SPANISH CRS USE AND EFFECTIVENESS SURVEY RESULTS

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ABSTRACT

The main findings of a recent survey conducted in Spain (totaling 1011 questionnaires) analyzing within the crash environment in rural areas the use and effectiveness of Child Restraint Systems (CRS) are described in this paper. A total of 15 items of information were included in the questionnaire covering information about the crash, vehicle and road type, Principal Direction Of Force (PDOF), seating position, injury outcome (severity and injured body region), injury source and airbag interaction, other occupants' morbidity and CRS use. The survey showed that almost one out of four crashes was a rollover and that head-on collision are still the most frequent crash mode (44 percent). Overall CRS use rate in the sample was very low, around 37%, meaning that non-use of child restraints is still a major issue for concern in Spain. Only 21% of the children where uninjured while 59% suffered from minor injuries. The survey includes seven cases with airbag interaction, whose particularities are discussed with some detail, though neither major concerns nor new findings are raised with this regard.

INTRODUCTION

Child Restraint Systems (CRS) are by far more effective than adult seat belts in preventing car occupant injuries: while optimally used rear-facing CRS can prevent up to a 96% of all serious and critical injuries [1], adult seat belt effectiveness in preventing fatalities only reaches a still very significant 60 percent [2, 3]. Unfortunately, non-use of CRS continues to be a major issue in many territories around the world and while in countries such as the United States less than 5 percent of the children still travel unrestrained [4], in other areas of the globe either the non-use represents a much higher share or no reliable information is actually available on CRS use rates. Even when children are buckled, high observed misuse rates diminishes the real-life CRS effectiveness: the US National SAFEKIDS Campaign observed in the USA and in 1997-98 a worrying 85 percent of car seat misuse, with an average of two errors per seat [5]. The new ISOFIX and LATCH attachment systems are expected to make CRS easier to install and consequently more difficult to misuse [6, 7]. In addition to non-use and misuse, a third front in the battle against child injury is represented by the attempts to improve CRS performance in crash modes absent from the existing regulations and a great deal of effort is currently being directed into CRS side impact performance [8].

Both to design public awareness and caregiver education campaigns in order to promote proper CRS use and to improve CRS protection, it is essential to continuously monitor the ways CRS are being used on the roads and how they are performing in crashes. This analysis of rear-world data to identify injury patterns and sources, and also the evaluation of other risk parameters, can be achieved by different means: by statistical analysis of national crash reporting systems generated from police reports such as NASS in the USA [9]; by in-depth crash investigation programs such as CREST in Europe, NHTSA's Special Crash Investigations program or PCPS in the USA [10, 11]; or by an intermediate approach based on the collection of additional or specific items of information during normal police reporting activities. This last intermediate approach has been used for the research presented in this paper.

To date, very little information on CRS use and effectiveness within the crash environment was available in Spain and this circumstance helped consolidate the initiative of collecting CRS information via an ad-hoc questionnaire designed by the Traffic Safety Department of the Royal Automobile Club of Spain in close cooperation with the Spanish General Directorate for Traffic (Home Affairs Ministry) and the Agrupación de Tráfico de la Guardia Civil (main traffic Spanish policy agency operating outside built-up areas). The results of this survey are expected to be utilized in Spain in the immediate future for the design of child passenger safety promotion activities.

METHOD

A *CRS Use and Effectiveness Questionnaire* containing a total of 15 items of information was designed to collect relevant child passenger information (the complete form is included here as Appendix 1). An equilibrium between the design of

the already in-use in Spain statistical traffic crash reports [12] and the ISO standard evaluation form [13] was sought for the Spanish CRS anonymous form. Possible answers to the various fields were chosen on the basis of crash investigator familiarity and for that reason in some instances standardized available coding systems such as the CDC system for vehicle damage or the ISS for passenger injuries were not used in the form. Comments to the preliminary version were kindly provided by experts at the John Hopkins University in the USA and at the GDV in Germany and incorporated into the final version. This definitive version of the form was also checked for in-the-field usability by the collaborating police agency.

