles that occurred at an intersection in a rural area resulted in 725% increase in the likelihood of severe/fatal injury (compared to all other highway locations) whereas accidents in urban areas resulted in a 10.3% decrease in the likelihood of a severe/fatal injury. The presence of concrete median barriers in rural areas reduced the likelihood of severe/fatal injury by 68.7%, and driving in the left lane (equivalent to driving in the right lane in Australia) increased the likelihood of a severe/fatal injury by 268.1% in rural areas. The authors concluded that the significant differences between urban and rural areas exist and that complex interactions between driver behaviour and factors such as environment, geometrics, play a significant role in driver-injury severity. Results of other work by Lee and Mannering [(43)] also support that accident severities vary significantly between rural and urban areas.

2.4 Age specific associations and motor vehicle accidents in the general population

When general population crash or involvement data are analysed in terms of crashes or involvement rate per distance travelled, a characteristic "U" shaped curve results indicating the higher risk for both younger (≤ 25 years) and older (≥ 65 years) drivers [(44-48)]. When crash rates are examined for crash injury severity, older drivers are over-represented in crashes of high severity; older drivers have a greater susceptibility to injury due to their physical fragility and the nature of the impact/collision they are typically involved [(45, 48-50)]. With ageing it is normal to have age-related declines in functional (cognitive, physical, sensory) abilities [(3)] and an increased likelihood of diagnoses of medical conditions that may impair driving skills [(51, 52)]. However it is important to acknowledge that people "age" at different rates and as it is inappropriate to generalise risk taking behaviours to all young drivers, it is also inappropriate to make generalisations of all drivers over the age of 65 years. However, results do indicate that older drivers ≱ 65 years) in the general population are at a higher risk of crash, particularly in collisions at intersections, crossing traffic and failing to give way.

The extent to which general population statistics of younger and older non-professional drivers are translatable to the younger and older commercial heavy vehicle driver is questionable. The statistics of younger drivers more often reflect driving during leisure time settings and it would be expected that younger commercial drivers may well have a more responsible approach to their work-related driving tasks. Likewise, the literature shows that the non-professional older driver≥(65 years) imposes self -restricted distance on driving and it would be expected that significant differences in driving skills set and behaviour would exist between the older non professional automobile driver and the commercial heavy vehicle driver.

2.5 Literature review discussion

Whilst limited data on age-related accident risk for heavy vehicle drivers are reported in peer-reviewed literature for the spectrum of age from less than 27 years to over 60 years of age, the strongest evidence was provided from studies using accident, fatality or insurance claim data. These studies demonstrated that younger drivers did carry an increased risk of crash involvement as did drivers aged 63 to 68 years. Results of the study of fatal accident involvement rates by driver age for large trucks by Campbell (6) showed that younger drivers were over-involved till the age of 27 years; involvement rates for truck configuration, night-time versus daytime driving, and road systems (intrastate versus interstate) demonstrated over-involvement for younger drivers. The night-time driving risk was elevated for drivers till the age of 35 years, at which the risk declined and remained steady till the age of approximately 63 years where risk of involvement increased.

Increased risk of accidents and fatalities for younger drivers of trucks was also supported by McCall and Horwitz (7), Häkkänen and Summala (8), Braver et al. (9), Stein and Jones (13) and Hamelin (11) and Summala and Mikkola (12). McCall and Horwitz (7) found an over-representation of insurance claims related to accidents for truck drivers' ≤ 25 years of age of 19.5% of claims while for the same period truck drivers 25 years or younger represented only 8.5% of truck drivers in Oregon; the majority of claimants were truck drivers under the age of 35 years (51.4%). Häkkänen and Summala (8) found that of trailer-truck drivers in Finland the risk of being responsible for an accident increased by a factor of 3.5 for drivers younger than 30 years of age (OR, p-value: 3.45, 0.04). Likewise, Summala and Mikkola (12) in a study of accidents where at least one occupant had died, found that for trailer-truck drivers who either fell asleep or were tired to the extent that it contributed to an accident were younger than those involved in other types of fatalities (31.9 versus 35.7 years; p=0.043, Mann Whitney U test, p=0.043).

These results also supported by Hamelin [11] where for French lorry drivers' the relative contribution to the global accident risk was higher for "younger drivers" (18-29 years) than "senior drivers" (≥30years) with risk rates reported for driving "all hours" for < 30 years to be 1.97 and for ≥30 years, 1.32. The high risk rate of younger drivers was suggested to reflect lack of driving experience, which is also supported by Kaneko and Jovanis [35]. Over involvement in crashes of younger drivers of large heavy vehicles was also reported by Stein and Jones [13] with risk measure OR and 95%CI for "all truck crashes" for younger drivers ≤ 30 years of age of 1.51 (1.20, 1.92) compared to referent group of drivers over the age of 30. Braver et al. [9] also reported that drivers 33 years or younger had a higher risk of work time violation and therefore associated higher risk of accident involvement than older drivers; the risk of being an "hours of service" violator decreased with increasing age. Whilst Driscoll [14] examined more general work-related motor vehicle traffic incidents for which truck drivers had a high rate of death (49% death in Australia, and 37% in US and NZ) work-related traffic fatalities (rate/100,000 person years) were recorded for both younger and older age groups: younger workers for 20-24 years and 25-34 years were 1.8 and 2.1, respectively, these rates decreased slightly and tended to plateau until the age of 65 years after which steep inclines were reported (3.3 for 65-69 years, 6.0 for ≥ 70 years). Whilst limited information is reported for accident risk of drivers older than 60 years, the evidence supports that younger drivers of heavy vehicles are over-involved in accidents.

Generally there is an association between age and truck configuration whereby younger drivers more predominantly drive single rather than multiple trailer heavy vehicles [9]. Given that heavy vehicles with multiple trailer combinations have more commonly demonstrated particular control problems than single-trailer combinations, this would appear to support staging the issue of drivers licences for heavy vehicles whereby drivers are restricted to upgrading their licence to multiple trailer combinations until they have held lower grade licences for a number of years.

Age-related effects of fatigue and predicted accident risk are not consistent. Many studies use self-reported sleep and accident involvement data, and others use level of sleepiness to predict expected level of accident risk; these studies can be prone to recall bias and do not have objective accident data. The evidence from larger fatigue studies supports that younger drivers (<27 years) are at increased risk of fatigue and accident risk which decreases with increase in age (18, 19) Maycock 1997; (12). Studies presented that did not report an association between fatigue and accident risk and age used small sample sizes and obtained data through self-report. Performance testing suggests that the alertness of younger drivers decreases during the period of driving and that they find it more difficult to drive in low traffic conditions (e.g. low traffic long distance driving); younger drivers may be better suited to shorter urban driving than long distance haulage. A vast number of studies have focused on fatigue and accident risk and have identified other factors such as sleep debt, sleep disorders, work scheduling, company safety practices and obesity that contribute significantly to accident risk, independent of age (24, 27-31)

The heavy vehicle industry in Australia plays an important role in the transportation of goods both intra- and interstate. Long distance heavy vehicle drivers face a significant risk of being injured or killed in a single vehicle or multiple vehicle crash. Further, collisions between articulated heavy vehicles and other vehicles (predominantly cars) as well as incidents involving passengers in heavy vehicles, pedestrians and bystanders means that heavy vehicle drivers are not the only casualties. Most persons killed in fatal incidents involving heavy vehicles are not heavy vehicle drivers but members of the public, adding a serious public safety dimension to considerations about the safety performance of the long distance road transport industry (53). Despite who is at fault, the consequences of a crash involvement with a heavy vehicle are usually grave as a result of the impact with the heavy weight of the heavy vehicle (17, 54).

2.6 Literature review conclusion

Whilst a vast volume of literature is available on truck accidents and contributing factors such as age, fatigue, truck configuration, urban or rural travel, distance travelled, there is an under-reporting of results for age-specific accident rates that include drivers younger than 27 years of age and those older than 60 years of age. From the limited number of studies for which age specific accident rates were reported for the spectrum of driver age from younger than 27 up to 60 years of age, younger drivers of heavy vehicles demonstrated higher rates of accident/fatality involvement which tend to steadily decline and plateau until the age of 63 years where increased rates are again observed. More detailed analyses of accident risk, including “at-fault” involvement and inability to avert an accident (indicator of the effect of less driving experience), and other factors that contribute to accidents across the full spectrum of age of heavy vehicle drivers involved in collisions may give further clarification to the degree of safety of both younger and older commercial heavy vehicle drivers.

3 Project Aim and Objectives

3.1 Aim

The aim of this project is to provide empirical evidence to the Transport Workers Union, New South Wales WorkCover and national transport companies to assist in answering the question:

Are the recommendations of the Australian Government to diversify the working population to include more older workers (> 65 years) desirable or appropriate to the Australian transport industry, particularly heavy vehicle drivers, and if not would it be appropriate for the Transport Workers Union to encourage the employment of younger drivers (< 26 years) without this endangering workplace and road safety?

3.2 Objectives

The objectives of the study are to:

1. Compare accident rates of younger and older heavy vehicle drivers relative to middle age drivers using data from the New South Wales Roads and Traffic Authority and the Australian Bureau of Statistics.
2. To test for an interaction between vehicle type and controller age group for various other factors which may contribute to accident causation, e.g. time of day, weather conditions road service, speeding and fatigue.

3.3 Expected benefits/outcomes

The expected outcome from this research is that the TWU will have access to empirical data that will have the capacity to demonstrate to insurance companies, industry and the wider community the effect of age on driver performance and safety.

In addition, the research is expected to have a number of impact outcomes in the workplace. These are:

1. Allow the TWU and various other bodies to formulate their strategies for meeting the looming shortage of skilled professional heavy vehicle drivers in Australia based on evidence rather the data from recreational driving.
2. If the evidence from the study suggests that recruiting younger drivers into the industry is appropriate the evidence will allow the TWU to lobby those bodies whose policies create the glass floor currently in place restricting younger drivers entering the industry.

4 Methods

4.1 Study design

In Australia all road and traffic accidents which involve the towing away of a damaged vehicle, an accident where a person has required medical attention or an accident which has resulted in a fatality are reported to police.

In NSW Police reports are subsequently forwarded to the Road Safety Statistics Unit of the Roads and Traffic Authority where information from the reports is coded in accordance with the “Traffic Accident Database System” Coding Manual.”

This study utilised a retrospective cohort study design to analyse all accidents involving heavy vehicles reported in the New South Wales Roads and Traffic Authority Accident Database between 1999 and 2006. To calculate the rate of accident involvement the numerator was involvement in an accident and the denominator was the number of kilometres travelled each year as estimated by the Australian Bureau of Statistics Survey of Motor Vehicle Use.[55]

4.2 Study population

The study population consists of all vehicle controllers in New South Wales who had an accident that involved a heavy vehicle between 1999 and 2006. Driver age is categorised into the age groups 18-20, 21-25, 26-34, 35-44, 45-54, 55-64 and 65-98.

4.3 NSW Roads and Traffic Authority Traffic Accident Dataset

All accidents involving heavy vehicles were extracted from the New South Wales Roads and Traffic Authority (RTA) Traffic Accident database for the period 1999 to 2006 for analysis. This dataset included all accidents where a heavy vehicle involved. Where the accident involved more than one vehicle, multiple observations were present for an accident. Table 2 lists the data variables extracted from the database.

Table 2: Variables used from the New South Wales Roads and Traffic Authority database

Analysis factor	Coding of variable
Event number	eventNO
Traffic unit number	Tuno 01 key vehicle in the accident 02 other vehicle in the accident
Date of birth of controller	tuDOB dd/mm/yyyy

Analysis factor	Coding of variable
Gender of controller	tuSEX 01 male 02 female 09 unknown
Vehicle type	tuTYPEG 01 cars 02 light trucks 03 heavy rigid trucks 04 articulated trucks 05 buses 06 emergency vehicles 07 other motor vehicles 08 motorcycles 09 pedal cycles 10 non-motorised vehicles 11 pedestrians 12 other traffic units or unknown
Stated vehicle speed	TuSPEED 0 to 180 900 speed not stated but described by police as excessive 999 = unknown/not stated
Speeding controller	TuEXSPD 01 yes 02 no or unknown
Speed limit	accSPEED speed limit applicable at location of accident
Equipment failure	TuEQUIP 20 brake failure or fault 21 steering failure or fault 22 tyre failure or fault 23 tyre tread smooth 24 wheel, axle or suspension failure or fault 25 towing or coupling fault or separation 26 headlamp failure or fault 27 rear lamp or clearance lamp failure or fault 28 vehicle with insecure or projecting load 29 vehicle overload 97 other vehicle equipment failure 98 no relevant equipment failure

Analysis factor	Coding of variable
Distraction a factor	tuDISTR 01 controller with physical infirmity or chronic illness 02 controller with sudden illness 03 controller asleep, drowsy or fatigued 04 controller districted or vision obscured by passenger (including passengers interfering with controls 05 controlled distracted or vision obscured by something inside vehicle 06 controlled distracted or vision obscured by something outside vehicle 07 controller being pursued by police 08 emergency vehicle sounding warning within earshot 09 controller using hand-held telephone 97 other distraction a factor 98 no distraction
Error a factor	tuERRFAC Unusual Manoeuvre 10 controller error in manipulation of controls 11 controller swerving to avoid another vehicle 12 controller swerving to avoid object 13 controller swerving to avoid animal 14 controller swerving for any other reason 15 controller overtaking on left 16 controller overtaking on right 17 controller turning right from wrong lane 18 controller turning left from wrong lane 19 controller disobeying traffic controls 20 controller breaking hard 21 described as driving at excessive speed 22 controller jumping/falling from vehicle 23 described as loss of control Other 19 pedestrian disobeying traffic controls 30 passenger jumping/falling from vehicle 31 controller/passenger protruding from vehicle 40 pedestrian from behind parked or stationary vehicle 41 pedestrian from behind other object 42 pedestrian under influence of alcohol or other drug 43 pedestrian confused or indecisive 44 child pedestrian breaking free from supervisor 45 pedestrian falling, tripping, jumping into path 97 other error a factor 98 no error at the
Driver fatigued	tuFATIG 01 = yes 02 = no or unknown

Analysis factor	Coding of variable
Severity of accident	accDEG3 01 fatal 02 Injury 03 non-casualty(tow away)
Date of accident	accDATE dd/mm/yyyy
Time of day	accHOUR1 24 hour time recorded
Alcohol group of controller	accbacg 01 illegal 02 legal 9 unknown
Speed limit of area	accSPEED speed limit of area recorded 999 unknown
Area where accident occurred	accURBAN 01 Sydney metropolitan area 02 Newcastle metropolitan area 03 Wollongong metropolitan area 04 Country urban areas 05 Country non-urban areas 06 Country unknown
Road classification	accROAD 01 freeway or motorway 02 state highway 03 other classified road 04 unclassified road
Road surface conditions	accSFCND 03 wet 04 dry 05 snow or ice 09 unknown/not stated
Hazardous road surface	accHAZ 01 loose gravel on sealed road 02 loose gravel on shoulder 03 pot holes, corrugations, other rough surface 04 slippery surface 05 flooded or submerged 97 other 98 no identifiable hazardous feature

Analysis factor	Coding of variable
Temporary feature at the location that was a factor in the accident	accTEMP 01 roadworks, detour, deviation 02 previous accident 03 roadblock, random breath testing, radar 04 thick raised dust 05 other temporary feature 98 no identifiable temporary feature
Weather conditions at time of accident	AccWTHR 01 fine 02 raining 03 overcast 04 fog or mist 05 snowing or sleeting 06 other 09 unknown/not stated

4.4 Motor vehicle usage

To enable a calculation of a risk rate a measure of risk is required. Measures that could be used include number of licence holders, number of registered vehicles by type and number of kilometres travelled. All have a variety of weaknesses; number of licence holders for a study such as those investigating heavy vehicle accidents would be biased as my drivers hold licences other than C class and never drive a heavy vehicle because the highest attained level remains whilst ever they are licensed. Number of licence holders would therefore be great than those who actually drive that type of vehicle routinely and therefore be at risk.

The number of registered vehicles by type is problematic because the age of the registered owner does not always reflect the age of the vehicle driver. Many vehicles have either multiple drivers or as in the case of heavy vehicles and vehicles used for business use, the owner is a company rather than a person.

The total kilometres travelled by vehicle type and age of the driver is routine collected by the Australian Bureau of Statistics (ABS) in the Survey of Motor Vehicle Use (SMVU). The quarterly surveys are of a stratified sample of registered owners each year. The scope of the survey comprises all vehicles that were registered with a motor vehicle authority for road use at some stage during the twelve months ended 31 October each surveyed year. The surveys do not include caravans, trailers, tractors, plant and equipment, vehicles belonging to the defence services and vehicles with diplomatic or consular plates. Where they are registered as such, vintage and veteran cars are also excluded from the surveys. For the 2006 SMVU, a stratified sample of 16,000 vehicles was selected to report on vehicle use over a three-month period within the reference year of 1 November 2005 to 31 October 2006. Of these, 24.8% were passenger vehicles and motor cycles, 62.1% were freight vehicles, 9.9% were buses and 3.3% were non-freight carrying vehicles. The sample size was chosen to give a suitable level of precision for estimates of total distance travelled and tonne-kilometres for each state/territory of registration by type of vehicle category.[1] (55)

The SMVU data is the most appropriate determination of a period at risk of having an accident; therefore this was used as the denominator in calculating the accident rates. Kilometres travelled by year, age and gender of driver and vehicle type for New South Wales was provided to the researchers by the ABS. The driver age groups are: 0 – 15 years, 16 – 17 years, 18 – 20 years, 21 – 25 years, 26 – 34 years, 35 – 44 years, 45 – 54 years, 55 – 64 years, and 65 – 98 years The vehicle types are: passenger vehicles, light commercial vehicles, rigid trucks, articulated trucks, non-freight carrying trucks and motor cycles.

4.5 Vehicle types

Vehicle types were categorised as passenger and light commercial vehicles, rigid trucks articulated trucks or all other types.

1. Passenger vehicle, implement and light commercial vehicles were defined as motor vehicles no more than 4.5 tonnes GVM and included cars, station wagons, utilities, panel vans, passenger vans, 4 wheel drives, cab-chassis, small goods carrying vans and light truck. To operate these vehicle types a driver is required to hold a C class licence. (For further information relating to licence requirements see Figure 3 on page 25)
2. Rigid trucks were defined as any motor vehicle exceeding 4.5 tonnes GVM constructed with a load carrying area and included light rigid, medium rigid and heavy rigid trucks. To operate these vehicle types a driver is required to hold a LR, MR or HR class licence dependent on the weight and configuration of the vehicle.

[1] Further information relating to survey methodology is available in the yearly report's explanatory and technical notes.

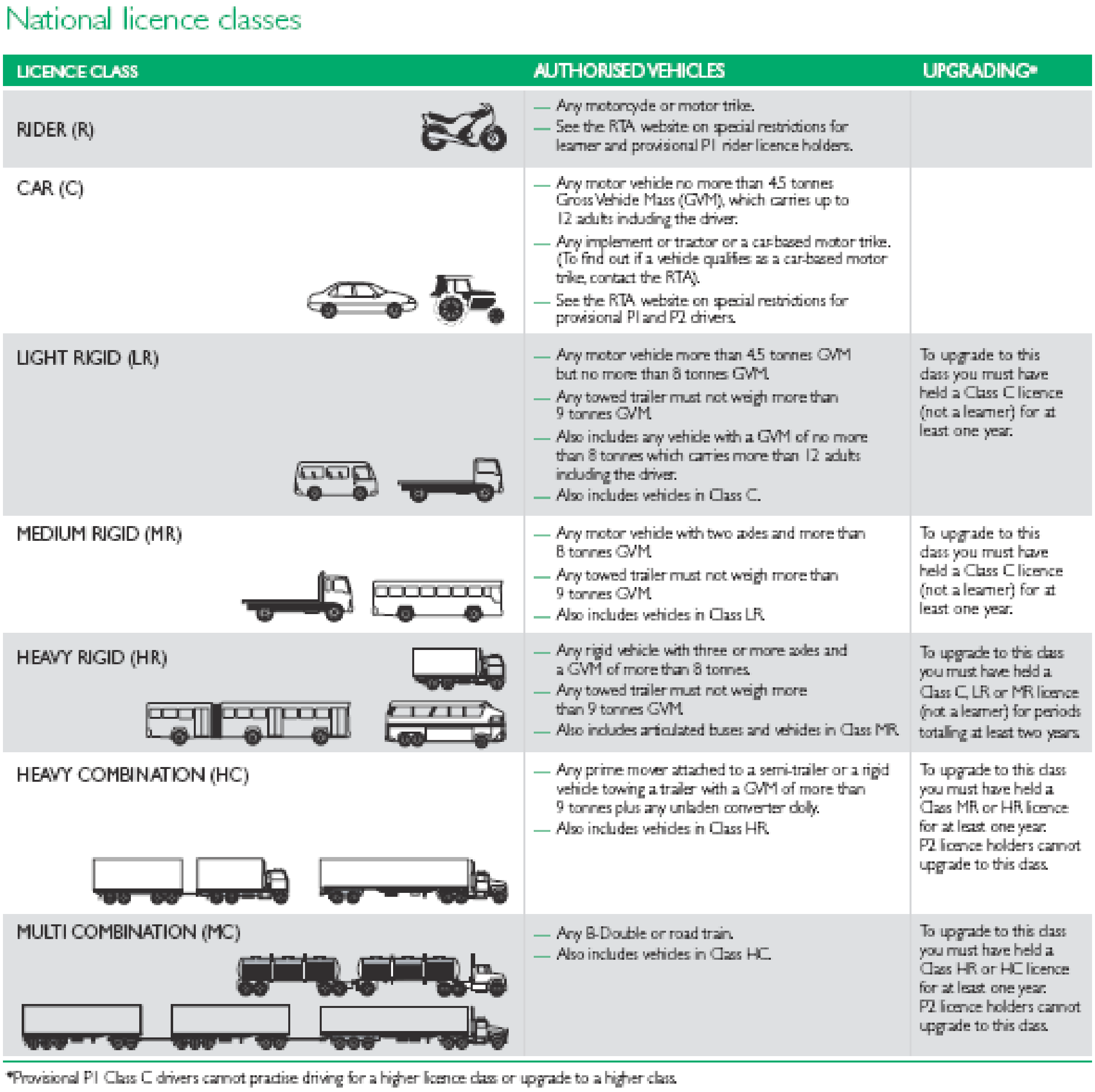
3. Articulated trucks were defined as a motor vehicle constructed primarily for load carrying, consisting of a prime mover which has no significant load carrying area, but with a turntable device which is linked to a semi trailer. This includes any heavy or multiple combination vehicles (road train, B double) which require a driver to hold a HC of MC licence to operate.
4. All other types of vehicles. This included: non-freight carrying vehicles, taxis, busses, motor cycles, fire-brigade, ambulance and police vehicles..

