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PUBLISHER

Tuv Sud

VERSION

VoR (Version of Record)

PUBLISHER STATEMENT

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Kirk, Alan, Philippe Lesire, and Sylvia Schick. 2019. "Child Car Passenger Fatalities – European Figures and In-depth Study". figshare. <https://hdl.handle.net/2134/21851>.

Child Car Passenger Fatalities – European Figures and In-Depth Study

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Abstract This paper reports on three approaches undertaken to study overall child car passenger fatality numbers across Europe and examine conditions when fatalities occur. Firstly, a literature review of previous specific studies and public data finds data from WHO for estimating the relevance of child road accident fatalities. Detail for child fatalities as car passengers is found to be limited and for the future it is important to collect and harmonise exposure data (especially distance travelled) to compare countries and different modes of traffic for their fatality risk. Secondly, interrogation of the EC CARE database (Community database on Accidents on the Roads in Europe) for child car passenger fatalities finds that 392 children (0 to 13 years) were killed as car (or taxi) passengers in 23 countries of the EU during 2008, 44% of all road fatalities for this age group. Over the previous 10 year period the reduction in child car passenger fatalities is estimated to be 50% for the EU-19 countries with available data. Thirdly, in depth analysis of French police child passenger fatality files has taken place. The CASIMIR project (Child Accident Study Investigating Mortal Incident on the Road), the collation and in-depth analysis of French police child passenger fatality files from 2001 to 2003, was reported at FISITA 2010. An update of this study with data from 2005 to 2010 is on-going, in order to see if there are some evolutions (for example, new child restraint systems, new generation of cars and changes in parents' behaviour) and more than 250 fatal accidents will be included in the 2nd phase. From previous results, frontal and side impacts remain a priority, with a small proportion killed in rear impacts and fatalities in roll-overs mostly unrestrained. In this kind of study there are some limits on the information regarding the quality of use of the restraint systems. Therefore a sample of 60 accidents was investigated in-depth (mostly front and side impacts) with special attention paid to the quality of restraint use. Results of these in depth investigations are reported in the present paper. The complete data of the 2nd phase of the CASIMIR project, also considering sociological data, will be published when all fatal accidents for the period have been coded.

Parts of this work have been undertaken in the EC CASPER project and are reported in Deliverable 3.2.1 (Kirk et al, 2011). The activities regarding the French police fatal files have been undertaken in both the CASIMIR project and CASPER.

Keywords EU road fatalities, Child road accident fatalities, Child restraints

Introduction and Methods This paper reports on work undertaken in the EC CASPER (Child Advanced Safety Project for European Roads) project and the CASIMIR project regarding fatality studies. The majority of the work undertaken in CASPER focuses on a deep understanding of child occupant injuries, biomechanics and restraint conditions (type, use and misuse). This is of course necessary for the scientific aims of the project. What has not been so clear is the bigger picture in terms of child occupant fatalities across Europe (or in fact internationally), setting the aims of the CASPER project in overall context.

Literature review The first approach is to look at the literature, examining International fatality figures available from published literature and any fatality studies, trying to keep a focus on car occupants wherever possible. A focus is set on grabbing the size of the issue (world-wide and Europe) and on detecting the main fatality reasons, restraint conditions and crash configurations. The focus is on fatality studies in particular rather than injury studies.

Information from Initiatives, Associations, Non-Governmental Organisations, European Projects, and reviews has been used, but only if not already covered by the output in public databases. Furthermore, studies published in scientific literature are screened.

EU child passenger fatalities Published figures for child fatalities often group child occupant and child pedestrian fatalities together and/or in large age groups (for example 0-17 years old) that do not correlate well to the key child restraint groups. Therefore the EC CARE (Community database on Accidents on the Roads in Europe) database has been interrogated to present results by a more tightly defined age group and as car passengers rather than overall child fatalities. CARE is a Community database on road accidents resulting in death or injury, developed and hosted by the European Commission with co-operation and input from EU member states. Data for 2008 and 1999 to 2008 are presented. Of the EU-27 countries, data are not included in this report for Bulgaria, Cyprus, Lithuania and Malta, the resulting country set referred to as EU-23. For some countries data for the last 10 years are not completely available for use in time series analysis, so a reduced set referred to as EU-19 is used.

EU-19:	Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Sweden, United Kingdom (Great Britain and Northern Ireland).
EU-23:	Those above plus Estonia, Latvia, Hungary, Slovakia

The sample selected is children, aged 0 to 13 years inclusive, as passengers in cars or taxis, being referred to as ‘child car passengers’. In the CARE database the ages of 0 and 1 are combined into a <2 years old group and are presented as such here. Generally age is rounded down to whole number of years (except for Greece, Italy and Northern Ireland: rounded to nearest year - CARE Glossary). Limitations to this macro data are a lack of restraint and crash configuration or severity information but the figures are important as a first step in understanding the overall issue and putting in-depth activities into context.

