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The prevalence of in-vehicle driving distractions in road traffic collisions as a function of road type

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Abstract
While some previous research suggests that conversing with passengers is the most prevalent in-vehicle distraction while driving, others have concluded instead that it is mobile phone use. One possible explanation for these differences is that distraction prevalence varies with road type. To test this proposal the current study investigated the prevalence of in-vehicle driving distraction in road traffic collisions (RTCs) as recorded in national records from the US and New Zealand. Analysis using odds ratios suggested conversing with passengers to be a more prevalent distraction in RTCs on minor roads than on major roads, and mobile phone use to be a more prevalent distraction on major roads than on minor roads. These results show the importance of considering the type of road when investigating the prevalence of driving distractions in RTCs in future research.

1. Introduction

Driver distraction, a contributing factor in road traffic collisions (RTCs) (Young et al., 2007), is diversion of the mind or attention from the task of driving to another task (Regan et al., 2011) which can result in the driver's cognitive resources not being sufficient for them to adequately or safely perform the driving task (Salvucci, 2002). The US National Highway Traffic Safety Administration (NHTSA) found that distracted driving was reported to be a factor in 8.5% of fatal RTCs in 2019 (NHTSA, 2020). In New Zealand, in 2019, driver distraction was a contributing factor on 5% of fatal RTCs (International Transport Forum, 2018).

A recent review (Robbins & Fotios, 2020), conducted to inform research of lighting for driving (Fotios et al., 2020), concluded that conversing with passenger(s) was the most prevalent distraction from driving, confirming the findings of earlier work (Young & Salmon, 2012). For those studies included in the review (Table 1) the contexts in which distractions were identified can be categorised as distraction in use, as determined by roadside observation, or distraction at the time of an RTC, as determined using in-vehicle cameras, police reported crashes and self-report interviews when attending hospital after the RTC. Distractions may be in-vehicle (e.g. looking at or handling something inside the vehicle) or out-vehicle (e.g. looking at something outside the vehicle that was not necessary for safe driving). Studies employing self-report and police reported crashes are able to include both in-vehicle and out-vehicle distractions; studies using in-vehicle cameras and roadside observation include only in-vehicle distractions. The current study focuses on in-vehicle distractions.

A more recent study, however, reached a different conclusion. From roadside observation of 1,337 vehicles on a two-lane motorway in Norway, Sagberg et al. (2019) found that hand-held mobile phone use was the most prevalent distraction, with conversing with passenger(s) being second, followed by eating and drinking.

One explanation for different conclusions being drawn is the type of road. To make comparisons across road type we categorised roads as either main or minor, following previous work (van Langevelde et al., 2009). Minor roads include local roads and collector roads; major roads include arterial roads and motorways. Roads defined as motorways and local roads in previous research were categorised as major and minor roads, respectively. While Sagberg et al. (2019) observed drivers on major roads, all but one of the roadside observation studies included in Robbins and Fotios (2020) conducted their observations on minor roads (Gras et al., 2012; Huisingh et al., 2015; Prat et al., 2015; Sabzevari et al., 2016; Sullman et al., 2012; 2015). The remaining roadside observation study (Kidd et al., 2016) included in Robbins and Fotios (2020) conducted observations of drivers on major roads and a signalised intersection: their observation on major roads found mobile phone use to be more prevalent than conversing with passenger(s), which agrees with Sagberg et al. (2019).

Table 1: Studies of in-vehicle distraction used in the review by Robbins and Fotios (2020) to establish the prevalence of different types of distraction. Studies are categorised by whether distraction prevalence was established in use or in RTCs.

Study	Method	Location	Sample Period	Sample Size	Road type	Most prevalent distraction**
Distraction at time of an RTC						
Beanland et al. (2013)	Self-report-interview at hospital	Australia	2000-2011	54	Not reported	Conversing with passenger(s)
Dingus et al. (2006)	In-vehicle cameras	US	Not reported	124	Not reported	Conversing with passenger(s)
Dingus et al. (2016)	In-vehicle cameras	US	Not reported	1,694	Not reported	Conversing with passenger(s)
Gordon (2005)	Police reported crashes	New Zealand	2002-2003	878	Major and minor roads	Conversing with passenger(s)
McEvoy et al. (2007)	Self-report-interview at hospital	Australia	2002-2004	539	Not reported	Conversing with passenger(s)
Nee et al. (2019)	Self-report-interview at hospital	France	2010-2015	851	Not reported	Listening to Music
Distraction in use						
Gras et al. (2012)	Roadside observation	Spain	2009	1,268	Minor roads (30 mph or below)	Conversing with passenger(s)
Huisingh et al. (2015)	Roadside observation	US	2012	1,069	Minor roads (30 mph or below)	Conversing with passenger(s)
Kidd et al. (2016)	Roadside observation	US	2014	3,874	Motorway*, roundabout, intersection	Using a mobile phone
Prat et al. (2015)	Roadside observation	Spain	2011	1,250	Minor roads (30 mph or below)	Conversing with passenger(s)
Sabzevari et al. (2016)	Roadside observation	Iran	2011	1,022	Minor roads (30 mph or below)	Conversing with passenger(s)
Sullman (2012)	Roadside observation	UK	2011	1,035	Minor roads (30 mph or below)	Conversing with passenger(s)
Sullman et al. (2015)	Roadside observation	UK	2012	1,845	Minor roads (30 mph or below)	Conversing with passenger(s)

* Kidd et al., (2016) referred to a motorway as a freeway.

** Conversing with passengers includes from previous studies the terms conversing with passenger(s) (Nee et al., 2019; Gras et al., 2012; Prat et al., 2015; Sullman, 2012; Sullman et al., 2015; McEvoy et al., 2007), talking to passenger(s) (Sabzevari et al., 2016), talking or singing with a passenger (Kidd et al., 2016), interaction with passenger (Dingus et al., 2006; Dingus et al., 2016; Huisingh et al., 2015), passenger interactions (Beanland et al., 2013) and passengers (Gordon, 2005).