Classification of motor vehicle drivers' licences

Motor Vehicle Drivers Licences in Australia (see Figure 3 below) are classified nationally and based on experience and a graded progression from:

1. Car Licence (C)
2. Light Rigid (LR)
3. Medium Rigid (MR)
4. Heavy Rigid (HR)
5. Heavy Combination (HC)
6. Multi Combination (MC)

Upgrading criteria for each licence class is provided in Figure 3.



National licence classes

LICENCE CLASS	AUTHORISED VEHICLES	UPGRADING*
RIDER (R)	— Any motorcycle or motor trike. — See the RTA website on special restrictions for learner and provisional P1 rider licence holders.	
CAR (C)	— Any motor vehicle no more than 4.5 tonnes Gross Vehicle Mass (GVM), which carries up to 12 adults including the driver. — Any implement or tractor or a car-based motor trike. (To find out if a vehicle qualifies as a car-based motor trike, contact the RTA). — See the RTA website on special restrictions for provisional P1 and P2 drivers.	
LIGHT RIGID (LR)	— Any motor vehicle more than 4.5 tonnes GVM but no more than 8 tonnes GVM. — Any towed trailer must not weigh more than 9 tonnes GVM. — Also includes any vehicle with a GVM of no more than 8 tonnes which carries more than 12 adults including the driver. — Also includes vehicles in Class C.	To upgrade to this class you must have held a Class C licence (not a learner) for at least one year.
MEDIUM RIGID (MR)	— Any motor vehicle with two axles and more than 8 tonnes GVM. — Any towed trailer must not weigh more than 9 tonnes GVM. — Also includes vehicles in Class LR.	To upgrade to this class you must have held a Class C licence (not a learner) for at least one year.
HEAVY RIGID (HR)	— Any rigid vehicle with three or more axles and a GVM of more than 8 tonnes. — Any towed trailer must not weigh more than 9 tonnes GVM. — Also includes articulated buses and vehicles in Class MR.	To upgrade to this class you must have held a Class C, LR or MR licence (not a learner) for periods totalling at least two years.
HEAVY COMBINATION (HC)	— Any prime mover attached to a semi-trailer or a rigid vehicle towing a trailer with a GVM of more than 9 tonnes plus any unladen converter dolly. — Also includes vehicles in Class HR.	To upgrade to this class you must have held a Class MR or HR licence for at least one year. P2 licence holders cannot upgrade to this class.
MULTI COMBINATION (MC)	— Any B-Double or road train. — Also includes vehicles in Class HC.	To upgrade to this class you must have held a Class HR or HC licence for at least one year. P2 licence holders cannot upgrade to this class.

*Provisional P1 Class C drivers cannot practise driving for a higher licence class or upgrade to a higher class.

Figure 3: National licence classes

4.6 Inclusion and exclusion criteria

Involvement in an accident was determined as having been recorded in the New South Wales Roads and Traffic Authority Traffic Accident dataset. To be included in the analysis an accident needed to meet the following inclusion criteria:

1. The vehicle was towed away, or an injury or fatality occurred
2. Accident recorded between 1999 and 2006
3. Age and gender of the vehicle controller was known
4. Licensed vehicle controller was aged 18 or over

Observations were excluded from the dataset if they met the following exclusion criteria:

1. vehicle types was a: taxi, motorised wheelchair, tractor, bicycle, train, pedestrian, pedal car and where the vehicle type was unspecified
2. the key vehicle in the accident was unoccupied
3. Accident involved a stolen motor vehicle
4. Accident error factor was identified as relating to a pedestrian
5. Accident error factor was identified as relating to an animal
6. Accident error factor was identified as relating to an object being thrown at vehicle

4.7 Creating the analysis dataset

The RTA dataset also contained the information listed below relating to accidents which in some cases were re-categorised to the following:

1. Event number
2. Traffic unit number; variable created to identify key (at fault) vehicle in accident
3. Age of vehicle controller (recoded to age categories of 0 – 15 years, 16 – 17 years, 18 – 20 years, 21 – 25 years, 26 – 34 years, 35 – 44 years, 45 – 54 years, 55 – 64 years, and 65 – 98 years); variable created from date of birth of controller
4. Vehicle type categories were passenger vehicle and light commercials, heavy rigid trucks, articulated trucks and all other; variable created group and vehicle type
5. Severity of accident; fatal accident, injury accident and tow away only
6. Year of accident (recoded from date of accident)
7. Time of accident (recoded to 7am to 7pm or 7pm to 7am)
8. Weather conditions i.e. fine, raining, overcast, fog/mist, snowing/sleeting, other (recoded to fine or poor)
9. Road surface conditions i.e. wet, snow/ice, dry (recoded to dry or not dry)
10. Natural lighting i.e. daylight, dawn, dusk, darkness (recoded to daylight or dark)
11. Speed limit area (recoded to <100klm/hr or >100klm/hr)

12. Speed excessive (not excessive, excessive or unknown)
13. Urbanisation (recoded to metropolitan or country area)
14. Age of vehicle (recoded to <10 or >10 years)
15. Hazardous road surface features identified i.e. loose gravel on road or shoulder, pot holes, corrugations, rough surfaces, oily/greasy surface, flooded or submerged (recoded to hazard present or no hazard present)
16. Equipment failure i.e. brakes, steering, tyre, wheel, towing or coupling fault, headlamp, overloaded (recoded to equipment failure or no equipment failure)
17. Fatigue (fatigued or not fatigued)
18. Alcohol involved in the accident (yes or no)
19. Driver took alcohol (yes or no)

4.8 Statistical analysis

All analysis was done using SAS(56) and Stata(57) statistical software. The following analysis was undertaken:

1. A descriptive analysis was undertaken tabulating number of events by key vehicle type and controller age group together.
2. Annual accident incidence rates were modelled using Poisson regression with the explanatory variables of vehicle type and age group of the controller. The interaction of these two variables was included to allow the model to estimate the accident rate for each age and vehicle type combination. In addition mileage travelled was used as the exposure variable.
3. Accident factors were modelled using linear, logistic, or multinomial logistic regression containing the interaction term for vehicle type and controller age group to test whether the interaction is significantly at the 0.05 level. If it is significant then we are unable to reject the null hypothesis that the age has the same effect on the accident factor regardless of vehicle type.

5 Results

A total of 26,146 accidents occurred in New South Wales between 1st January, 1999 and 30th December 2006 which involved a light commercial vehicle, a rigid truck or an articulated truck. A total of 54,191 traffic units (which includes motor vehicles, motor cycles, powered plant, bicycles, pedestrians, pedal cars and horse drawn vehicle) were involved in these accidents. 13,451 observations did not meet the inclusion criteria for the study and were excluded from the analysis leaving 40,740 observations representing 20,401 accidents.

5.1 Demographic factors

In this section results will be reported information relating to the 20,401 accidents. Vehicle type and vehicle controlled information relates to the vehicle identified as the key vehicle in the accident.

Year of accident

In accidents in New South Wales between 1999 and 2006 which involved a light commercial vehicle, rigid trucks or articulated trucks, motor vehicles including light commercials were the key vehicle in 38.5% of accidents, rigid trucks in 28.6% and articulated trucks in 32.9% (see Table 3). The year of the accident by age and vehicle type does differ significantly when tested for an interaction ($p=0.01$). In addition the main effect of age is also strongly significant ($p<0.01$); the main effect for vehicle is insignificant ($p=0.48$).

Table 3: Number of accidents by year, age group and vehicle type

Age group	1999 N	1999 %	2000 N	2000 %	2001 N	2001 %	2002 N	2002 %	2003 N	2003 %	2004 N	2004 %	2005 N	2005 %	2006 N	2006 %	Total
Passenger and light commercial vehicles																	
18-20	122	11.8	145	14.1	155	15.0	128	12.4	123	11.9	128	12.4	118	11.4	112	10.9	1,031
21-25	189	15.6	173	14.3	137	11.3	133	11.0	174	14.4	123	10.2	152	12.6	128	10.6	1,209
26-34	262	14.7	252	14.2	210	11.8	230	12.9	229	12.9	229	12.9	201	11.3	167	9.4	1,780
35-44	181	13.8	175	13.3	154	11.7	162	12.3	163	12.4	182	13.8	147	11.2	152	11.6	1,316
45-54	116	11.5	138	13.7	127	12.6	110	10.9	114	11.3	141	14.0	131	13.0	132	13.1	1,009
55-64	88	12.9	84	12.3	64	9.4	80	11.7	92	13.5	95	13.9	91	13.3	88	12.9	682
65-98	98	11.9	99	12.1	95	11.6	91	11.1	113	13.8	112	13.6	114	13.9	99	12.1	821
Total	1,056	13.5	1,066	13.6	942	12.0	934	11.9	1,008	12.8	1,010	12.9	954	12.2	878	11.2	7,848
Rigid trucks																	
18-20	15	16.7	21	23.3	12	13.3	8	8.9	12	13.3	11	12.2	4	4.4	7	7.8	90
21-25	86	16.6	76	14.6	62	11.9	60	11.6	52	10.0	69	13.3	52	10.0	62	11.9	519
26-34	235	14.1	248	14.9	219	13.2	210	12.6	213	12.8	205	12.3	177	10.6	157	9.4	1,664
35-44	192	11.3	226	13.3	193	11.4	210	12.4	234	13.8	243	14.4	228	13.5	167	9.9	1,693
45-54	138	11.4	154	12.7	138	11.4	158	13.1	186	15.4	152	12.6	134	11.1	149	12.3	1,209
55-64	62	10.4	63	10.6	66	11.1	68	11.4	74	12.5	99	16.7	76	12.8	86	14.5	594
65-98	7	10.1	7	10.1	12	17.4	6	8.7	9	13.0	9	13.0	8	11.6	11	15.9	69
Total	735	12.6	795	13.6	702	12.0	720	12.3	780	13.4	788	13.5	679	11.6	639	10.9	5,838
Articulated trucks																	
18-20	8	25.8	4	12.9	7	22.6	3	9.7	2	6.5	1	3.2	3	9.7	3	9.7	31
21-25	60	16.4	64	17.5	46	12.6	48	13.2	40	11.0	35	9.6	42	11.5	30	8.2	365

26-34	312	15.2	311	15.1	259	12.6	270	13.2	249	12.1	255	12.4	223	10.9	174	8.5	2,053
35-44	262	12.5	266	12.7	266	12.7	270	12.9	270	12.9	269	12.8	258	12.3	239	11.4	2,100
45-54	168	11.2	193	12.9	192	12.8	180	12.0	184	12.3	203	13.6	197	13.2	178	11.9	1,495
55-64	54	9.0	62	10.3	74	12.3	66	11.0	72	12.0	88	14.6	94	15.6	92	15.3	602
65-98	4	5.8	9	13.0	10	14.5	5	7.2	8	11.6	11	15.9	8	11.6	14	20.3	69
Total	868	12.9	909	13.5	854	12.7	842	12.5	825	12.3	862	12.8	825	12.3	730	10.9	6,715

Mileage travelled

Table 4 summarises total mileage travelled, as estimated by the Australian Bureau of Statistics (ABS) by vehicle type and age of the controller between 1999 and 2006. It should be noted that the ABS collect this data in a survey of a representative sample of vehicle owners.

There were large differences in the mileages travelled by vehicle types and age groups. For all vehicle types the two younger age groups and the oldest age group drove far less kilometres than the two middle aged groups.

Table 4: Mileage travelled by age group and vehicle type

Total mileage travelled (Mkm)			
Age group	**Passenger and Light Commercial Vehicles**	**Rigid Trucks**	**Articulated trucks**
18-20	14 033.6	90.9	2.3
21-25	32 930.9	821.1	182.1
26-34	67 242.1	3 477.9	1 723.8
35-44	98 854.4	5 748.0	3 358.3
45-54	100 045.3	4 792.3	2 899.3
55-64	57 391.1	1 904.4	1 123.3
65-98	34 024.2	371.3	100.6
Total	404 520.6	17 205.9	9 389.8

5.2 Accident incident rate ratio analysis

The annual accident incidence rate ratios for age group were modelled using Poisson regression for individual vehicle types using the age group 35-44 years as the reference group and mileage travelled as the exposure variable.

For accidents involving the controllers of passenger and light commercial vehicles only, 18 – 20 year old vehicle controllers of any vehicle type are almost eight times more likely and 21 – 25 year olds three times more likely to be involved in an accident which involved a heavy vehicle than 35 – 44 year old controllers. Vehicle controllers aged more that 64 years were 1.6 times more likely to be involved in an accident with involved a heavy vehicle than 35 – 44 year old controllers (see Table 5). All associations are statistically significant at the 0.05 level (see Figure 4).

Table 5: Incident rate ratio (passenger and light commercial vehicles)

Variable	Variable detail	IRR	95% CI
Age	35 – 44 years (reference)		
	18 – 20 years	8.0	7.1, 8.72
	21 – 25 years	2.9	2.62, 3.19
	26 – 34 years	2.2	1.98, 2.37
	45 – 54 years	0.7	0.6, 0.74
	55 – 64 years	0.8	0.7, 0.89
	65 – 98 years	1.7	1.49, 1.85

For accidents involving the controllers of rigid trucks only, 18 – 20 year old vehicle controllers of any vehicle type are 3.4 times more likely, 21 – 25 year olds twice as likely and 26 – 34 year olds are 1.6 times more likely to be involved in an accident which involved a heavy vehicle than 35 – 44 year old controllers. Vehicle controllers aged more that 64 years are almost less likely to be involved in an accident with involved a heavy vehicle than 35 – 44 year old controllers (see Table 6 and Figure 4).

Table 6: Incident rate ratio (rigid trucks)

Variable	Variable detail	IRR	95% CI
Age	35 – 44 years (reference)		
	18 – 20 years	3.37	2.66, 4.09
	21 – 25 years	2.14	1.93, 2.35
	26 – 34 years	1.63	1.52, 1.74
	45 – 54 years	0.85	0.79, 0.91
	55 – 64 years	1.06	0.96, 1.16
	65 – 98 years	0.63	0.48, 0.78

For accidents involving the controllers of articulated trucks only, 18 – 20 year old vehicle controllers of any vehicle type are thirteen times more likely and 21 – 25 year olds 3.2 times as likely to be involved in an accident which involved a heavy vehicle than 35 – 44 year old controllers. Vehicle controllers aged more that 64 years are no more likely to be involved in an accident with involved a heavy vehicle than 35 – 44 year old controllers (see Table 7 and Figure 4). In interpreting this rate ratios care is required as most of the confidence intervals overlap, indicating that there is little difference between the vehicle types.

Table 7: Incident rate ratio (articulated trucks)

Variable	Variable detail	IRR	95% CI
Age	35 – 44 years (reference)		
	18 – 20 years	13.01	8.4, 17.62
	21 – 25 years	3.21	2.85, 3.56
	26 – 34 years	1.91	1.79, 2.02
	45 – 54 years	0.82	0.77, 0.88
	55 – 64 years	0.86	0.78, 0.94
	65 – 98 years	1.09	0.83, 1.36

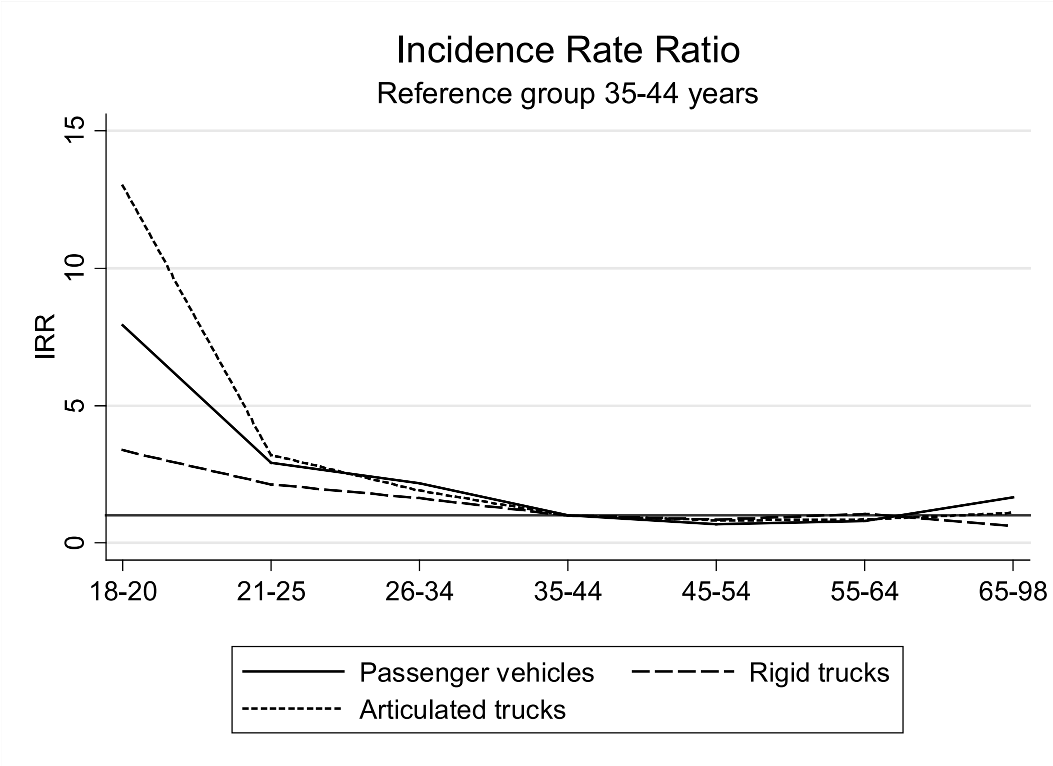


Figure 4: Incidence rate ratio (by vehicle type and age group)

Severity of accident

Of the 20,401 accidents reported, 58.7% were tow-away only, in 38.7% at least one person sustained an injury and 2.6% a fatality occurred. Table 8 presents the severity of accidents between 1999 and 2006 that involved a heavy vehicle by age group and vehicle type. The severity of accident by age and vehicle type does not differ significantly when tested for an interaction (p=0.07). However, the main effect of vehicle type is strongly significant (p<0.01); the main effect for age is insignificant (p=0.58) (see Figure 5).

Table 8: Severity of accidents by age group and vehicle type

Severity of Accident							
Age group	**Fatal**		**Injurious**		**Tow-away only**		**Total**
	N	**%**	**N**	**%**	**N**	**%**	**Accidents**
All	536	2.6	7,888	38.7	11,977	58.7	20,401
Passenger and light commercial							
18-20	46	4.5	397	38.5	588	57.0	1,031
21-25	35	2.9	442	36.6	732	60.5	1,209
26-34	63	3.5	630	35.4	1,087	61.1	1,780
35-44	46	3.5	499	37.9	771	58.6	1,316
45-54	41	4.1	385	38.2	583	57.8	1,009
55-64	26	3.8	269	39.4	387	56.7	682
65-98	58	7.1	327	39.8	436	53.1	821
All	315	4.0	2,949	37.6	4,584	58.4	7,848
Rigid trucks							
18-20	0	0.0	35	38.9	55	61.1	90
21-25	7	1.3	209	40.3	303	58.4	519
26-34	12	0.7	621	37.3	1,031	62.0	1,664
35-44	16	0.9	628	37.1	1,049	62.0	1,693
45-54	15	1.2	427	35.3	767	63.4	1,209
55-64	8	1.3	205	34.5	381	64.1	594
65-98	0	0.0	27	39.1	42	60.9	69
All	58	1.0	2,152	36.9	3,628	62.1	5,838
Articulated trucks							
18-20	0	0.0	15	48.4	16	51.6	31
21-25	5	1.4	134	36.7	226	61.9	365
26-34	50	2.4	873	42.5	1,130	55.0	2,053
35-44	58	2.8	890	42.4	1,152	54.9	2,100
45-54	34	2.3	603	40.3	858	57.4	1,495
55-64	10	1.7	244	40.5	348	57.8	602
65-98	6	8.7	28	40.6	35	50.7	69
All	163	2.4	2,787	41.5	3,765	56.1	6,715

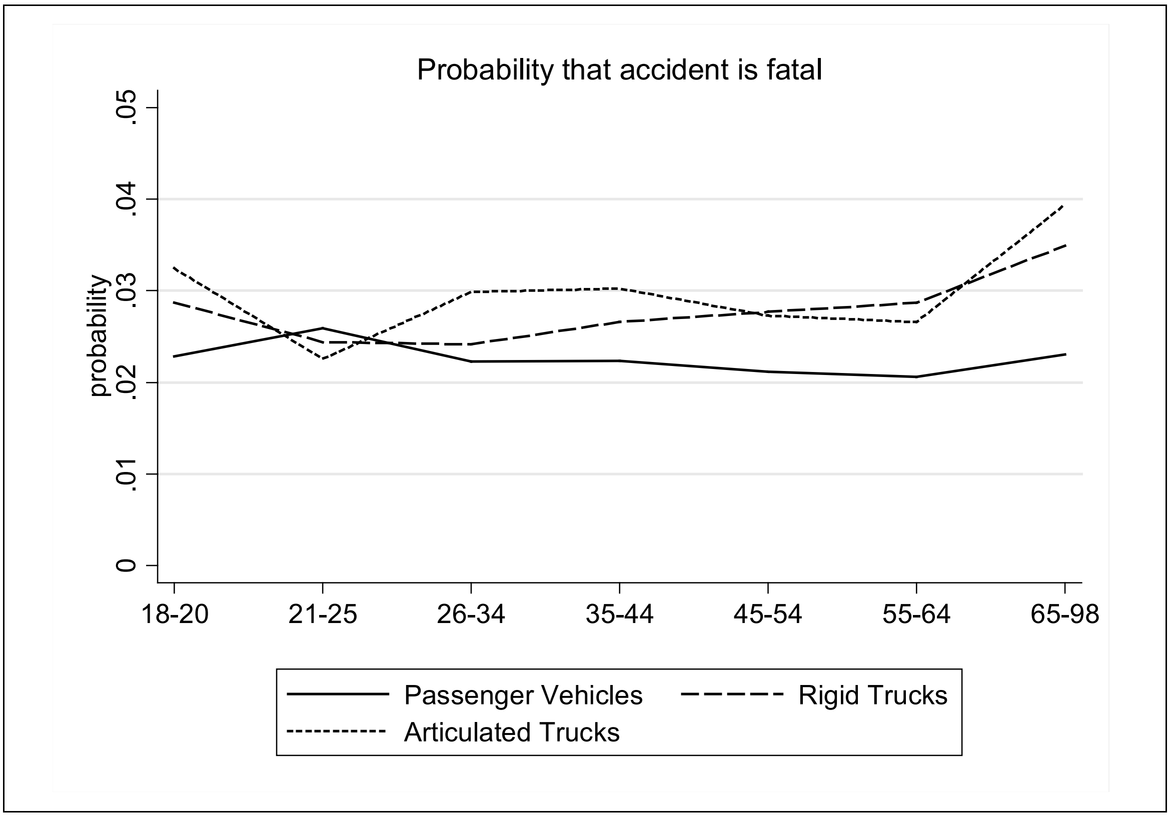


Figure 5: Severity of accident

5.3 Time, weather and road factors

Time of day

Overall, 76.3% of accidents occurred between the hours of 7am and 7pm with rigid trucks experiencing the highest day time proportion (83.9%). The over 64 years age group have the highest proportion of their accidents (92%) occur in this time frame (see Table 9). The time of occurrence of the accident by age and vehicle type does differ significantly when tested for an interaction ($p<0.01$). In addition the main effect of vehicle type is also strongly significant ($p<0.01$); the main effect for age is insignificant ($p=0.39$) (see Figure 6).

