For whom didn't it click? A study of the non-use of seat belts in motor vehicle fatalities in New Zealand

Lily Hirsch[1], Hamish Mackie[1], Richard Scott[1], John de Pont[2], Simon Douglas[3], and Dylan Thomsen[3]

[1] *Mackie Research, Auckland, New Zealand*
[2] *TERNZ, Auckland, New Zealand*
[3] *AA Research Foundation, Wellington, New Zealand*

Corresponding Author: Lily Hirsch, PO Box 106525, Auckland City, Auckland, 1143, New Zealand, lily@mackieresearch.co.nz, +64 9 394 7040

Key Findings

- Seat belts substantially reduce the likelihood of injury or death in a crash
- In New Zealand, between 2006-2016, vehicle occupant fatalities where a seat belt was not worn accounted for 19-30% of the total road fatalities
- The research identified five occupant profiles for people who did not wear a seat belt and died on New Zealand's roads
- The development of profiles can lead to better-targeted safety initiatives

Abstract

There is an increased risk of death or serious injury for occupants who did not wear a seat belt in a crash. In New Zealand, between 2006 and 2016, the non-use of seat belts accounted for 19-30% of the overall motor vehicle road deaths, and this figure shows no sign of decreasing. It is important to better understand the contextual factors associated with crashes where seat belts are not worn, so that more relevant and effective road safety interventions can be designed and implemented. The aim of this research was to determine the profiles for seat belt non-users who were killed in motor vehicle crashes in New Zealand between 2011 and 2015. An in-depth analysis of 200 fatalities where seat belts were not worn (186 crash cases) was carried out following a Safe System framework, using NZ Police reports. Following this, a Multiple Correspondence Analysis (MCA) developed five profiles of vehicle occupants who were killed in crashes where seat belts were not worn. While the stereotypical 'young risky' males were an important group, a range of other people and contexts emerged: 'driving for work'; 'elderly and retired'; 'overseas passengers'; and 'people driving in rural settings'. This has implications for tailored road safety interventions, as a variety of motivations and influences are likely to be at play, depending on the people involved.

Keywords

Seat belt non-use, crash analysis, Safe System, profile development

Introduction

It has been well documented that in a crash, occupants who wear seat belts are less likely to experience serious injury or fatal outcomes (Fildes et al., 2003; de Pont, 2016; Han, 2017). Seat belts protect vehicle occupants from crash forces by retaining them in their seat during a crash, limiting their movement, and managing the energy transmitted (World Health Organisation, 2009; Road Safety Observatory, 2013). For front seat drivers and passengers, seat belt use reduces fatal and non-fatal crash injuries by between 40-60% (Høye, 2016; World Health Organisation, 2016). Likewise, for rear seat passengers, seat belt use reduces fatality risk by between 25-75% (World Health Organisation, 2016), and also dramatically reduces fatality risk for front occupants (Bose et al., 2013; Høye 2016).

In New Zealand, wearing a seat belt has been mandatory for vehicle occupants since 1989. Surveys of vehicle occupants generally show a high rate of compliance with these laws. In 2014, seat belt usage rates in the front seats were 97.1% and 92% for people seated in the rear. However, in 2016, front seat usage rates dropped to 96.5% (Ministry of Transport, 2014; Ministry of Transport, 2016). These wearing rates may not be representative of the entire New Zealand population, however they are the most comprehensive rates available.

Between 2006 and 2016, fatalities where people were not wearing a seat belt annually accounted for 19-30% of the overall motor vehicle occupant road deaths. Over this period, the proportion of these fatalities has fluctuated but in 2015 and 2016 seat belt non-use fatalities were at their highest, accounting for 29-30% of all motor vehicle road deaths (New Zealand Transport Agency, 2017). Note that these figures were produced from a database query. The number is likely to be an under-estimate of the true figures as there are were several "unknown" entries under the 'seat belt wearing' option.

Many variables associated with the non-use of seat belts, both in New Zealand and internationally are well understood. For example: males are more likely to die in crashes whilst not wearing a seat belt than women (Palamara et al., 2009; Romano & Voas, 2011); drivers aged 75 and older are most likely to wear a seat belt (Romano & Voas, 2011), whilst drivers in their late teens and early 20s are least likely to wear a seat belt (Eluru & Bhat, 2007; Alver et al., 2014); and seat belt usage can be understood as an equity issue, with usage rates being lower among people with fewer academic qualifications (Begg & Langley, 2000; Demirer, Durat & Haşimoğlu, 2012), and lower among people from marginalised and minority ethnic backgrounds (Raftery & Wundersitz, 2011; Shin et al., 1999).