The remaining studies in Table 1 used self-report and in-vehicle cameras to record distractions at the time of an RTC. However, other than Gordon (2005), these further studies did not report road type. Data from these studies also suggests that conversing with passenger(s) was the most prevalent distraction, other than Nee et al. (2019) who found listening to music to be the most prevalent. While Gordon (2005) reported road types for their crash data, being major and minor roads, they did not compare distraction prevalence as a function of road type and the data reported do not enable subsequent evaluation.

These data therefore support the proposal that the prevalence of driver distraction varies according to road type.

Reviews of crash records (Levine & Wachs, 1998) and roadside observation (Gan et al., 2005) suggest that cars tend to carry more passengers in local journeys than on longer journeys. With fewer passengers there is of course reduced opportunity for conversing with passenger(s). Furthermore, observation studies suggest that mobile phone usage is higher amongst drivers with no passengers compared to drivers with one or more passengers (Arvin et al., 2017; Shaaban, 2013; Wundersitz, 2014). Therefore, one reason why conversing with passenger(s) is the most prevalent in-vehicle distraction on minor roads but not on major roads is that cars tend to carry more passengers in local journeys. Passengers have a protective effect, with their presence leading to a more responsible driving behaviour such as driving more slowly and leaving greater gaps behind the vehicle ahead (Vollrath et al., 2002). Roadside observation of drivers suggests a greater tendency to engage in road safety violations such as not wearing a seatbelt or using a hand-held mobile phone amongst people driving alone than those driving with passengers (Rosenbloom & Perlman, 2016). One caveat to the protection effect of passengers is that it varies with driver age: for young drivers, commonly defined as <24 years, passengers (in particular if these are also young) reduce the protective effect and may even lead to an increase in RTC risk (Engström et al., 2008; Lee & Abdel-Aty, 2008; Orsi et al., 2013).

We therefore propose that the prevalence for different types of in-vehicle driving distraction will depend on road type; on minor roads where passenger numbers tend to be higher the most prevalent distraction will be conversing with passenger(s), while on major roads where passenger numbers tend to be fewer it will be mobile phone use. This proposal was investigated through analysis of RTC data which include information on the type of distraction causing an RTC, where known, and also the type of road. Further discussion in the current article of the prevalence of distractions therefore means the prevalence of distractions in RTCs.

2 Method

2.1 Data sources

Data for these analyses were drawn from two national RTC databases, the Fatality Analysis Reporting System (FARS) database from the US (NHTSA, 2020) and the Crash Analysis System (CAS) database from New Zealand. These databases are the only freely available databases found by the authors which identify the distraction associated with a specific RTC, where relevant. This is not the case for other RTC databases such as STATS19 in the UK (DfT, 2020): the data are freely available but do not categorise distractions for specific RTCs. For FARS data, an eight-year period was used from January 2011 to December 2018. Distractions were not reported prior to 2011 and data are not published online after 2018. CAS reports RTCs for a 41-year period from January 1980 to April 2021; the current analyses used CAS data from January 2011 to December 2018 to match the FARS data period.

FARS provides police-reported data from fatal injury RTCs in the US. CAS provides police-reported data from RTCs of all injury-severities in New Zealand. The databases include a number of variables regarding the vehicles and casualties involved in the RTC. Of particular interest for the current work were the data regarding in-vehicle distraction, with attending police officers identifying the attributes which they considered best described the drivers' distraction from driving immediately prior to the RTC. The types of in-vehicle distraction used by FARS and CAS are shown in Table 2. The FARS categories included in the current analysis are those used in Stutts et al. (2001), as these categories do not involve any ambiguity about the nature of the distraction. A complete list of the distraction categories in FARS and CAS can be seen in Appendix 1. Neither FARS nor CAS include a category labelled 'conversing with a passenger'; they do include distraction 'by other occupant (s)' (FARS) or 'attention diverted by passengers' (CAS) which we assumed to be similar. Table 2 shows how the category labels used in FARS and CAS were collated for the current analysis.

In three cases, two types of distraction category were collapsed into a single category to enable comparison across the two databases, e.g. the FARS categories ‘eating and drinking’ and ‘smoking related’ were combined into a single category to match that used in CAS.

Table 2: Distraction categories as used in the current analysis and as used in the FARS and CAS databases.

Current analysis	FARS distraction codes	CAS distraction codes
Conversing with passenger(s)	• By other occupant(s)	• Attention diverted by passengers
Using mobile phone	• While manipulating cell phone • While talking or listening on cell phone	• Attention diverted by cell phone
Reaching for object/device	• While using or reaching for device/object in vehicle	• Objects dropped/sliding/falling
Adjusting audio or climate controls	• While adjusting audio or climate controls	• Attention diverted by console inbuilt features e.g. radio or air conditioning
Eating/Drinking/Smoking	• Eating or drinking • Smoking related	• Attention diverted by food, cigarettes/beverages
Moving object in vehicle	• By a moving object in vehicle	• Attention diverted by animal or insect in vehicle
Other components/controls	• While using other component/controls integral to vehicle	• Attention diverted by CB radio or non-cell device • Attention diverted by navigation device

The overall proportions of RTCs involving distraction were established by filtering the datasets for these variables. For FARS, distraction was taken from the ‘DISTRACT’ data file for each year and inputted to the ‘ACCDIENT’ data file by matching the case ID. For CAS, all crash data was downloaded and the contributory factors were examined.

The prevalence of RTCs involving distraction was filtered separately for major and minor roads.

In FARS, road type was taken from the ‘ROAD_FNC’ variable for the years 2011-2014 and from the ‘FUNC_SYS’ variable from the years 2015-2018. In CAS, road type was indicated by the variable ‘ROAD CATEGORY’.