The form included questions regarding:

- The crash itself: crash type and road type. Both answers are already being code in the general crash reporting form and were repeated here.
- The vehicle: type of vehicle, extent of damage, and principal direction of force.
- The CRS: type of CRS, CRS attachment method and final situation (inside/outside the vehicle).
- The child occupant: age, injury outcome (no-injury, minor injury, serious injury, fatal injury and unknown), injured body region, source of injury, airbag interaction and seating position.
- Other occupants: number and injury outcome of other (adult) occupants.

A 15-page explanatory guide was prepared keeping as closely as possible the format of the already-in-use explanatory guide associated to the Spanish statistical traffic crash questionnaire. Approximately 400 copies of the guide were distributed among the 124 units of the Guardia Civil de Tráfico, the police agency in charge of traffic crash data collection outside built-up areas in the entire Spanish territory excluding the Basque Country and Catalonia (two Autonomous Communities with fully transferred competences in traffic safety and policing).

Criteria for inclusion in the survey were: all children 11 years of age an under, passengers of a light four-wheeled vehicle (up to 3500 kg) involved in a crash outside built-up areas where a statistical police report was filled out regardless of the child injury outcome. Should more than one child be involved in the same crash, a separate form was completed for every child passenger. Due to an ambiguity in the explanatory guide, nine questionnaires with 12-year-old children were completed and they have been maintained in the following analysis whenever possible.

A total of 1011 questionnaires (corresponding to children traveling in a total of 721 different vehicles) were filled out by the Guardia Civil during a six-month period (March 2002 to September 2002). This period of time covered school-time months as well as the long Spanish Summer vacation break (from end of June until mid September). The crash investigation units sent the completed forms to the provincial offices were a unique crash number was assigned. This crash number will allow in the future linking the CRS form to the standard crash reporting form. The provincial offices sent every month the collected forms to the Traffic General Directorate in Madrid, which assembled the final monthly package that was sent to the Royal Automobile Club of Spain for response coding and processing. This task and the preparation of the initial contingency tables (including logical checks to check data quality) were performed by a subcontracted company: Sigma Dos. No personal data (names, addresses…) were coded in the database to ensure confidentiality.

RESULTS

Average child occupancy per vehicle was 1.4: there was only one child in 68.4% of the vehicles, two children in 25.2% of vehicles, three in 4.4%, four in 1.8% and six in 0.1% (one mixed cargo/passengers van). Most of the crashes in the sample were frontal collisions, as shown next.

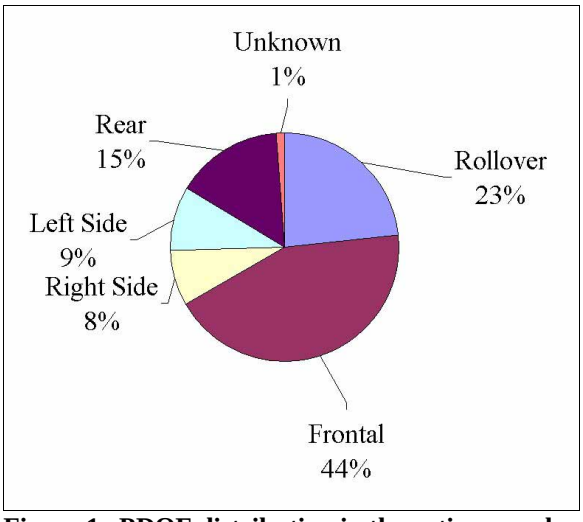

Figure 1. PDOF distribution in the entire sample.