French fatal police files study The aim of this study is to conduct an exhaustive analysis of road accidents where children have been killed as car passengers in France and to determine the main typology of these accidents. The study is named CASIMIR (Child Accident Study Investigating Mortal Incident on the Road). It has been possible to establish it in the frame of a collaboration, which first aimed to study absorption of alcohol or drugs by drivers involved in all fatal road accidents between October 2001 and September 2003 in France. Approximately 10,000 fatal road accident reports have been established during the period of the study. CASIMIR is an extract from this database that includes all children killed in road accidents as a car passenger, with 198 accidents involving 210 child fatalities. It has been possible to collect, code and study 194 reports giving data for 809 occupants, including 206 child fatalities in 196 vehicles (the study’s sample). Police reports often contain victim and witness statements, descriptions of the accident scene and conditions (including a detailed sketch or plan), descriptions of involved vehicles, accident scene pictures and medical reports, if any. Expert judgement has been used to understand the crash configurations and severity, and the influence of restraint conditions (use and misuse). The study is representative of the situation of the French territory (excluding over-seas departments). In 2003, France was the European country with the highest number of child car occupant fatalities with 25% of the total (Source IRTAD - International Road Traffic Accident Data base). Following this first phase of the project, data from the same source are collected for fatal child car occupant accidents that occurred between 2005 and 2010. This work is still on-going and has been supplemented by the in-depth investigation of about 60 cases by an accidentology research team. This is in order to increase the quality of the knowledge of parameters that are important to define priorities in terms of child safety

improvements, such as the quality of use of restraint systems and the values of structural deformations of cars.

Results

Literature Review

Fatality figures According to the World Health Organization (WHO), an estimated 122,571 children in the age group of 0-14 years old died because of road traffic accidents in 2008. This represents 1.3% of those children dying before the age of 15 and approximately 10% of RTA fatalities world-wide. In these figures all kinds of transport modes and pedestrians are included. For some countries no data exist, and for many countries underreporting is known, thus the WHO includes some best estimates. No numbers on child fatalities as car passengers for the whole world can be found in published data from WHO or the IRTAD database. The UNECE provides these data for 40 countries in 2001, but in the years 2005 to 2009 less than 3 country figures are provided.

For the WHO Europe region (which includes, in addition to EU-27, large countries such as the Russian Federation and Turkey) approximately 2.5% of those children dying before the age of 15 died because of Road Traffic Accidents in 2008, estimated to be 4,408 children (WHO). They represent approximately 4.1% of RTA fatalities in the WHO Europe region.

Children dying as car passengers For the EU, the European Child Safety Alliance provides country rates for the age group 0-19 years, which are 1.23 (female) and 2.87 (male) per 100,000 inhabitants in 2009. No published information for a smaller and younger age group or for more detailed age classes can be found and, as it refers to up to 19 years old, drivers are being included. The UNECE provides data for the age group 0-14, with the opportunity to select passenger cars. Most of the country rates lie between 0.5 and 1.5 per 100,000 population in this age group. However, these data show a lot of missing values and for most countries the latest figures refer to 2004.

The U.S. Centre for Disease Control (CDC) provides detailed data on child fatalities as motor vehicle occupants. Information on every single age group can be found. Overall in the age group 0-13 years the occupant death rate is 1.01 (females) and 1.05 (males) per 100,000 in 2007 (both sexes 1.03 per 100,000). The rate lies at 1.42 below the age of one year. Between 1 and 11 years the rate lies around 1, increases at the age of 12 to 1.18, and rises further to 1.66 per 100,000 at the age of 13. No details on children fatalities as car passengers solely are provided, but the majority will be car passengers.

Risk factors The NHTSA Child Traffic Safety Facts 2009 report gives some detail regarding restraint use and effectiveness for occupants involved in fatal accidents. The risk reduction in passenger cars for fatal injury by child safety seats compared to being unrestrained for younger than 1 year olds lies at 71% and for 1 to 4 years old at 54%. For the analysis presented in the IIHS Status Report 32, No.9, the Insurance Institute for Highway safety used data from the US FARS (Fatality Analysis Reporting System) involving children up to 12 years in vehicles involved in fatal crashes between 1988 to 1995 (overall 26,233 children). They found that “*Young children restrained in child safety seats have an 80 percent lower risk of fatal injury than those who are unrestrained*”. By using FARS data from 1989 to 1998, Glass et al. (2000), analysed fatal vehicle crashes with child passengers up to 13 years old and also showed that restraint condition and rear seating independently can reduce the odds for dying in a car crash significantly. Javouhey et al. (2006), calculated an odds ratio of around 5 for unrestrained children up to 15 years old dying as car passengers compared to restrained children when taking data from a French road trauma registry from 1996–2002.

Viano et al. (2008), present a large overview on seat position influence on fatality risk for 0 to 7 year old children in the US. They state that the fatality risk on the front seat is 0.53%, in

the second row only 0.30% and in the third row only 0.22%. Overall the middle second row seat showed the lowest fatality risk with 0.27%. Further, Viano et al. give a fatality risk in rollover accidents for children aged 0 to 7 of 1.37%, which is higher than right-side crashes with a fatality risk of 0.47% and left-side impacts with 0.34%. Rivara et al. (2003), present an adjusted relative risk for fatality in a rollover of 1.8 (95% CI 1.1 to 2.8).

Fatality reasons Quinones-Hinojosa et al. (2005) used data from NHTSA and the National Pediatric Trauma Registry from 1993 to 2002 to show that for infant fatalities (up to 1 year old) head injuries only were the cause of death. In other age groups of children a combination of injuries was found. Fatal injuries are said to include skull and cervical spine fractures, subdural haemorrhages, diffuse axonal injuries, cord transections and decapitations. Stawicki et al. 2009 analysed fatal cervical spine injuries (CSI) for child (0-15 years) motor vehicle occupants by linking national mortality datasets (US) on individual levels to compare injuries and crash characteristics. In 176 of 6,065 children fatalities they found CSI. They found those injuries more often in females, together with traumatic brain injury, and more often in restrained conditions. It is noted that *'the reported incidence of paediatric spinal injuries may be underestimated, because children with the most severe trauma often do not survive beyond the accident scene due to associated lethal injuries'*. Regarding the interesting result for restraint use it is proposed, *'one potential way to reconcile these observations is the hypothesis that proportionately more fatal events among restrained accident victims may be due to the CSI itself. Conversely, inappropriate or absent restraints among accident survivors may predispose this group to survivable CSI'*. No association was found with age, vehicle model, year or type, exposure to airbag, severe vehicle intrusion, collision speed or direction, drivability of the vehicle or seating position.

