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Drivers with child passengers: distracted but cautious?

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ABSTRACT

Objective: A remarkable portion of children's traffic-related deaths occurred when travelling in as passengers in vehicles, but so far, few studies have focused on crash characteristics and crash risks of drivers with child passengers. It has been assumed that drivers with child passengers drive responsibly, but on the contrary, children in vehicles can distract drivers, increasing crash risks. In this study, we examined fatal crash characteristics and fatal crash risks of drivers with child passengers.
Methods: Fatal crash data from the U.S. Fatality Analysis Reporting System (FARS) for 1996–2015 were used. Only passenger-vehicle drivers aged 23–46 years old were included in the analysis because they represent the typical age of drivers with 0–9-year-old child passengers in the database. Prevalence of crash characteristics and the odds of being at fault were examined for drivers with only child passengers and compared to drivers with only adult passengers, with no passengers and with both adult and child passengers. Analyses were done separately for intersection crashes and non-junction crashes.
Results: Female drivers were involved in twice as many fatal crashes alone with child passengers compared to male drivers. Drivers with only child passengers were more often reported as being inattentive, but for them, risk-taking behaviours were less typical than for drivers without child passengers. Our results showed that these differences were more evident in non-junction crashes than in intersection crashes. When risk-taking behaviours were controlled, both male and female drivers with only child passengers had higher odds of being at fault than drivers with adult passengers (with or without children) in non-junction crashes, but these differences were not significant in intersection crashes.
Conclusions: Drivers with child passengers represent a specific driver population. They have a higher tendency to engage in distractions while driving, but they have fewer risk-taking behaviour-related fatal crashes compared to drivers with no child passengers. Our results indicate that the effects of child-passenger-related distractions on fatal crash risks are more relevant outside intersections, presumably because drivers may try to self-regulate their interactions with child passengers and focus on driving in more demanding traffic situations.

1. Introduction

WHO has estimated that more than 140 000 children aged under 15 years die in the road traffic crashes in every year (WHO, 2016). Especially in high-income countries, a remarkable portion of children's road traffic deaths occurred when travelling as passengers in vehicles (Peden, 2008). In order to reduce the deaths of children, it is important to examine which factors are affecting the drivers' fatal crash risks when driving with child passengers. So far, few studies have focused on the crash characteristics and crash risks of drivers with child passengers using accident statistics. The aim of this study is to examine the fatal crash characteristics and fatal crash risks of drivers with child passengers using fatal crash data from the United States between 1996 and 2015.

According to previous research, presence of passengers affects drivers' crash risks and the severity of crashes and this phenomenon is suggested to be either positive or negative depending on drivers' and passengers' age and gender (e.g. Rueda-Domingo et al., 2004; Lee and Abdel-Aty, 2008; Orsi et al., 2013; Braitman et al., 2014; Ouimet et al., 2015; Behnood and Mannering, 2017). Studies have shown that the presence of an adult passenger reduces adult drivers' crash risks (e.g. Lee and Abdel-Aty, 2008; Vollrath et al., 2002) and it has been suggested that the presence of a child passenger also reduces adult drivers' crash risks (Dingus et al., 2016; Rueda-Domingo et al., 2004). Adult passengers may reduce crash risks by helping the driver (e.g. in co-piloting), but this same mechanism cannot explain the lower risks with small child passengers. Instead, risk-reducing effects related to the

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presence of child passengers could be hypothesized to be due e.g. to drivers' sense of responsibility when child passengers are in the vehicle (Taubman - Ben-Ari and Noy, 2011). However, it can be that the drivers with children have different characteristics than drivers without, which influences their crash risk. For example, they may have more driving experience, they may drive at different times, or have a higher socioeconomic status than those without.

Previous studies have also shown that drivers with child passengers are less likely to be drunk or speeding than drivers without child passengers (Maasalo et al., 2016, 2017; Chen et al., 2005; Kelley-Baker and Romano, 2014). Consequently, the presence of child passengers could be expected to reduce especially the number of males' crashes, because it is known that male drivers have more crashes related to risk-taking behaviours in traffic (Harré et al., 1996: Rhodes and Pivik, 2011; Turner and McClure, 2003). In line with this, our previous study, based on a Finnish fatal crash database, showed that male drivers with child passengers had indeed lower crash risks than male drivers with no passengers or with only adult passengers (Maasalo et al., 2016).

The Finnish crash study also showed that, contrary to male drivers, female drivers with child passengers were more often at fault for crashes than female drivers with no child passengers (Maasalo et al., 2016). Previous naturalistic driving studies have shown that child passengers could be a potential source of distraction (Stutts et al., 2005; Koppel et al., 2011), and although our Finnish crash study cannot establish causal link between the crashes and driver distractions, results suggest that especially mothers are potentially sensitive to distractions caused by child passengers while driving (Maasalo et al., 2016). In addition, the crash risks of mothers of young children might be elevated due to fatigue (Livingstone et al., 2009), which could at least partly explain our results.

In a follow-up study (Maasalo et al., 2017), which was based on the U.S. Fatality Analysis Reporting System (FARS) database, we examined in more detail the effects of drivers' ages on the fatal crash risks while driving with an infant passenger aged under one. Only female drivers were included in the study because the number of male drivers with an infant passenger and without an adult passenger in the vehicle was low in the database. Our results showed that even though both young and older female drivers with an infant passenger were more often fatigued or inattentive than similar-aged drivers without passengers, only young female drivers with an infant had elevated fatal crash risks. It could be hypothesized that young female drivers had higher crash risks with an infant passenger due to their inexperience in driving and, thus, undeveloped skills to share attention between distractions and traffic demands (Wikman et al., 1998; Curry et al., 2012).