Table 9: Time of accident by age group and vehicle type

Time of accident					
Age Group	Day		Night		Total
	N	%	N	%	N
Passenger vehicles and light commercials					
18 - 20	763	74.0	268	26.0	1,031
21 - 25	895	74.0	314	26.0	1,209
26 - 34	1,350	75.8	430	24.2	1,780
35 - 44	1,052	79.9	264	20.1	1,316
45 - 54	809	80.2	200	19.8	1,009
55 - 64	586	85.9	96	14.1	682
65 - 98	761	92.7	60	7.3	821
Total	6,216	79.2	1,632	20.8	7,848
Rigid trucks					
18 - 20	69	76.7	21	23.3	90
21 - 25	437	84.2	82	15.8	519
26 - 34	1,393	83.7	271	16.3	1,664
35 - 44	1,420	83.9	273	16.1	1,693
45 - 54	1,013	83.8	196	16.2	1,209
55 - 64	501	84.3	93	15.7	594
65 - 98	63	91.3	6	8.7	69
Total	4,896	83.9	942	16.1	5,838
Articulated trucks					
18 - 20	21	67.7	10	32.3	31
21 - 25	230	63.0	135	37.0	365
26 - 34	1,291	62.9	762	37.1	2,053
35 - 44	1,348	64.2	752	35.8	2,100
45 - 54	1,074	71.8	421	28.2	1,495
55 - 64	440	73.1	162	26.9	602
65 - 98	58	84.1	11	15.9	69
Total	4,462	66.4	2,253	33.6	6,715

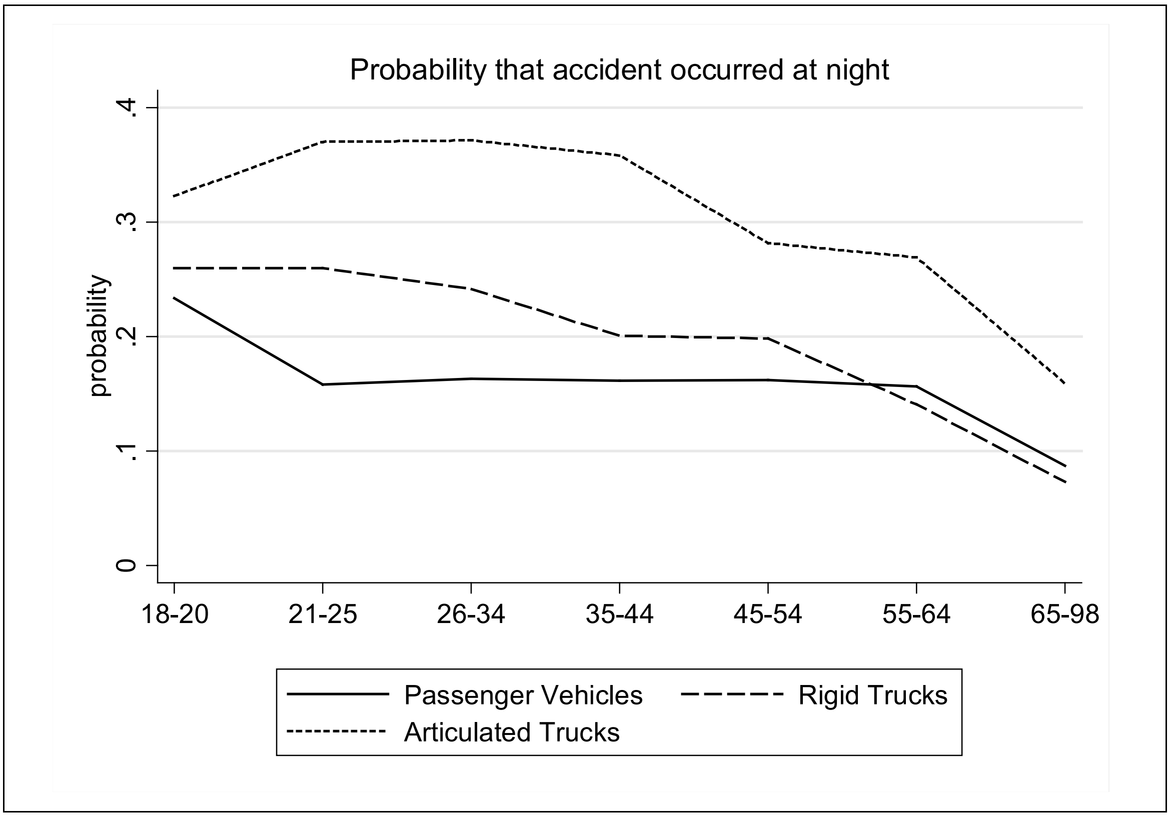


Figure 6: Time of accident (day or night)

Urbanisation

Sixty four (64) percent of accidents involving heavy vehicles occurred in the metropolitan area. For rigid trucks 74.2% occurred in metropolitan areas and for articulated trucks the proportion of metropolitan to country was almost even (49.0% vs 51.0%). By age group of the vehicle controller the proportion all hover within the range of 62.6% to 70.9% with the exception of the 64 plus years where the proportion is almost even (51.9% vs 48.1%) (see Table 10). The metropolitan/country location of the accident by age and vehicle type does differ significantly when tested for an interaction ($p<0.01$). In addition the main effect of age is also strongly significant ($p<0.01$) as is the main effect for vehicle ($p<0.01$) (see Figure 7).

Table 10: Urbanisation of accident by age group and vehicle type

Urbanisation					
Age Group	Metropolitan area		Country areas		Total
	N	%	N	%	N
Passenger vehicles and light commercials					
18 - 20	696	67.5	335	32.5	1,031
21 - 25	913	75.5	296	24.5	1,209
26 - 34	1,308	73.5	472	26.5	1,780
35 - 44	950	72.2	366	27.8	1,316
45 - 54	690	68.4	319	31.6	1,009
55 - 64	442	64.8	240	35.2	682
65 - 98	434	52.9	387	47.1	821
Total	5,433	69.2	2,415	30.8	7,848
Rigid trucks					
18 - 20	65	72.2	25	27.8	90
21 - 25	404	77.8	115	22.2	519
26 - 34	1,255	75.4	409	24.6	1,664
35 - 44	1,258	74.3	435	25.7	1,693
45 - 54	891	73.7	318	26.3	1,209
55 - 64	426	71.7	168	28.3	594
65 - 98	35	50.7	34	49.3	69
Total	4,334	74.2	1,504	25.8	5,838
Articulated trucks					
18 - 20	8	25.8	23	74.2	31
21 - 25	167	45.8	198	54.2	365
26 - 34	974	47.4	1,079	52.6	2,053
35 - 44	991	47.2	1,109	52.8	2,100
45 - 54	789	52.8	706	47.2	1,495
55 - 64	336	55.8	266	44.2	602
65 - 98	29	42.0	40	58.0	69
Total	3,294	49.1	3,421	50.9	6,715

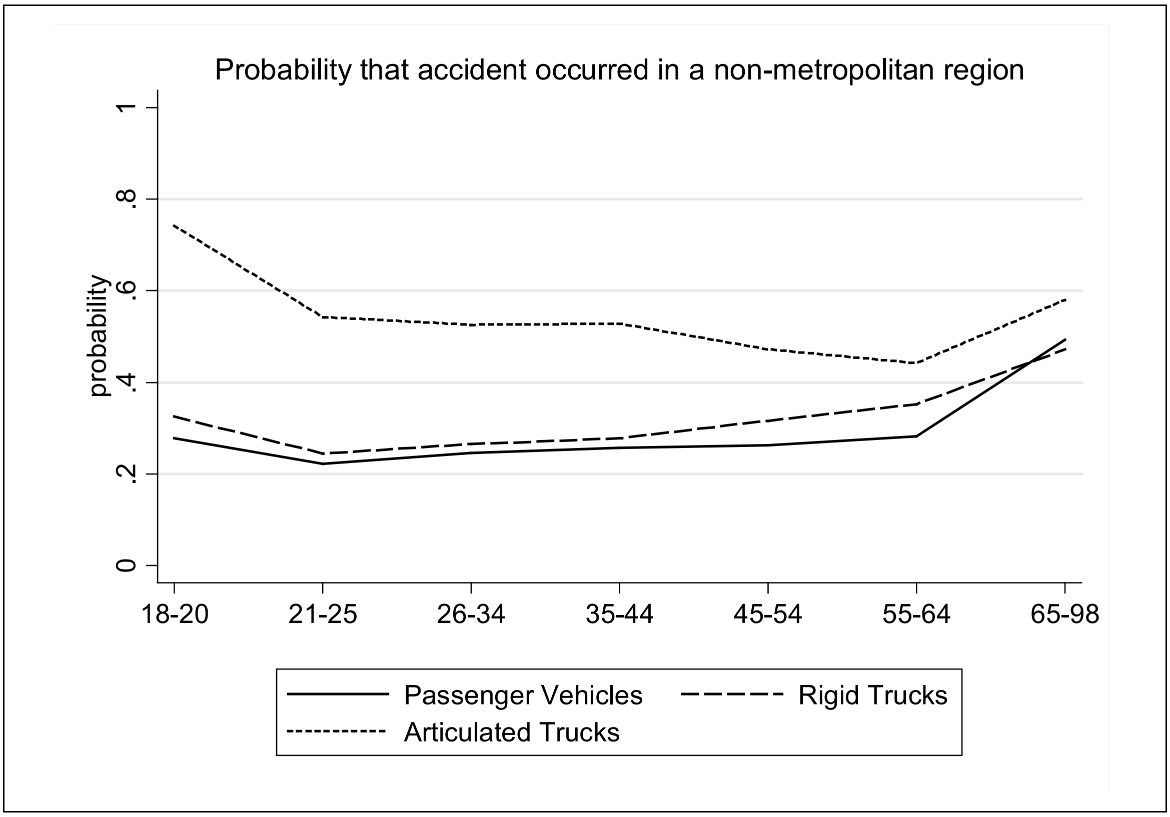


Figure 7: Location of accident (metropolitan or country/)

Road classification

Overall, 5.8% of accidents occur on freeways or motorways, 33.6% on state highways, 36.5% on 'other' classified road types and 24.1% on unclassified roads. In the rigid trucks 41.3% percent of accidents occurred on 'other' road types. Thirty one (31) percent of accidents in articulated trucks occurred on 'other' roads and 48% occurred on highways (see Table 11). The road classification of the location of accidents by age and vehicle type does differ significantly when tested for an interaction ($p<0.01$). In addition the main effect of vehicle type is also strongly significant ($p<0.01$); however the main effect for age is insignificant ($p=0.37$) (see Figure 8).

Table 11: Road classification at accident location by age group and vehicle type

Road Classification									
age	freeway/motorway		state highway		other classified road		unclassified road		Total
	N	%	N	%	N	%	N	%	N
Passenger vehicles and light commercials									
18 - 20	57	5.5	286	27.7	375	36.4	313	30.4	1,031
21 - 25	81	6.7	297	24.6	474	39.2	357	29.5	1,209
26 - 34	130	7.3	443	24.9	679	38.1	528	29.7	1,780
35 - 44	77	5.9	377	28.6	485	36.9	377	28.6	1,316
45 - 54	69	6.8	287	28.4	371	36.8	282	27.9	1,009
55 - 64	40	5.9	210	30.8	244	35.8	188	27.6	682
65 - 98	28	3.4	255	31.1	305	37.1	233	28.4	821
Total	482	6.1	2,155	27.5	2,933	37.4	2,278	29.0	7,848
Rigid trucks									
18 - 20	5	5.6	21	23.3	33	36.7	31	34.4	90
21 - 25	35	6.7	122	23.5	218	42.0	144	27.7	519
26 - 34	78	4.7	402	24.2	713	42.8	471	28.3	1,664
35 - 44	82	4.8	441	26.0	690	40.8	480	28.4	1,693
45 - 54	52	4.3	324	26.8	479	39.6	354	29.3	1,209
55 - 64	25	4.2	149	25.1	259	43.6	161	27.1	594
65 - 98	2	2.9	24	34.8	20	29.0	23	33.3	69
Total	279	4.8	1,483	25.4	2,412	41.3	1,664	28.5	5,838
Articulated trucks									
18 - 20	2	6.5	12	38.7	11	35.5	6	19.4	31
21 - 25	23	6.3	179	49.0	118	32.3	45	12.3	365
26 - 34	109	5.3	1,023	49.8	646	31.5	275	13.4	2,053
35 - 44	125	6.0	1,039	49.5	653	31.1	283	13.5	2,100
45 - 54	105	7.0	715	47.8	436	29.2	239	16.0	1,495
55 - 64	44	7.3	216	35.9	223	37.0	119	19.8	602
65 - 98	8	11.6	29	42.0	21	30.4	11	15.9	69
Total	416	6.2	3,213	47.8	2,108	31.4	978	14.6	6,715

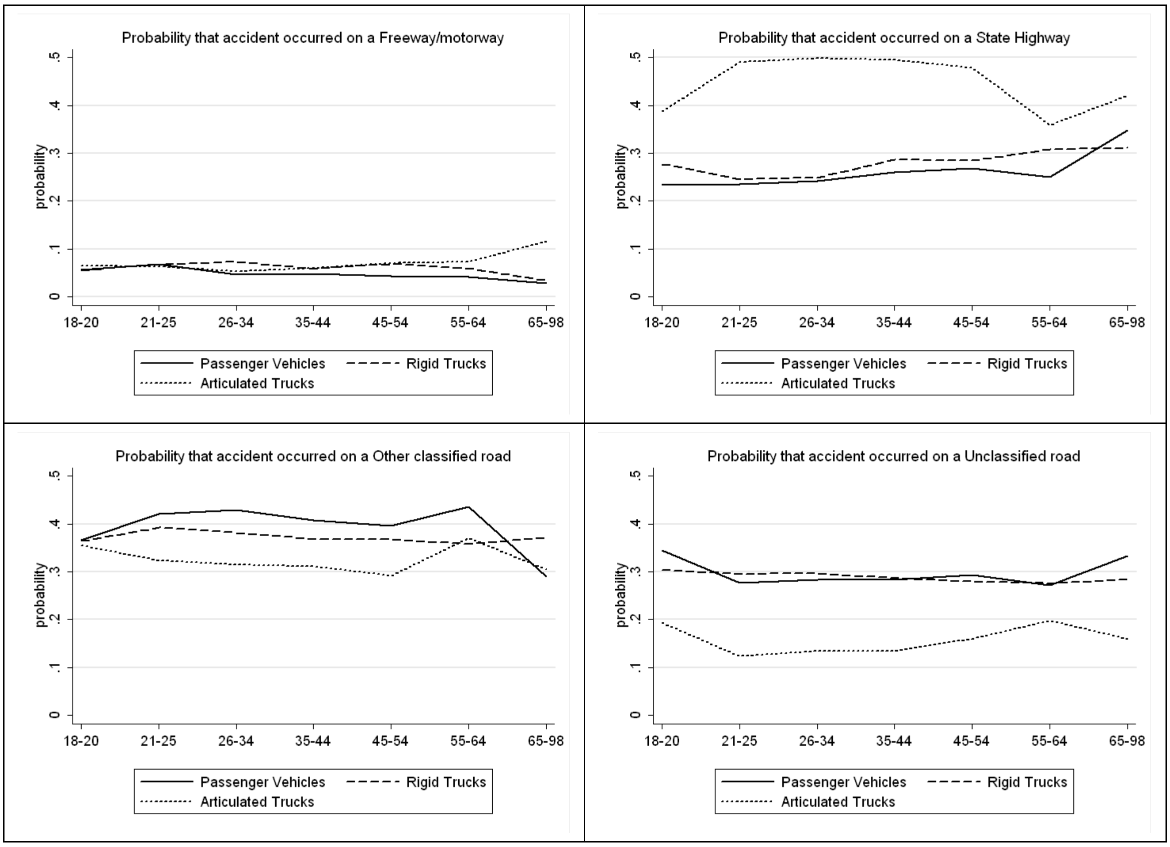


Figure 8: Road classification of accident site

Type of location

Thirty nine (39.6%) percent of accidents occurred at an intersection with the highest proportion occurring in rigid trucks (45.0%) and in drivers over 64 years (52.5%) (see Table 12). The type of location of the accidents by age and vehicle type does not differ significantly when tested for an interaction (p=0.33). Also the main effect of age is insignificant (p = 0.83); however the main effect for vehicle type is significant (p<0.01) (see Figure 9).

Table 12: Type of location where accident occurred by age group and vehicle type

Location Type					
Age Group	Non-intersection locations		Intersection Locations		Total
	N	%	N	%	N
Passenger and light commercial vehicles					
18 - 20	646	62.7	385	37.3	1,031
21 - 25	745	61.6	464	38.4	1,209
26 - 34	1,084	60.9	696	39.1	1,780
35 - 44	777	59.0	539	41.0	1,316
45 - 54	587	58.2	422	41.8	1,009
55 - 64	378	55.4	304	44.6	682

Location Type					
65 - 98	380	46.3	441	53.7	821
Total	4,597	58.6	3,251	41.4	7,848
Rigid trucks					
18 - 20	52	57.8	38	42.2	90
21 - 25	296	57.0	223	43.0	519
26 - 34	902	54.2	762	45.8	1,664
35 - 44	939	55.5	754	44.5	1,693
45 - 54	658	54.4	551	45.6	1,209
55 - 64	328	55.2	266	44.8	594
65 - 98	34	49.3	35	50.7	69
Total	3,209	55.0	2,629	45.0	5,838
Articulated trucks					
18 - 20	21	67.7	10	32.3	31
21 - 25	240	65.8	125	34.2	365
26 - 34	1,386	67.5	667	32.5	2,053
35 - 44	1,469	70.0	631	30.0	2,100
45 - 54	970	64.9	525	35.1	1,495
55 - 64	393	65.3	209	34.7	602
65 - 98	42	60.9	27	39.1	69
Total	4,521	67.3	2,194	32.7	6,715

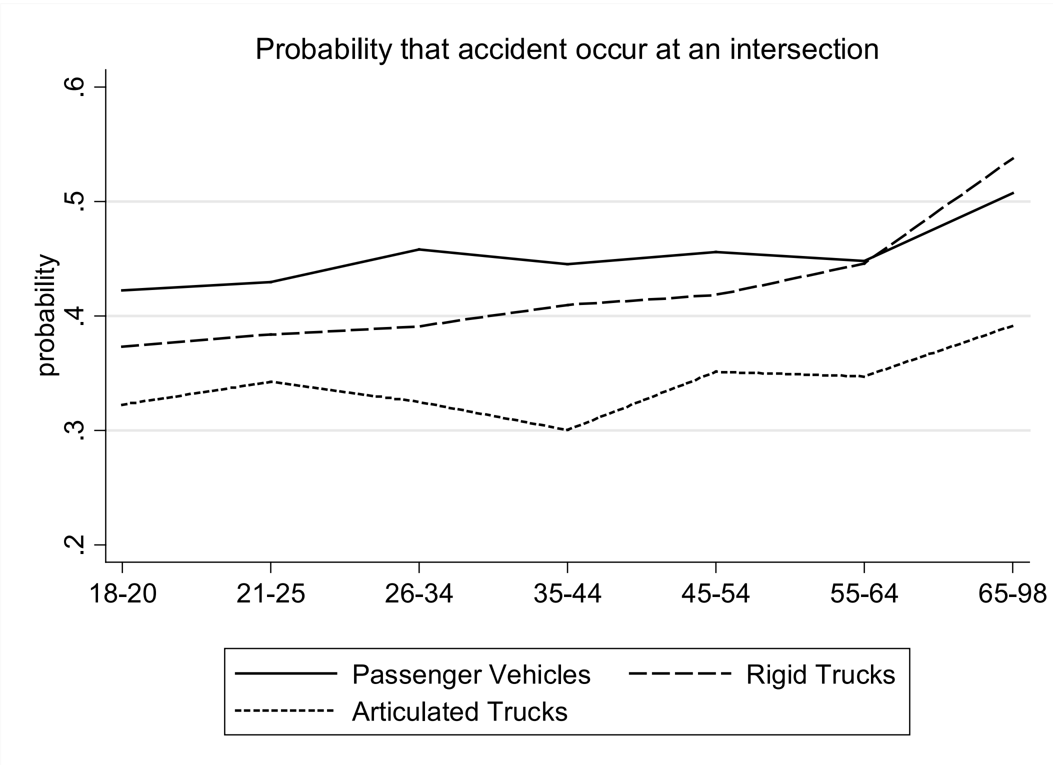


Figure 9: Accident location (non-intersection/intersection)

Speed limit

Fifty one (51.2%) percent of accidents occurred in a location where the speed limit is between 30 – 60 kilometres per hour (kph). In the 30-60 kph zones rigid trucks have the highest proportions of accidents (59.2%). In the 70-80kph zones the proportions are approximately equal, however for the 90-110 zones articulated trucks has the highest proportion (39.9%). The highest proportion of accidents by age group in the 30-60kph zones occurs in the over 64 year age group (57.8%). Once again the proportions in the 70-80kph zones are approximately equal. For the 90-110 kph zones the highest proportion range from 21.4% to 27.4% (see Table 13). The speed limit at the location of the accident by age and vehicle type does differ significantly when tested for an interaction (p<0.01). In addition the main effect for vehicle type is also strongly significant (p<0.01); however the main effect for age is insignificant (p=0.40) (see Figure 10).