Road types used in FARS and CAS were collapsed into two categories, labelled major and minor roads, as shown in Table 3. For FARS, the road types included in these category groups are identical to that of previous work in the US (Levine & Wachs, 1998), with RTCs on roads coded as 'Traffic Not in State Inventory', 'Not reported' and 'Unknown' being excluded. For CAS, New Zealand road types that were documented in a higher and lower hierarchy were included (Macbeth, 2007), with unreported road types including 'Medium urban', 'Medium rural', 'Ferry Car', 'Ferry Passenger', 'Footpath', 'Foot track' and 'null'.

Table 3: Categorisation of road types as used in FARS and CAS as either major or minor roads.

Current analysis	FARS road type codes	CAS road type codes
Major roads	• Interstate • Principal Arterial- Freeways and Expressways • Principle Arterial- Other • Minor Arterial	• Motorways • Arterial rural • Arterial urban • Major rural • Major urban
Minor roads	• Major collector • Minor collector • Local roads	• Minor local rural • Minor local urban

2.2 Data Analysis

Comparisons of the prevalence of specific distractions in RTCs on major and minor roads were investigated using Odds Ratios (OR) (Bland & Altman, 2000). Following previous work (Guo et al., 2017; Lu et al., 2020) we compared the number of RTCs with a specific distraction against RTCs with no distraction for road types here collated as major and minor roads.

The OR and associated 95% confidence intervals (95%CI) were established using Equations 1 and 2. To determine the significance of departure from 1.0, the p-value for each OR was determined using a Chi-square test. Table 4 defines the data used when calculating ORs and 95% CIs. An OR significantly greater than 1.0 would indicate a greater prevalence of RTCs with a specific type of distraction on major roads compared to minor roads.

Equation 1

Odds Ratio= $^{A/B}/_{C/D}$

Equation 2

Confidence interval= $\exp\left(ln(Odds\ Ratio) \pm 1.96 \times \sqrt{\frac{1}{A}+\frac{1}{B}+\frac{1}{C}+\frac{1}{D}}\right)$

Table 4. Description of terms for calculating OR (Eq. 1) and 95%CI (Eq. 2) to compare specific in-vehicle distractions for major and minor roads.

Effect measured by the OR		Terms of equation			
		A	**B**	**C**	**D**
1	Prevalence of in-vehicle distractions on major roads compared to minor roads	RTCs reporting type of distraction on major roads	RTCs reporting type of distraction on minor roads	RTCs reporting no distraction on major roads	RTCs reporting no distraction on minor roads

3 Results

3.1 Data available

For the period 2011 to 2018 the FARS database includes 256,631 fatal RTCs. In 164,239 (64.0%) of these, the presence or absence of a distraction was established by the attending police officer. The remaining 36.0% (92,392 RTCs) were classified as either 'no driver present/unknown if driver present' or 'reported as unknown if distracted' and these cases were excluded from the current analysis. In 24,296 RTCs (14.8% of the 164,239 cases where the presence or absence of distraction is known) the database recorded the presence of a distraction at the time of the RTC (the remaining 85.2% of cases stated no distraction at the moment of the RTC). Of these, in-vehicle distractions were reported for 4,310 RTCs.

For the period 2011 to 2018 the CAS database includes 456,562 RTCs. The presence of a distraction at the time of the RTC was reported in 23,131 cases (5.1%), while the remainder reported no distraction (433,431 RTCs). Of the 23,131 cases that reported a distraction, the included in-vehicle distractions represented 6,718 of these RTCs. Appendix 2 shows the total number of RTCs in each database reported as occurring with a distraction, no distraction and unknown.

3.2. Types of distraction

Table 5 shows the numbers (and percentages) of RTCs involving distractions using the distraction categories shown in Table 2 for both the pooled data and for the FARS and CAS databases separately for the years 2011-2018.

Of the 11,028 RTCs in the pooled dataset, the most prevalent distraction was conversing with passenger(s) (3,976 cases, 36.1%), followed by using mobile phone (3,385 cases, 30.7%). The two datasets disagree, however, when considered separately, with conversing with passenger(s) found to be the most prevalent distraction in the CAS data, with mobile phone use second, while in FARS using a mobile phone was more prevalent than conserving with passenger(s). Both types of distraction are much more prevalent than any other type of in-vehicle distraction.

Table 5: The numbers (and percentage) of distracted RTCs from the FARS and CAS database according to distraction type for the years 2011-2018. These data are for all types of road.

Type of distraction	Number (%) of distracted RTCs		
	FARS & CAS	FARS only	CAS only
Any in-vehicle distraction	11,028	4,310	6,718
Conversing with passenger(s)	3,976 (36.1%)	1,116 (25.9%)	2,860 (42.6%)
Using mobile phone	3,385 (30.7%)	1,634 (37.9%)	1,751 (26.1%)
Moving object in vehicle	580 (5.3%)	105 (2.4%)	475 (7.1%)
Eating/Drinking/Smoking	995 (9.0%)	368 (8.5%)	627 (9.3%)
Adjusting audio or climate controls	792 (7.2%)	297 (6.9%)	495 (7.4%)
Other components/controls	602 (5.5%)	197 (4.6%)	405 (6.0%)
Reaching for object/device	698 (6.3%)	593 (13.8%)	105 (1.6%)

3.3. Road type

Table 6 shows the numbers of RTCs recorded as involving an in-vehicle distraction at the time of the RTC for the years 2011-2018, for major and minor roads separately. Table 6 also shows the ORs, 95% CIs and associated p-values for the comparison of the prevalence of distraction on major and minor roads.