EC CARE database results

Transport mode Figure 1 gives the distribution of child fatalities (0 to 13 years old) by mode of transport. Overall the CARE database reports that 896 child (aged 0 to 13 years old) road accident fatalities occurred in 2008 (EU-23).

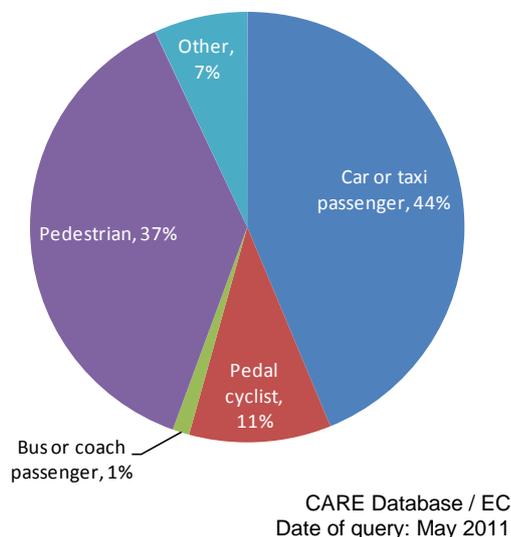


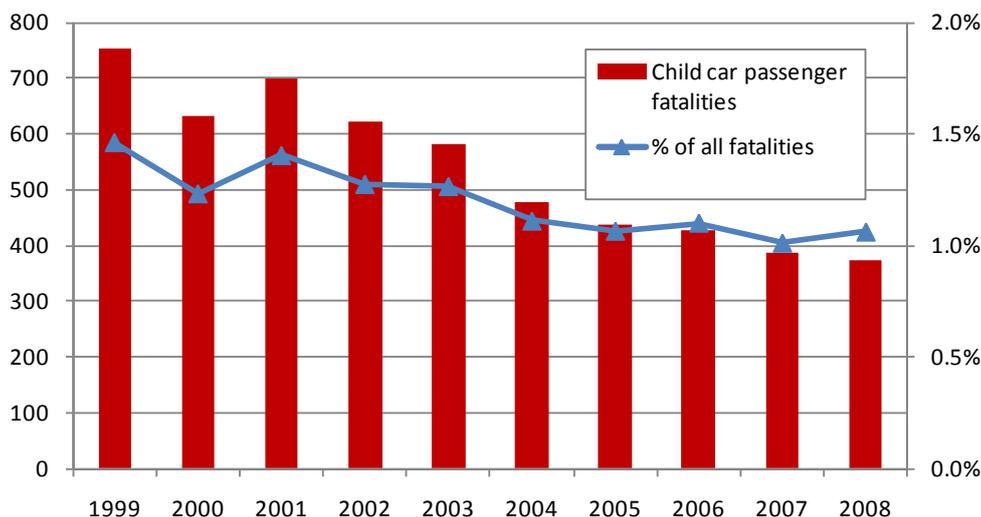
Figure 1: Child fatalities (0-13yrs) by mode of transport - 2008 EU-23 (n=892)

*Other includes other vehicles such as goods vehicles and also car drivers.

There are 392 fatalities recorded for children (0 to 13 years old) as car or taxi passengers in 2008, plus 1 as a car driver. Car passengers account for 44% of all child fatalities, closely followed by pedestrians at 37%. There are 337 accidents recorded in the CARE dataset for 2008 (EU-23) which involve child car passenger fatalities. Overall, there are estimated to be 37,265 fatalities of all ages and modes of transport reported for 2008 (EU-23), 1.1% are child car passenger fatalities. Otherwise, of all fatalities, car drivers are 32%, pedestrians 20%

and those on powered two wheelers 18%. Car passenger fatalities (all ages) account for 16% of the 37,265 fatalities with the child car passenger sample representing 6.6% of all car passenger fatalities.

Fatalities over the last 10 years Figure 2 shows the number of reported child passenger fatalities for the 10 year period from 1999 to 2008 in the EU-19 countries with available data (or if only missing for just the first or first two years, the figures have been estimated to be the next known value). Hungary is the only country omitted from the EU-19 total that has fatality values in double figures for years when data are available.