Table 13: Speed limit at location of accident by age group and vehicle type

speed limit							
Age Group	30 - 60 KPH		70 - 80 KPH		90 - 110 KPH		Total
	N	%	N	%	N	%	N
Passenger and light commercial vehicles							
18 - 20	572	55.5	249	24.2	209	20.3	1,030
21 - 25	709	58.8	275	22.8	222	18.4	1,206
26 - 34	997	56.1	422	23.8	357	20.1	1,776
35 - 44	762	58.0	307	23.4	245	18.6	1,314
45 - 54	549	54.5	228	22.6	230	22.8	1,007
55 - 64	369	54.2	148	21.7	164	24.1	681
65 - 98	490	59.8	143	17.4	187	22.8	820
Total	4,448	56.8	1,772	22.6	1,614	20.6	7,834
Rigid trucks							
18 - 20	50	55.6	20	22.2	20	22.2	90
21 - 25	306	59.1	124	23.9	88	17.0	518
26 - 34	1,015	61.0	378	22.7	270	16.2	1,663
35 - 44	968	57.3	416	24.6	304	18.0	1,688
45 - 54	721	59.7	282	23.3	205	17.0	1,208
55 - 64	350	59.0	143	24.1	100	16.9	593
65 - 98	38	55.9	11	16.2	19	27.9	68
Total	3,448	59.2	1,374	23.6	1,006	17.3	5,828
Articulated trucks							

speed limit							
18 - 20	7	22.6	7	22.6	17	54.8	31
21 - 25	129	35.4	77	21.2	158	43.4	364
26 - 34	755	36.9	429	21.0	860	42.1	2,044
35 - 44	738	35.2	507	24.2	850	40.6	2,095
45 - 54	594	40.0	345	23.2	547	36.8	1,486
55 - 64	272	45.3	126	21.0	203	33.8	601
65 - 98	25	36.2	12	17.4	32	46.4	69
Total	2,520	37.7	1,503	22.5	2,667	39.9	6,690

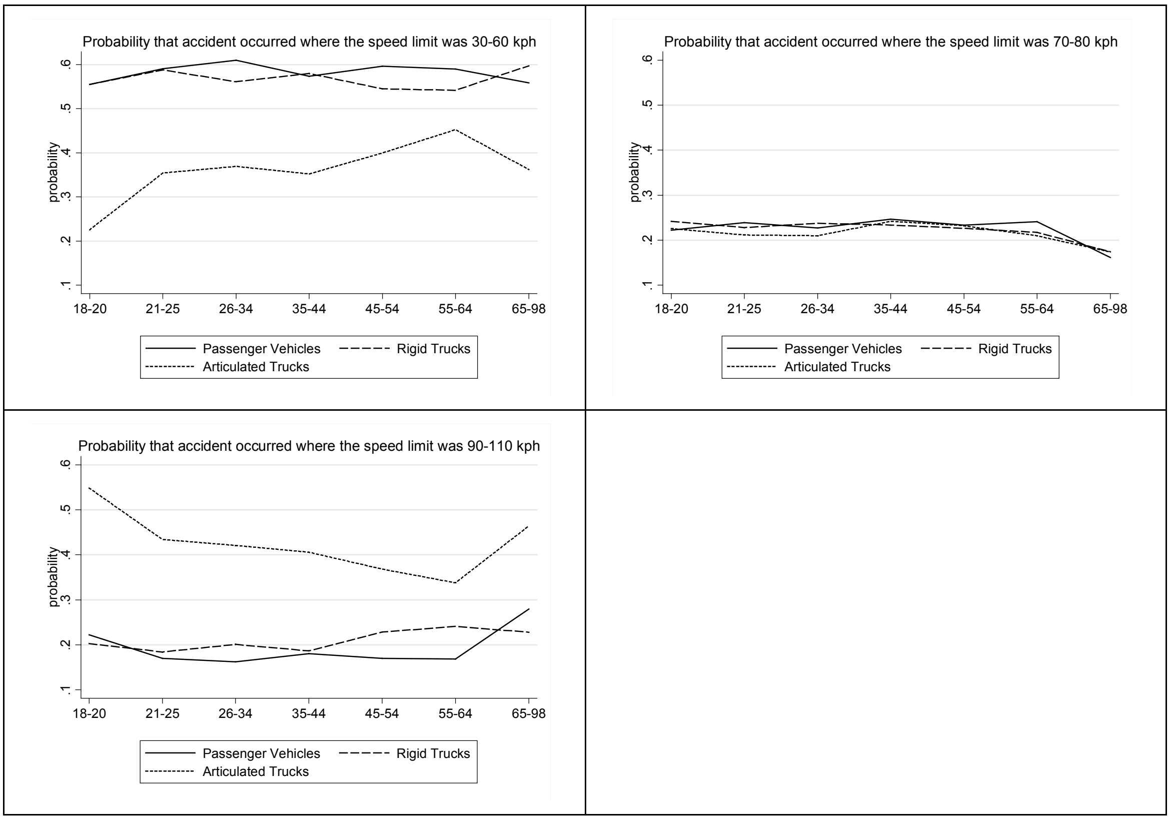


Figure 10: Speed limit at accident site

Road surface

Overall, 1.6% of accidents occurred on unsealed roads. For the rigid vehicle types, higher proportions of accidents on unsealed roads occurred in the over 64 age group (5.8%) compared to all younger age groups (range 1.1% to 2.7%). For the articulated vehicles, proportions of accidents on unsealed roads were relatively uniform across all age groups (range 1.4% to 2.7%) (see Table 14). The road surface at the location of the accident by age and vehicle type is marginally significantly when tested for an interaction (p=0.06). In addition the main effect for age is also significant (p = 0.03); however the main effect for vehicle type is insignificant (p=0.46) (see Figure 11).

Table 14: Road surface at accident location by age group and vehicle type

Road Surface Type					
age	Sealed		Unsealed		Total
	N	%	N	%	N
Passenger & light commercial vehicle					
18 - 20	1,019	98.9	11	1.1	1,030
21 - 25	1,191	98.5	18	1.5	1,209
26 - 34	1,754	98.7	23	1.3	1,777
35 - 44	1,294	98.3	22	1.7	1,316
45 - 54	993	98.4	16	1.6	1,009
55 - 64	676	99.1	6	0.9	682
65 - 98	817	99.5	4	0.5	821
Total	7,744	98.7	100	1.3	7,844
Rigid Trucks					
18 - 20	89	98.9	1	1.1	90
21 - 25	510	98.5	8	1.5	518
26 - 34	1,645	98.9	18	1.1	1,663
35 - 44	1,665	98.3	28	1.7	1,693
45 - 54	1,190	98.6	17	1.4	1,207
55 - 64	578	97.3	16	2.7	594
65 - 98	65	94.2	4	5.8	69
Total	5,742	98.4	92	1.6	5,834
Articulated trucks					
18 - 20	30	96.8	1	3.2	31
21 - 25	355	97.3	10	2.7	365
26 - 34	2,023	98.6	28	1.4	2,051
35 - 44	2,055	97.9	45	2.1	2,100
45 - 54	1,454	97.3	41	2.7	1,495
55 - 64	586	97.3	16	2.7	602
65 - 98	68	98.6	1	1.4	69
Total	6,571	97.9	142	2.1	6,713

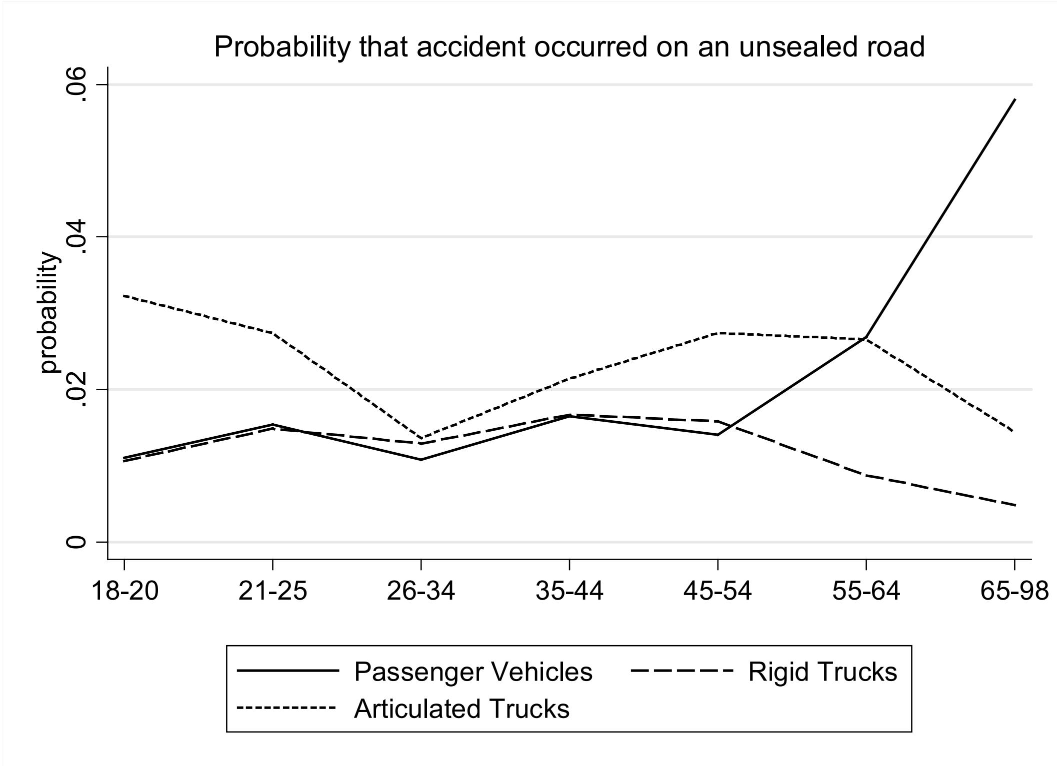


Figure 11: Road surface at accident site

Weather conditions

Seventy seven (77.1) percent of accidents occurred in fine weather conditions (see Table 15). Age and vehicle type are not predictive of the weather conditions at the time of the accident. The interaction effect has p=0.29, the main effect for age has p=0.18 and the main effect for vehicle type has p=0.21 (see Figure 12).

Table 15: Weather conditions at the time of accident by age group and vehicle types

Weather Conditions					
Age Group	Fine		Not fine		Total
	N	%	N	%	N
Passenger & light commercial vehicle					
18 - 20	766	74.7	260	25.3	1,026
21 - 25	914	75.9	291	24.1	1,205
26 - 34	1,350	76.2	422	23.8	1,772
35 - 44	992	75.4	323	24.6	1,315
45 - 54	745	74.1	260	25.9	1,005
55 - 64	531	78.0	150	22.0	681
65 - 98	648	78.9	173	21.1	821
Total	5,946	76.0	1,879	24.0	7,825
Rigid trucks					

18 - 20	70	77.8	20	22.2	90
21 - 25	393	75.9	125	24.1	518
26 - 34	1,338	80.5	324	19.5	1,662
35 - 44	1,313	77.7	376	22.3	1,689
45 - 54	966	80.0	241	20.0	1,207
55 - 64	466	78.6	127	21.4	593
65 - 98	51	73.9	18	26.1	69
Total	4,597	78.9	1,231	21.1	5,828
Articulated trucks					
18 - 20	24	77.4	7	22.6	31
21 - 25	287	78.8	77	21.2	364
26 - 34	1,558	76.4	482	23.6	2,040
35 - 44	1,582	75.5	513	24.5	2,095
45 - 54	1,164	78.2	325	21.8	1,489
55 - 64	470	78.3	130	21.7	600
65 - 98	52	75.4	17	24.6	69
Total	5,137	76.8	1,551	23.2	6,688

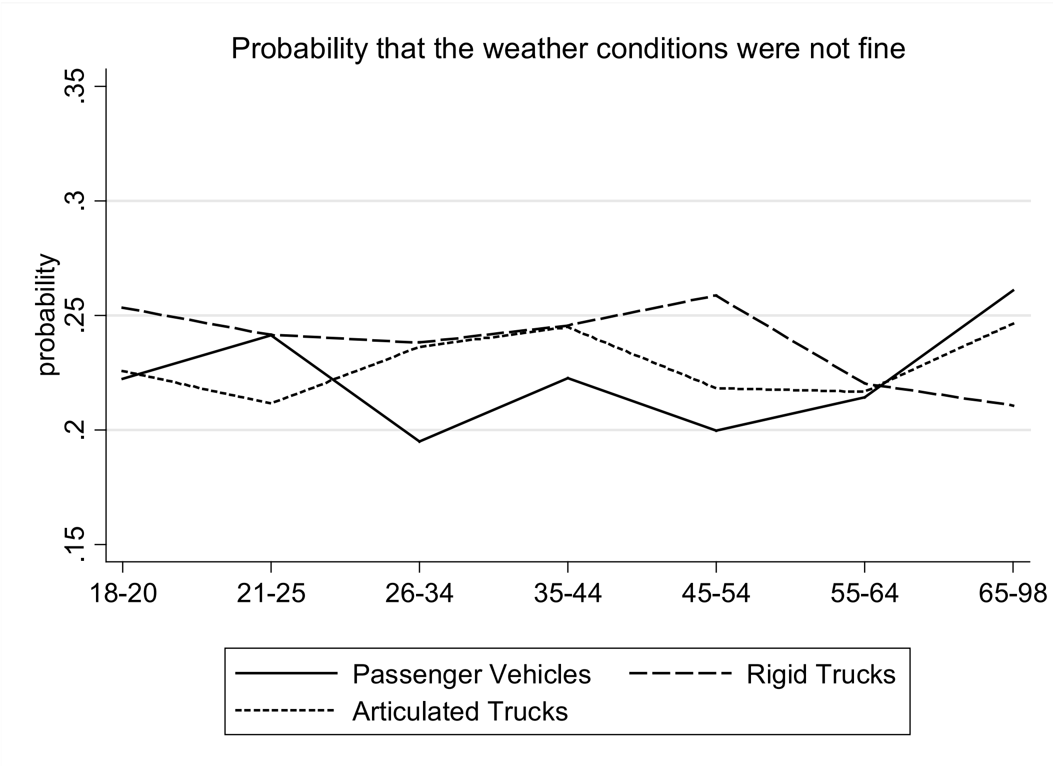


Figure 12: Weather conditions at accident location (fine/not fine)

Road surface condition

Seventeen (17.1) percent of accidents occurred in wet, snow or ice conditions. The highest proportion of accidents in non-dry conditions in articulated trucks occurred with vehicle controllers aged over 64 years (20%) compared to 12.9% in drivers aged 18 to 20. For rigid trucks the oldest and youngest age groups both had twenty (20%) percent of accidents (see Table 16). The road surface condition at the location of the accident by age and vehicle type does not differ significantly when tested for an interaction (p=0.29). The main effect for age is also insignificant (p = 0.19); however the main effect for vehicle type is significant (p=0.01) (Figure 13).

Table 16: Road surface condition at accident location by age group and vehicle type

Surface Condition					
age	Dry		Wet/snow/ice		Total
	N	%	N	%	N
Passenger & Light Commercial Vehicle					
18 - 20	810	78.8	218	21.2	1,028
21 - 25	975	80.8	232	19.2	1,207
26 - 34	1,447	81.5	328	18.5	1,775
35 - 44	1,050	79.8	266	20.2	1,316
45 - 54	799	79.3	209	20.7	1,008
55 - 64	565	82.8	117	17.2	682
65 - 98	694	84.5	127	15.5	821
Total	6,340	80.9	1,497	19.1	7,837
Rigid trucks					
18 - 20	72	80.0	18	20.0	90
21 - 25	434	83.8	84	16.2	518
26 - 34	1,423	85.6	239	14.4	1,662
35 - 44	1,422	84.0	270	16.0	1,692
45 - 54	1,041	86.2	166	13.8	1,207
55 - 64	516	86.9	78	13.1	594
65 - 98	55	79.7	14	20.3	69
Total	4,963	85.1	869	14.9	5,832
Articulated trucks					
18 - 20	27	87.1	4	12.9	31
21 - 25	310	85.2	54	14.8	364
26 - 34	1,724	84.2	323	15.8	2,047
35 - 44	1,715	81.7	383	18.3	2,098
45 - 54	1,254	83.9	240	16.1	1,494
55 - 64	499	82.9	103	17.1	602
65 - 98	55	79.7	14	20.3	69
Total	5,584	83.3	1,121	16.7	6,705

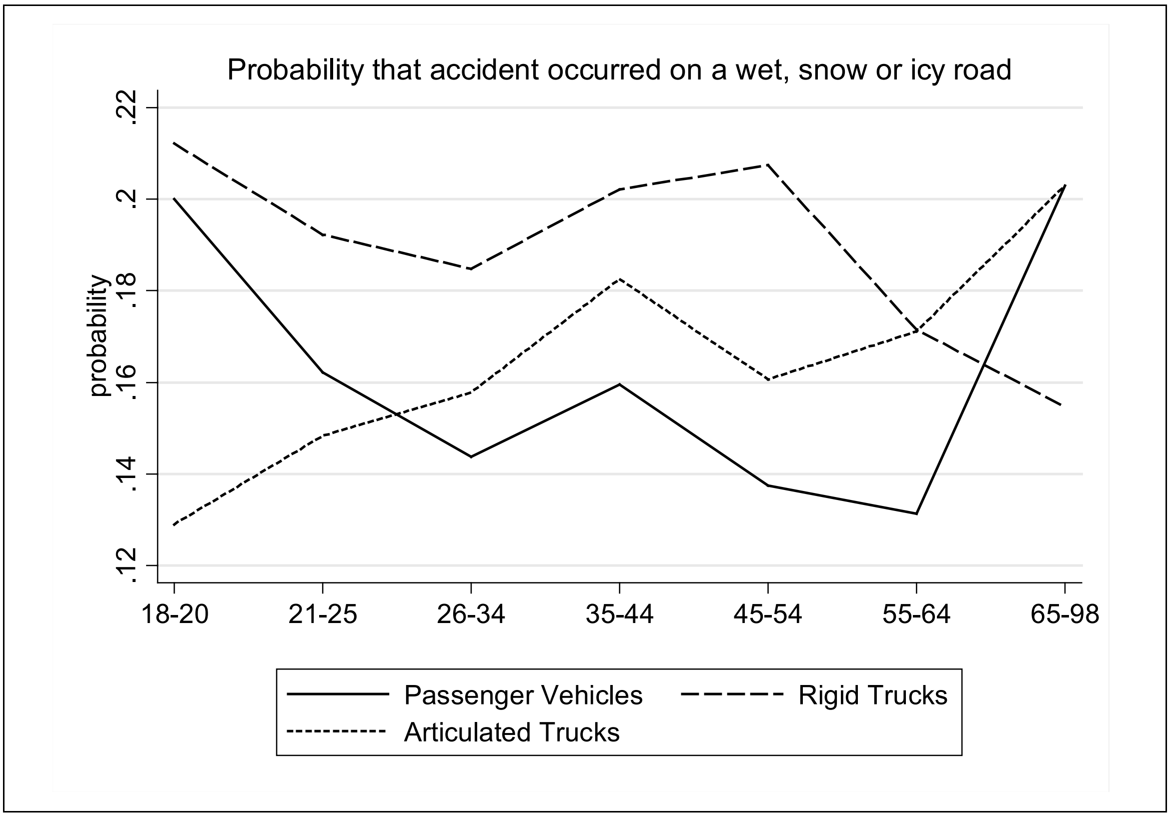


Figure 13: Surface conditions at accident site (dry, wet/snow/ice)

Permanent feature

Seventy one (71) percent of accidents occurred where a permanent hazardous feature exists. The proportion of accidents at a permanent feature is lowest for articulated trucks (66.6%) (see Table 17). The existence of a permanent feature at the location of the accident by age and vehicle type does not differ significantly when tested for an interaction (p=0.28). Also the main effect for age is insignificant (p = 0.27); however the main effect for vehicle type is significant (p<0.01) (Figure 14).

Table 17: Permanent feature at accident location by age group and vehicle type

age	No permanent hazard		Permanent hazard existed		Total
	N	%	N	%	N
Passenger & light commercial vehicle					
18 - 20	275	26.7	756	73.3	1,031
21 - 25	317	26.2	892	73.8	1,209
26 - 34	454	25.5	1,326	74.5	1,780
35 - 44	335	25.5	981	74.5	1,316
45 - 54	273	27.1	736	72.9	1,009
55 - 64	190	27.9	492	72.1	682
65 - 98	221	26.9	600	73.1	821
Total	2,065	26.3	5,783	73.7	7,848

Rigid trucks					
18 - 20	26	28.9	64	71.1	90
21 - 25	156	30.1	363	69.9	519
26 - 34	451	27.1	1,213	72.9	1,664
35 - 44	456	26.9	1,237	73.1	1,693
45 - 54	339	28.0	870	72.0	1,209
55 - 64	138	23.2	456	76.8	594
65 - 98	20	29.0	49	71.0	69
Total	1,586	27.2	4,252	72.8	5,838
Articulated trucks					
18 - 20	10	32.3	21	67.7	31
21 - 25	122	33.4	243	66.6	365
26 - 34	674	32.8	1,379	67.2	2,053
35 - 44	742	35.3	1,358	64.7	2,100
45 - 54	470	31.4	1,025	68.6	1,495
55 - 64	198	32.9	404	67.1	602
65 - 98	27	39.1	42	60.9	69
Total	2,243	33.4	4,472	66.6	6,715

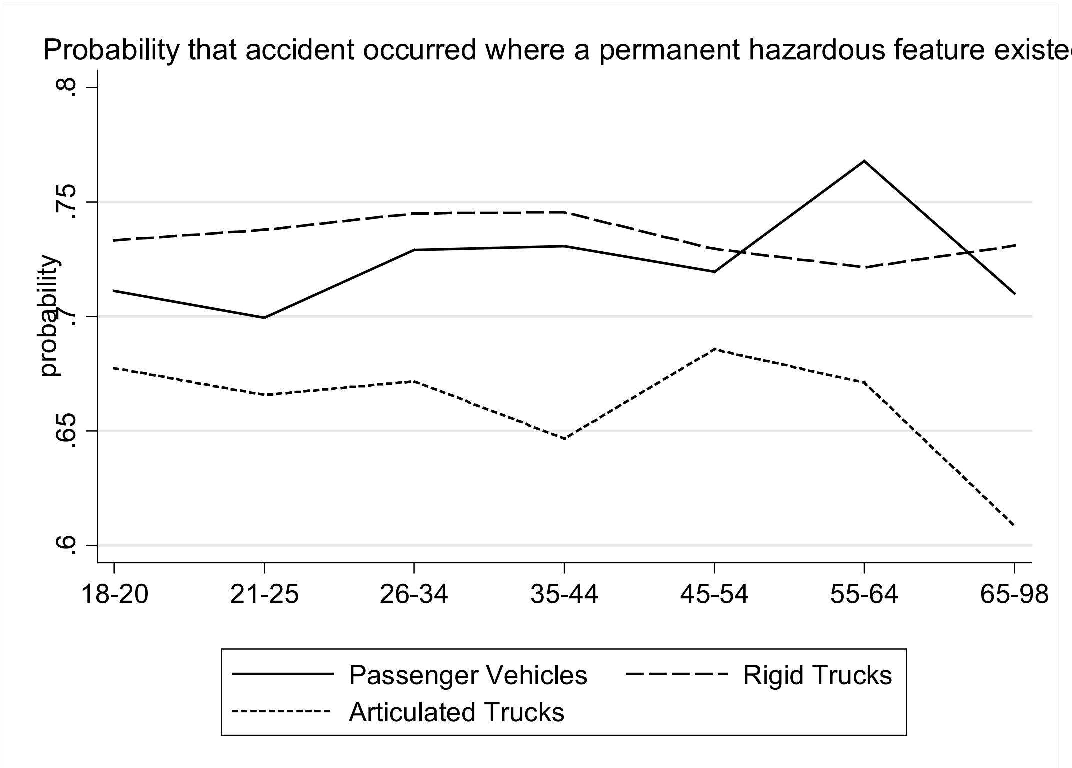


Figure 14: Permanent hazardous feature at accident site

Hazardous feature

A very low proportion of accidents (1.8%) occurred where a hazardous feature existed. The proportion of accidents at a hazardous feature is highest for articulated trucks (2.7%) and in vehicle controllers aged 35 to 44 years (2.1%) (see Table 18).The existence of a hazardous feature at the location of the accident by age and vehicle type is marginally significant when tested for an interaction (p=0.06). In addition the main effect for age is insignificant (p=0.10); however the main effect for vehicle type is significant (p<0.01) (see Figure 15).