Whilst there is some understanding of 'why' people do not wear seat belts, mostly this information is understood as individual variables only. For example: there is a link between seat belt enforcement laws and wearing rates (Shults et al., 2016; Bhat et al., 2012); for some people, the discomfort of wearing, or the difficulty of fastening a seat belt may result in non-use particularly by those aged over 75 years, people who are obese, and people who experience arthritis (Fong et al., 2016; Begg & Langley, 2012). Finally, the influence and attitudes of other people in the vehicle and a person's perceptions of the riskiness of a journey can affect the 'decision policy' to wear or not to wear a seat belt (Alattar et al., 2016).

The way in which factors associated with the non-use of seatbelts interrelate is less well understood. This is an important gap in the research as the complexity of humans means that the isolated study of one variable will result in a full picture. Therefore, understanding this interrelationship of variables will give a fuller picture of the 'profiles' of people who did not wear seat belts and who were killed in road crashes. This clearer understanding of 'who' does not wear seat belts can lead to better and more informed research to establish 'why' particular user groups do not wear seat belts.

Aim

In the New Zealand context, the fact that these potentially preventable deaths are not decreasing is an issue worthy of investigation. The aim of this research was to understand common contextual factors associated with seat belt non-use fatalities for people aged fifteen years and over in New Zealand, and in doing so develop profiles of seat belt non-user types. This may lead to the design and implementation of more relevant and effective road safety interventions.

Methods

The goal for the analysis was to understand the context relating to fatalities where seat belts had not been worn. To achieve this, the method was divided into two parts: 1) a crash analysis of seat belt non-use fatalities in New Zealand using a Safe System framework; and 2) the development of occupant profiles through MCA.

Data

In New Zealand, between 2011-2015 there were 290 crash cases where at least one fatally injured vehicle occupant was not wearing a seat belt (New Zealand Transport Agency, 2017). Data from New Zealand's Crash Analysis System (CAS) database in the form of Traffic Crash Reports (TCRs) and Serious Crash Unit (SCU) reports produced by NZ Police were retrieved. Traffic crash reports are completed by police officers at the scene of all road crashes. They record the details of where, when, how and why the crash happened. For fatal crashes, the Serious Crash Unit conducts an in-depth investigation of the crash case to ensure all causative factors are identified. These reports include witness statements, blood analyses, photographs, and details of the condition of the road and vehicle. Although serious injury cases are relevant to this field of research, they were excluded from this study because the detail provided in serious injury crash reports (TCR reports only) was not sufficient.

Empirical Analysis

Criteria were developed which excluded 76 crash cases. The criteria were: crashes involving a bus, tractor, or vehicles where seat belts are not required; cases where people travelled out of the vehicle i.e. the tray of a ute; crashes not occurring on a public road; and unrestrained, or incorrectly restrained children aged under 15 years. Of the remaining crash list, each fatality was assigned a randomly generated number using the MS Excel RAND function. These were then sorted from the smallest to largest number and the first 200 fatalities (186 crashes) were analysed for this study.

The TCR and SCU reports were coded into 53 nominal and 10 continuous variables by a single analyst following a Safe System framework which acknowledged that fatal crashes happen when a range of system failures occur (Larsson & Tingvall, 2013; New Zealand Government & National Road Safety Committee, 2016). Each fatality case was examined using variables relating to the four Safe System Pillars: Speed; Roads and Roadsides; Vehicles; and Users (New Zealand Government, & National Road Safety Committee, 2016). As the aim of the research was ultimately to understand occupant behaviour in relation to seat belt use, the user pillar was investigated in-depth, whereas the other pillars were more superficially explored. To ensure coding rigour, ten 'test' cases were initially coded by the analyst, then separately by the first author. There was a strong level of agreement, which is understandable given that the exercise mostly involved identifying data, rather than subjective coding.

Statistical Analysis

Whilst the involvement of many individual factors in seat belt non-use crashes are well known, the combination and pattern in which these factors present are less well understood. In the R statistics programme and FactomineR add-in package (Husson et al., 2014; Das et al., 2018), a Multiple Correspondence Analysis (MCA) was conducted

Table 1. Variables for the Multiple Correspondence Analysis

Variable	Categories
Time	Evening; Middle of day; Middle of night; Morning
Vehicle age (years)	1-7; 8-14; 15-21; 22+
Intended trip duration	Long; Short; Unknown
Crash location	Urban; rural
Journey purpose	Driving after drinking (pub) driving after drinking (party); evading police; joy ride; possible suicide; recreation; tourism; utility trip; driving for work; unknown
Previous driving offences	Yes/ no/ unknown
Kilometers over the speed limit	0km/h; 10 km/h; 20 km/h; 30 km/h; 40 km/h; 50 km/h; 60 km/h; 70 km/h; 80 km/h; 90 km/h; unknown
Location in vehicle	Driver; passenger
Drugs present	Yes/ no/ unknown
Evidence victim was a habitual seat belt non-user	Yes/ no/ suspected
Heightened emotional state	Yes/ no
Vehicle type	4WD/SUV; car; rental; ute; van; truck
WoF/ CoF[1]	Yes; No
Victim age (bands)	16-25; 26-35; 36-45; 46-55; 56-65; 66-75; 76+
Victim gender	Male; female
Occupation	Technicians and trades workers; community and personal service workers; sales workers; machinery operators and drivers; labourers; beneficiary; retired; student; unemployed; unknown
Victim ethnicity	Pākehā[2]; Māori; Asian; Pasifika
Driver's licence type	Disqualified/ suspended/ forbidden; expired; unlicenced; full; lerner; restricted; overseas
Alcohol present	Yes/ no
Evidence of fatigue	Yes/ no/ unknown
Medical condition or event leading to the crash	Yes/ no/ unknown