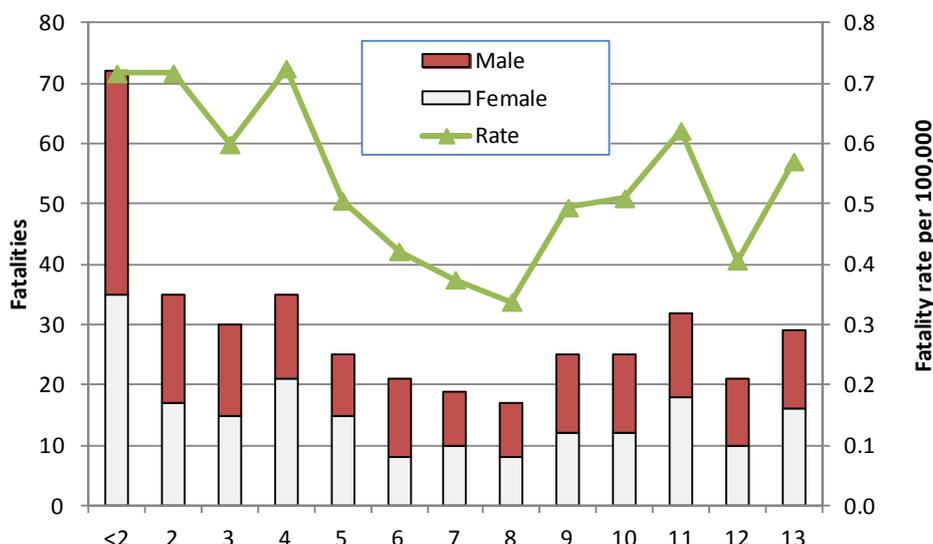
CARE Database / EC

Date of query: May 2011

Figure 2: Child car passenger fatalities (0-13yrs) by year and as proportion of all fatalities – 2008 EU-19

Over the 10 year period the reduction in child car passenger fatalities is estimated to be 50% for the EU-19 countries, from 752 to 374. For all fatalities the reduction over this period is estimated to be 32% for the EU-19 countries (from 51,425 to 35,215). Of all fatalities in 2008, child car passenger fatalities account for 1.1%, a fall from 1.5% in 1999.

Age and gender Figure 3 shows the number of child car passenger fatalities by age with gender distribution and fatality rate (by 100,000 population at that age).



CARE Database / EC

Population data: EUROSTAT

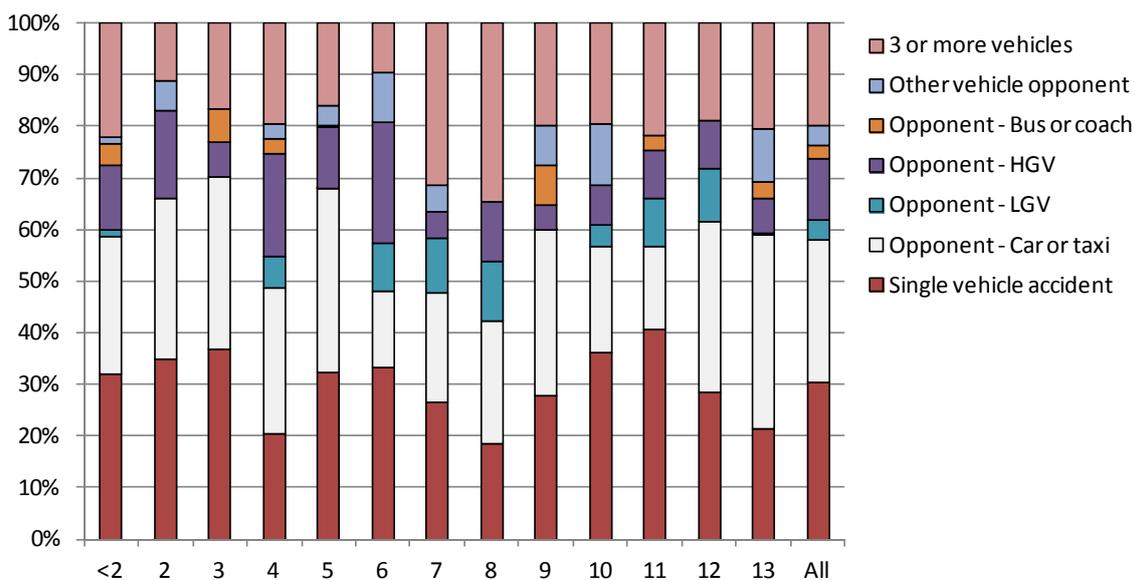
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Figure 3: Child car passenger fatalities by age and distribution of gender – 2008 EU-23 (n=392)

It should be noted that the <2 age group is two years (0 and 1 year olds). Across all ages reported here the distribution between genders is generally even, with a slightly higher overall figure for females of 200 compared to 192 for males. For all 37,265 fatalities reported for 2008 (EU-23), 76% are male. The fatality numbers are seen to drop around 5 and 6 years of age and then rise again towards 11, dropping at 12 and then rising again at 13. If it was estimated that the figures for the first two years were evenly distributed then figures of 36 would be comparable to the figure for 2 years old.

The fatality rate per 100,000 inhabitants for each age follows the rise and fall of the number of fatalities with the population for each age point being similar (around 5 million). It is highest for those below 3 years old and then again for 4 year olds. The overall fatality rate for 0-13 year old child car passenger fatalities is 0.55 per 100,000 inhabitants (the figures do not account for non-nationals injured whilst travelling in another country). The highest fatality rate by population is Romania at 1.35 (population in 0-13 age group 3,045,204). Two countries Slovenia and Luxembourg have fatality figures of zero but have very low populations for this age group (260,276 and 81,868 respectively). Of the countries with fatalities, Sweden has the lowest fatality rate of 0.14 (population in this age group 1,420,247).

Vehicle involvement Figure 4 gives a distribution of vehicle involvement for child car passenger fatalities. There is no definition that a collision has taken place between the vehicles involved in the accident, but in general it can be presumed that the majority of accidents here will involve a collision between the vehicles.



CARE Database / EC

Date of query: May 2011

Figure 4: Distribution of vehicle involvement for child car passenger fatalities – 2008 EU-23

*other includes pedal cycles, motorcycles, mopeds, agricultural tractor, other and unknown.

**lorries cannot systematically be categorised as less than 3.5 tonnes for DK, IT, LU [CARE Glossary]

Across the whole sample of 392, just under one third were killed in single vehicle accidents, half in 2 vehicle accidents and one fifth in 3 or more vehicle accidents. Of the 195 fatalities that occurred in 2 vehicle accidents, 55% were in accidents involving 2 cars, followed by 23% in accidents involving a heavy goods vehicle (HGV).