Previous results have showed that an adult passenger in the vehicle beside a child passenger lowers drivers' fatal crash risk. (Maasalo et al., 2016, 2017). It has also been shown that although drivers seem to be aware of the crash risks associated to engagement in child-related activities while driving (Young and Lenné, 2010; Prat et al., 2017), they keep interacting with the child passengers while driving (Schroeder et al., 2013; Lansdown, 2012; Macy et al., 2014). For example, according to the survey study conducted by Macy et al (2014), parents reported that almost 70% had fed child passengers and 40% had picked up a child's toy while driving in the prior month. These results indicate that child passengers may distract both male and female drivers and capture their attention away from the driving task, but when other adult passengers are also in the vehicle, the adult passengers may assist the driver by taking care of the children, enabling the driver to focus on driving.

The aim of this study was to examine if drivers with child passengers represent a specific driver population that differs from drivers with no child passengers in their fatal crash characteristics and fatal crash risks. Data from the U.S. FARS database during 1996–2015 were used. As far as we know, the effect of child passengers' age on crash risks together its interaction with driver's gender have been examined only in our previous study, which was based on fatal crashes in Finland in 1988–2012. Thus, one purpose of this study was to replicate the previous results, which indicated that female drivers' fatal crash risks are elevated whereas male drivers' risks are lowered when driving with a small child passenger. As in our previous study (Maasalo et al., 2016), drivers with child passengers under 10 years old were used in this study. In addition, the U.S. FARS database, being more extensive, allowed us to consider the effects of the traffic environment on the prevalence of crash-related factors and fatal crash risks.

The following study questions were formed:

(1) Do drivers with child passengers differ in their fatal crash-related characteristics and fatal crash risks from drivers without child passengers?
(2) Do drivers with child passengers differ in their fatal crash-related characteristics and fatal crash risks from drivers with child and adult passengers?
(3) Do female drivers with child passengers have higher fatal crash risks than male drivers with child passengers?
(4) Does the age of the child passenger have an effect on the fatal crash risks?

2. Methods

2.1. Data and drivers' inclusion criteria

Data from the U.S. FARS database during 1996–2015 were used in this study. The FARS database, based on police reports, contains information about crashes that occurred in the United States on public traffic ways in which at least one person (e.g. the involved driver or passenger) died within 30 days of the crash.

Only drivers with a passenger vehicle were included in the analysis. Larger vans, truck-based pickups and pickups with chamber, as well as vehicles in special use (e.g. taxi or police), were excluded. Drivers whose information about age or gender was missing, or their passengers' ages were missing, were excluded. In addition, drivers who were ill, suffered reaction to or failed to take drugs or were charged with a non-traffic violation (e.g. homicide) when the crash occurred as well as crashes involving police pursuit were excluded from the analysis. See Appendix A for detailed allocation of all variables from the FARS database used in this study.

Because we were interested in parents' fatal crash risks, we excluded the youngest and oldest drivers from the analysis whom presumably were siblings or grandparents of the child passengers. This exclusion made the comparison of drivers with child passengers to drivers with no child passengers reasonable. In the FARS database, the mean age of passenger vehicle drivers with at least one 0–9-year-old child passenger was 34.96 [standard deviation (SD) 11.76]. The selected age range was the mean age plus and minus one SD; thus, only 23–46-year-old drivers were included in the analysis.

In order to examine the influence of child passengers, we formed passenger condition groups, which included:

- drivers with only 0–9-year-old child passengers (A-C+)
- drivers with only 16+-year-old adult passengers (A+C-)
- drivers with 0–9-year-old child and 16+-year-old adult passengers (A+C+)
- drivers with no passengers (A-C-).

Please note that drivers with 10–15-year-old passengers in the vehicle were not included in any passenger condition in order to have a clear difference between adult and child passengers. It was thus assumed that 16+-year-old passengers are old enough to help the driver if needed and was thus included in the "adult passenger" category.

Detailed information on background characteristics of crashes for male and female drivers in our passenger conditions is presented in Appendix B.

In addition to drivers' exclusions described before, more crashes had to be excluded in the fatal crash risk analysis (detailed methods used are described in the following subsection "2.3 Fatal crash risk estimation"). Crashes that involved persons outside the motor vehicles (e.g. pedestrians or cyclists) or in vehicles not in transport were excluded and only crashes between two passenger vehicles were included. We also excluded the crashes in which there were more than one at-fault driver or not-at-fault driver, and thus, in every included crash there was only one at-fault driver and one not-at-fault driver. Thus, fewer drivers were included to the analysis concerning drivers' crash risk than to the analysis concerning drivers' characteristics in order to find as accurate as possible estimations.

2.2. Drivers' characteristics

Drivers' characteristics were examined for each passenger condition group by drivers' gender. Percentages and the Pearson Chi square test were used to compare different groups.

Because our preliminary analysis indicated that the prevalence of specific drivers' condition-related factors depends on the traffic environment, characteristics of the drivers were examined in all crashes as well as in intersection crashes and non-junction crashes separately. In the analysis concerning intersection crashes, only crashes occurred in the non-interchange areas were included.