[1] A regular vehicle check in New Zealand to ensure that the vehicle meets specific safety standards. Warrant of Fitness (WoF) or Certificate of Fitness (CoF).

[2] New Zealanders of European descent.

on 21 of the variables coded from the 200 fatality cases (Table 1). MCA is an extension of correspondence analysis (CA) because of its applicability to explore the association between a large set of categorical variables rather than ordinal data. Through its proximity mapping, MCA helps to reveal the main features from a multi-dimensional dataset (Das et al., 2018), analyse the correlations between the category variables, and develop new composite variables which are combinations of the category variables and are independent of each other. The MCA analysis was used as pre-processor for a Euclidean cluster analysis which identified groups of individuals close to each other in terms of composite variables. The aim was to detect and represent the underlying relationships between variables and thereby identify clusters or 'profiles' of individual fatality cases with similar characteristics.

Most of the variables in the database were nominal categorical variables, for example, the vehicle type can be "car", "truck", "van" etc. Some variables such as victim age, vehicle age, and km/h travelling over the speed limit were continuous numerical variables and these were converted into category variables as shown in Table 1.

Finally, a probability sampling method through the generation of a random number applied to each fatality case was conducted. The random numbers were sorted from smallest to largest and the first 10 cases were selected. A manual 'sensemaking' check was conducted to validate that each case was best suited to the cluster or 'profile' derived through the MCA. This process returned full agreement and no further checking was conducted.

Results

Empirical Results

User factors

The empirical analysis identified that fatally injured seat belt non-users were predominantly male, representing 75% of victims (Figure 1). For both males and females, those aged 15-24 were more strongly associated with seat belt non-use fatalities than people aged 25 years or over. For women, the age group 15-19 was overrepresented in fatality cases with 13 cases, or 26.5% of all female cases in the study. In 12 of these cases the deceased was a passenger in a vehicle and in 10 of these cases the driver was a young male (average age 21.5 years).

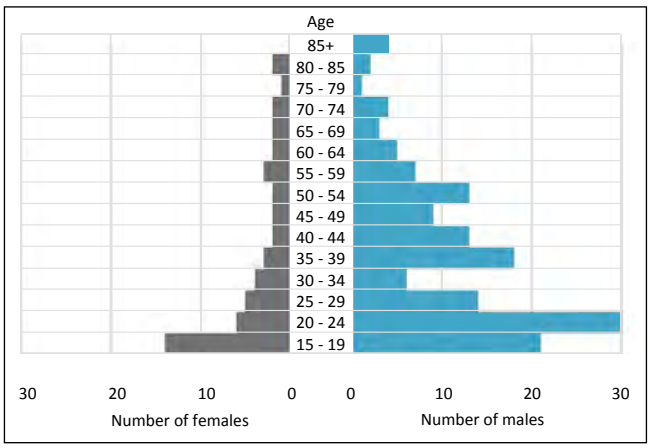

Figure 1. Age and gender profile of seat belt non-use victims

A summary of how the key variables coded under the User Pillar, were associated with fatalities and crashes is presented in Table 2.

Of those fatality cases where alcohol was involved (n=107 fatalities, n=95 crashes), in 95% of the crash cases the driver's blood alcohol content was over the legal driving limit of 50mg per 100ml. In 38% (n=36) of alcohol-involved crash cases, the driver's blood alcohol was more than 200mg per 100ml. Alcohol-involved fatalities were typified with the journey purpose being driving home from a party or the pub (n=64), and utility trips (n=26).

Through interviews and witness statements, the Police reports identified that in 4 cases the victim usually wore a seat belt but had not worn it on that occasion. In 31 cases the fatally injured victims were described as habitual non-wearers of seat belts and 9 victims were described as part-time non-users of seat belts. Some witness statements elaborated on the reasons for the habitual or part-time non-use which included: frequent stops; short trip duration; difficult to fasten; more people in the vehicle than seat belts; physical discomfort; others were not wearing them.

Time of day

Two thirds (n=122) of the crashes occurred during dusk or after dark, with the modal time occurring between 11pm and 2am (24.7%, n=46). These late-night crashes were more associated with multiple fatality outcomes. This pattern is counter to normal travel patterns which have a peak demand in the morning and afternoon. Only 4.3% (n=8) of the crashes happened during the regular commuting hours of 8-9am and 5-6pm.