Time of year Figure 5 shows the distribution across the year of when child car passenger fatalities occurred during 2008.

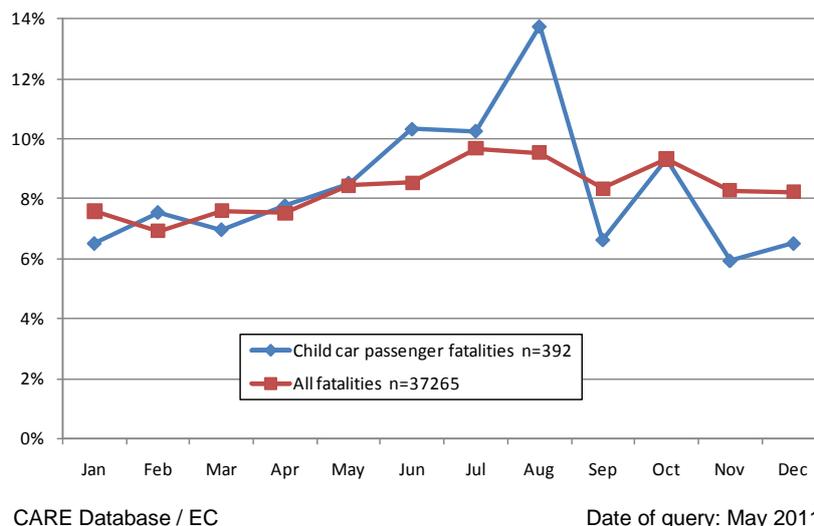


Figure 5: Distribution of month for child car passenger fatalities – 2008 EU-23

An increase in child car passenger fatalities numbers is evident in summer months, peaking in August, although a dip is then evident for September. Fatality numbers seem to be affected by the summer holiday period where exposure, as distance travelled on long journeys, is likely to be higher. For all fatalities there is also a rise in the summer months but it is proportionally not as large compared to the rest of the year.

Day of week and time of day The hour usually indicates the accidents that took place in the 60 minutes of that time period – except for Spain, Greece and Italy, where hours are rounded to the nearest hour. No data is available for Germany and this adds to the large number of unknown data. For Portugal unknown hours during daytime are coded as ‘12’ and during night time ‘0’ (midnight). Figure 6 combines day of week and grouped time of day data with unknown values not included.

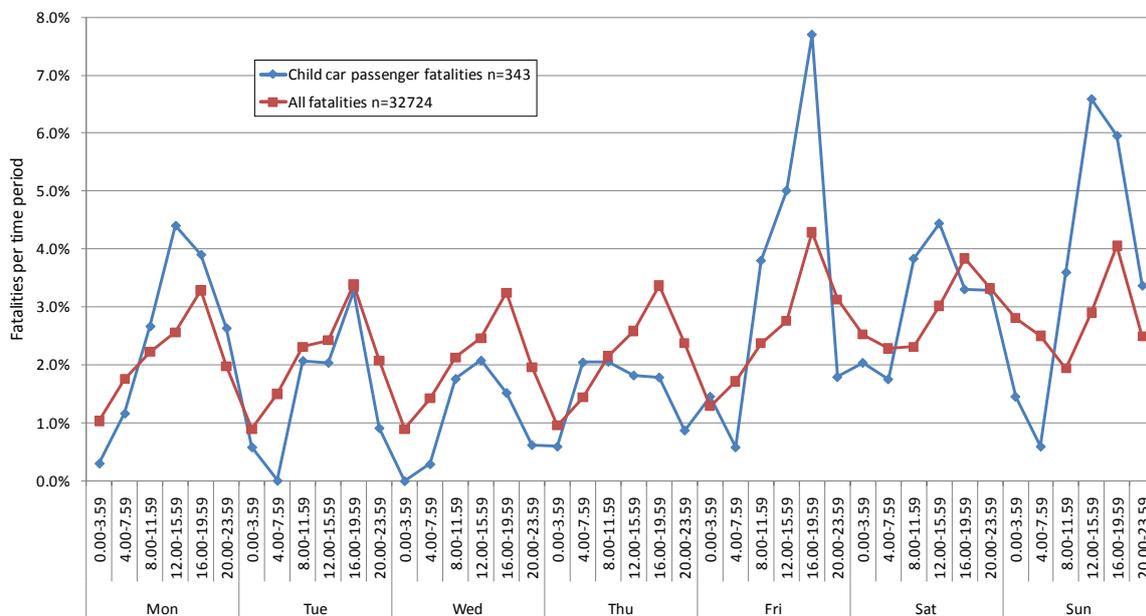


Figure 6: Distribution of day of week and time of day combined for child car passenger fatalities – 2008 EU-23

With this level of disaggregation individual counts are low but the figure does reflect the general trends seen when the time of day and day of week data are split. There is a dip in

child car passenger fatalities during ‘mid-week’ (only 25% occur on Tuesday, Wednesday and Thursday), which is not seen in the data for all fatalities. Particular peaks are evident for late afternoon/early evening on Friday and midday/early afternoon on Sunday for child car passenger fatalities. For hour of the accident alone, a rise during the late morning occurs with a peak at 3 pm and then a steady decrease towards the evening.

Location The majority, 64%, of child car passenger fatalities occur away from junctions, outside urban areas (no motorway). Motorway crashes account for 11% of child car passenger fatalities.