Table 18: Hazardous feature at accident location by age group and vehicle type

age	No hazard		Hazard existed		Total
	N	%	N	%	N
Passenger & light commercial vehicle					
18 - 20	1,021	99.0	10	1.0	1,031
21 - 25	1,198	99.1	11	0.9	1,209
26 - 34	1,750	98.3	30	1.7	1,780
35 - 44	1,297	98.6	19	1.4	1,316
45 - 54	994	98.5	15	1.5	1,009
55 - 64	674	98.8	8	1.2	682
65 - 98	814	99.1	7	0.9	821
Total	7,748	98.7	100	1.3	7,848
Rigid trucks					
18 - 20	86	95.6	4	4.4	90
21 - 25	517	99.6	2	0.4	519
26 - 34	1,642	98.7	22	1.3	1,664
35 - 44	1,668	98.5	25	1.5	1,693
45 - 54	1,195	98.8	14	1.2	1,209
55 - 64	587	98.8	7	1.2	594
65 - 98	67	97.1	2	2.9	69
Total	5,762	98.7	76	1.3	5,838
Articulated trucks					
18 - 20	27	87.1	4	12.9	31
21 - 25	356	97.5	9	2.5	365
26 - 34	2,000	97.4	53	2.6	2,053
35 - 44	2,037	97.0	63	3.0	2,100
45 - 54	1,459	97.6	36	2.4	1,495
55 - 64	585	97.2	17	2.8	602
65 - 98	67	97.1	2	2.9	69
Total	6,531	97.3	184	2.7	6,715

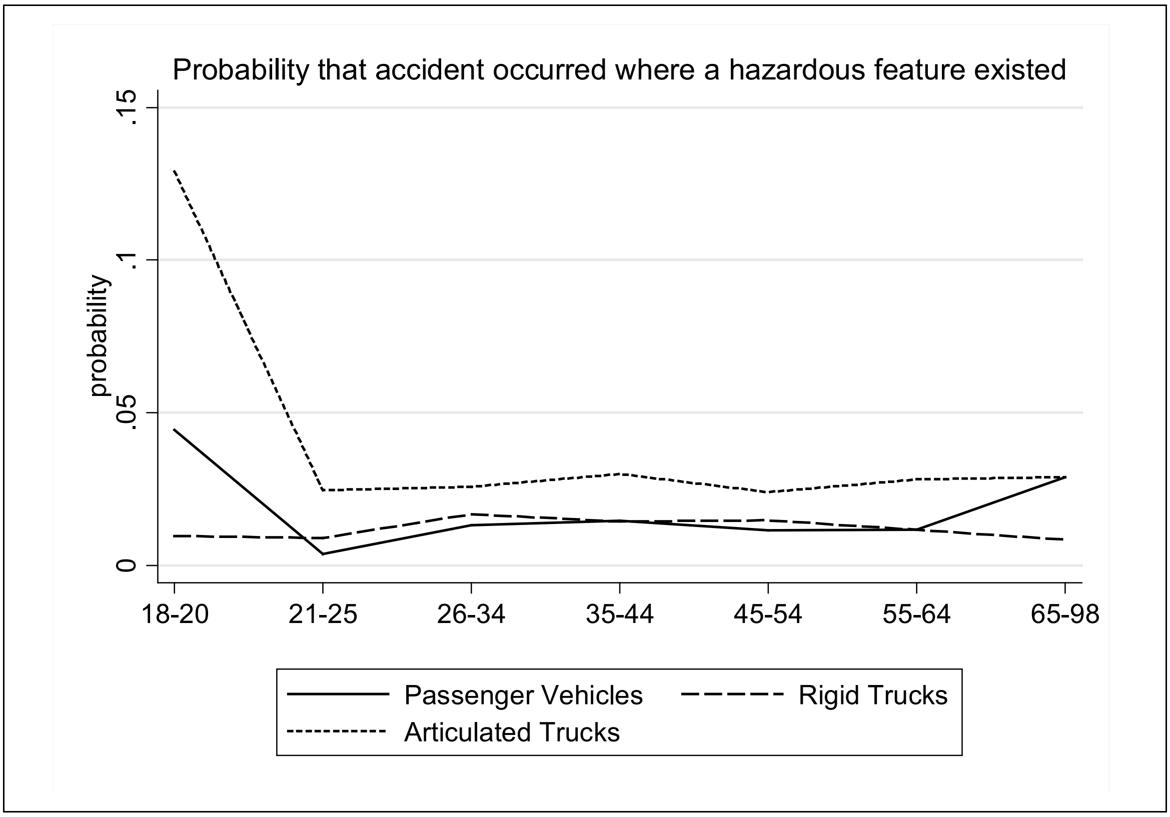


Figure 15: Hazardous feature existed at accident site

Temporary hazardous feature

Overall, 2.7% of accidents occurred where a temporary feature on the road was a factor. For the rigid vehicle types, higher proportions of accidents where a temporary road feature was a factor occurred in the over 64 age group (7.2%) compared to all younger age groups (range 2.0% to 4.4%). For the articulated vehicle types, proportions of accidents due to temporary road features were relatively uniform for controllers over the age of 20 years (range 2.9% to 4.3%) (see Table 19). The existence of a temporary hazardous feature at the location of the accident by age and vehicle type is insignificant when tested for an interaction (p=0.13). In addition the main effect for vehicle type is insignificant (p=0.24); however the main effect for age is significant (p = 0.02).

Table 19: Temporary hazardous feature at accident location by age group and vehicle type

Age	No temporary hazard		Temporary hazard existed		Total
	N	%	N	%	N
Passenger & light commercial vehicle					
18 - 20	1,013	98.3	18	1.7	1,031
21 - 25	1,185	98.0	24	2.0	1,209
26 - 34	1,752	98.4	28	1.6	1,780
35 - 44	1,281	97.3	35	2.7	1,316
45 - 54	992	98.3	17	1.7	1,009
55 - 64	657	96.3	25	3.7	682
65 - 98	804	97.9	17	2.1	821
Total	7,684	97.9	164	2.1	7,848
Rigid trucks					
18 - 20	86	95.6	4	4.4	90
21 - 25	507	97.7	12	2.3	519
26 - 34	1,621	97.4	43	2.6	1,664
35 - 44	1,659	98.0	34	2.0	1,693
45 - 54	1,176	97.3	33	2.7	1,209
55 - 64	568	95.6	26	4.4	594
65 - 98	64	92.8	5	7.2	69
Total	5,681	97.3	157	2.7	5,838
Articulated trucks					
18 - 20	31	100.0	0	0.0	31
21 - 25	354	97.0	11	3.0	365
26 - 34	1,993	97.1	60	2.9	2,053
35 - 44	2,040	97.1	60	2.9	2,100
45 - 54	1,434	95.9	61	4.1	1,495
55 - 64	576	95.7	26	4.3	602
65 - 98	67	97.1	2	2.9	69
Total	6,495	96.7	220	3.3	6,715

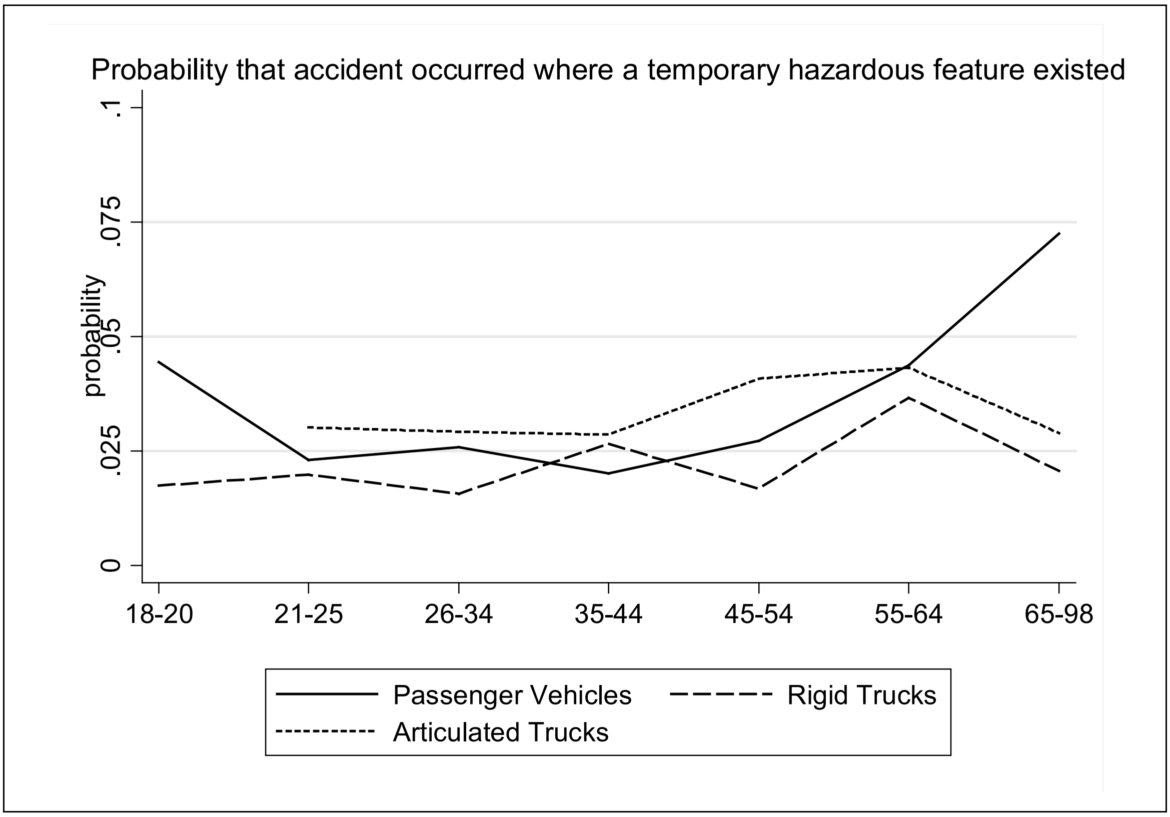


Figure 16: Temporary feature at accident site

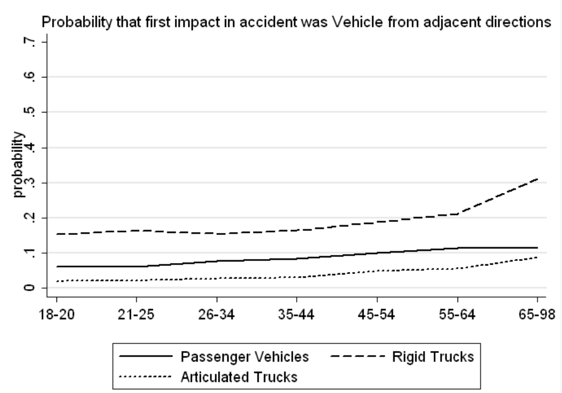
Road user movement at time of accident

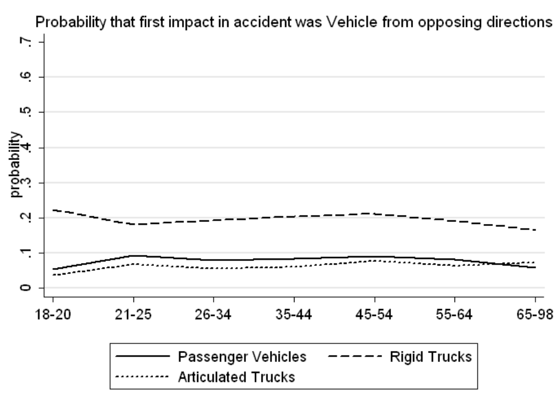
The majority of accidents (45%) occur where vehicles are travelling in the same direction (see Table 20). The road user movement at the time of the accident by age and vehicle type is significant when tested for an interaction ($p<0.01$). In addition the main effect for vehicle type is strongly significant ($p<0.01$); however the main effect for age is marginally significant ($p = 0.06$) (see Figure 17).

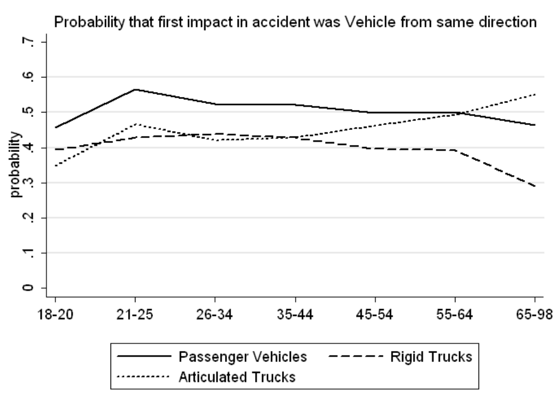
Table 20: Road user movement at time of accident by age group and vehicle type

Age	Vehicle from adjacent directions		Vehicle from opposing directions		Vehicle from same direction		Manoeuvring		Overtaking		On path		Off path		Miscellaneous		Total
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Passenger & light commercial vehicle																	
18 - 20	157	15.3	230	22.4	405	39.4	50	4.9	21	2.0	59	5.7	102	9.9	5	0.5	1,029
21 - 25	197	16.3	218	18.0	517	42.8	57	4.7	24	2.0	69	5.7	112	9.3	14	1.2	1,208
26 - 34	270	15.2	333	18.7	784	44.1	107	6.0	29	1.6	83	4.7	154	8.7	19	1.1	1,779
35 - 44	216	16.4	267	20.3	571	43.4	92	7.0	20	1.5	50	3.8	83	6.3	17	1.3	1,316
45 - 54	199	19.7	216	21.4	388	38.5	68	6.7	23	2.3	41	4.1	59	5.8	15	1.5	1,009
55 - 64	138	20.2	138	20.2	267	39.1	40	5.9	17	2.5	29	4.3	39	5.7	14	2.1	682
65 - 98	255	31.1	136	16.6	238	29.0	104	12.7	26	3.2	20	2.4	36	4.4	5	0.6	820
Total	1,432	18.3	1,538	19.6	3,170	40.4	518	6.6	160	2.0	351	4.5	585	7.5	89	1.1	7,843
Rigid trucks																	
18 - 20	6	6.7	3	3.3	47	52.2	12	13.3	1	1.1	0	0.0	19	21.1	2	2.2	90
21 - 25	31	6.0	50	9.6	304	58.6	34	6.6	3	0.6	15	2.9	81	15.6	1	0.2	519
26 - 34	133	8.0	139	8.4	853	51.3	133	8.0	11	0.7	62	3.7	323	19.4	10	0.6	1,664
35 - 44	142	8.4	145	8.6	877	51.8	127	7.5	10	0.6	54	3.2	326	19.3	11	0.7	1,692
45 - 54	109	9.0	106	8.8	613	50.8	100	8.3	4	0.3	41	3.4	229	19.0	5	0.4	1,207
55 - 64	74	12.5	41	6.9	298	50.2	49	8.2	2	0.3	18	3.0	107	18.0	5	0.8	594
65 - 98	8	11.6	4	5.8	32	46.4	3	4.3	0	0.0	0	0.0	19	27.5	3	4.3	69
Total	503	8.6	488	8.4	3,024	51.8	458	7.8	31	0.5	190	3.3	1,104	18.9	37	0.6	5,835
Articulated trucks																	
18 - 20	0	0.0	3	9.7	5	16.1	2	6.5	0	0.0	1	3.2	20	64.5	0	0.0	31

21 - 25	8	2.2	23	6.3	160	43.8	11	3.0	5	1.4	7	1.9	148	40.5	3	0.8	365
26 - 34	55	2.7	114	5.6	879	42.8	48	2.3	28	1.4	56	2.7	863	42.0	10	0.5	2,053
35 - 44	63	3.0	124	5.9	899	42.8	58	2.8	26	1.2	63	3.0	858	40.9	8	0.4	2,099
45 - 54	72	4.8	115	7.7	691	46.3	44	2.9	16	1.1	53	3.5	496	33.2	7	0.5	1,494
55 - 64	33	5.5	38	6.3	297	49.3	25	4.2	5	0.8	20	3.3	181	30.1	3	0.5	602
65 - 98	6	8.7	5	7.2	38	55.1	1	1.4	0	0.0	1	1.4	17	24.6	1	1.4	69
Total	237	3.5	422	6.3	2,969	44.2	189	2.8	80	1.2	201	3.0	2,583	38.5	32	0.5	6,713







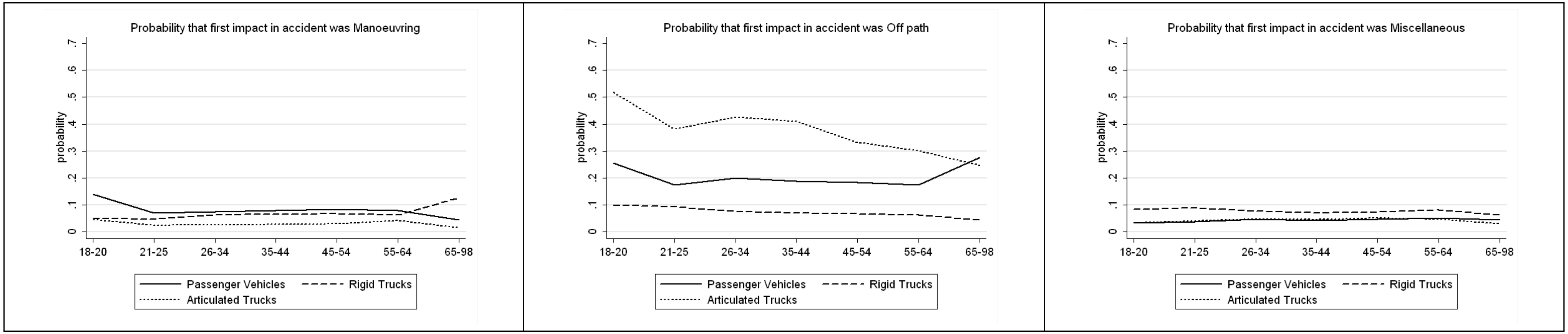


Figure 17: Road user movement at first impact

5.4 Vehicle factors

Vehicle age

Sixty one percent (61.4%) of vehicles involved in a heavy vehicle accident are less than 10 year old, with articulated trucks having a higher proportion than average (70.7%) (see Table 21). The age of the vehicle involved in the accident by controller age and vehicle type is strongly significant when tested for an interaction (p<0.01). In addition the main effect for vehicle is also strongly significant (p<0.01); and the main effect for controller age is also strongly significant (p<0.01) (see Figure 18).