The ORs show that distraction by conversing with passenger(s) was significantly lower on major roads than on minor roads, while using mobile phone was significantly higher on major roads than on minor roads. These findings were consistent for the pooled dataset and for FARS and CAS when considered separately.

A consistent and significant effect of road type was found for only one other type of distraction, eating/drinking/smoking, where the ORs indicate significantly greater prevalence on major roads than on minor roads.

3.4. Additional CAS analyses

Two additional analyses were conducted using the CAS database. The first extended the data range to include the period from 2000 to 2018. This was done to find out whether the results changed when using the larger sample whilst omitting data from the 1980s and 1990s when the use of mobile phones was not widespread in New Zealand (NZIER, 2014). The second analysis included only the fatal RTCs recorded in CAS, thus matching the injury severity of the FARS database. This analysis of fatal RTCs also used data from the period 2000 to 2018, rather than matching the 2011-2018 period of FARS, as sample sizes with the shorter data period were too small to calculate ORs. To demonstrate this limitation, Appendix 3 shows the sample sizes for each distraction on major and minor roads for fatal RTCs in CAS for the 2011-2018 period: in five of the seven distraction categories there are cells with 5 or less RTC instances on minor roads. These small samples violate an assumption of Chi-Square which assumes that 80% of all cells are expected to have greater than 5 instances (McHugh, 2009).

Table 7 shows the numbers (and percentages) of RTCs involving distractions using the distraction categories for original and additional analyses using CAS. For all three scenarios, the most prevalent distraction was conversing with passenger(s) followed by using mobile phone. In other words, changing the data range or isolation of fatal RTCs did not affect the rank order of these two types of distraction.

Table 8 shows the ORs, 95% CIs and associated p-values for the comparison of the prevalence of distraction by conversation with passenger(s) or mobile phone use on major and minor roads. The results of these two additional analyses confirm the earlier finding that conversing with passenger(s) was associated with significantly lower prevalence of RTCs on major roads than on minor roads, while using a mobile phone was associated with significantly greater prevalence of RTCs on major roads than on minor roads. Once again, changing the data range or isolation of fatal RTCs did not affect the interaction between distraction prevalence and road type.

4. Discussion

4.1. Main findings

This study investigated the prevalence of in-vehicle driver distraction through analysis of the distractions reported in the FARS and CAS records of RTCs in the US and New Zealand respectively. Overall, conversing with passenger(s) was the most prevalent distraction. It was proposed that distraction prevalence would vary with road type, specifically that conversing with passenger(s) would be more prevalent on minor roads than on major roads, while mobile phone use would be more prevalent on major roads than minor roads. This proposal was confirmed. These differences may be a result of cars being more likely to carry passengers on local journeys, giving more opportunity on minor roads to be distracted by conversing with passenger(s).

Table 6: The numbers of RTCs with in-vehicle distractions between 2011-2018, for major and minor roads, for the CAS and FARS databases separately and combined. ORs, 95% CIs and significance when comparing the numbers of RTCs on each road category for each type of distraction.

Note: For the FARS data, 89,597 RTCs reported no distraction on major roads, and 49,527 RTCs reported no distraction on minor roads. For CAS, 365,006

	FARS & CAS					FARS only					CAS only				
Type of distraction	**Major Roads**	**Minor Roads**	**OR**	**95% CI**	**Sig.**	**Major Roads**	**Minor Roads**	**OR**	**95% CI**	**Sig.**	**Major Roads**	**Minor Roads**	**OR**	**95% CI**	**Sig.**
Conversing with passenger(s)	2,912	1,045	0.69	0.64-0.74	p<.001	656	454	0.80	0.71-0.90	p<.001	2,256	591	0.66	0.60-0.73	p<.001
Using mobile phone	2,750	617	1.11	1.01-1.21	p<.05	1,082	538	1.11	1.01-1.23	p<.05	1,668	79	3.66	2.92-4.59	p<.001
Moving object in vehicle	463	110	1.04	0.84-1.29	p=.68	64	39	0.91	0.61-1.35	p=.63	399	71	0.97	0.75-1.25	p=.84
Eating/Drinking/Smoking	843	149	1.40	1.17-1.67	p<.001	282	85	1.83	1.44-2.34	p<.001	561	64	1.52	1.17-1.97	p<.01
Adjusting audio or climate controls	630	157	1.00	0.83-1.19	p=.96	187	107	0.97	0.76-1.23	p=.78	443	50	1.54	1.14-2.06	p<.01
Other components/controls	487	107	1.13	0.92-1.39	p=.26	136	60	1.25	0.93-1.70	p=.15	351	47	1.29	0.96-1.76	p=.10
Reaching for object/device	484	209	0.57	0.48-0.68	p<.001	393	196	1.11	0.93-1.32	p=.24	91	13	1.21	0.67-2.17	p=.51

RTCs reported no distraction on major roads and 63,262 reported no distraction on minor roads. This totaled 454,603 control RTCs for major roads and 112,789 control RTCs for minor roads for the pooled dataset.

Table 7: The numbers (and percentage) of distracted RTCs from CAS for the three analyses (i) 2011-2018 for all RTCs, (ii) 2000-2018 for all RTCs and (iii) 2000-2018 for fatal RTCs Only. These data are for all types of road.

Type of distraction	**Number (%) of distracted RTCs**		
	2011-2018: All RTCs	**2000-2018: All RTCs**	**2000-2018: Fatal RTCs only**
Any in-vehicle distraction	6,718	12,528	838
Conversing with passenger(s)	2,860 (42.6%)	5397 (43.1%)	412 (49.2%)
Using mobile phone	1,751 (26.1%)	3771 (30.1%)	280 (33.4%)
Moving object in vehicle	475 (7.1%)	1204 (9.6%)	71 (8.5%)
Eating/Drinking/Smoking	627 (9.3%)	836 (6.7%)	30 (3.6%)
Adjusting audio or climate controls	495 (7.4%)	629 (5.0%)	18 (2.1%)
Other components/controls	405 (6.0%)	544 (4.3%)	23 (2.7%)
Reaching for object/device	105 (1.6%)	147 (1.2%)	4 (0.5%)

Table 8: The numbers of RTCs with conversing with passenger(s) and using mobile phone calculated separately for major and minor roads in CAS for the three analyses (i) 2011-2018 for all RTCs, (ii) 2000-2018 for all RTCs and (iii) 2000-2018 for fatal RTCs Only. ORs, 95% CIs and significance when comparing the number of RTCs with each distraction.