French fatality study results

CASIMIR The study sample is composed of 206 children that have been killed in 196 passenger vehicles. The distribution of collision type is as following. The majority of the time (56%) it is composed of another vehicle: cars (31%), HGV (17%) and light utility vehicles (9%). Trees and poles grouped together (13%) represent the second category, while the ground (13%) is only considered in case of roll-over. The other types of impact remain at a low level and are mainly composed of ditches and embankments, water points and impacts with atypical vehicles such as trains and motorbikes.

Considering the typology of accident location, 50% of the accidents occurred on secondary roads, 26% on high traffic roads and 18% on highways. Remaining cases were observed on very small roads. It is interesting to note that only 9% of the fatal child accidents occurred in built-up areas, compared with the 18% observed for all fatalities in France. The rate of accidents at crossroads is 37% in built-up areas, while it is only 7% in non built-up areas.

The distribution of child car fatalities according to age is shown in Figure 7 and relative peaks are observed in the distribution. The under 1 year old peak can be attributed to a switch from rearward facing to forward facing restraint systems too early in France. This is confirmed by field surveys on restraint use that are regularly run and that show a rate of children not properly transported in that range of age.

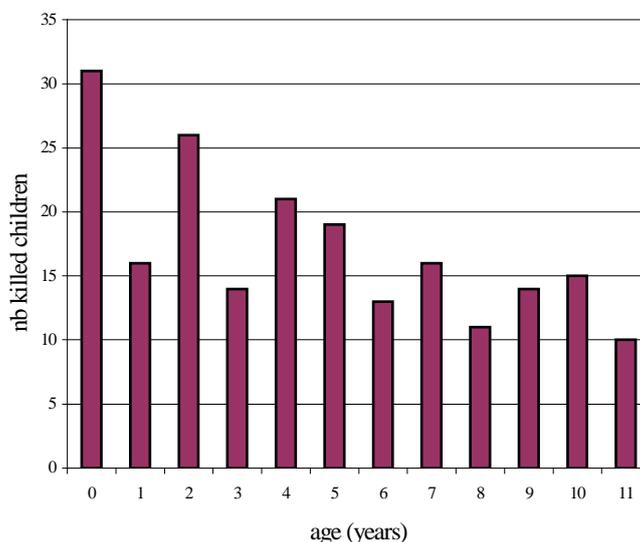


Figure 7: CASIMIR study, fatal child car occupants by age (n=206 period Oct 2001 - Sept 2003)

Regarding accident configuration, the distribution of impact type is shown in Table 1.

Impact type	Frontal	Side	Roll over	Rear	Multiple	Others
Child fatalities	70 (34%)	58 (28%)	38 (18%)	8 (4%)	7 (3%)	25 (12%)

Table 1: Distribution of fatal child car occupants by type of impact (n=206)

The analysis of the characteristics of the crash according to the type of impact shows that:

- 34% of the children were killed in frontal impact although two thirds of them used a specific restraint,
- 28% of the fatalities occurred in lateral impact, with a restraint rate similar to the one observed in frontal impact,
- 18% of the children were killed in a roll over. The number of children ejected is high and as the majority of these children were not restrained (rate of restraint use is lower than 25%), it could be said that most of these fatalities might have been avoided with the use of a restraint system.

Child fatalities occur in a rear impact in only 4% of cases, 3% are involved in multiple collisions and 12% are involved in the category 'others' which is mainly composed of unusual situations, examples being falls into rivers, fire and rock falls. For comparison, the distribution of the impact type for all the fatalities (adult and children) is as follows: 45% frontal impact, 33% side impact, 13% roll over, 2% rear and 7% 'others'.

The estimation of the quality of use of CRS is often difficult when it's only based on the analysis of police reports. Nevertheless, it has been possible to determine that of the 206 fatal child car occupants, 99 were using an appropriate CRS, among which 66 have shown no evidence of misuse. This makes a maximum rate of 32% of children correctly restrained, knowing that this figure is over-estimated. The distribution is shown in Figure 8. 'Inappropriate' considers CRS selection only while misuse addresses incorrect use of a CRS.

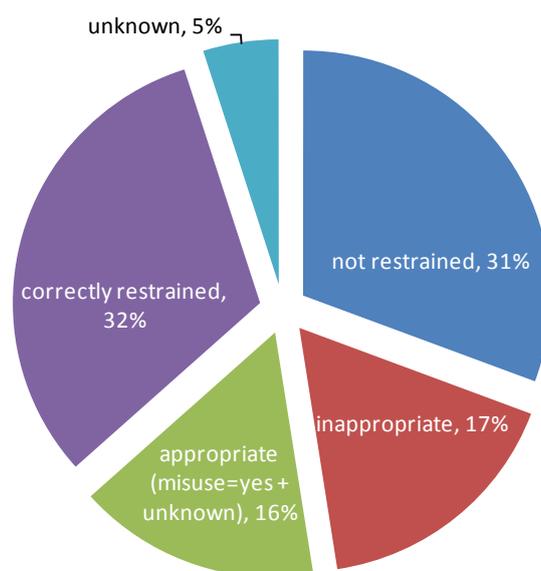


Figure 8: CASIMIR study, fatal child car occupants by restraint use (n=206)

Three major types of impacts have shown significant numbers of children killed in France: frontal, side and roll-over.