Table 21: Age of key vehicle by age group and vehicle type

tuage										
age	0 - 4 years		5 - 9 years		10 - 14 years		15 - 20 years		> 20 years		Total
	N	%	N	%	N	%	N	%	N	%	N
Passenger & light commercial vehicle											
18 - 20	185	18.3	249	24.6	294	29.0	220	21.7	65	6.4	1,013
21 - 25	344	29.1	324	27.4	274	23.2	184	15.6	56	4.7	1,182
26 - 34	556	31.9	472	27.1	396	22.7	235	13.5	85	4.9	1,744
35 - 44	424	33.0	419	32.6	241	18.7	146	11.4	56	4.4	1,286
45 - 54	327	33.1	307	31.0	206	20.8	113	11.4	36	3.6	989
55 - 64	230	34.7	193	29.1	140	21.1	74	11.2	26	3.9	663
65 - 98	182	22.5	227	28.1	187	23.1	139	17.2	73	9.0	808
Total	2,248	29.3	2,191	28.5	1,738	22.6	1,111	14.5	397	5.2	7,685
Rigid trucks											
18 - 20	17	20.7	23	28.0	18	22.0	15	18.3	9	11.0	82
21 - 25	161	32.5	120	24.2	93	18.8	83	16.8	38	7.7	495
26 - 34	496	31.0	421	26.3	325	20.3	249	15.6	109	6.8	1,600
35 - 44	527	32.7	418	25.9	314	19.5	240	14.9	113	7.0	1,612
45 - 54	339	29.2	310	26.7	225	19.4	184	15.9	102	8.8	1,160
55 - 64	151	26.6	150	26.4	95	16.7	108	19.0	64	11.3	568
65 - 98	14	20.9	10	14.9	15	22.4	8	11.9	20	29.9	67
Total	1,705	30.5	1,452	26.0	1,085	19.4	887	15.9	455	8.1	5,584
Articulated trucks											
18 - 20	6	23.1	7	26.9	7	26.9	1	3.8	5	19.2	26
21 - 25	108	32.7	106	32.1	63	19.1	30	9.1	23	7.0	330
26 - 34	788	43.2	569	31.2	269	14.8	133	7.3	64	3.5	1,823
35 - 44	865	46.2	501	26.8	264	14.1	160	8.6	81	4.3	1,871
45 - 54	513	38.1	382	28.4	218	16.2	132	9.8	102	7.6	1,347

55 - 64	208	37.9	158	28.8	86	15.7	53	9.7	44	8.0	549
65 - 98	18	27.7	19	29.2	13	20.0	13	20.0	2	3.1	65
Total	2,506	41.7	1,742	29.0	920	15.3	522	8.7	321	5.3	6,011

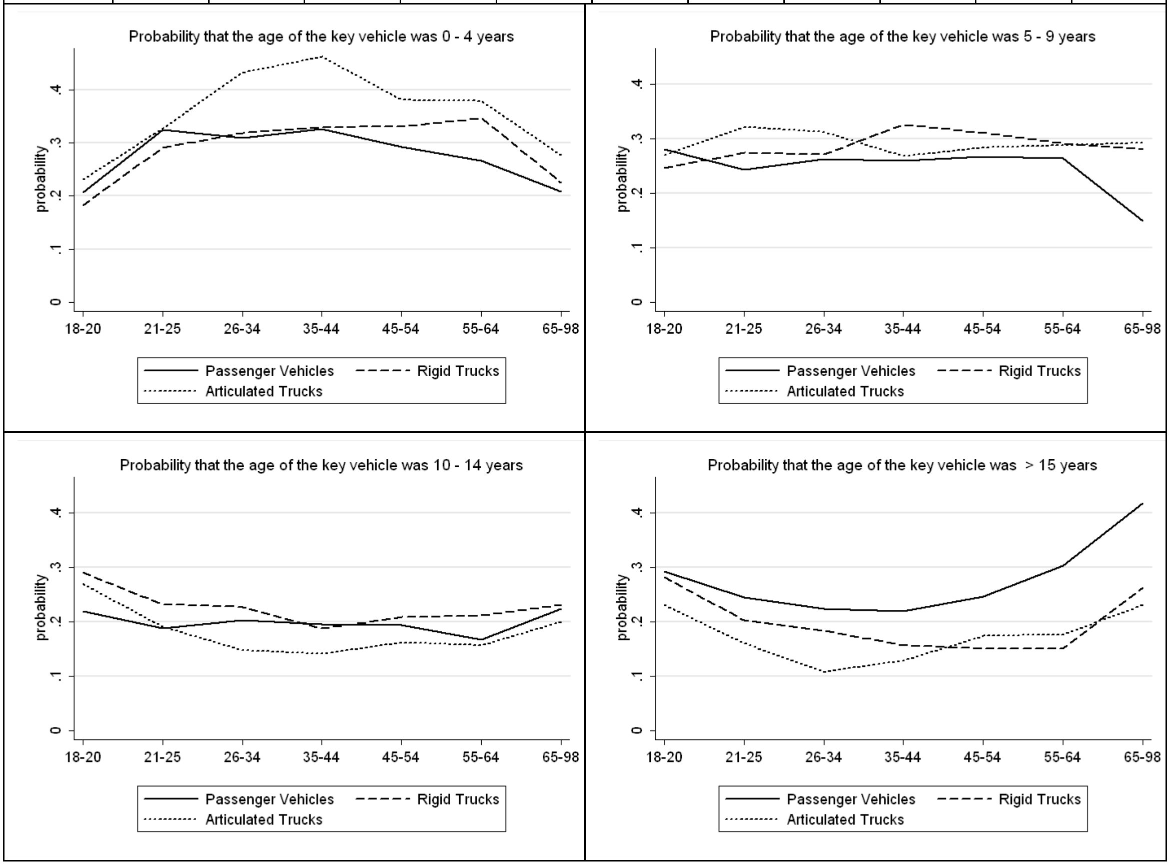


Figure 18: Age of key vehicle

Unusual vehicle factor

Overall, eleven (10.6%) percent of accidents occurred due to an unusual vehicle factor. In the articulated vehicle type, 14.6% of accidents were attributed to an unusual vehicle factor compared to 5.2% in the rigid truck type. The proportions of accidents in the rigid vehicle type were similar across all age groups (See Table 22). The existence of an unusual vehicle factor by age and vehicle type is not significant when tested for an interaction ($p=0.16$). In addition the main effect for age is insignificant ($p=0.33$); however the main effect for vehicle type is significant ($p<0.01$) (Figure 19).

Table 22: Unusual vehicle factor by age group and vehicle type

unusual vehicle factor					
age	No unusual vehicle factors		Unusual vehicle factor		Total
	N	%	N	%	N
Passenger & light commercial vehicle					
18 - 20	909	88.2	122	11.8	1,031
21 - 25	1,078	89.2	131	10.8	1,209
26 - 34	1,632	91.7	148	8.3	1,780
35 - 44	1,197	91.0	119	9.0	1,316
45 - 54	912	90.4	97	9.6	1,009
55 - 64	623	91.3	59	8.7	682
65 - 98	786	95.7	35	4.3	821
Total	7,137	90.9	711	9.1	7,848
Rigid trucks					
18 - 20	86	95.6	4	4.4	90
21 - 25	493	95.0	26	5.0	519
26 - 34	1,566	94.1	98	5.9	1,664
35 - 44	1,616	95.5	77	4.5	1,693
45 - 54	1,145	94.7	64	5.3	1,209
55 - 64	559	94.1	35	5.9	594
65 - 98	67	97.1	2	2.9	69
Total	5,532	94.8	306	5.2	5,838
Articulated trucks					
18 - 20	26	83.9	5	16.1	31
21 - 25	316	86.6	49	13.4	365
26 - 34	1,724	84.0	329	16.0	2,053
35 - 44	1,772	84.4	328	15.6	2,100
45 - 54	1,309	87.6	186	12.4	1,495
55 - 64	528	87.7	74	12.3	602
65 - 98	62	89.9	7	10.1	69
Total	5,737	85.4	978	14.6	6,715

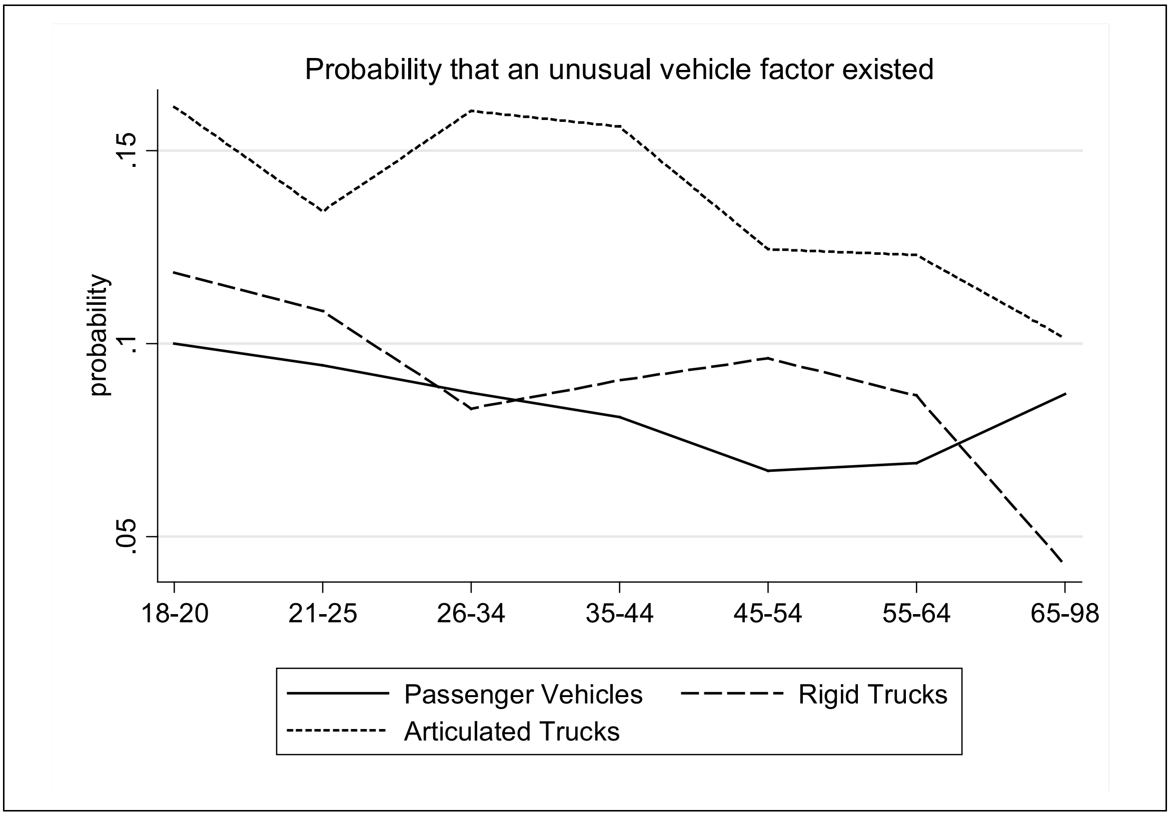


Figure 19: Unusual factor in key vehicle

Equipment failure

A small proportion of accidents, four (3.9%) percent, occur due to equipment failure. A higher proportion of accidents due to equipment failure occurred in the rigid trucks and articulated truck vehicle types (5.2% and 6.1% respectively) compared to passenger and light commercial vehicles (1.0 %) (see Table 23). An equipment failure in the key vehicle by age and vehicle type is not significant when tested for an interaction (p=0.09). In addition the main effect for age is insignificant (p=0.62); however the main effect for vehicle type is significant (p<0.01) (Figure 20).

Table 23: Equipment failure by age group and vehicle type

Age	No equipment failure		Equipment failure		Total
	N	%	N	%	N
Passenger & light commercial vehicle					
18 - 20	1,020	98.9	11	1.1	1,031
21 - 25	1,201	99.3	8	0.7	1,209
26 - 34	1,759	98.8	21	1.2	1,780
35 - 44	1,308	99.4	8	0.6	1,316
45 - 54	992	98.3	17	1.7	1,009
55 - 64	678	99.4	4	0.6	682
65 - 98	814	99.1	7	0.9	821

Total	7,772	99.0	76	1.0	7,848
Rigid trucks					
18 - 20	86	95.6	4	4.4	90
21 - 25	493	95.0	26	5.0	519
26 - 34	1,566	94.1	98	5.9	1,664
35 - 44	1,616	95.5	77	4.5	1,693
45 - 54	1,145	94.7	64	5.3	1,209
55 - 64	559	94.1	35	5.9	594
65 - 98	67	97.1	2	2.9	69
Total	5,532	94.8	306	5.2	5,838
Articulated trucks					
18 - 20	30	96.8	1	3.2	31
21 - 25	343	94.0	22	6.0	365
26 - 34	1,923	93.7	130	6.3	2,053
35 - 44	1,960	93.3	140	6.7	2,100
45 - 54	1,426	95.4	69	4.6	1,495
55 - 64	556	92.4	46	7.6	602
65 - 98	66	95.7	3	4.3	69
Total	6,304	93.9	411	6.1	6,715

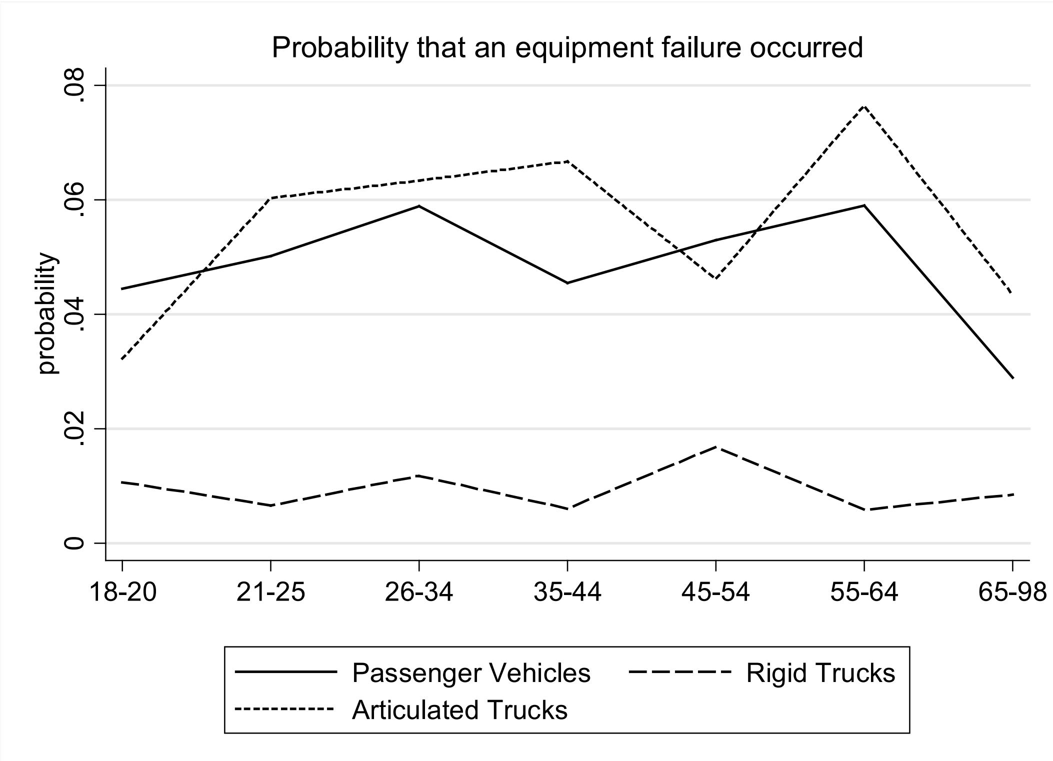


Figure 20: Equipment failure

5.5 Vehicle controller factors

Gender of vehicle controller

Of the 20,401 accidents reported, 86.5% had male vehicle controllers. The majority of accidents involving female controllers occurred when driving a passenger or light commercial vehicle (see Table 24). The gender of the controller by age and vehicle type is not significant when tested for an interaction (p=0.22). However, the main effect for age is strongly significant (p<0.01); as is the main effect for vehicle type (p<0.01) (see Figure 21).

Table 24: Gender of vehicle controller by age group and vehicle type

Gender					
age	Male		Female		Total
	N	%	N	%	N
Passenger & light commercial vehicle					
18 - 20	707	68.6	324	31.4	1,031
21 - 25	810	67.0	399	33.0	1,209
26 - 34	1,204	67.6	576	32.4	1,780
35 - 44	793	60.3	523	39.7	1,316
45 - 54	630	62.4	379	37.6	1,009
55 - 64	451	66.1	231	33.9	682
65 - 98	548	66.7	273	33.3	821
Total	5,143	65.5	2,705	34.5	7,848
Rigid trucks					
18 - 20	90	100.0	0	0.0	90
21 - 25	517	99.6	2	0.4	519
26 - 34	1,656	99.5	8	0.5	1,664
35 - 44	1,689	99.8	4	0.2	1,693
45 - 54	1,203	99.5	6	0.5	1,209
55 - 64	593	99.8	1	0.2	594
65 - 98	69	100.0	0	0.0	69
Total	5,817	99.6	21	0.4	5,838
Articulated trucks					
18 - 20	31	100.0	0	0.0	31
21 - 25	364	99.7	1	0.3	365
26 - 34	2,038	99.3	15	0.7	2,053
35 - 44	2,090	99.5	10	0.5	2,100
45 - 54	1,491	99.7	4	0.3	1,495
55 - 64	602	100.0	0	0.0	602

65 - 98	68	98.6	1	1.4	69
Total	6,684	99.5	31	0.5	6,715

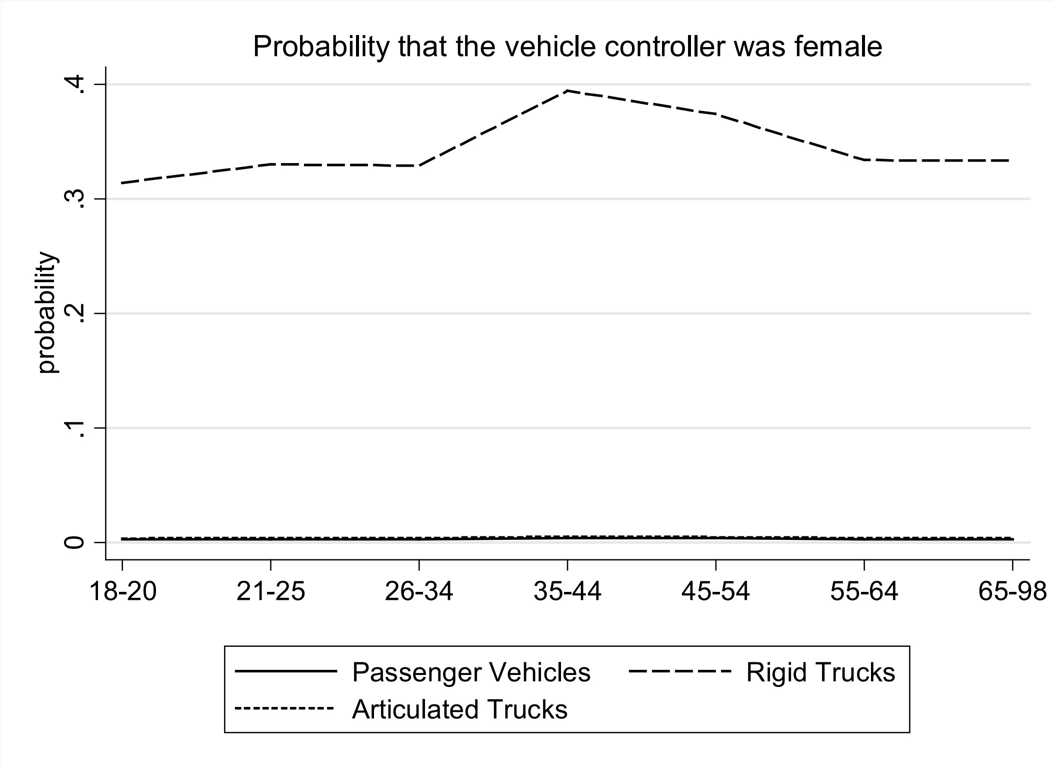


Figure 21: Vehicle controller gender

Controller error

Overall, twenty one (20.6%) percent of accidents occurred due to controller error. Controller error was a factor in 16.2% of rigid truck accidents and 18.9% in articulated truck accidents. Controller error was highest in the over 64 year age group (30.8%) followed by 27.9% in the 18 – 20 year age group (see Table 25). Controller error by age and vehicle type is not significant when tested for an interaction (p=0.50). In addition the main effect for age is insignificant (p=0.66); however the main effect for vehicle type is significant (p<0.01) (see Figure 22).

Table 25: Controller error by age group and vehicle type

Controller Error					
age	No error factor		Error factor		Total
	N	%	N	%	N
Passenger and light commercial vehicles					
18 - 20	735	71.3	296	28.7	1,031
21 - 25	918	75.9	291	24.1	1,209
26 - 34	1,360	76.4	420	23.6	1,780
35 - 44	1,027	78.0	289	22.0	1,316
45 - 54	755	74.8	254	25.2	1,009
55 - 64	509	74.6	173	25.4	682
65 - 98	558	68.0	263	32.0	821
Total	5,862	74.7	1,986	25.3	7,848
Rigid trucks					
18 - 20	73	81.1	17	18.9	90
21 - 25	446	85.9	73	14.1	519
26 - 34	1,403	84.3	261	15.7	1,664
35 - 44	1,413	83.5	280	16.5	1,693
45 - 54	1,004	83.0	205	17.0	1,209
55 - 64	500	84.2	94	15.8	594
65 - 98	55	79.7	14	20.3	69
Total	4,894	83.8	944	16.2	5,838
Articulated trucks					
18 - 20	23	74.2	8	25.8	31
21 - 25	303	83.0	62	17.0	365
26 - 34	1,655	80.6	398	19.4	2,053
35 - 44	1,685	80.2	415	19.8	2,100
45 - 54	1,227	82.1	268	17.9	1,495
55 - 64	500	83.1	102	16.9	602
65 - 98	51	73.9	18	26.1	69
Total	5,444	81.1	1,271	18.9	6,715

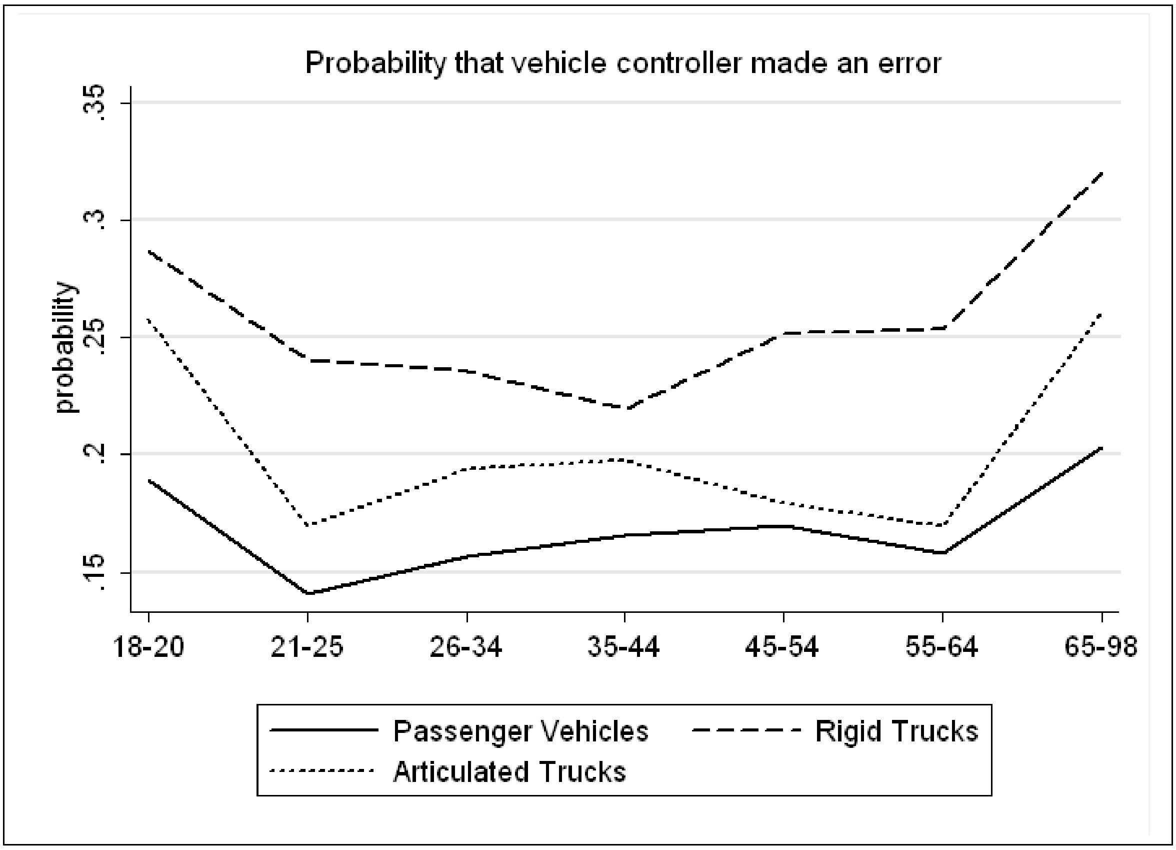


Figure 22: Controller error

Distraction of controller

Overall, ten (9.8) percent of accidents occurred where controller distraction was judged to be a factor. Controllers of passenger and light commercial vehicles and articulated trucks are more likely to be distracted (11.3% and 10.0% respectfully). The younger the controller the more likely a factor in an accident is distraction. For 18 – 20 year olds, in 12.7% of accidents distraction was a factor (see Table 26). A distraction of the vehicle controller by age and vehicle type is not significant when tested for an interaction (p=0.14). However the main effect for age is significant (p=0.01); as is the main effect for vehicle type (p = 0.02) (see Figure 23).