The FARS database contains more detailed information about the drivers' distractions only from the beginning of the year 2010 in the distraction data file. For the previous study period 1995–2009, drivers' inattention/distractions were defined using the data element 'related factors-driver level', which describes drivers' conditions or/and some errors that the drivers made before a crash. Thus, in the analysis concerning the whole study period 1995–2015, drivers were assessed as 'inattentive/distracted' if they were identified as being distracted by any source in the distraction data file (years 2010–2015) and if they were coded with 'inattentive/careless (e.g. talking, eating, car phones)' in the data element 'related factors-driver level' (years 1995–2009) (see Appendix A for detailed allocation of variables used). It was verified that there were not any significant changes between the passenger condition groups in their prevalence of inattentive or distracted drivers between these time periods. In addition, more detailed sources of distraction were examined in the study period 2010–2015.

2.3. Fatal crash risk estimation

Drivers' fatal crash risks in different groups were estimated by the ratio of at-fault drivers to not-at-fault drivers. This assumes that not at-fault drivers are selected randomly and thus the number of not at-fault drivers in one passenger condition group represents the exposure of that group (Carr, 1969) (see also for quasi-induced exposure technique: Chandraratna and Stamatiadis, 2009; Stamatiadis and Deacon, 1997).

We allocated drivers to at-fault versus not-at-fault categories using 'driver-related factors'. Allocation for at-fault and not-at-fault drivers was made using the same method that was used in the Braitman et al (2014) study except factors describing drivers' conditions were not used to define drivers' probable culpability. It was assumed that the relation of the factors 'inattentive/distracted' or 'asleep/fatigued' to the culpability is not always clear, even though these factors may affect the fatal crash risks. Thus, only factors which indicated that the at-fault driver made an error that probably lead to a crash, were used to define culpability (e.g. 'passing wrong side' or 'improper or erratic lane change'). See Appendix C for detailed information about the allocation of probable at-fault and not-at-fault drivers used in this analysis. Also, percentages of crashes when a specific driver-related factor, which was used to define culpability, was present in different passenger condition groups are presented for at-fault drivers in Appendix D.

Like mentioned before, only crashes between two passenger vehicles included in the analysis. Crashes that involved persons outside the motor vehicles or in vehicles not in transport excluded. We also excluded the crashes in which there were more than one at-fault driver or not-at-fault driver.

Binary logistic regression models were used to examine if the drivers with child passengers differ from the drivers in the other passenger condition groups in their fatal crash risks. The driver culpability (1 = at fault and 0 = not at fault) was assessed as the dependent variable in the models. We first built a crude model, which included only passenger condition and driver gender as explanatory variables and the interaction term between these two variables.

In the adjusted model, we controlled possible effects of background and risk-taking-behaviour-related factors on drivers' fatal crash risks by adding variables that described drivers' vehicles and driving licence validity as well as variables that described if the driver was intoxicated or did not use a seat belt to the models. Forest plots were used to describe changes in odd rations and their 95% confidence intervals in the different models.

In the models, the reference category for the passenger condition variable was A-C+. This enabled us to compare it to the drivers in other passenger conditions. In order to examine the passenger condition effect for both drivers' gender separately, models were done first by assessing female drivers as the reference category and then rerunning these same models by assessing male drivers as the reference category.

Finally, effects of drivers' gender and child passengers' ages on the fatal crash risks were examined by using binary logistic regression models. Only drivers with child passengers were included in this analysis, and possible effects of the presence of an adult passenger on the fatal crash risks were controlled in the models. Also the effect of number of child passengers in the vehicle (one, two or more than two) and the seating position of child passengers (a child on the front seat or not) were examined in the models. Like analysis concerning the prevalence of drivers' condition-related factors, drivers' fatal crash risks were examined in all crashes as well as in intersection crashes and non-junction crashes separately. All the analyses were done with software SPSS, version 24.

3. Results

3.1. Prevalence of drivers' characteristic-related factors

Female A–C + were involved in fatal crashes (n = 10,861) more often than male A-C+ (n = 4455). In contrast, female A + C+ (n = 5672) were involved in fatal crashes less often than male A + C+ (n = 8680) (Table 1).

As Table 1 shows, drivers in group A–C + were inattentive or distracted more often than A + C- or A-C- in all crashes. Our more detailed analysis about the distraction sources in Table 2 shows that percentages of other occupants and phone-related crashes were higher for A–C + than for A + C-. Tables 1 and 2 show that in intersection crashes these differences were less evident than in non-junction crashes.

On the contrary, it was less typical for A–C + to be involved in a crash while speeding, intoxicated or without a seat belt than for A-C- or A + C- in all crashes (Table 1). As Table 1 shows, these differences were less evident in intersection crashes than in non-junction crashes.

It was more typical for male A–C + to be intoxicated ($\chi^2(1) = 262.32$, $p < 0.001$), speeding ($\chi^2(1) = 17.34$, $p < 0.001$), driving without a seat belt ($\chi^2(1) = 36.29$, $p < 0.001$) or driving without a valid driving licence ($\chi^2(1) = 109.17$, $p < 0.001$) than for female A–C + in all crashes (Table 1). In addition, among non-junction crashes, male A–C + were asleep or fatigued more often than female A-C+ ($\chi^2(1) = 8.08$, $p = 0.004$), but there were no significant differences in the intersection crashes. Female and male A–C + did not significantly differ in their prevalence of inattentive or distraction-related crashes.