Frontal impact: Analysis of the characteristics of the crashes according to the type of impacts shows that 34% of the children were killed in frontal impact although two thirds of them used a specific restraint. To quantify the crash severity in frontal impact experts in the research team decided to use the EES (Equivalent Energy Speed) which is a translation of the energy absorbed by the car during the crash. An estimated method is used based on comparing structural deformations of the case car to deformations sustained during crash-tests. For 25% of the children killed in a frontal impact as a car occupant, the crash severity was far above the design criteria of cars and CRS ($EES \geq 75$ kph) and following that somehow not survivable and considered as the main reason of death. But the main reason of fatality for children in frontal impacts is that they are not correctly restrained: 32% are unrestrained

and 23% use an inappropriate and/or a misused restraint system. By experience it's known that the estimation of misuse rate in analysing police reports gives lower figures than the real ones. Even knowing this, the estimated total number of killed children that are not correctly restrained in frontal impact is 55%.

Side impact: The rate of effective restraint is close to the one of frontal impact at 66% but the rate of children killed by ejection reaches 18%, compared to only 3% in frontal impacts. In contrast to frontal impacts, misuse or inappropriate CRS was in most cases not the reason for the fatality and improvement of CRS dynamic behaviour would result in a larger benefit than for frontal impact. An important factor in side impact is the presence or not of intrusion. For that reason, children killed in side impacts were put into 2 categories: those with intrusion observed at their initial seating position (n=42) and those with no intrusion, even if seated on the struck side (n=16). When the value of intrusion at a given seating position was higher than 450mm, the accident severity was considered as difficult to survive from the experience of the research team. For children in the area of intrusion, 8 of 42 were not restrained. For the 34 restrained children, the intrusion value was over the defined limit in 21 instances, 6 sustained an impact with a rigid part of the car interior and 3 were ejected because of an incorrect use of their restraint systems. For the 16 children with no intrusion, the main fatality reasons were impacts in the vehicle and non use or misuse of restraint systems.

Roll-over and tip-over: The rate of restraint use in this category is particularly low compared to the other crash configurations at only 24%. For 68% ejection was the reason of fatality, which then increases by an additional 10% with those with death attributed to the lack of correct use of an appropriate restraint system. This makes nearly four fifths in roll over or tip over dying due of the lack of correct restraint system use. The priority to protect children in this kind of impact is to prevent them being ejected by the correct use of an appropriate restraint system.

CASPER additional data In order to be able to have a better view on restraint conditions of children killed and on the main reasons of death, a second phase of the French police files project has been initiated in Work Package 3 (Diagnosis of child safety issues) of the CASPER project. It consists of a similar approach for all fatal accidents that occurred between 2005 and 2010. The number of child fatalities in this period was 324. As both in-depth accident investigations and coding of the data are time consuming, it has not been possible to consider all the accidents with such detailed information, but 57 of the fatal cases have been retrospectively investigated in-depth with a close look to the restraint systems of all occupants and an analysis of the structural deformation of the vehicles. A selection has been done according to the first available data issued from the police, giving priority to restrained children in frontal and side impacts. Of course the criteria that the car has not been destroyed since the accident also limits the number of cases that can be investigated. Data are available for 264 occupants: 158 adults, 14 uninjured children, 11 sustaining slight injuries, 21 being severely injured and 60 fatal children. Some medical data are available for fatally injured children, but that analysis is not yet available at the present time.

The distribution of the 60 fatalities by impact type is as following: 28 are killed in a frontal impact, 24 in a lateral impact, 6 in a rear impact and 2 during roll-overs. Of the 28 vehicles involved in frontal impacts, 21 of them are registered after the year 2000, so are relatively recent vehicles in terms of frontal crash protection design concepts. Ten children were using only the seatbelt, additional restraint systems have been collected or analyzed by experts in 28 cases (in addition to vehicle seatbelts) and 6 of them were only seen in pictures taken by the police on the scene or in the police station, but then not available anymore for analysis. This sample has been coded and analyzed for the CASPER project, the results are reported for frontal and side impacts only, as a first update of the previous CASIMIR section.

Frontal impacts: All the 28 child fatalities involved in a frontal impact are restrained and 26 of them are using appropriate restraint systems regarding the French law. Concerning the

type of opposite object or vehicle, 21 children were killed in a car to car collision, 5 in an accident against a pole or a tree, and 2 against heavy vehicles such as a train or tractor. Concerning the EES, it is estimated $\geq 65\text{kph}$ in 17 cases (including 11 $\geq 75\text{kph}$) and in 11 cases it is estimated under 65kph. In these 11 cases, misuse situations have been observed in 6 cases and it is unknown for 2 cases. On the 3 remaining cases, no evidence of misuse has been observed.

Side impacts: Of the 24 children killed in lateral impact, only two were not restrained and 19 were using appropriate restraint systems. Considering intrusion, 14 children were seated in an area where intrusion occurred, all using an appropriate restraint system. For these 14 children, the excessive intrusion or a direct contact with the intruding object was in 9 cases the cause of the death. For the remaining 5, 2 misuse situations have been observed and twice the CRS sustained a failure of its integrity. Ten children were in a seating position for which no structural deformation has been noted with 2 unrestrained and the other 8 using an appropriate restraint system. Misuse situations have been noticed by the accident investigator for 4 children, only 1 having a minor influence on the death of the child.

Discussion

Regarding world-wide figures, by literature review and screening of publicly accessible databases, a scope of the overall problem of children fatalities can be gained, but selecting car passengers is more difficult. Using the WHO figures, the European data can be compared with the world-wide figures to show, firstly, that other causes of death are more prominent world-wide (reflecting a high level of infant (baby) mortality in some large areas of the world) and secondly that, due to a different age distribution, higher shares of road traffic accident fatalities are children. Following economic development world-wide the figures might change and raise road traffic accidents also to the third most frequent cause of death, as seen for high-income countries (Lopez et al, 2006).