Roads and Roadsides and Speed Environment factors

A summary of the location of crashes, and the surface condition of the road at the time of the crash is presented in Table 3.

In New Zealand, speed limits are default 50 km/h in urban areas and 100 km/h on rural or open roads unless stated otherwise. Therefore, it is logical that these speed limits were represented in 88% of crash cases. Vehicles in areas with a posted speed limit of 100 km/h were involved in 137 crash cases and 150 fatalities. Fewer cases were reported in 50 km/h zones, with 27 crash cases and 28 fatalities.

Vehicle factors

A summary of vehicle factors recorded from the crash reports is presented in Table 4.

Statistical Results

The MCA analysis revealed five profiles of people who did not wear seat belts and who were fatally injured in crashes: 'young and risky'; 'driving for work'; 'elderly and retired'; 'overseas passengers'; and 'people driving in rural settings'. Every one of the 200 victims was ascribed to one and only one profile. Because the profiles show the best fit of the occupant groups, they are not equally populated. The five profiles have been retrospectively named based on the pattern of variables that they represent.

Young and risky

This profile comprised 28% (n=56) of the study's sample. Within this profile, 46 victims were male, 39 were aged between 15-25 years, and 14 were aged between 26 and 40 years. People whose ethnic background was Māori or Pasifika represented 35 fatalities, with the remaining being Pākehā. In 18 of the fatalities the driver was either unlicensed, had their licence suspended, or held an illegal licence, and in 24 cases the driver was reported to have had previous driving offences. Vehicles associated with these crashes were predominated by older vehicles of more than 14 years of age (n=46).

The behavioural characteristics of members of this profile leading up to the crash were associated with inherently risky behaviours. These included: high speeds – in 41 cases, vehicle speed prior to the crash was more than 20 km/h over the speed limit; alcohol involvement - for 32 fatalities, alcohol readings were more than 100mg per 100ml of

Table 2. User Pillar empirical resuls for dichotomous and polychotomous variables by fatality and crash cases

Variable		Crash cases (n=186)	Fatalities (n=200)
Gender			
	Female	48	49
	Male	138	151
Ethnicity			
	Māori	63	71
	Pākehā	106	111
	Pasifika	9	9
	Other	8	9
Journey purpose			
	Driving home from a party	34	38
	Driving home from the pub	24	26
	Driving for work	18	18
	Utility trip (to work, shops, school)	70	77
	Recreation/ tourists	8	8
	Joy ride/ evading police	18	19
	Possible suicide	7	7
	Unknown	7	7
Intended journey duration			
	Short	53	55
	Long	125	137
	Unknown	8	8
Speed above the limit			
	10-25 km/h over limit	18	19
	25-40 km/h over limit	21	22
	40+ km/h over limit	20	20
Alcohol involvement[3]			
	Yes	95	107
	No	87	88
	Unknown	4	5
Evidence of illegal drugs (i.e. THC, methamphetamine, ketamine), or overdose of prescription medication			
	Yes	52	53
	No	127	137
	Unknown	7	10
Evidence of fatigue (of victim)			
	Yes	67	73
	No	108	110
	Unsure	11	17
Driver's emotional state compromised (i.e. clear evidence of anger or being upset)			
	Yes	33	33
Medical conditions or event attributed to the crash (i.e. heart attack, stroke, seizure, panic attack)			
	Yes	29	29
Evidence of habitual seat belt non-use			
	Yes	40	40

[3] In fatal crashes, there can sometimes be a delay of hours or days before the victims are found, or before blood is taken for testing, so in some cases, the degree of alcohol-involvement may be uncertain.

Table 3. Roads and Roadsides Pillar empirical results for dichotomous and polychotomous variables by fatality and crash cases

Variable		Crash cases (n=186)	Fatalities (n=200)
Road surface condition			
	Dry	132	139
	Wet	50	54
	Icy	3	6
	Unknown	1	1
Location			
	Rural roads[4]	152	165
	Urban roads	34	35
	Mid-block	169	183
	Intersection	17	17

[4] For the purposes of this research, the definitions of 'urban' and 'rural' were based on images from the crash location. An urban area was classified as having a high density of buildings, and urban motorways were also included. A rural area included farmland, forest, and/or a low density of buildings. Speed was not used to identify a rural versus urban location as the measurement is too crude (complicating factors can include urban motorways and temporary speed restrictions on rural roads).

blood alcohol; drug involvement - in 18 cases THC and/ or methamphetamine were identified in the victim's system; and a risky journey purpose – such as 18 cases of 'driving home from a party or the pub', and 19 cases of 'evading police' or 'joy ride'. In addition, in 23 cases there was evidence of unbalanced emotional state including suicidal tendencies and anger.

Driving for work

This category comprised 10% (n=20) of the total sample used in this study, 19 of whom were male. They were typified by their journey purpose which was driving a vehicle for work. Trucks and vans were the predominant vehicles, and the majority (n=18) of drivers were travelling within the speed limit and had their full license (n=16).