Table 26: Controller distracted by age group and vehicle type

distraction factor					
age	No distraction		Distraction		Total
	N	%	N	%	N
Passenger and light commercial vehicles					
18 - 20	894	86.7	137	13.3	1,031
21 - 25	1,038	85.9	171	14.1	1,209
26 - 34	1,582	88.9	198	11.1	1,780
35 - 44	1,175	89.3	141	10.7	1,316
45 - 54	910	90.2	99	9.8	1,009
55 - 64	604	88.6	78	11.4	682
65 - 98	759	92.4	62	7.6	821
Total	6,962	88.7	886	11.3	7,848
Rigid trucks					
18 - 20	84	93.3	6	6.7	90
21 - 25	472	90.9	47	9.1	519
26 - 34	1,525	91.6	139	8.4	1,664
35 - 44	1,554	91.8	139	8.2	1,693
45 - 54	1,150	95.1	59	4.9	1,209
55 - 64	551	92.8	43	7.2	594
65 - 98	64	92.8	5	7.2	69
Total	5,400	92.5	438	7.5	5,838
Articulated trucks					
18 - 20	28	90.3	3	9.7	31
21 - 25	327	89.6	38	10.4	365
26 - 34	1,815	88.4	238	11.6	2,053
35 - 44	1,876	89.3	224	10.7	2,100
45 - 54	1,369	91.6	126	8.4	1,495
55 - 64	563	93.5	39	6.5	602
65 - 98	64	92.8	5	7.2	69
Total	6,042	90.0	673	10.0	6,715

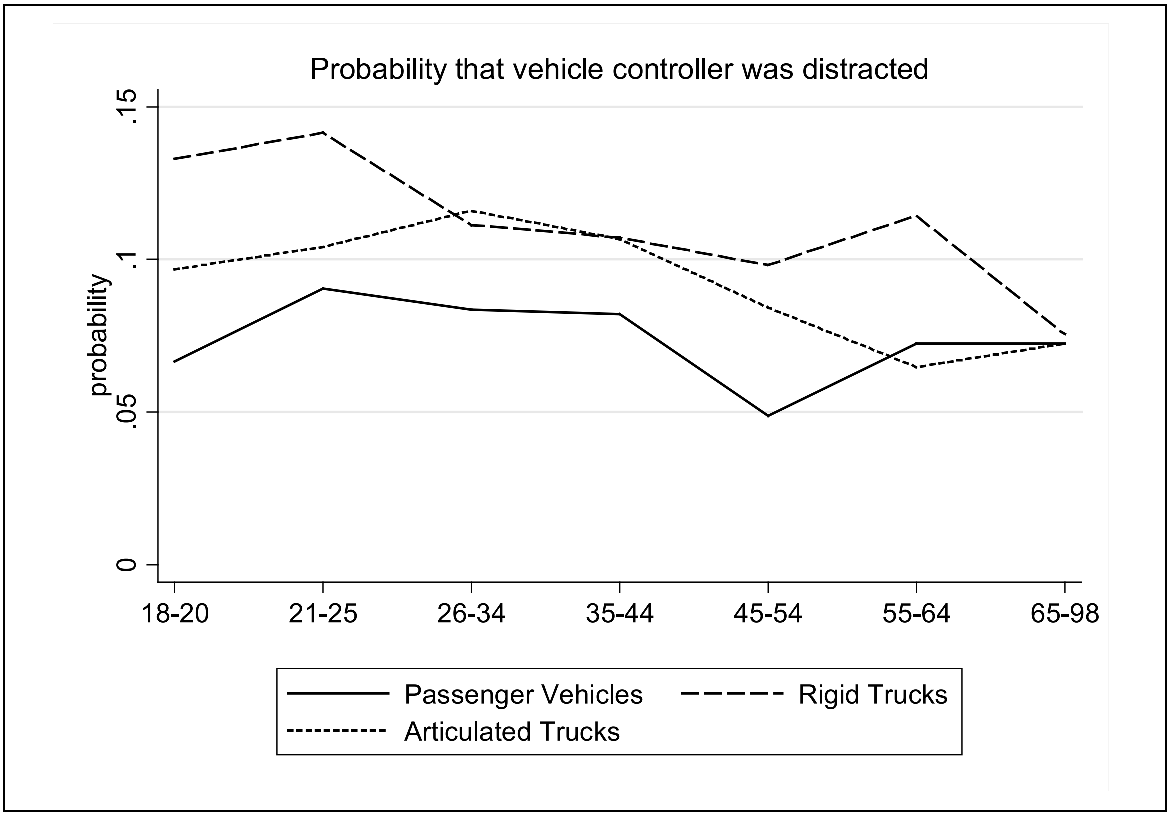


Figure 23: Distraction of controller

Fatigued controller

Overall, eight (8.5%) percent of accidents occurred where controller fatigue was a factor. In the articulated vehicles, 11.9% of accidents were attributed to controller fatigue compared to 6.0% in the rigid truck type (see Table 27). The existence of fatigue in a controller by age and vehicle type is not significant when tested for an interaction (p=0.78). In addition the main effect for age is insignificant (p=0.42); however the main effect for vehicle type is strongly significant (p<0.01).

Table 27: Fatigued controller by age group and vehicle type

fatigued controller					
age	Not fatigued or unknown		Fatigued		Total
	N	%	N	%	N
Passenger and light commercial vehicles					
18 - 20	939	91.1	92	8.9	1,031
21 - 25	1,100	91.0	109	9.0	1,209
26 - 34	1,645	92.4	135	7.6	1,780
35 - 44	1,219	92.6	97	7.4	1,316
45 - 54	942	93.4	67	6.6	1,009
55 - 64	641	94.0	41	6.0	682
65 - 98	784	95.5	37	4.5	821

Total	7,270	92.6	578	7.4	7,848
Rigid trucks					
18 - 20	83	92.2	7	7.8	90
21 - 25	488	94.0	31	6.0	519
26 - 34	1,547	93.0	117	7.0	1,664
35 - 44	1,597	94.3	96	5.7	1,693
45 - 54	1,144	94.6	65	5.4	1,209
55 - 64	564	94.9	30	5.1	594
65 - 98	66	95.7	3	4.3	69
Total	5,489	94.0	349	6.0	5,838
Articulated trucks					
18 - 20	24	77.4	7	22.6	31
21 - 25	309	84.7	56	15.3	365
26 - 34	1,763	85.9	290	14.1	2,053
35 - 44	1,860	88.6	240	11.4	2,100
45 - 54	1,342	89.8	153	10.2	1,495
55 - 64	555	92.2	47	7.8	602
65 - 98	65	94.2	4	5.8	69
Total	5,918	88.1	797	11.9	6,715

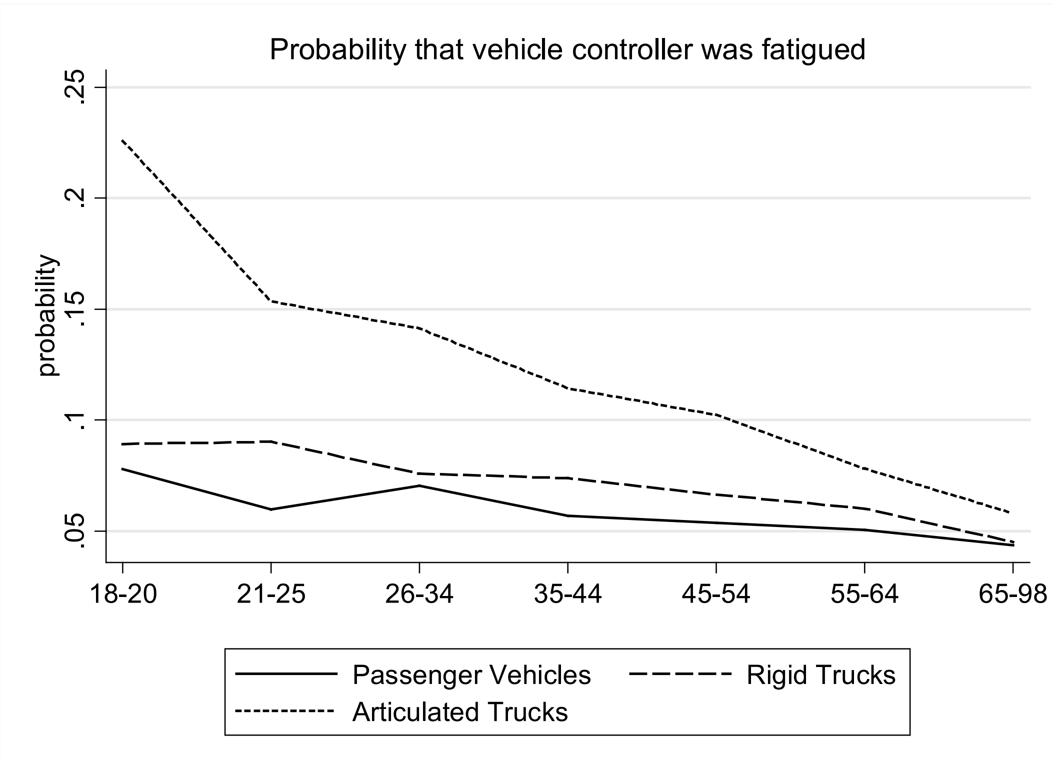


Figure 24: Vehicle controller fatigued

Alcohol a Factor

Overall, two (1.8%) percent of accidents occurred where alcohol was identified as a factor in the accident. Alcohol is less likely to be a factor in articulated truck accidents where the proportion is 0.9%. The younger the controller the more likely a factor in an accident is alcohol. For 18 – 20 year olds, in 2.8% of accidents alcohol was a factor (see Table 28). The existence of alcohol as a factor in an accident by age and vehicle type is not significant when tested for an interaction (p=0.58). However the main effect for age is significant (p<0.01), as is the main effect for vehicle type is significant (p<0.01) (see Figure 25).

Table 28: Alcohol a factor in accident by age group and vehicle type

Age	No or Unknown		Yes		Total
	N	%	N	%	N
Passenger and light commercial vehicles					
18 – 20	999	96.9	32	3.1	1,031
21 – 25	1,156	95.6	53	4.4	1,209
26 – 34	1,711	96.1	69	3.9	1,780
35 – 44	1,261	95.8	55	4.2	1,316
45 - 54	979	97.0	30	3.0	1,009
55 - 64	674	98.8	8	1.2	682
65 - 98	812	98.9	9	1.1	821
Total	7,592	96.7	256	3.3	7,848
Rigid trucks					
18 - 20	90	100.0	0	0.0	90
21 - 25	512	98.7	7	1.3	519
26 - 34	1,640	98.6	24	1.4	1,664
35 - 44	1,675	98.9	18	1.1	1,693
45 - 54	1,200	99.3	9	0.7	1,209
55 - 64	590	99.3	4	0.7	594
65 - 98	68	98.6	1	1.4	69
Total	5,775	98.9	63	1.1	5,838
Articulated trucks					
18 - 20	31	100.0	0	0.0	31
21 - 25	361	98.9	4	1.1	365
26 - 34	2,037	99.2	16	0.8	2,053
35 - 44	2,081	99.1	19	0.9	2,100
45 - 54	1,481	99.1	14	0.9	1,495
55 - 64	598	99.3	4	0.7	602

65 - 98	69	100.0	0	0.0	69
Total	6,658	99.2	57	0.8	6,715

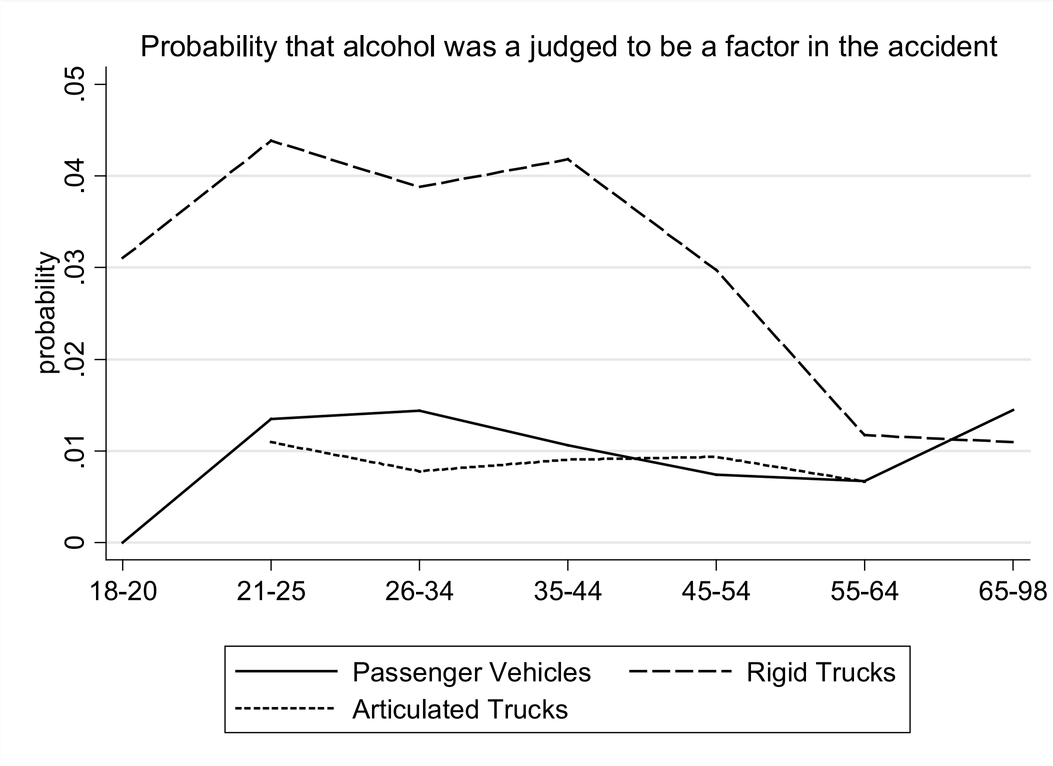


Figure 25: Alcohol judged a factor in accident

Blood Alcohol of Controller

Overall, two (2.0) percent of accidents occurred where the vehicle controller's blood alcohol was over the legal limit. The younger the controller the more likely a factor in an accident is illegal blood alcohol. The proportion of accidents where the vehicle controller's blood alcohol was over the legal limit was greater than two percent in all age groups under 45 years. The proportion of illegal blood alcohol levels of vehicle controllers was greatest in passenger vehicles and light commercials (3.7%) followed by rigid trucks (1.1%) and articulated trucks (0.7%) (see Table 29). An illegal blood alcohol of the key vehicle controller by age and vehicle type is not significant when tested for an interaction ($p=0.32$). In addition the main effect for age is insignificant ($p=0.13$); however the main effect for vehicle type is significant ($p<0.01$) (see Figure 26).

Table 29: Blood alcohol of vehicle controller by age group and vehicle type

alcohol group					
age	Legal		Illegal		Total
	N	%	N	%	N
Passenger and light commercial vehicles					
18 - 20	894	96.8	30	3.2	924
21 - 25	995	95.1	51	4.9	1,046
26 - 34	1,419	95.4	68	4.6	1,487
35 - 44	1,053	95.0	55	5.0	1,108
45 - 54	845	96.7	29	3.3	874
55 - 64	576	98.8	7	1.2	583
65 - 98	701	98.7	9	1.3	710
Total	6,483	96.3	249	3.7	6,732
Rigid trucks					
18 - 20	76	100.0	0	0.0	76
21 - 25	415	99.0	4	1.0	419
26 - 34	1,267	98.3	22	1.7	1,289
35 - 44	1,318	98.9	14	1.1	1,332
45 - 54	931	99.1	8	0.9	939
55 - 64	445	99.3	3	0.7	448
65 - 98	51	98.1	1	1.9	52
Total	4,503	98.9	52	1.1	4,555
Articulated trucks					
18 - 20	24	100.0	0	0.0	24
21 - 25	312	100.0	0	0.0	312
26 - 34	1,737	99.3	12	0.7	1,749
35 - 44	1,736	99.1	16	0.9	1,752
45 - 54	1,222	99.3	8	0.7	1,230
55 - 64	480	99.4	3	0.6	483
65 - 98	55	100.0	0	0.0	55
Total	5,566	99.3	39	0.7	5,605

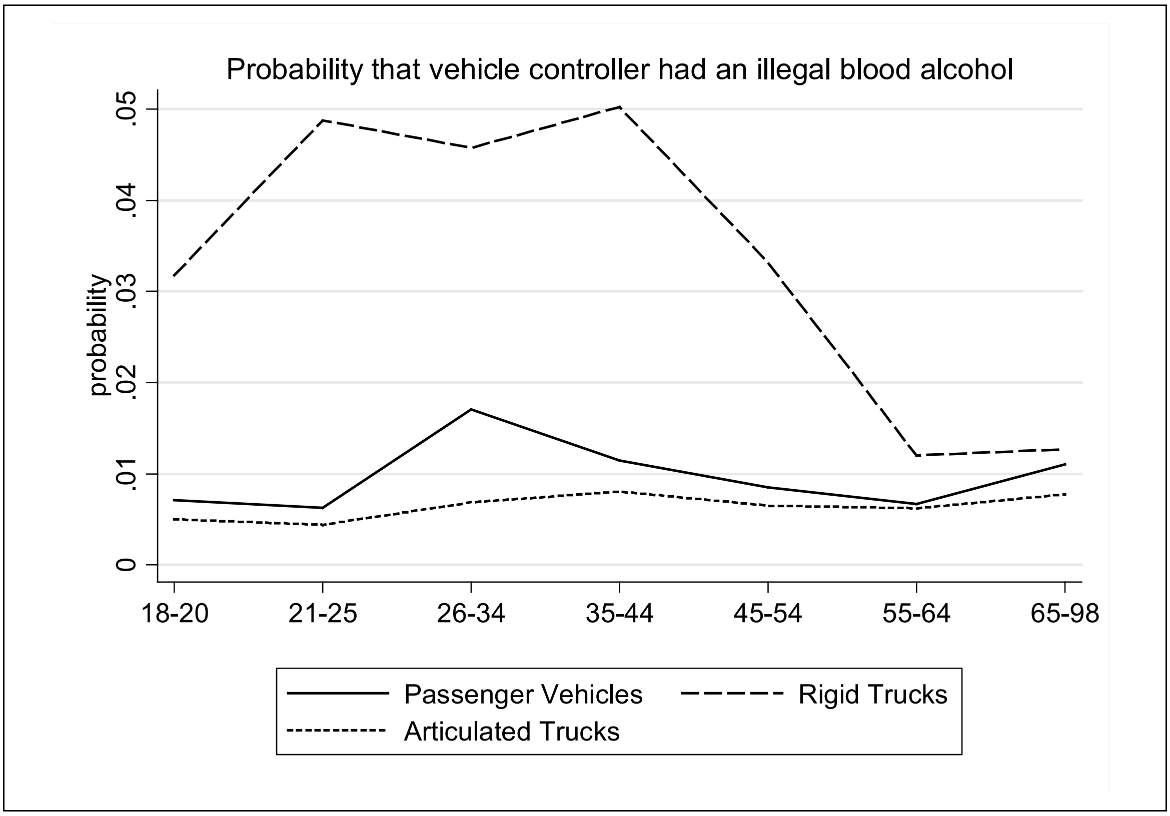


Figure 26: Blood alcohol of controller (legal/illegal)

Controller speeding

Overall fourteen (13.6) percent of accidents occurred due to controller speeding. The highest proportions occur in the 26 – 34 year age group (15.0%) and the 35 – 44 year age group (15.7%). The highest proportion of controller speeding occurs in articulated trucks (22.7%) (see Table 30). A speeding controller by age and vehicle type is significant when tested for an interaction (p=0.01). In addition the main effect for type is strongly significant (p<0.01); however the main effect for age is not significant (p = 0.80) (Figure 27).