The same general pattern is seen in the EU-23 fatality rate per 100,000 inhabitants to the US figures, although the US data also includes occupants of other vehicles. There is a high start for the youngest children, then a reduction in the middle part of the age group, then the start of an increase towards the higher ages.

Even with the information available it is difficult to accurately describe the size of the problem in numbers and rates. Rather than using the more readily available 'population as number of inhabitants' it would give a better focus to use distance travelled by car as a measure of exposure data, as shown by Christie et al (2007). Some countries do have data but harmonised measures across the EU, by mode of travel and age of child would be more suitable data to use. Even so, in the EU-23 countries, using fatality rates by population (for countries with non-zero fatalities) there is a large range from 0.14 to 1.35 per 100,000 (the average is 0.55). Although there are environmental, geographic and cultural differences between member states, countries with high rates should take the opportunity to observe activities regarding child safety in the better performing countries.

In the studies found the restraint situation in fatal accidents was often poor and other risk factors for child fatalities as car passengers comprise seating position (front compared to rear) and rollover crashes. Fatal injuries seem to be most often head injuries for the children up to one year old, and multiple trauma to older children.

Work in the CASPER project deals with and understands child injuries by small age groups and, whilst the work is also applicable to other vehicles and modes of transport, there is a focus on car passengers. It is therefore interesting to disaggregate the EU data to see what the 'fatality target' for the CASPER project is – appreciating that the fatality numbers will include a variety of crash and restraint conditions that cannot be fully examined at the macro level. It is also an opportunity for those working in the field of child restraints to see improvements regarding child fatalities away from figures that also include pedestrians. Over

a 10 year period the reduction in child car passenger fatalities is estimated to be 50% for the EU-19 countries, higher than the improvement of 32% for all fatalities. By presenting results by age, gender, time and location (in this short paper the possibilities are only touched upon) it is possible to examine particular fatality groups to evaluate what interventions could improve the situation, be it in terms of targeting why the figures are poor for certain ages or looking at when child restraint law enforcement could be best deployed (for instance summer months). Consideration of any interventions would benefit from detailed exposure data.

For 20 countries of the EU-23 countries (not EE, FI and IT) there are separate figures for fatal, serious and slight casualties, with 3,257 seriously injured child car passengers recorded in 2008 (although it is recognised that the harmonisation of non-fatal injury definitions is a challenge across all countries). This particular activity has concentrated on fatalities, but the work undertaken in the CASPER project can of course influence not just the recordable fatalities but also many of the severe serious injuries that children in cars sustain. In addition, less severe serious and slight injuries will also benefit from an improvement in the quality of restraint - in terms of dynamic performance, appropriate restraint use and avoiding misuse.

Four countries of EU-27 are missing from this analysis, Bulgaria, Cyprus, Lithuania and Malta (Bulgaria having the largest population at 7.5 million). The EC CARE database is on-going and it would be beneficial to update these results as data from these countries become available (and validated) and new annual data is added.

In the overall fatality figures there will naturally be a mixture of circumstances and events that lead to fatalities occurring. Examples will include;

- No CRS or seat belt has been used,
- The restraint used is inappropriate for the child or has been misused in some way (either in fitting or by the child),
- Crash severity is so high or crash circumstances are such (for example, direct intrusion, airbag or luggage loading, contacts inside vehicle or structural failure) that the crash has been unsurvivable for the child.

Also, unfortunately some children will have underlying medical conditions that may predispose them to injury (for example, brittle bone disease - osteogenesis imperfecta) or create problems in the treatment phase (for example, haemophilia). The level of detail is not available in the macro data to disaggregate the fatality figures into these groups, or direction of impact, but this work is an initial step in reporting the overall figures.

In the French study using police fatal files (CASIMIR methodology) a limitation is that the analysis is sometimes limited by the lack of homogeneity in the quality of police reports (for example, lack of photos or data related to children). It is therefore difficult in some cases to precisely determine restraint condition and quality of use, although when possible retrospective in-depth investigation of the car and restraints can improve this. Also, very few results from autopsy are available, as it is not usual in France for child car fatalities, so no work on injury mechanisms was possible in this paper. The study is representative of the French situation but generalisation of results to other countries should be done with some caution. But this type of study does offer insight into the role of restraint use and crash severity in fatal impacts and can also be used to give an estimation of the distribution of the points above regarding fatality cause, where data aren't available in the CARE database.

For frontal impact fatalities in France, the priority is to improve the quality of use of restraint systems. This can be done with a number of approaches including simplifying the criteria to choose the appropriate CRS, designing CRS in order that they become easy to use and improving parental/carer education. When the child is correctly restrained, very few fatal cases are observed in conditions of severity that are lower or equal to the frontal test of the current regulation that is performed at 50 kph.

In side impact, the current level of protection does not seem sufficient, the level of intrusion and the direct impacts with intruding objects are important for children on the struck side. Correctly restrained children are present in the sample of side impact fatal cases with and without intrusion at their seating position.

For roll-overs the priority is to protect children from being ejected from the car and from projection inside of the car. The rate of correctly restrained children in this type of fatal accident is very low in France, which indicates that existing using systems when correctly used could be preventing these fatalities. Rear impact remains rare in the French fatality study.

Acknowledgements

The CASPER Project (Grant Agreement 218564) is funded by the European Commission under the EC 7th Framework Programme.



Data from the EC CARE (Community database on Accidents on the Roads in Europe) dataset are used in this report for fatality figures in Europe.

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