Elderly and retired

A total of 6% (n=12) of the sample used in this study formed this category. Two were aged between 66 and 75 years and ten were aged 76 years or over. All occupants were retired, none were speeding, eleven had a full license, and ten were Pākehā. Medical conditions which were acknowledged in the SCU reports as likely contributing factors to the crash were identified in eleven cases. These included seizures, strokes, and suicidal tendencies.

Table 4. Vehicle Pillar empirical results for dichotomous and polychotomous variables by fatality and crash cases

Variable		Crash cases (n=186)	Fatalities (n=200)
Vehicle Age			
	14 or under	56	58
	15 or over	130	142
Vehicle Type			
	Passenger sedan	114	121
	4x4/ van/ SUV	62	69
	Truck	10	10
Current Warrant or Certificate of Fitness?			
	Yes	143	153
	No	43	47
Did the vehicle roll?			
	Yes	84	90
	No	102	110
Vehicle safety systems			
	Front airbags present	65	69
	Side airbags present	14	14
	Seat belt reminder present	17	17

Overseas passengers

This was a reasonably small group, but an important group when considering the safety outcomes of tourists in New Zealand. The group comprised 4.5% (n=7) of the study's sample and consisted of people who were visiting New Zealand. Six of the group were female and four were of Asian descent. All members of this cohort were passengers in vehicles where a long journey had been planned and many were asleep across the rear seats when the crash occurred.

People driving in rural settings

This large group comprising 52.5% (n=105) of the sample all crashed in rural settings. Most (n=83) had been planning a long trip and all vehicles were light vehicles such as passenger sedans (n=56) and 4-wheel drives, vans, or utes (n=49). The presence of drugs and alcohol was 10% higher in this cohort than the overall sample, with 70 cases involving alcohol, and 29 cases involving illegal, or abused prescription drugs.

Discussion

This research furthered the understanding of seat belt non-use crashes in the New Zealand context by identifying how patterns of factors were associated with different crash types and the formation of the five profiles. Whilst some authors have previously identified the 'young and risky' category (Begg & Langley, 2000; Shults et al., 2016), other seat belt non-use profiles have not previously been described.

With regards to individual crash factors, this research reiterated findings from the USA (Alattar et al., 2016; McCartt & Northrup, 2004; Steinhardt & Watson, 2007) and Australia (Raftery & Wundersitz, 2011; Steinhardt et al., 2007) that most crashes occur in the evening and early morning. In addition, crashes on rural roads were more commonly associated with seat belt non-use fatalities than urban roads. This may partly be due to the typically higher speed environment and the decreased chance of survivability in high-speed crashes (Bédard et al., 2002; Elvik 2012), but also reflects USA and Australian literature which suggests that seat belt wearing rates may be lower in rural settings (Knight, Harris, & Iverson, 2008; Raftery & Wundersitz, 2011; Steinhardt et al., 2007).

This study showed a significant disparity between fatal outcomes between men and women – with far fewer women being represented. Whilst this research did not describe seat belt usage rates, it did examine non-use outcomes. Evidence that women are more likely to wear seat belts than men has been demonstrated in New Zealand (Fergusson et al., 2003), USA (Eluru & Bhat, 2007; Reagan et al., 2013), the United Kingdom (Richards et al., 2008), and Turkey (Alver, Demirel, & Mutlu, 2014). In addition, there is a common theme that those not wearing seat belts in fatal crashes are more likely to be male (Palamara et al., 2009; Raftery & Wundersitz, 2011; Romano & Voas, 2011).

An association between age and seat belt use is a common theme throughout the literature, with drivers in their late teens and early 20s being least likely to wear seat belts (Alver et al., 2014; Eluru et al., 2007; Romano et al., 2011). This trend is compounded for young males (Alattar et al., 2016; McCartt et al., 2004; Raftery & Wundersitz, 2011). These patterns were reiterated by this study, but were associated for all vehicle occupants, not just drivers. Women in the age group 15-19 were overrepresented in this study's fatality cases (n=13), although in 10 of these cases the deceased was a passenger in a vehicle driven by a young male who fit the criteria for the 'young and risky' profile (note, driver survivors were not included in the analysis). The non-use of a seat belt in these crashes may in part be due to peer pressure (Jaccard et al., 2005).

Māori were overrepresented in seat belt non-use fatalities (35%), compared to their proportion of the New Zealand population (15%). Conversely, Pākehā were under-represented (54%) compared to their proportion of the population (74%) (Statistics New Zealand, 2013). This raises questions about underlying socioeconomic and colonialisation issues. Indeed, the association between lower seat belt-wearing rates and people from disadvantaged ethnic backgrounds has been described for Indigenous Australians (Raftery & Wundersitz, 2011) and in the USA for people from African American and Hispanic backgrounds (Shin et al., 1999; Shults et al., 2016).