Among non-junction crashes, A–C + were more often inattentive or distracted, intoxicated or/and without a seat belt when the crash

Table 1
Percentages of drivers marked with some specific driver condition-related factors in all crashes and also separately in non-junction and intersection crashes by different passenger conditions for male and female drivers. Differences between passenger condition groups were tested with Pearson Chi square tests.

Male drivers		Percentages				Chi square tests		
		Child passengers	Child and adult passengers	Adult passengers	No passengers	Child passengers vs. child and adult passengers	Child passengers vs. adult passengers	Child passengers vs. no passengers
All crashes		(n = 4455)	(n = 8680)	(n = 63,080)	(n = 157,790)			
	Inattentive or distracted	9.2	6.3	7.1	7.0	37.34***	27.63***	31.32***
	Asleep or fatigued	1.9	3.0	2.1	2.2	14.73***	0.95^{ns}	1.52^{ns}
	Intoxicated	17.8	12.1	42.1	36.2	79.64***	1022.52***	640.53***
	No seat belt [a]	28.3	23.9	43.3	43.2	28.04***	360.10***	365.43***
	Speeding [b]	13.7	14.0	29.7	24.2	0.23^{ns}	522.56***	261.28***
	No valid driving licence [c]	14.7	16.3	23.2	16.5	6.17*	172.55***	10.64**
Non-junction crashes		(n = 2781)	(n = 5848)	(n = 45,324)	(n = 111,789)			
	Inattentive or distracted	10.1	6.5	7.5	7.3	34.54***	26.66***	32.58***
	Asleep or fatigued	2.9	4.3	2.7	2.8	10.45**	0.32^{ns}	0.12^{ns}
	Intoxicated	21.9	13.4	46.5	41.5	100.08***	640.05***	432.41***
	No seat belt [a]	32.6	25.4	46.7	48.5	46.45***	194.26***	254.01***
	Speeding [b]	17.5	17.4	34.5	28.0	0.19^{ns}	338.21***	149.89***
	No valid driving licence [c]	15.6	16.7	24.0	17.4	1.70^{ns}	102.05***	6.26*
Intersection crashes		(n = 1132)	(n = 1967)	(n = 11,481)	(n = 28,777)			
	Inattentive or distracted	6.2	5.0	5.3	5.2	1.85^{ns}	1.60^{ns}	2.35^{ns}
	Asleep or fatigued	0.2	0.0	0.3	0.3	3.48^{ns}	0.46^{ns}	0.79^{ns}
	Intoxicated	8.9	8.3	26.9	19.2	0.37^{ns}	177.03***	75.81***
	No seat belt [a]	21.2	21.1	32.6	27.6	0.00^{ns}	57.76***	21.34***
	Speeding [b]	4.8	5.3	12.5	10.7	0.40^{ns}	59.51***	40.79***
	No valid driving licence [c]	12.6	15.8	19.9	13.3	6.09*	35.74***	0.47^{ns}
Female drivers								
All crashes		(n = 10,861)	(n = 5672)	(n = 21,240)	(n = 63,329)			
	Inattentive or distracted	9.8	8.6	7.5	7.0	6.52*	50.33***	107.92***
	Asleep or fatigued	1.3	3.2	1.7	1.4	71.71***	8.77*	0.82^{ns}
	Intoxicated [a]	8.6	7.4	25.9	21.6	7.72**	1335.54***	980.47***
	No seat belt [a]	23.5	21.4	29.1	30.4	9.16**	107.39***	200.45***
	Speeding [b]	11.3	11.9	18.2	16.3	1.14^{ns}	252.82***	175.80***
	No valid driving licence [c]	8.9	11.5	13.8	9.1	27.77***	159.34***	0.36^{ns}
Non-junction crashes		(n = 6710)	(n = 3704)	(n = 14,475)	(n = 42,669)			
	Inattentive or distracted	10.9	9.6	8.1	7.2	4.12*	45.05***	109.58***
	Asleep or fatigued	1.9	4.7	2.4	1.9	63.11***	4.40*	0.06^{ns}
	Intoxicated	10.9	8.7	29.7	26.2	13.04***	890.26***	742.16***
	No seat belt [a]	26.9	23.3	32.5	35.7	16.08***	62.55***	184.11***
	Speeding [b]	15.6	15.6	22.9	20.5	0.00^{ns}	151.79***	87.64***
	No valid driving licence [c]	9.2	11.8	14.5	9.7	17.67***	113.24***	2.02^{ns}
Intersection crashes		(n = 2935)	(n = 1377)	(n = 4509)	(n = 13,490)			
	Inattentive or distracted	7.4	5.3	5.2	5.3	6.54*	15.17***	19.90***
	Asleep or fatigued	0.1	0.2	0.1	0.3	1.81^{ns}	0.09^{ns}	3.73^{ns}
	Intoxicated	4.6	4.6	15.5	9.6	0.01^{ns}	211.51***	73.69***
	No seat belt [a]	17.5	18.0	21.3	18.0	0.14^{ns}	14.52***	0.38^{ns}
	Speeding [b]	3.3	3.4	5.0	5.0	0.94^{ns}	12.77***	15.41***
	No valid driving licence [c]	8.1	11.2	11.8	6.8	10.26**	25.06***	6.05*

[a] Percentages and Chi square tests were calculated for crashes in which information about seat belt use was known. This information was missing for 4.5%–10.3% of crashes.
[b] We defined the driver as speeding if it was estimated that she or he was driving too fast for conditions, more than the posted speed limit or racing.
[c] Percentages and Chi square tests were calculated for crashes in which information about the driving licence status was known. This information was missing for 0.3%–1.9% of crashes.