For this analysis, 11, 12 and 1 o'clock positions are considered frontal impacts; 2, 3 and 4, right side impacts; 5, 6 and 7 rear-end crashes; and 8, 9 and 10 left side collisions. PDOF together with injury severity is shown in Table A1 in Appendix 2. The following picture shows the "vehicle extent of

damage" distribution in the vehicle sample included in this research, while Table A2 in Appendix 2 shows injury severity in connection with extent of damage:

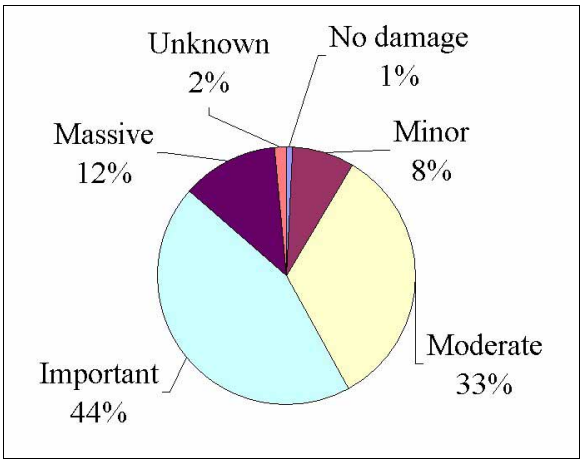

Figure 2. Vehicle extent of damage distribution.

By cross-comparing vehicle type and injury severity, conclusions on the safer types of vehicles can be explored. As can be seen in the following figure and also in Table A3 in Appendix 2, the safer vehicles for children seem to be the medium and large passenger vehicles. SUVs and cargo/passenger vans appear to be more dangerous: eleven percent of the children in the sample travel in these two types of vehicles, but they suffer 24% of all fatal injures. Note: the definition of a "serious injury" in Spain requires a hospital stay of more than 24 hours [12].

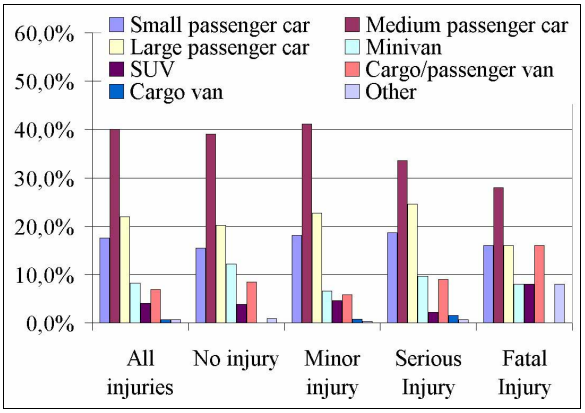

Figure 3. Injury severity and type of vehicle.

Together with hypothetical changes in CRS use rates for these types of vehicles; the fact that they have a higher rollover propensity could partially explain this increased risk. Table 1 next compares the types of vehicles where child fatalities occurred in Spain and in the USA (according to 1999 NASS data, 0 to 10 year old child casualties).

Table 1.
Body types in Spain (2002) and the USA (1999)

Vehicle type	Spain	USA
Passenger cars	60.0%	62.2%
Minivan	8.0%	11.7%
SUV/Pickup	8.0%	23.2%
Cargo/passenger van	16.0%	0.0%
Cargo van	0.0%	2.2%
Other/Unknown	8.0%	0.7%

The road network covered by this survey included the entire spectrum of rural types: high-speed divided highways (up to a generic speed limit of 120 km/h), single carriageway road (maximum speed limit of 100 km/h) and other types (normally narrower and with speed limits of 90 km/h and lower). Even though divided high-speed roads represent in Spain only a 6% of the total road network length (totaling 163,577 km), 43.3 percent of the crashes involving children occur on those roads. Another 52.9 % of crashes happen in conventional non-divided roads. The remaining 3.9 percent of the crashes happen on other types of roads. The influence of speed on the injury severity is clearly shown by the overrepresentation of seriously injured children (49,6%) and fatally injured children (68.0%) on the fastest roads. Table A4 in Appendix 2 shows this link road type-injury severity.

The child passenger age distribution in the sample offers a relatively homogenous pattern as shown next.