The literature reinforces that for many people the use of seat belts may be governed by numerous factors, known as a 'decision policy' (Alattar et al., 2016). Evidence of these factors were illustrated in this research, including: the influence of the behaviour and choices of others (Han, 2017; McCartt & Northrup, 2004; Jaccard et al., 2005); perceptions of the journey's risk (Begg & Langley, 2000); and the planned number, speed, and duration of trips (Reagan et al., 2013; Alattar et al., 2016). Kawsnicka et al. discuss that "habitual behaviours are likely to dominate when resources are limited" (2016, p.287) and for part-time seat belt users who do not have ingrained habitual behaviours regarding seat belt use, wearing a seat belt may be more influenced by external factors than those who habitually use them. The results of this study suggest that fatigue, which was present in 36.5% of fatality cases may have been a contributing factor to some victims', particularly passengers, lack of seat belt use. This was particularly evident for passengers sleeping across the rear seats. In addition, it is likely that alcohol consumption, which is a known limiter of cognitive resources may have played a part in the decision of some of the 53.5% of fatality cases to wear a seat belt prior to the crash. Indeed, the high rate of alcohol involvement in non-seat belt crashes is an international issue (Begg & Langley, 2000; Raftery et al., 2011; Romano et al., 2011; Bogstrand et al., 2015; Shults et al., 2016).

This research provides a part of the wholistic understanding of seat belt non-users in New Zealand. To that end, only seat belt non-use fatality cases were examined and therefore we were unable to draw comparisons between the profiles identified from this research and profiles of belted occupants who died in crashes. Further research to allow for comparison of these crash types would be beneficial when drawing broader conclusions. In addition, although developing an in-depth understanding of serious injury cases would have been beneficial to better inform the profiles, the analysis was limited by the available data. Another methodological limitation was that only people aged 15 years and over were examined, as the funding scope excluded unrestrained or incorrectly restrained children. With regards to the findings, the profile 'people driving in rural settings' contained just over half of the fatality cases and the MCA was unable to meaningfully split it into smaller categories. The individuals in this profile exhibited the least homogenous behavioural attributes and it may be that the MCA method was limited by the number of variables entered (n=21). However, it might simply be that some crash circumstances may not fit neatly into particular categories. Certainly, the patterns of factors in the other four profiles were strongly aligned. Finally, this research was designed to understand 'who' died on New Zealand's roads whilst not wearing a seat belt, not 'why'. Future research, particularly through qualitative interviews with seat belt non-use crash survivors, as well as non-crash-involved people who fit the profiles from this research would be valuable.

Conclusion

This research provides a deeper understanding into the contexts behind fatal crashes where seat belts were not worn in New Zealand. It shows that a broad range of people and situations are represented in these crashes, and highlights that for many victims, the non-use of a seat belt may be the only risky aspect of their otherwise normal journey.

Compared with the generally high rate of seat belt wearing in New Zealand, the number of fatalities for seat belt non-users as a proportion of all vehicle occupant fatalities (at least one quarter) is high. Merely getting vehicle occupants to wear their seat belt may not reduce their likelihood of crashing, but it should reduce their fatality rate substantially (Høye, 2016). These findings suggest that the issue of seat belt non-use will not be solved by focusing on seat belts alone, rather it is part of a broader Safe System issue.

The next step towards meaningful road safety initiatives to improve seat belt compliance is to understand *why* the profiles identified in this research do not wear seat belts. The data presented in this paper pertain only to people who did not wear a seat belt and died. A fatal crash is a relatively unusual driving outcome and it is therefore likely that there is a broader cohort of people who may fit the occupant profiles who are alive. There are a range of possibilities about why people do not wear seat belts, and if the mechanisms are more clearly defined for various contexts, then road safety initiatives can be better targeted to address these and have a greater likelihood of success. For some profiles, a general focus on risky driving is needed, or even support from outside of the transport system. For others, cultural norms and a focus on positive habits may be more relevant.

Acknowledgements

This work was financially supported by the AA Research Foundation. No conflicts of interest have been identified.

References

Alattar, L., Yates, J. F., Eby, D. W., LeBlanc, D. J., & Molnar, L. J. (2016). Understanding and reducing inconsistency in seatbelt-use decisions: Findings from a cardinal decision issue perspective. *Risk Analysis, 36*(1), 83-97. DOI: 10.1111/risa.12419

Alver, Y., Demirel, M. C., & Mutlu, M. M. (2014). Interaction between socio-demographic characteristics: Traffic rule violations and traffic crash history for young drivers. *Accident Analysis & Prevention, 72*, 95-104. DOI: 10.1016/j.aap.2014.06.015

Alattar, L., Yates, J. F., Eby, D. W., Le Blanc, D. J., Molnar, L. J. (2016). Understanding and reducing inconsistency in seatbelt-use decisions: Findings from a cardinal decision issue perspective. *Risk Analysis*. 36(1): 83-97. DOI: 10.1111/risa.12419