Table 30: Speeding controller by age group and vehicle type

speeding controller					
	No		Yes		Total
age	N	%	N	%	N
Passenger and light commercial vehicles					
18 - 20	892	86.5	139	13.5	1,031
21 - 25	1,070	88.5	139	11.5	1,209
26 - 34	1,597	89.7	183	10.3	1,780
35 - 44	1,206	91.6	110	8.4	1,316
45 - 54	924	91.6	85	8.4	1,009
55 - 64	632	92.7	50	7.3	682
65 - 98	791	96.3	30	3.7	821
Total	7,112	90.6	736	9.4	7,848
Rigid trucks					
18 - 20	86	95.6	4	4.4	90
21 - 25	479	92.3	40	7.7	519
26 - 34	1,516	91.1	148	8.9	1,664
35 - 44	1,542	91.1	151	8.9	1,693
45 - 54	1,104	91.3	105	8.7	1,209
55 - 64	540	90.9	54	9.1	594
65 - 98	62	89.9	7	10.1	69
Total	5,329	91.3	509	8.7	5,838
Articulated trucks					
18 - 20	20	64.5	11	35.5	31
21 - 25	281	77.0	84	23.0	365
26 - 34	1,557	75.8	496	24.2	2,053
35 - 44	1,586	75.5	514	24.5	2,100
45 - 54	1,192	79.7	303	20.3	1,495
55 - 64	491	81.6	111	18.4	602
65 - 98	61	88.4	8	11.6	69
Total	5,188	77.3	1,527	22.7	6,715

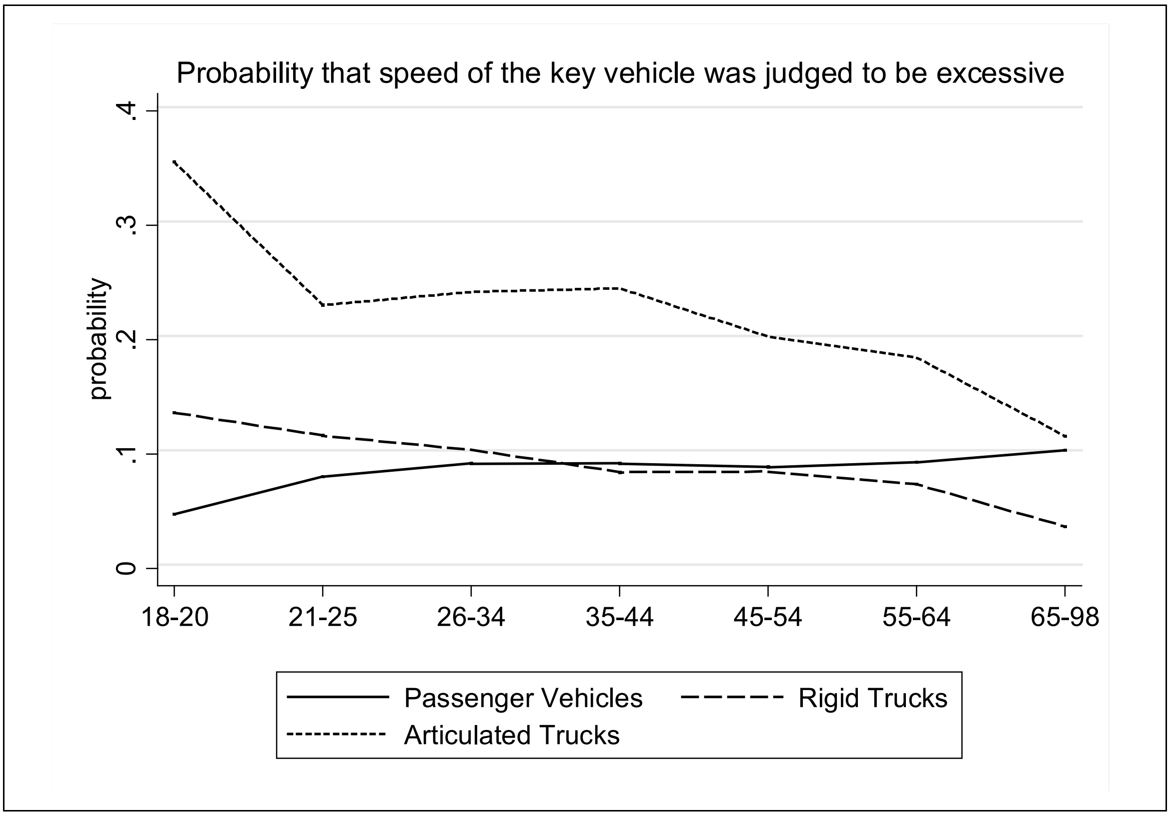


Figure 27: Excessive speed a factor in accident

5.6 Summary of accident factors analysis

Table 31 summarises the analysis of demographic, time, weather, road, vehicle and vehicle controller factors results described above. Of the twenty five models with an interaction of vehicle type and controller age group, in ten models the interaction was statistically significant. This means the effect of the age of the vehicle controller on the accident factor varies significantly by vehicle type at the 0.05 level.

Table 31: Summary of accident analysis

Factor	Age significant	Vehicle type significant	Interaction exists
Accident year	Yes	No	Yes
Mileage travelled	Yes	Yes	Yes
Severity of accident	No	Yes	No
Time of accident	No	Yes	Yes
Urbanisation	Yes	Yes	Yes
Road classification	No	Yes	Yes
Type of location	No	Yes	No
Speed limit at location	No	Yes	Yes
Weather conditions	No	No	No
Road surface	Yes	No	No

Factor	Age significant	Vehicle type significant	Interaction exists
Road surface condition	No	Yes	No
Permanent feature at location	No	Yes	No
Hazardous feature at location	Yes	Yes	Yes
Temporary hazardous feature at location	Yes	No	No
Road user movement	No	Yes	Yes
Age of vehicle	Yes	Yes	Yes
Unusual vehicle factor	No	Yes	No
Equipment failure	No	Yes	No
Controller gender	Yes	Yes	No
Controller error	No	Yes	No
Controller distracted	Yes	Yes	No
Controller fatigued	No	Yes	No
Alcohol a factor	No	Yes	No
Controller blood alcohol	Yes	Yes	No
Controller speeding	No	Yes	Yes

6 Discussion

The effect of controller age and vehicle type on accident occurrence has not previously been studied in heavy vehicle accidents in Australia. Internationally, a number of studies have been carried out using fatality data [6, 8, 12, 14], workers compensation claim data[7], law enforcement data[13] and survey data[9], therefore this study represents the first study where all accidents involving heavy a heavy vehicle where a vehicle was towed away, a person was injured or a fatality occurred has studied the effect of controller age and vehicle type. The more usual practice for studies of this nature is to analyse just fatality data. An additional key feature of this study is the use of an estimate of vehicle kilometres driven by state, vehicle type, controller age and gender of the controller. Estimates of kilometres driven data is routinely collected by the Australian Bureau of Statistics in quarterly surveys [55]. This estimate was used as a measure of kilometres at risk of having an accident, an approach that was used by Campbell [6].

6.1 Controller age, vehicle type and accident rates

The annual accident incident rate ratios were modelled using Poisson regression. The rate of accidents involving only passenger vehicles and light commercials vehicles show that compared to 35-44 year olds, younger drivers 18–20 years were 7.9 (95%

CI: 7.1, 8.7) more likely, drivers 21–25 years 2.9 (95% CI: 2.6, 3.2) more likely and drivers 26-34 years were 2.2 (95% CI: 2.0, 2.4) more likely to have an accident involving a heavy vehicle. Drivers aged over 64 years were 1.6 (95% CI: 1.5, 1.9) times more likely to be involved in an accident.

The modelling of accident incident rate ratios involving just rigid trucks show that compared to 35-44 year olds, younger drivers 18–20 years were 3.4 (95% CI: 2.7, 4.1) more likely, drivers 21–25 years 2.1 (95% CI: 1.9, 2.4) more likely and drivers 26-34 years were 1.6 (95% CI: 1.5, 1.7) more likely to have an accident involving a heavy vehicle. Drivers aged over 64 years were less likely (0.6 95% CI: 0.5, 0.78) to be involved in an accident. These associations are all statistically significant.

The modelling of accidents involving articulated trucks show that compared to 35-44 year olds, younger drivers 18–20 years were 13.0 (95% CI: 8.4, 17.6) more likely, drivers 21–25 years 3.21 (95% CI: 2.9, 3.6) and drivers 26-34 years were 1.9 (95% CI: 1.8, 2.0) more likely to have an accident involving a heavy vehicle. These associations are all statistically significant. Drivers aged over 64 years were 1.1 (0.8, 1.4) times more likely to be involved in an accident, however this association is not statistically significant as the 95% confidence interval contains the null value of 1.0.

Caution is required in interpreting this data; firstly, as the population in this analysis is not all drivers of passenger vehicles and light commercial vehicle controllers involved in accidents in New South Wales, rather just those involved in accidents with a heavy vehicle these results are not generalisable to all drivers of passenger vehicles and light commercial vehicles. Secondly, the number of accidents and mileage travelled are relatively small for some age groups and vehicle types (see Table 3 and Table 4). This is evidenced with wide confidence intervals (e.g. 18-20 years age group (n=32) and the low number of kilometres travelled in articulated vehicles).

These results approximately mirror the findings of Campbell[6] who also found that the risk for younger drivers was higher and that the risk increases after the approximate age of 60 years. However, as we were able to separate heavy vehicles into rigid and articulated trucks we also note that the risk for these to vehicle types differs. Most notable is the difference in risk rates for articulated trucks and rigid trucks in the age groups under 35 years. An examination of the confidence intervals surrounding the estimates of rate ratios in Figure 28 show that for passenger vehicles including light commercial vehicles and articulated trucks the confidence intervals overlap, thereby indicating that these is no statistically significant difference between these two groups, however for the rigid trucks the lower risk is significantly different. Younger drivers of rigid trucks are less likely to be involved in an accident than drivers of passenger vehicles and articulated trucks.

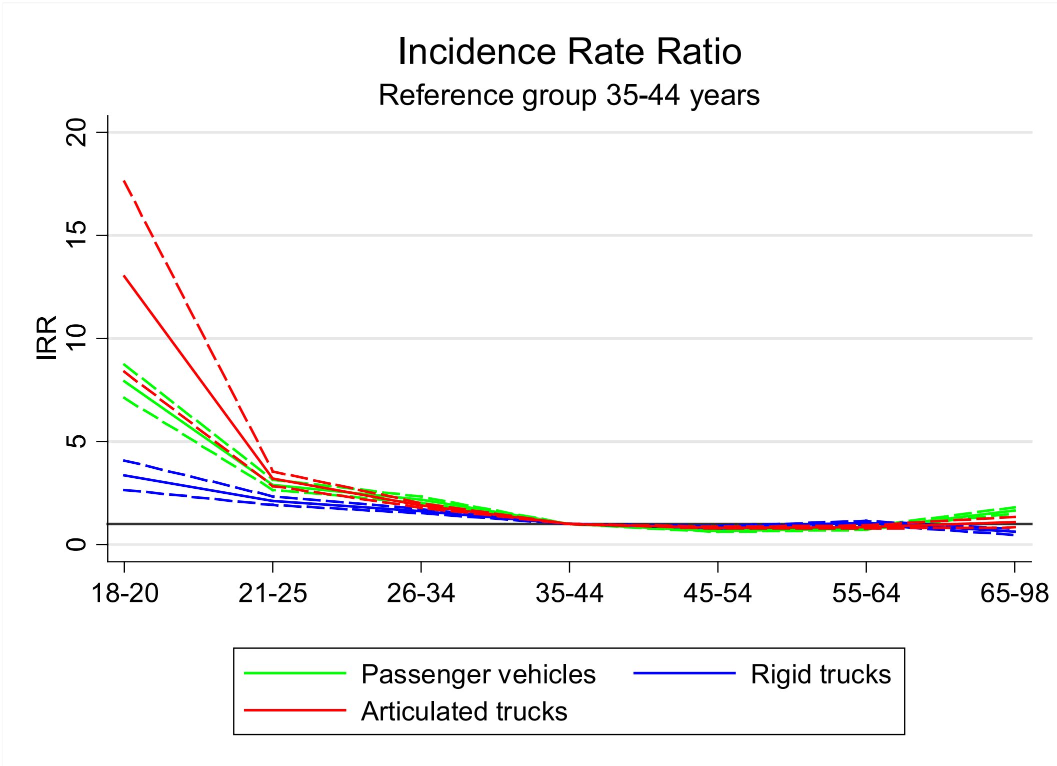


Figure 28: Incidence rate ratios with 95% confidence intervals

6.2 Significance of other accident factors

Severity of accident

Of the 20,401 accidents included in the analysis dataset, in 2.6% (n=536) a fatality occurred. The probability of being involved in a fatal accident is unaffected by age, however when a rigid or articulated truck is the key vehicle in an accident there is a higher risk of the accident being fatal (see Figure 5).

Time, weather and road factors

The probability of an accident occurring at night is highest for articulated trucks. Driver age is not a significant factor. It is difficult to make further comment upon this risk; to do so would require further data about the proportion of the time in one day an articulated truck is operated at night. In Campbell's analysis of such data the findings were that the fatal accident rate more than double at night compared with daytime [(6)].

The proportion of accidents to occur in metropolitan and country locations differs by vehicle type with the probability that an accident will occur in the country being significantly greater for articulated vehicles. Further an interaction does occur by vehicle type and driver age; that is the effect of vehicle type on the probability that an accident occurred in a country area varies with age. In other words for different driver age, the chance that the accident occurs in a country area varies according to the vehicle type they are operating. This is reflected in Figure 7 by observing that the three lines representing vehicle types are not parallel.

A significant interaction also occurs for the road classification where the accident occurred. The classifications were freeway/motorway, state highway, other classified road and unclassified road. There is a low probability that accidents occur on freeways/motorways (less than 10%) with the proportion approximately equal for all vehicle types and for all ages. The probability increases for state highway with articulated trucks significantly higher. For other classified roads the proportion is greater (approximately 40%) for all vehicle types however, for unclassified roads whilst passenger vehicles and rigid trucks are similar, articulated trucks are much less likely to have an accident (see Figure 8).

Vehicle type is the main difference in whether an accident occurs at an intersection or not. Although the main effect for age was not significant in the modelling of accident location, Figure 9 shows an interesting trend where the probability of an accident occurring at an intersection gradually increases with age. It is notable that of the three vehicle types the probability that the accident is at an intersection is lowest for articulated vehicles and highest at most ages for passenger vehicles including light commercials.

The speed limit at the location of the accident was modelled for 30-60kph, 70-80kph and 90-110kph zones. A strong effect was observed for vehicle type and an interaction exists between age and vehicle type. Whilst there was almost a 60% probability that the accident would occur in a 30-60kph zone for passenger vehicles including light commercials and rigid trucks, the experience of articulated trucks was much less. For 70-80kph zones the probability was equal for all vehicle types and all age drivers. Interestingly, clear differences exist in the probabilities of accidents in 90-110kph zones; rigid trucks and passenger vehicles including light commercials are similar with the probability approximately equal for age around 20%, however for rigid trucks the probability is greater and a reducing trend exist for age until 64 years (see Figure 10).

The road surface, whether it is sealed or unsealed intuitively has a strong effect on our ability to control any type motor vehicle. Vehicle type had no effect on accidents occurring on unsealed roads; however there was a strong age effect as well as a marginal interaction. Articulated trucks have the highest probability of an accident occurring on an unsealed road. Figure 11 shows some quite differing trends in younger and older drivers, however care is required in interpreting these as only 1.6% of accidents occurred on unsealed roads and the confidence intervals are quite wide.

Weather and road surface conditions are also important factors in accident causation. We observed no effect for vehicle type or driver age in wet weather accidents. However, for road surface (dry vs wet/snow/ice) 17.1% of accidents occurred in non-dry conditions. Whilst no difference exists for age of, a strong difference exists for vehicle type. Interestingly, the highest probability is for rigid trucks at ages under 65 years (see Figure 13).

The dataset contained variables which described the accident location in terms of permanent features, hazardous features or temporary hazardous features. Permanent features are described as constructed features (e.g. narrow roadway, one lane bridge, embankment or cutting) or lane features (e.g. merging lane, clearway) and road controls (e.g. freeway ramp or access road). No difference existed for the age of the driver, however the main effect for vehicle type was strongly significant with articulated trucks much less likely to be involved in an accident at a permanent feature. A hazardous feature is described as a road surface feature being a factor in the accident. Examples are potholes, loose gravel on a sealed road and loose gravel on the shoulder of a road. Whilst a marginal interaction exists the main effect for vehicle type is significant. Articulated trucks have a greater probability of having an accident where a hazardous feature exists. Temporary hazardous features are described as hazards of a temporary nature. Examples are roadwork, detour or road block. There is no difference in the probability of an accident occurring at a temporary hazardous feature by vehicle type, however there is a difference in age of the driver. The trend is quite different for vehicle types with drivers over 64 years driving rigid or articulated trucks reducing and passenger vehicle including light commercials driver increasing with age over 44 years (see Figure 16).

Road user movements were classified as impact occurring with a vehicle from adjacent direction, vehicle from opposing directions, vehicle from the same direction, key vehicle manoeuvring, key vehicle overtaking, key vehicle on path, key vehicle off path and all others were described as miscellaneous. The occurrence of an accident was strongly affected by age of the driver, the vehicle type and an interaction exists between vehicle type and age. The probability was very low for accidents involving manoeuvring and those classed as miscellaneous and there was no for age and vehicle (see Figure 17). For accidents with vehicles for an adjacent and opposing direction there was little effect for age with rigid trucks having the highest probability. For accidents with vehicles from the same direction there is a small and variable effect of age with passenger vehicles including light commercials having the highest probability. Off path accidents were highest in articulated trucks and lowest in rigid trucks. For passenger vehicles including light commercials and rigid trucks there is little variation for age, however for articulated trucks the probability reduces with age.

Vehicle factors

For modelling the effect of the key vehicle age, categories were created for 0-4 years, 5-9 years, 10-14 years and > 14 years. In accident causation the vehicle type and age of the controller are strongly affected by vehicle age (see Figure 18). In addition an interaction also exists. Younger and older drivers are less likely to have accidents in 0-4 year old vehicles and more likely in vehicle older that are older than 15 years. Articulated trucks have the highest probability in newer trucks and passenger vehicles including light commercial in the oldest vehicles.

Unusual vehicle factors are described as the key vehicle skidding, jack-knifing, aquaplaning or being parked dangerously. The probability of an accident occurring is strongly affected by the vehicle type. Figure 19 shows that whilst overall the probability is low (< 15%) the highest probability are for articulated vehicles.

The variable equipment factor describes any failure in the key vehicle which is a factor in an accident. Examples are brake, steering and tyre failures. Whilst there is no significant difference for the age of the driver, there is a strong effect for vehicle type as well as an interaction for vehicle type and age. The highest probability of an accident occurring due to an equipment failure is for articulated trucks. It is notable however that the lowest is for rigid trucks (see Figure 20).

Vehicle controller factors

There was no difference in the gender of the driver by age, however there was by vehicle types. For passenger vehicles including light commercials and articulated trucks the probability that the driver was female was almost nil, however for rigid trucks the probability that the driver was female was 3% (see Figure 21).

Where the driver of the key vehicle was judged to have make an error which caused the accident, this was classed as a controller error. One fifth of accidents were judged to be caused by a controller error. Examples of the types of errors are speeding, swerving, inappropriate overtaking or disobeying traffic signals. Age makes no difference to the probability of an error causing an accident, however vehicle type does. Of the three vehicle types the probability of a controller error is highest for rigid and articulated vehicles.

The variable controller distraction included a number of factors which hindered the driver in operating the vehicle safely. Examples include, vision obscured, sudden illness, falling asleep or fatigued and the use of hand held phones. The probability of a controller distraction is strongly affected by driver age and vehicle type. In addition there is an interaction between age and vehicle type. Of the three vehicle types the probability of controller distraction is highest for rigid trucks and lowest for passenger vehicles including light commercial vehicles. The effect of age is variable for all three vehicle types; in general it can be said to decrease with age in rigid and articulated truck drivers (see Figure 23).

Fatigue has long been an important issue in the long distance transport industry. Whilst the Roads and Traffic Authority have put in place a variety of fatigue management strategies, fatigue continues to be an issue in accident causation. Statistically there is no difference in fatigue being a factor in an accident by driver age, however by vehicle type it is. Of the three vehicle types the probability of a fatigued driver is highest for articulated vehicles, with passenger vehicles including light commercials and rigid trucks being similar. For articulated truck drivers the probability is highest in younger drivers and reduces with age as shown in Figure 24.

Alcohol is also an important road safety issue which has received much attention. Two variables in the dataset relate to alcohol and accidents. Firstly, alcohol being judged a factor in the accident; driver age and vehicle type were both significant in the model, however no interaction was taking place. For vehicle type the probability of alcohol being a factor is highest for rigid trucks, strongly influenced by age. The probability was highest in 21 to 44 year olds. This trend reduced with age. Passenger including light commercial vehicles and rigid trucks are similar and not so strongly affected by age (see Figure 25). The second variable was driver blood alcohol being either legal or illegal. Whilst there is no difference by age of the driver, there is a strong effect by vehicle type. Once again, rigid trucks are the highest and articulated trucks consistently the lowest. It should be noted that NSW RTA rules and regulations for heavy vehicle drivers have a the permissible blood alcohol level of 0.02 for vehicles with a gross vehicle mass greater than 13.9 tonnes rather than the usual 0.05 for other drivers. Our results could be interpreted as demonstrating the effectiveness of this reduced blood alcohol level (see Figure 26).

Finally, the modelling for whether speeding was a factor in the accident is perhaps one of the most interesting results. Most surprising is that driver age was not statistically different, however vehicle type was and there was also an interaction between vehicle type and driver age. The highest probability for speeding being judged a factor in the accident was for articulated trucks with the probability reduces with age (see Figure 27). The origins of this trend are puzzling given that most articulated trucks are speed limited.

6.3 Achievement of study aims and objectives

This data demonstrate the achievement of the proposed aims and objectives of this study including:

1. The provision of empirical evidence to the Transport Workers Union, WorkCover NSW and national transport companies to assist in answering the question: *Are the recommendations of the Australian Government to diversify the working population to include more older workers (> 65 years) desirable or appropriate to the Australian transport industry, particularly heavy vehicle drivers, and if not would it be appropriate for the Transport Workers Union to encourage the employment of younger drivers (< 26 years) without this endangering workplace and road safety?*

3. Compared accident rates of younger and older heavy vehicle drivers relative to middle age drivers using data from the New South Wales Roads and Traffic Authority and the Australian Bureau of Statistics.

2. Tested for an interaction between vehicle type and controller age group for various other factors which may contribute to accident causation, e.g. time of day, weather conditions road service, speeding and fatigue.

6.4 Study strengths and limitations

Strengths

The study is notable in its approach to meeting its stated aims and objectives in two ways. Firstly to enable the calculation of accident rates, the total kilometres travelled by vehicle type, age and gender of the vehicle controller was used at the denominator; this data is routinely collected by the Australian Bureau of Statistics [(55)]. This approach differs from most other studies of this nature apart from the study by Campbell using US data[(6)]. Secondly, we analysed data from 20,401 accidents. The majority of studies of this nature analyse data from fatal accidents only. Whilst the severity of accidents is vitally important, to determine whether it is appropriate for young drivers less than 26 years should drive heavy vehicles it was important to undertake an analysis of all accidents to gain the most realistic picture.

Limitations

Even with analysing all accidents in the years 1999 to 2006 the analysis was presented with a number of limitations. There were low number of observations and mileages for females and the younger age groups in heavy vehicles. This caused wide confidence intervals which made interpretation of results difficult.

7 Conclusions

Following this thorough analysis of all motor vehicle accidents where a vehicle was towed away, an injury or fatality occurred we conclude that the Australian Government initiative to diversify the working population to include older workers (> 65 years) is appropriate to the Australian transport industry, particularly heavy vehicle drivers following appropriate health surveillance. However this analysis has demonstrated that encouraging younger drivers (< 26 years), particularly to drive rigid trucks is also appropriate without this endangering workplace and road safety. We have demonstrated that for a number of important accident factors the age of the driver does not affect accident causation. This practice, with appropriate mentoring and training would lead to the creation of a more professional and skilled workforce.

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