Types of Distraction	2011-2018: All RTCs					2000-2018: All RTCs					2000-2018: Fatal RTCs only				
	Major Roads	Minor Roads	OR	95% CI	Sig.	Major Roads	Minor Roads	OR	95% CI	Sig.	Major Roads	Minor Roads	OR	95% CI	Sig.
Conversing with passenger(s)	2,256	591	0.66	0.60-0.73	p<.001	3,562	698	0.89	0.82-0.97	p<.01	213	53	0.72	0.53-0.98	p<.05
Using mobile phone	1,668	79	3.66	2.92-4.59	p<.001	2,852	294	1.69	1.50-1.91	P<.001	201	17	2.12	1.29-3.49	p<.01

Note: For 2000-2018 all RTCs, 746,248 RTCs reported no distraction on major roads, and 130,064 RTCs reported no distraction on minor roads. For 2000-2018 fatal RTCs only, 67.398 RTCs reported no distraction on major roads, and 12,105 RTCs reported no distraction on minor roads.

Such a finding provides an explanation for the differences in prevalence of in-vehicle distraction found in previous studies. Studies which conclude that using a mobile phone is the most prevalent in-vehicle distraction have observed drivers on major roads (Sagberg et al., 2019; Kidd et al., 2016). Those that concluded conversing with passenger(s) as the most prevalent distraction observed drivers on minor roads (Gras et al., 2012; Huisingh et al., 2015; Prat et al., 2015; Sabzevari et al., 2016; Sullman et al., 2012; 2015).

Another possible explanation for differences in conclusions could be the changing cultures around mobile phone ownership, as mobile phone use rose from 45% (New Zealand) and 57% (US) of the population in 2015 to 85% (New Zealand) and 97% (US) in 2021 (Statista, 2021a; Statista, 2021b). Of the studies included in the review (Table 1), those which collected data within the period 2000 to 2012 concluded that conversing with passenger(s) was the most prevalent in-vehicle distraction (Beanland et al., 2013; Gordon, 2005; McEvoy et al., 2007; Gras et al., 2012; Prat et al., 2015; Sabzevari et al., 2016; Sullman, 2012; Sullman et al., 2015), whereas studies that used a more recent sample period (2014 and 2018) concluded that using a mobile phone was the most prevalent distraction (Kidd et al., 2016; Sagberg et al., 2019).

The current analysis suggests that road type should be considered in further investigation of driving distraction and when designing behavioural experiments. For example, the prevalence of in-vehicle distraction can be broken down by the specific road type or driving situation, similar to that of Kidd et al. (2016). In terms of future experiments, it would be appropriate to simulate a passenger conversation as a secondary task for drivers where the context is driving on minor roads, reflecting the distraction which is most commonly performed by drivers in that setting.

4.2. Limitations

The current analysis relies on contributory distractions as reported by the attending police officer for each specific RTC. To our knowledge, this information is available and open to public access only in FARS and CAS. These databases represent two different countries, and may therefore be affected by differences in driving behaviour and transport infrastructure between those countries. As examples of those differences, consider RTC rates and infrastructure.

For the years 2000-2002, there were 14.7 fatalities per 100,000 population in the US and fewer (11.6) in New Zealand, with these two nations having the highest rates of the 25 included in that comparison (Conner et al., 2006). If driving exposure is instead characterised by the number of vehicles, it was again found that the RTC rate is higher in the US (1.8 deaths per 10,000 motor vehicles) than New Zealand (1.5).

One explanation why conversing with passenger(s) was found to be a more prevalent distraction in New Zealand than the US (Table 6) is because the proportion of minor roads is greater in New Zealand than in the US. This is confirmed by current road inventories. Of the total road length in the US, 86% are local roads and 14% are highways (FHWA, 2021) while in New Zealand 88.3% of the road length is local roads (Waka Kotahi, 2021a).

One question is whether roads have been correctly categorised as either major or minor. Definitions of both road types in the two countries are similar. Interstate and arterial roads in the US are defined as '*the highest classification of roadways, providing the highest level of mobility and the highest speeds over the longest uninterrupted distance*' (FHWA, 2000) and in New Zealand as '*a major road in the hierarchy for the area and carries high volumes of traffic*' (LTSA, 2003). Local roads are defined in the US to '*provide limited mobility and are the primary access to residential areas, business and other local areas*' (FHWA, 2000) and in New Zealand as '*serving the primary function of providing access to property. It is the lowest classification in the network and carries less traffic than the other classes of road in the area*' (LTSA, 2003).

Although road classification definitions in both countries are similar, the design of these roads differ. In New Zealand, the major roads can be narrow, winding, steep and are mostly two-lane single carriageway roads, with one lane in each direction (Waka Kotahi, 2021b). In contrast, major roads in the US are usually wide, straight, flat and are mostly four-way, with two lanes in each direction (FHWA, 2000). Despite these differences, in terms of road purpose, major roads are designed for long-distance travel whereas minor roads are not intended for use in long distance travel, serving smaller geographical areas (FHWA, 2000; LTSA, 2003). The current results indicate similar changes in distraction prevalence across road type. In other words, it is the purpose of the road rather than its design which influences the types of distractions in which drivers are engaged.