Bédard, M., Guyatt, G. H., Stones, M. J., & Hirdes, J. P. (2002). The independent contribution of driver, crash, and vehicle characteristics to driver fatalities. *Accident Analysis & Prevention*, 34(6), 717-727. DOI: 10.1016/S0001-4575(01)00072-0

Begg, D. J., & Langley, J. D. (2000). Seat-belt use and related behaviors among young adults. *Journal of Safety Research*, 31(4), 211-220. DOI: 10.1016/S0022-4375(00)00038-4

Bhat, G., Beck, L., Bergen, G., & Kresnow, M.-J. (2012). Predictors of rear seat belt use among US adults. *Journal of Safety Research, 53*, 103-106.

Bogstrand, S. T., Larsson, M., Holtan, A., Staff, T., Vindenes, V., & Gjerde, H. (2015). Associations between driving under the influence of alcohol or drugs, speeding and seatbelt use among fatally injured car drivers in Norway. *Accident Analysis & Prevention, 78*, 14-19. DOI: 10.1016/j.app.2014.12.025

Bose, D., C. Arregui-Dalmases, D. Sanchez-Molina, J. Velazquez-Ameijide and J. Crandall (2013). "Increased risk of driver fatality due to unrestrained rear-seat passengers in severe frontal crashes." *Accident Analysis & Prevention* 53(1): 100-104. DOI: 10.1016/j.aap.2012.11.031

Chliaoutakis, J. E., Gnardellis, C., Drakou, I., Darviri, C., & Sboukis, V. (2000). Modelling the factors related to the seatbelt use by the young drivers of Athens. *Accident Analysis & Prevention, 32*(6), 815-825. DOI: 10.1016/S001-4575(00)00006-3

de Pont, J. (2016). Why do people die in road crashes?, Ministry of Transport.

Eluru, N., & Bhat, C. R. (2007). A joint econometric analysis of seat belt use and crash-related injury severity. *Accident Analysis & Prevention, 39*(5), 1037-1049. DOI: 10.1016/j.aap.2007.02.001

Das, S., Avelar, R., Dixon, K., & Sun, X. (2018). Investigation on the wrong way driving crash patterns using multiple correspondence analysis. *Accident Analysis & Prevention*, 111, 43-55. DOI: 10.1016/j.aap.2017.11.016

Demirer, A., Durat, M., Haşimoğlu, C. (2012). Investigation of seat belt use among the drivers of different education levels. *Safety Science*, 50(4), 1005-1008. DOI: 10.1016/j.ssci.2011.12.013

Elvik, R. (2012). Speed limits, enforcement, and health consequences. *Annual Review of Public Health*, 33, 225-238. DOI: 10.1146/annurev-publhealth-031811-124634

Fergusson, D., Swain-Campbell, N., & Horwood, J. (2003). Risky driving behaviour in young people: Prevalence, personal characteristics and traffic accidents. *Australian and New Zealand Journal of Public Health, 27*(3), 337-342. DOI: 10.1375/acri.36.3.354

Fildes, B., M. Fitzharris, S. Koppel, P. Vulcan and C. Brooks (2003). Benefits of seat belt reminder systems. *Annual Proceedings/Association for the Advancement of Automotive Medicine* (Vol. 47).

Fildes, B., Stevenson, M., Hoque, S., & Hammid, A. (2016). Restraint use in the Eastern Province of the Kingdom of Saudi Arabia. *Traffic Injury Prevention, 17*(5), 488-494. DOI: 10.1080/15389588.2015.1103849

Fong, C. K., Keay, L., Coxon, K., Clarke, E., Brown, J. (2016). Seat belt use and fit among drivers aged 75 years and older in their own vehicles. *Traffic Injury Prevention*, 17(2): 142-150. DOI: 10.1080/15389588.2015.1052420

Hatamabadi, H., Vafaee, R., Haddadi, M., Abdalvand, A., Esnaashari, H., & Soori, H. (2012). Epidemiologic study of road traffic injuries by road user type characteristics and road environment in Iran: A community-based approach. *Traffic Injury Prevention, 13*(1), 61-64.

Han, G.-M. (2017). Non-seatbelt use and associated factors among passengers. *International Journal of Injury Control and Safety Promotion* 24(2): 251-255

Høye, A. (2016). How would increasing seat belt use affect the number of killed or seriously injured light vehicle occupants? *Accident Analysis & Prevention, 88*, 175-186. DOI: 10.1016/j.app.2015.12.022

Husson, F., Josse, J., Le, S., Mazet, J. FactoMineR: Multivariate Exploratory Data Analysis and Data Mining with R. R package version 1.25. http://CRAN.R project.org/package=FactoMineR. Accessed June 3, 2019.