Table 2.
Age distribution in the sample

Age in years (n=1011)	Percentage
Under 1 year of age	10.2 %
1	7.0 %
2	10.4 %
3	7.6 %
4	7.8 %
5	9.2 %
6	7.8 %
7	7.5 %
8	8.9 %
9	7.9 %
10	7.4 %
11	7.0 %
12	0.9 %
Unknown	0.3 %

As far as the child passenger seating position is concerned, the following figure shows the predominance of the second row right seating

position, while Figure 5 disaggregates this chart by age groups:

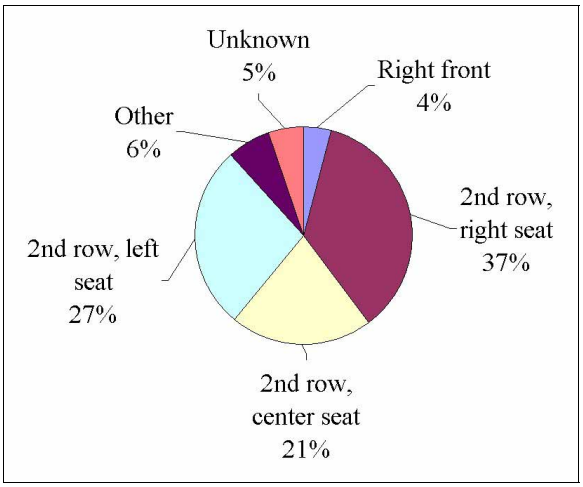

Figure 4. Seating position in the entire sample.

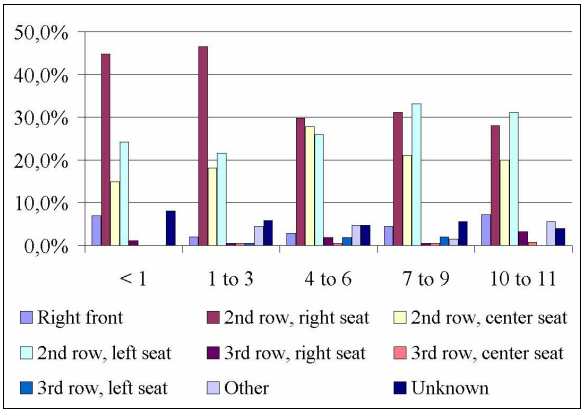

Figure 5. Seating position by age group.

It is still worrying that 6.9% of the children under one year of age are traveling in the right front position and this can represent a serious hazard should the vehicle be equipped with an active frontal. The analysis of the injury severity as a function of seating position (Table A5, Appendix 2) shows that:

a) The most dangerous position is the front right seat, supporting the need to restrain children in the rear seats: 4.1 % of children in the sample is seating in the right front passenger position, while 9.5 percent of the fatalities occur here.
b) The third row and other seating positions (cargo area in small vans, for instance) are also more dangerous than average: 6,4 percent of the children in the sample seat here, while 14.3 percent of the fatalities occur in the category denominated "Other seating positions".
c) The second row center position is the safest position in the vehicle: 21.2% of all children travel in this seating position and only a 14.3 percent of fatally injured children travel here.

CRS Use and Misuse

While in some countries CRS use rates reaches values as high as 95 percent, this is not the situation in Spain. Non-use of CRS represents currently the main issue to tackle, as the following table shows.

Table 3.
Restraint type distribution in the sample

Restraint Type (n=1011)	%
Baby cradle (carry cot)	1.6%
Group 0/0+ rear facing	2.2%
Group 0/0+ forward facing (misuse)	6.1%
ECE 44R Group I	11.3%
Booster with back rest (Group II)	2.1%
Booster without back rest (Group III)	3.2%
Integrated seat	1.2%
Two-point adult seat belt	2.7%
Three-point adult seat belt	6.3%
Child not strapped to CRS	0.5%
Sitting in someone's lap	3.9%
No restraint	56.3%
Unknown	2.8%

The CRS groups in this table correspond to those defined in ECE Regulation 44, version 03 [14]. The relatively high percentage of baby cradles (carry cots as denominated in ECE 44) in the sample, compared to the real-life scarce use of this CRS type, could indicate that some "rear facing infant seats" would have been improperly coded as "baby cradles". Use rates by age group are shown in Table A6 in Appendix 2. The following table shows the methods utilized to attach the CRS to the vehicle before the crash. The almost non-existing presence of the ISOFIX system is clearly highlighted in this table.