Identifying distractions moments before the RTC is a difficult task for police officers, and may be the reason why large proportions of RTCs were included in categories such as 'unknown' or 'no distraction reported'. However, such reporting from police officers is similar to that of roadside observations, the method used in the majority of previous distraction prevalence studies (Table 1), in terms of the in-vehicle distraction being reported by a third-party observer.

FARS and CAS use slightly different categories for recording in-vehicle distractions, and furthermore some categories within a database were combined to enable a pooled analysis using both databases. For example, the FARS distraction categories ‘while manipulating cell phone’ and ‘while talking and listening on cell phone’ were collated for the current analysis into the category ‘using mobile phone’ to enable comparison with the CAS category of ‘attention diverted by cell phone’. It is therefore critical to ask whether like-for-like categories are being compared, and we used Table 2 to clarify which distraction categories were collated and compared. The collation of two or more categories clearly inflates the proportion represented by that combined category: it may therefore be useful to ask whether this matters. For the current analysis we collated two distractions related to mobile-phones in FARS, giving the potential to inflate the proportion of distractions represented by that category, which may be considered a conservative approach when our general conclusion is that conversing with passenger(s) is the more prevalent distraction.

The two databases differ in the types of injury-severity included and in the periods for which data are available to the public. Specifically, CAS reports RTCs of all serveries (fatal, serious, minor and non-injury) since 1980 while FARS includes only fatal RTCs, and reports distractions only for the period 2011 to 2018. The first analysis (sections 3.1 to 3.3) used data in the 2011 to 2018 period, thus matching the two data sets. This had the further advantage of removing potential confounds associated with changes to mobile phone access (being limited before the 2000s) and abnormal passenger rates in 2020 to 2021 due to the COVID pandemic.

Additional analysis (section 3.4) did not suggest that extending the data range nor isolating fatal RTCs would change the conclusions drawn regarding the prevalence of in-vehicle driver distractions, nor the influence on this prevalence of road type.

5. Conclusion

Previous studies of in-vehicle driver distraction have reached conflicting conclusions regarding which distraction is most prevalent, with some concluding this to be conversing with passenger(s) and others concluding it to be mobile phone use. The current study investigated whether this difference can be explained by road type, using as data the prevalence of in-vehicle driving distractions in RTCs. Specifically, it was proposed that conversation with passengers would be more prevalent in RTCs on minor roads and mobile phone use more prevalent in RTCs on major roads. This proposal was confirmed through analysis of national records of police reported RTCs in the US (FARS) and New Zealand (CAS). These differences are thought to be a result of cars being more likely to carry passengers on local journeys. Such findings suggest that road type should be considered in future investigations of in-vehicle distraction and when designing future experiments.

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None.

References

Arvin, R., Khademi, M., & Razi-Ardakani, H. (2017). Study on mobile phone use while driving in a sample of Iranian drivers. *International Journal of Injury Control and Safety Promotion*, *24*(2), 256-262.

Beanland, V., Fitzharris, M., Young, K. L., & Lenné, M. G. (2013). Driver inattention and driver distraction in serious casualty crashes: Data from the Australian National Crash In-depth Study. *Accident Analysis & Prevention*, *54*, 99-107.

Bland, J. M., & Altman, D. G. (2000). The odds ratio. *BMJ*, *320*(7247), 1468.

Connor, J., Langley, J., Cryer, C. (2006) International comparison of injury deaths: Road Traffic. Retrieved from: https://www.cdc.gov/nchs/data/ice/int_comp_combined_9_07_2_-w.pdf

Department for Transport (DfT) (2020) Road Safety Data. Retrieved from: https://data.gov.uk/dataset/cb7ae6f0-4be6-4935-9277-47e5ce24a11f/road-safety-data

Dingus, T. A., Guo, F., Lee, S., Antin, J. F., Perez, M., Buchanan-King, M., & Hankey, J. (2016). Driver crash risk factors and prevalence evaluation using naturalistic driving data. *Proceedings of the National Academy of Sciences*, *113*(10), 2636-2641.

Dingus, T. A., Klauer, S. G., Neale, V. L., Petersen, A., Lee, S. E., Sudweeks, J., ... & Knipling, R. R. (2006). *The 100-car naturalistic driving study, Phase II-results of the 100-car field experiment* (No. DOT-HS-810-593). United States. Department of Transportation. National Highway Traffic Safety Administration.

Engström, I., Gregersen, N. P., Granström, K., & Nyberg, A. (2008). Young drivers—reduced crash risk with passengers in the vehicle. *Accident Analysis & Prevention*, *40*(1), 341-348.

Federal Highway Administration (FHWA) (2000) Highway Functional Classification Concepts, Criteria and Procedures. Retrieved from: https://dot.sd.gov/media/documents/HwyFunctionalClassification.pdf

Federal Highway Administration (FHWA) (2021) Office of Highway Policy Information. Length by functional system. Retrieved from: https://www.fhwa.dot.gov/policyinformation/statistics/2019/

Fotios, S., Robbins, C. J., Fox, S. R., Cheal, C., & Rowe, R. (2020). The effect of distraction, response mode and age on peripheral target detection to inform studies of lighting for driving. *Lighting Research & Technology*, 1477153520979011.Online first 10 December 2020. https://doi.org/10.1177/1477153520979011

Gan, A., Jung, R., Liu, K., Li, X., & Sandoval, D. (2005). Vehicle occupancy data collection methods. *Transportation Statistics Office, Florida Department of Transportation, Tallahassee, FL*.

Gordon, C. (2005). Driver distraction: An initial examination of the 'attention diverted by' contributory factor codes from crash reports and focus group research on perceived risks. In *2005 IPENZ Conference, Auckland* (pp. 96-98).