Table 2
Percentages of drivers marked with some detailed distraction-related factors in all crashes and also separately in non-junction and intersection crashes by different passenger conditions for male and female drivers for years 2010–2015. Differences between passenger condition groups were tested with Pearson Chi square tests.

Male drivers		Percentages				Chi square tests		
		Child passengers	Child and adult passengers	Adult passengers	No passengers	Child passengers vs. child and adult passengers	Child passengers vs. adult passengers	Child passengers vs. no passengers
All crashes		(n = 887)	(n = 1590)	(n = 11,129)	(n = 29,671)			
	Other occupant	3.6	1.3	1.2	–	15.297***	36.760***	–
	Phone-related	2.0	0.7	0.9	1.6	8.803**	11.900**	1.202 ^{ns}
	Other distraction [a]	6.1	5.5	6.1	6.9	0.323 ^{ns}	0.005 ^{ns}	0.816 ^{ns}
	Missing (n) [b]	*165*	*273*	*3207*	*9136*			
Non-junction crashes		(n = 551)	(n = 1009)	(n = 7730)	(n = 20,280)			
	Other occupant	4.9	1.1	1.4	–	21.77***	39.939***	–
	Phone-related	2.7	0.8	1.0	1.8	9.13**	13.596***	2.794 ^{ns}
	Other distraction [a]	6.5	4.5	6.1	6.9	3.11 ^{ns}	0.144 ^{ns}	0.133 ^{ns}
	Missing (n) [b]	*118*	*197*	*2349*	*6744*			
Intersection crashes		(n = 362)	(n = 187)	(n = 334)	(n = 1792)			
	Other occupant	1.1	0.6	0.8	–	0.35 ^{ns}	0.107 ^{ns}	–
	Phone-related	1.6	0.6	0.5	1.1	1.28 ^{ns}	3.412 ^{ns}	0.404 ^{ns}
	Other distraction [a]	3.7	6.9	5.5	5.4	2.18 ^{ns}	1.060 ^{ns}	0.945 ^{ns}
	Missing (n) [b]	*26*	*54*	*451*	*1135*			
Female drivers								
All crashes		(n = 2055)	(n = 1133)	(n = 4125)	(n = 12,714)			
	Other occupant	3.5	2.1	1.8	–	4.799*	16.781***	–
	Phone-related	2.4	0.9	1.0	2.6	9.069**	16.845***	0.293 ^{ns}
	Other distraction [a]	6.2	7.4	6.2	6.5	1.799 ^{ns}	0.006 ^{ns}	0.370 ^{ns}
	Missing (n) [b]	*458*	*196*	*997*	*3534*			
Non-junction crashes		(n = 1226)	(n = 681)	(n = 2722)	(n = 8143)			
	Other occupant	4.2	2.9	2.1	–	1.83 ^{ns}	12.963***	–
	Phone-related	2.5	1.3	1.1	2.9	3.12 ^{ns}	12.091***	0.462 ^{ns}
	Other distraction [a]	7.0	7.3	6.6	6.9	0.71 ^{ns}	0.260 ^{ns}	0.037 ^{ns}
	Missing (n) [b]	*305*	*131*	*681*	*2522*			
Intersection crashes		(n = 501)	(n = 286)	(n = 788)	(n = 2526)			
	Other occupant	2.8	0.7	0.8	–	4.01*	8.287**	–
	Phone-related	2.6	0.3	0.8	1.8	5.25 *	7.089**	1.472 ^{ns}
	Other distraction [a]	5.2	5.9	4.8	5.2	0.02 ^{ns}	0.088 ^{ns}	0.001 ^{ns}
	Missing (n) [b]	*92*	*42*	*181*	*536*			

[a] Included all other distraction sources (e.g.' distracted/inattention, details unknown', 'eating/drinking' and 'distracted by outside person/object/event'.
[b] Number of drivers with no information about distraction. Percentages and Chi square tests were calculated for crashes in which information about whether the driver was distracted or not was known.

occurred than A + C+ regardless of the drivers' gender (Table 1). In the intersection crashes, these differences between A–C + and A + C + were not significantly different – except the group of female A-C+, who were more often inattentive in intersection crashes compared to female A + C+. However, it was more common for A + C + to be asleep or fatigued in non-junction crashes than for A-C+ (Table 1).

3.2. Fatal crash risk estimation and factors affecting the fatal crash risks

Drivers' likelihood of being at fault was examined by binary logistic regression models. Crude and adjusted odds rations and their 95% confidence intervals for drivers in different passenger conditions in relation to drivers with child passengers are shown among female drivers in Fig. 1 and among male drivers in Fig. 2. Complete binary logistic regression models are shown in Appendix E.

In addition, frequencies of at-fault and not-at-fault drivers and the at-fault rate in different passenger conditions in five-year sections are shown in Appendix F. This analysis indicates that there seems to be no specific time-related phenomenon in the at-fault rate of different passenger conditions over the study period.

As seen in Figs. 1 and 2, in the adjusted models where risk-taking-related factors were controlled, A–C + seems to have higher odds of being at fault compared to crude models in relation to A-C- or A + C-. This indicates that A-C- and A + C- had more often risk-taking-related behaviours behind their fatal crash risks than A-C+, and thus, when controlling this behaviour in the models, it elevated crash risks of A–C + in relation to A-C- or A + C-. Our results also show that drivers' odds of being at fault seem to be essentially different depending on the traffic environment (Figs. 1 and 2).