Jaccard, J., H. Blanton and T. Dodge (2005). Peer influences on risk behaviour: An analysis of the effects of a close friend. *Developmental Psychology* 41(1): 135-147. DOI: 10.1037/0012-1649.41.1.135

Knight, P. J., Harris, M. F., & Iverson, D. (2008). *Early driving experience and risk perception in young rural people*. Paper presented at the Australasian Road Safety Research, Policing and Education Conference, Adelaide, Australia.

Kawsnicka, D., Dombrowski, S. U., White, M., & Sniehotta, F. (2016) Theoretical explanations for maintenance of behaviour change: A systematic review of behaviour theories. *Health Psychology Review* 10(3): 277-296. DOI:10.1080/17437199.2016.1151372

Larsson, P., & Tingvall, C. (2013). The Safe System Approach – A Road Safety Strategy Based on Human Factors Principles. In D. Harris (Ed.), *Engineering Psychology and Cognitive Ergonomics. Applications and Services* (Vol. 8020, pp. 19-28): Springer Berlin Heidelberg.

McCartt, A. T., & Northrup, V. S. (2004). Factors related to seat belt use among fatally injured teenage drivers. *Journal of Safety Research, 35*(1), 29-38. DOI: 10.1016/j.jsr.2003.09.016

Ministry of Transport. (2014). *Front seat safety belt use by adults: Results of a national survey 2014*. Wellington, New Zealand:

Ministry of Transport. (2016). *2016 adult front seat occupants*. Retrieved from https://www.transport.govt.nz/resources/road-safety-resources/roadsafetysurveys/safetybeltstatisticsandchildrestraintsurveys/2016-adult-front-seat-occupants/

New Zealand Government, & National Road Safety Committee. (2016). *Safer Journeys Action Plan 2016-2020*. Retrieved from https://www.saferjourneys.govt.nz/action-plans/2016-2020-action-plan/

New Zealand Transport Agency (2017, March 27). *Seat-belt non-use fatality search 2011-2015.* Retrieved from Crash Analysis System database

Palamara, P., Oxley, J., Langford, J., Thompson, C., & Chapman, A.-M. (2009). *An investigation of the factors associated with the non-use of a seat belt through the analysis of linked Western Australian crash, death and hospitalisation data*. Paper presented at the Australasian Road Safety Research, Policing and Education Conference, Sydney, Australia.

Raftery, S., & Wundersitz, L. (2011). No restraint? Understanding differences in seat belt use between fatal crashes and observational surveys. *Journal of Safety Research*, 31(4), 211-220.

Reagan, I. J., McClafferty, J. A., Berlin, S. P., & Hankey, J. M. (2013). Using naturalistic driving data to identify variables associated with infrequent, occasional, and consistent seat belt use. *Accident Analysis & Prevention, 50*, 600-607. DOI: 10.1016/j.app.2012.06.008

Richards, D. C., Hutchins, R., Cookson, R. E., Massie, P., & Cuerden, R. W. (2008). *Who doesn't wear seat belts?* Paper presented at the International conference: Expert Symposium on Accident Research, Hannover, Germany.

Road Safety Observatory (2013). Seat belts review. UK

Romano, E., & Voas, R. B. (2011). Drug and alcohol involvement in four types of fatal crashes. *Journal of Studies on Alcohol and Drugs, 72*(4), 567-576. DOI: 10.15288/jsand.2011.72.567

Routley, V., Ozanne-Smith, J., Li, D., Hu, X., Wang, P., & Qin, Y. (2007). Pattern of seat belt wearing in Nanjing, China. *Injury Prevention, 13*(6), 388-393. DOI: 10.1136/ip.2007.015701

Shin, D., Hong, L., & Waldron, I. (1999). Possible causes of socioeconomic and ethnic differences in seat belt use among high school students. *Accident Analysis & Prevention, 31*(5), 485-496. DOI: 10.1016/S0001-4575(99)00004-4

Shults, R. A., Haegerich, T. M., Bhat, G., & Zhang, X. (2016). Teens and seat belt use: What makes them click? *Journal of Safety Research, 57*, 19-25. DOI: 10.1016/j.jsr.2016.03.003

Statistics New Zealand. (2013). 2013 Census - Major ethnic groups in New Zealand.

Steinhardt, D. A., & Watson, B. C. (2007). *Night time seatbelt non-use in serious crashes: A comparison of contributing factors in rural and urban areas of the United States and Queensland*. Paper presented at the Australasian Road Safety Research, Policing & Education Conference, Melbourne, Australia.

Traynor, T. (2005). The impact of driver alcohol use on crash severity: A crash specific analysis. *Transportation Research Part E: Logistics and Transportation Review, 41*(5), 421-437. DOI: 10.1016/j.tre.2005.03.005

World Health Organisation (2009). The need for seat-belts and child restraints, World Health Organisation.

World Health Organisation. (2016). "Road Traffic Injuries." Retrieved from http://www.who.int/mediacentre/factsheets/fs358/en/