Gras, M. E., Planes, M., Font-Mayolas, S., Sullman, M. J., Jiménez, M., & Prat, F. (2012). Driving distractions in Spain. In *Driver behaviour and Training* (pp. 299-305). Ashgate Publishing Ltd.

Guo, F., Klauer, S. G., Fang, Y., Hankey, J. M., Antin, J. F., Perez, M. A., ... & Dingus, T. A. (2017). The effects of age on crash risk associated with driver distraction. *International Journal of Epidemiology*, *46*(1), 258-265.

Huisingh, C., Griffin, R., & McGwin Jr, G. (2015). The prevalence of distraction among passenger vehicle drivers: a roadside observational approach. *Traffic Injury Prevention*, *16*(2), 140-146.

International Transport Forum (2018) New Zealand. OECD Publishing, Paris. Retrieved from: https://www.itf-oecd.org/sites/default/files/new-zealand-road-safety.pdf

Kidd, D. G., Tison, J., Chaudhary, N. K., McCartt, A. T., & Casanova-Powell, T. D. (2016). The influence of roadway situation, other contextual factors, and driver characteristics on the prevalence of driver secondary behaviors. *Transportation Research Part F: Traffic Psychology and Behaviour*, *41*, 1-9.

Land Transport Safety Authority (LTSA) (2003) Land Transport Rule: Setting of Speed Limits 2003. Retrieved from: https://www.westernbay.govt.nz/repository/libraries/id:25p4fe6mo17q9stw0v5w/hierarchy/transportation-roads-water/speed-limits/Speed%20Limits%20New%20Zealand.pdf

Lee, C., & Abdel-Aty, M. (2008). Presence of passengers: does it increase or reduce driver's crash potential? *Accident Analysis & Prevention*, 40(5), 1703-1712.

Levine, N., & Wachs, M. (1998). Factors affecting vehicle occupancy measurement. *Transportation Research Part A: Policy and Practice*, *32*(3), 215-229.

Lu, D., Guo, F., & Li, F. (2020). Evaluating the causal effects of cellphone distraction on crash risk using propensity score methods. *Accident Analysis & Prevention*, *143*, 105579.

Macbeth, A. G. (2007). A national road hierarchy—are we ready. In *IPENZ Transportation Conference*. Wellington: IPENZ.

McEvoy, S. P., Stevenson, M. R., & Woodward, M. (2007). The prevalence of, and factors associated with, serious crashes involving a distracting activity. *Accident Analysis & Prevention*, *39*(3), 475-482.

McHugh, M. L. (2009). The odds ratio: calculation, usage, and interpretation. *Biochemia medica*, *19*(2), 120-126.

National Highway Traffic Safety Administration (NHTSA) (2020) Detailing the Factors Behind Traffic Fatalities on our Roads. Retrieved from: https://www.nhtsa.gov/research-data/fatality-analysis-reporting-system-fars

Née, M., Contrand, B., Orriols, L., Gil-Jardiné, C., Galéra, C., & Lagarde, E. (2019). Road safety and distraction, results from a responsibility case-control study among a sample of road users interviewed at the emergency room. *Accident Analysis & Prevention*, *122*, 19-24.

New Zealand Institute of Economic Research (NZIER) (2014) Mobile industry in New Zealand. Performance and prospects. Retrieved from: https://www.sparknz.co.nz/content/dam/telecomcms/sparknz/content/news/NZIER-Mobile-Industry-in-NZ.pdf

Orsi, C., Marchetti, P., Montomoli, C., & Morandi, A. (2013). Car crashes: The effect of passenger presence and other factors on driver outcome. *Safety science*, *57*, 35-43.

Prat, F., Planes, M., Gras, M. E., & Sullman, M. J. M. (2015). An observational study of driving distractions on urban roads in Spain. *Accident Analysis & Prevention*, *74*, 8-16.

Regan, M. A., Hallett, C., & Gordon, C. P. (2011). Driver distraction and driver inattention: Definition, relationship and taxonomy. *Accident Analysis & Prevention*, *43*(5), 1771-1781.

Robbins, C. J., & Fotios, S. (2020). Road lighting and distraction whilst driving: Establishing the significant types of distraction. *Lighting Research & Technology*, 53(1), 30-40

Rosenbloom, T., & Perlman, A. (2016). Tendency to commit traffic violations and presence of passengers in the car. *Transportation Research Part F: Traffic Psychology and Behaviour*, *39*, 10-18.

Sabzevari, J. T., Nabipour, A. R., Khanjani, N., Tajkooh, A. M., & Sullman, M. J. (2016). An observational study of secondary task engagement while driving on urban streets in Iranian Safe Communities. *Accident Analysis & Prevention*, *96*, 56-63.

Sagberg, F., Johansson, O. J., & Sundfør, H. B. (2019). Combining roadside interviews and on-road observation for assessing prevalence of driver inattention. *Transportation Research Part F: Traffic Psychology and Behaviour*, *62*, 305-315.

Salvucci, D. D. (2002). Modeling driver distraction from cognitive tasks. In *Proceedings of the Annual Meeting of the Cognitive Science Society* (Vol. 24, No. 24).

Shaaban, K. (2013). Investigating cell phone use while driving in Qatar. *Procedia-social and Behavioral Sciences*, *104*, 1058-1067.

Statista (2021a) Percentage of U.S adults who own a smartphone from 2011 to 2021. Retrieved from: https://www.statista.com/statistics/219865/percentage-of-us-adults-who-own-a-smartphone/

Statista (2021b) Active mobile social media users as percentage of the total population in New Zealand from 2015 to 2021. Retrieved from: https://www.statista.com/statistics/680711/new-zealand-mobile-social-media-penetration/

Stutts, J. C., Reinfurt, D. W., Staplin, L., & Rodgman, E. (2001). The role of driver distraction in traffic crashes.