In non-junction crashes, both male and female A–C + were more likely to be at fault compared to A + C- in the adjusted model, but in the crude model this difference was not significant among male drivers and it seemed to be smaller among female drivers – even staying still significantly (Figs. 1 and 2).

In intersection crashes, both male and female A–C + were less likely to be at fault compared to A + C- in the crude model, but in the adjusted model these differences were not significant. Figs. 1 and 2 show that the odds of being at fault were lower for both female and male A + C + in relation to A–C + in non-junction crashes. However, there were no significant differences between A–C + and A + C + in the intersection crashes (Figs. 1 and 2).

As seen in Fig. 1, in non-junction crashes, female A–C + were less likely to be at fault than female A-C- in the crude model, but in the adjusted model this difference was not significant. In intersection

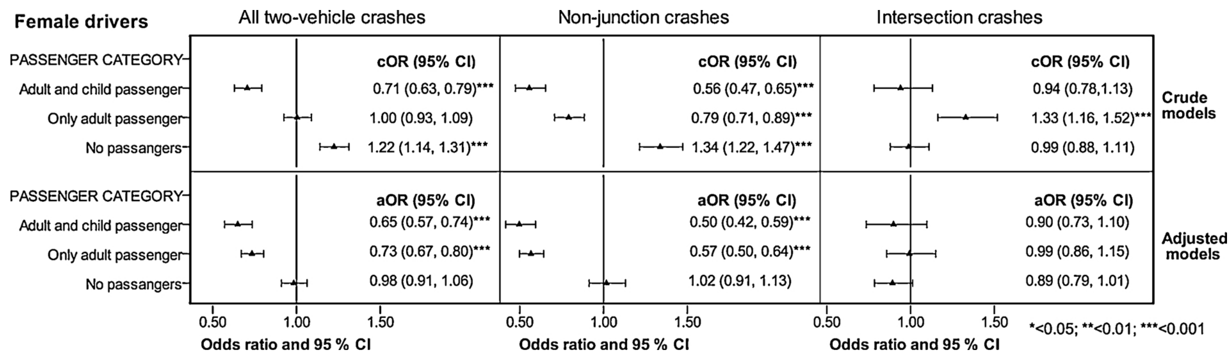

Fig. 1. Crude (cOR) and adjusted (aOR) odds rations with their 95% confidence intervals to predict culpability for female drivers in different passenger condition groups (drivers with child passengers as the reference category). All models included drivers' gender variables (female drivers as reference category) and interaction between the passenger category and the drivers' gender variables.

crashes there were no significant differences of being at fault between female A–C + and A-C- in the crude and adjusted models. As Fig. 2 shows, in non-junction crashes, the odds of being at fault were lower for male A–C + in relation to male A-C- in both the crude and adjusted models, but in intersection crashes, male A–C + had lower odds of being at fault than male A-C- only in the crude model, and in the adjusted model there were no significant differences.

3.2.1. Drivers' gender and the age of the child passenger

The effects of drivers' gender and child passengers' ages on the fatal crash risks were examined by binary logistic regression models. Only drivers with child passengers were included in this analysis. Crude and adjusted odds rations and their 95% confidence intervals for variables that described if there were child passengers under five years old in the vehicle and drivers' gender are shown in Table 3. All models included variables that described if there was an adult passenger in the vehicle. Complete models are shown in Appendix G. All models entered two-way interaction between drivers' gender and ages of the child passengers, but this interaction was not significant and was removed from the models. In addition, variables representing the number of child passengers and child passengers seating position were included to the models, but these variables were not significant and did not improved the models and were thus removed from the models.

As seen in Table 3, in intersection crashes, female drivers with child passengers were more likely to be at fault than male drivers with child passengers in the adjusted model, but in the crude model there were no significant differences. In non-junction crashes there were no significant differences between male and female drivers with child passengers regardless of the model. In non-junction crashes, drivers with 0–4-year-old child passengers were more likely to be at fault than drivers with older child passengers in the adjusted model, but contrary, among intersection crashes, drivers with 0–4-year-old child passengers were less likely to be at fault than drivers with older child passengers regardless of the model (Table 3).

4. Discussion

In this study we examined if drivers with child passengers differ from drivers with no child passengers in their fatal crash-related characteristics and fatal crash risks using fatal crash data from the U.S. FARS database for 1996–2015. Our results indicated that drivers with child passengers represent a specific driver population who has different factors behind their fatal crash risks compared to drivers without child passengers.

Our results showed that drivers with child passengers were more often assessed as inattentive compared to drivers without child passengers, which indicates that children in the vehicle represents a potential source of distraction (Stutts et al., 2005; Koppel et al., 2011) (Table 1). Our more detailed analysis about distraction sources for years 2010–2015 supports this suggestion as it showed that drivers with child passengers were more often distracted by other occupants than drivers with only adult passengers (Table 2). Our results also showed that differences in distraction-related crashes were more evident in non-junction crashes than in intersection crashes. It is possible that drivers attend more to the driving task in more complex traffic environments, such as in intersections, even when they have in the vehicle a child passenger who needs to be taken care of. However, in fewer task-demanding traffic environments, such as non-junctions, drivers might assume that they could allocate attention towards tasks related to the child passengers (e.g. feed the child passenger or pick up the child's toys while driving) (Macy et al., 2014).

Our results showed that risk-taking behaviours – being intoxicated, speeding or failing to use a seatbelt – were less typical for drivers with child passengers than for drivers without child passengers, suggesting that drivers with child passengers tend to drive more responsibly (Taubman - Ben-Ari and Noy, 2011) (Table 1). These differences were more marked in non-junctions than in intersections. This is in line with the previous research as the risk-taking behaviour – in this case especially being intoxicated and speeding – is known to be linked to 'loss of control' accidents (Clarke et al., 2010) that normally occur outside intersections. Previous research has also showed that risk-taking behaviours are more typical for male drivers than for female drivers (Harré et al., 1996; Rhodes and Pivik, 2011; Turner and McClure, 2003). Our fatal crash data based study showed that male drivers, also when they have child passengers in the vehicle, were more often speeding, intoxicated or without a seatbelt compared to female drivers.

According to our results, it was more typical for female drivers to be involved in fatal crashes alone with child passengers compared to male drivers. In contrast, for male drivers it was more typical to be involved in fatal crash with both child and adult passengers compared to female drivers. This probably reflects different exposure levels between male and female drivers with child passengers with and without adult passengers in the vehicle.

Like in our previous study (Maasalo et al., 2017), which focused on female drivers only, drivers with child passengers without an adult passenger had more crashes related to inattention compared to drivers with both child and adult passengers, indicating that another adult in the vehicle could take care of the child passenger instead of the driver. In addition, drivers with only child passengers were more often intoxicated and without seat belt than drivers with both child and adult passengers. Somewhat surprisingly, male and female drivers with both child and adult passengers were more often assessed as fatigued than drivers with only children in non-junction crashes. It is possible that in some crashes all factors related to drivers' conditions are not reported (Radun and Summala, 2004). Possibly the information about whether the drivers were inattentive or fatigued when the crashes occurred could be missing, especially if there was no other adult in the vehicle in addition to the driver who could tell afterwards how the crash situation developed.

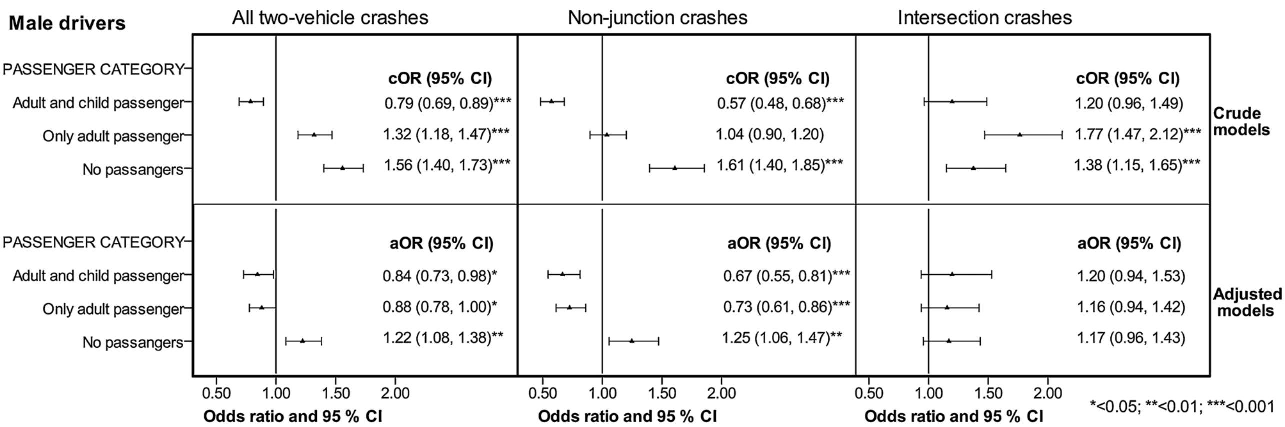

Fig. 2. Crude (cOR) and adjusted (aOR) odds rations with their 95% confidence intervals to predict culpability for male drivers in different passenger condition groups (drivers with child passengers as the reference category). All models included drivers' gender variables (male drivers as reference category) and interaction between the passenger category and the drivers' gender variables.

Table 3
Crude (cOR) and adjusted (aOR) odds rations with their 95% confidence intervals for only drivers with child passengers by presence of 0-4-year-old passengers and drivers' gender in all two-vehicle crashes and also separately in non-junction and intersection crashes. The dependent variable was the driver's culpability (1 = at fault, 0 = not at fault). All models included the variable that described if an adult passenger was in the vehicle.

	Crude model cOR (95 % CI)	Adjusted model aOR (95 % CI)
All two-vehicle crashes		
Drivers' gender [a]	0.96 (0.88, 1.05) [ns]	0.89 (0.80, 0.98) [*]
0-4-year-old passengers [b]	0.94 (0.86, 1.03) [ns]	0.98 (0.89, 1.08) [ns]
Non-junction crashes		
Drivers' gender [a]	1.05 (0.93, 1.18) [ns]	0.97 (0.85, 1.10) [ns]
0–4-year-old passengers [b]	1.08 (0.96, 1.22) [ns]	1.15 (1.01, 1.31) [**]
Intersection crashes		
Drivers' gender [a]	0.84 (0.73, 0.97) [*]	0.79 (0.67, 0.92) [**]
0–4-year-old passengers [b]	0.83 (0.72, 0.96) [*]	0.85 (0.73, 1.00) [*]

[a] Reference group: female drivers.
[b] Reference group: 5–9-year-old passengers.
* $p < 0.05$.
** $p < 0.01$.
[ns] not significant.