Sullman, M. J., Prat, F., & Tasci, D. K. (2015). A roadside study of observable driver distractions. *Traffic Injury Prevention*, *16*(6), 552-557.

Sullman, M. J. (2012). An observational study of driver distraction in England. *Transportation Research Part F: Traffic Psychology and Behaviour*, *15*(3), 272-278.

van Langevelde, F., van Dooremalen, C., & Jaarsma, C. F. (2009). Traffic mortality and the role of minor roads. *Journal of Environmental Management*, *90*(1), 660-667.

Vollrath, M., Meilinger, T., & Krüger, H. P. (2002). How the presence of passengers influences the risk of a collision with another vehicle. *Accident Analysis & Prevention*, *34*(5), 649-654.

Waka Kotahi (2021a) State highways frequently asked questions. Retrieved from: https://www.nzta.govt.nz/roads-and-rail/research-and-data/state-highway-frequently-asked-questions/#state-highways

Waka Kotahi (2021b) Visiting New Zealand. Retrieved from: https://www.nzta.govt.nz/roads-and-rail/research-and-data/state-highway-frequently-asked-questions/#state-highways

Wundersitz, L. N. (2014). Phone use while driving: results from an observational survey. *Traffic Injury Prevention*, *15*(6), 537-541.

Young, K. L., & Salmon, P. M. (2012). Examining the relationship between driver distraction and driving errors: A discussion of theory, studies and methods. *Safety Science*, *50*(2), 165-174.

Young, K., Regan, M., & Hammer, M. (2007). Driver distraction: A review of the literature. *Distracted Driving*, *2007*, 379-405.

Appendix

Appendix 1: Inclusion and omission in the current analysis of distraction categories from FARS and CAS.

Distraction presence in current analysis	FARS	CAS
Included	• By other occupant(s) • While manipulating cellular phone • While talking or listening to cellular phone • Using or reaching for device/object in vehicle • While adjusting audio or climate controls • Eating or drinking • Using other component/controls integral to vehicle • By a moving object in vehicle • Smoking related	• Attention diverted by passengers • Attention diverted by animal or insect in vehicle • Attention diverted by cell phone • Attention diverted by navigation device • Attention diverted by CB radio/non-cell device • Console inbuilt features e.g. Radio and AC • Objects dropped/falling/sliding • Attention directed by food, cigarettes, beverages
Omitted	• Distracted by outside person, object or event • Looked but did not see • Other cellular phone related • Distraction/inattention • Distraction/careless • Careless/inattentive • Distraction/inattention, details unknown • Inattention (inattentive), details unknown • Inattentive or lost in thought • Other distraction	• Attention diverted by scenery/persons outside vehicle • Attention diverted by other traffic • Attention diverted by finding intersection, house, etc. • Attention diverted by advertising or signs • Driver dazzled • Other attention diverted • Emotionally upset/road rage

Appendix 2: The number of RTCs with distractions (and in-vehicle distractions included in the current study), with no distraction and unknown for FARS and CAS databases (for the three analyses), for major, minor and unknown road types. A breakdown of the in-vehicle distractions used in the current study is also given for major, minor and unknown road types. Shaded sections show total numbers.

Database	**FARS**				**CAS (2011-2018)**				**CAS (2000-2018)**				**CAS Fatal Only (2000-2018)**			
Road type	**Major Roads**	**Minor Roads**	**Other**	**Total**	**Major Roads**	**Minor Roads**	**Other**	**Total**	**Major Roads**	**Minor Roads**	**Other**	**Total**	**Major Roads**	**Minor Roads**	**Other**	**Total**
All distractions	15,767	8,301	228	24.296	20,174	2,737	220	23,131	41,724	5,400	60,334	107,458	2,671	404	978	4,053
Included In-vehicle distractions	2,800	1,479	31	4,310	5,769	915	34	6,718	8,819	1,310	2,399	12,528	515	88	235	838
No distraction	89,597	49,527	819	139,943	365,006	63,262	5,163	433,431	753,943	130,837	275,020	1,159,800	67,868	12,175	24,949	104,992
Unknown	59,375	32,665	352	92,392	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total number of RTCs	164,739	90,493	1,399	256,631	385,180	65,999	5,383	456,562	795,667	136,237	335,354	1,267,258	70,539	12,579	25,927	109,045
Included In-vehicle distractions	**Major Roads**	**Minor Roads**	**Other**	**Total**	**Major Roads**	**Minor Roads**	**Other**	**Total**	**Major Roads**	**Minor Roads**	**Other**	**Total**	**Major Roads**	**Minor Roads**	**Other**	**Total**
Conversing with passenger(s)	656	454	6	1,116	2,256	591	13	2,860	3,562	698	1,137	5,397	213	53	146	412
Using mobile phone	1,082	538	14	1,634	1,668	79	4	1,751	2,852	294	625	3,771	201	17	62	280
Moving object in vehicle	64	39	2	105	399	71	5	475	800	111	293	1,204	52	6	13	71
Eating/Drinking/Smoking	282	85	1	368	561	64	2	627	621	76	139	836	22	1	7	30
Adjusting audio or climate controls	187	107	3	297	443	50	2	495	497	61	71	629	13	3	2	18
Other components/controls	136	60	1	197	351	47	7	405	386	53	105	544	13	6	4	23
Reaching for object/device	393	196	4	593	91	13	1	105	101	17	29	147	1	2	1	4

Appendix 3: The sample sizes for each distraction category for CAS fatal crashes between 2011-2018. * indicates distractions where cells in an OR analysis would have five or fewer RTCs.

Included In-vehicle distractions	Major Roads	Minor Roads
Conversing with passenger(s)	87	19
Using mobile phone*	75	5
Moving object in vehicle*	23	3
Eating/drinking/smoking*	22	1
Adjusting audio or climate controls*	13	3
Other components/controls	12	6
Reaching for object/device*	1	2