Our crash risk analysis indicated that drivers with no child passengers have higher fatal crash risks compared to drivers with child passengers when risk-taking-behaviour-related factors are not controlled. When these factors were controlled these differences were smaller or not significant.

This suggests, not surprisingly, that risk-taking-behaviour-related factors are more often behind the fatal crash risks of drivers with no child passengers than they are behind the fatal crash risks of drivers with child passengers.

The presence of a child passenger without an adult passenger was linked to higher fatal crash risks compared to drivers with an adult passenger (with or without a child passenger) outside intersections when risk-taking behaviours were controlled. This suggests that child passengers distract drivers, increasing the fatal crash risks, but adult passengers who can help the driver in child-passenger-related tasks reduces distraction. The lack of the effect in the intersections can be because drivers try to self-regulate their interactions with child passengers, focusing more on driving in more demanding traffic situations. It is also possible that an adult passenger, but not a child passenger, lowers drivers' fatal crash risks especially in non-junctions by helping in driving-related tasks (e.g. in co-piloting). Thus, it cannot be excluded that in non-junctions this could also affect the difference in the fatal crash risks between drivers with child passengers and drivers with adult passengers (with or without a child passenger) in addition to child-passenger-related distractions.

Our results showed that drivers with child passengers did not have higher fatal crash risks than drivers with no passengers when risk-taking behaviours were controlled. If the presence of a child passenger distracts the driver, then it could be expected that drivers with child passengers would have had higher crash risks than drivers with no passengers. However, it is possible that the tendency of risk-taking behaviours influenced the drivers' fatal crash risks in our analysis even though we tried to control it in the models (e.g. the information about alcohol involvement is often missing in the FARS database). This means that drivers with no passengers did not necessarily represent eligible 'baseline' drivers. Thus, comparison of fatal crash risks between drivers with no passengers and drivers with child passengers does not probably accurately define how much the child-passenger-related distraction affects the fatal crash risks.

One purpose of this study was to replicate the results from our previous study (Maasalo et al., 2016), which found that female drivers with child passengers have elevated fatal crash risks. The results were expected because of mothers' higher sensitivity to child-passenger-related distractions and because they suffer fatigue more often (see also Livingstone et al., 2009). However, our current results showed that male and female drivers with child passengers did not significantly differ in their prevalence of inattention, and percentages of fatigue-related crashes were even significantly higher for male drivers with child passengers than for female drivers. Our fatal crash risk analysis showed that female drivers with child passengers had higher fatal crash risks than males in intersection crashes, but there were no significant differences in non-junction crashes. In our previous study (Maasalo et al., 2016), female drivers with child passengers were more inexperienced drivers than males, and it is possible that this was also the case in this study (see also Hakamies-Blomqvist, 1994). Inexperienced drivers are known to have less developed hazard perception skills, which possibly affect crash risks, especially in intersections (Borowsky et al., 2010). More studies are needed to examine the effect of drivers' inexperience, child-passenger-related distractions and their combined effect on crash risks (see Maasalo et al., 2017).

Our analysis showed that among non-junction crashes, drivers with small child passengers (aged under five years) had higher fatal crash risks than drivers with older child passengers (aged 5–9 years) if risk-taking-related factors were controlled. This suggests that in non-junctions, drivers are more often exposed to child-passenger-related distractions if they have smaller children in the vehicle. However, somewhat surprisingly, drivers with only older child passengers had higher fatal crash risks than drivers with smaller child passengers in intersections. Further studies are needed to examine possible effects of child passengers' age on the crash risks in different traffic environments.

4.1. Limitations

It should be taken into consideration that the FARS database only contains information on fatal crashes, which often include special characteristics and risk-taking behaviours. Thus, our results should be generalized to non-fatal crashes with caution.

The distraction is likely not well coded in FARS and the prevalence of distraction related crashes is probably underestimated in all of our examined drivers' passenger condition groups.

Our fatal crash risk analysis was based on quasi-induced exposure technique which gives us only estimations about the drivers' exposure by the number of not at-fault parties of crashes. Drivers in our different passenger condition groups may drive in different kinds of environments and traffic settings, which may influence their crash risk.

The FARS database does not include information on the child passengers' relationship to the driver. It is reasonable to assume that in most of the cases the driver was a parent of that child. However, even though we excluded the youngest and oldest drivers, possibly some drivers with child passengers included to the analysis were not their parents.

We used Pearson Chi square tests to compare differences in drivers' characteristics in different passenger condition groups. Large n and multiple tests increases the chances to obtain statistically significant differences. More advanced statistical methods like network models (e.g. Mattsson, 2019) could help to address this problem.

5. Conclusions

Our fatal crash data based study showed that drivers with child passengers represent a specific driver population. Their tendency to engage in distractions while driving is higher, but they have fewer risk-taking behaviour-related crashes compared to drivers with no child passengers. Our results indicate that a child-passenger-related distraction can still pose a risk outside intersections. Presence of an adult passenger reduces fatal crash risks, suggesting that another adult in the vehicle can help the driver with child-related tasks. Female drivers had twice as many fatal crashes alone with child passengers compared to male drivers. These results should be considered when planning traffic safety campaigns or interventions for parents.

Conflict of interest

None.

Acknowledgments

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Appendix A–G Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.aap.2019.06.004.

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