Table 4.
CRS attachment method distribution

Attachment method (n=295)	Percentage
Two-point adult seat belt	27.1%
Three-point adult seat belt	47.8%
Retrofitted/aftermarket seat belt	2.7%
ISOFIX	1.0%
CRS not attached to the vehicle	6.4%
Unknown	15.0%

As the previously table shows, there still appears to be a relatively high percentage of CRS not properly attached to the vehicle. The possibility of this

circumstance resulting in ejection of the CRS outside the vehicle was explored by including in the CRS form a dedicated field called “CRS Position after the Crash”. Only 0.7 percent of the CRS was found to be outside the vehicle after the crash; while a more significant 12.5% was found not attached to the vehicle after the crash. CRS manipulation after the crash (for instance during the rescue of passengers) could not be totally eliminated in these cases.

In all the cases where the CRS was found outside the vehicle after the crash , the reported CRS attachment method before the crash was the three-point adult seat belt. In the cases where the CRS was found inside the vehicle but not attached to the vehicle seat after the crash, the reported CRS attachment method before the crash was the two-point adult seat belt in 32.4% of the cases, the three-point adult seat belt in 29.7% of the cases, the 10.8 percent was unknown, and in 27 percent of the cases the CRS was believed not to be attached to the vehicle before the crash occurred.

For subsequent analyses of CRS use, the following three categories were defined:

1. CRS Non-use: including here children sitting on another passenger’s lap together with unrestrained children.

2. Appropriate CRS use: including baby cradles (carry cots) and rear-facing group 0/0+ for children under one year of age, group I or integrated seat for children 1 to 3 years, group II for children 4-6 years and group III for children 7 to 9 years of age.

3. Inappropriate CRS use: any other combination of CRS type and age group (i.e. babies in a group 0/0+ forward facing).

Children of ages between 10 and 11 were not considered in this categorization since both adult seat belts and booster seats could represent “appropriate” use depending on child body development.

The decrease in CRS use rates as the age increases is clearly shown in the next figure and in Table A7 in the appendix. This decrease is very similar to that found in the CREST database [15].

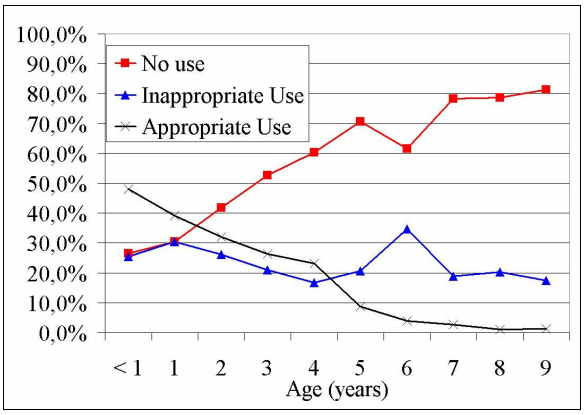

Figure 6. Age and CRS use.

The following figure shows the restraint use as a function of road type (and indirectly speed limit):

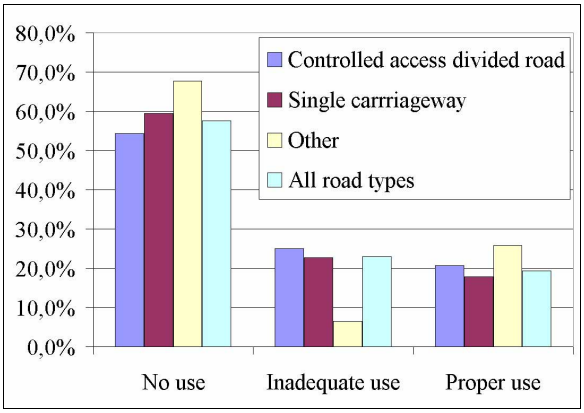

Figure 7. Road type and CRS use.

The previous figure above shows that as the quality of the road and the speed limit decreases the non-use of CRS increases. Numeric values are shown in Table A8 in Appendix 2. The same type of analysis is shown next with connection to vehicle type (and again in corresponding Table A9 in Appendix 2):

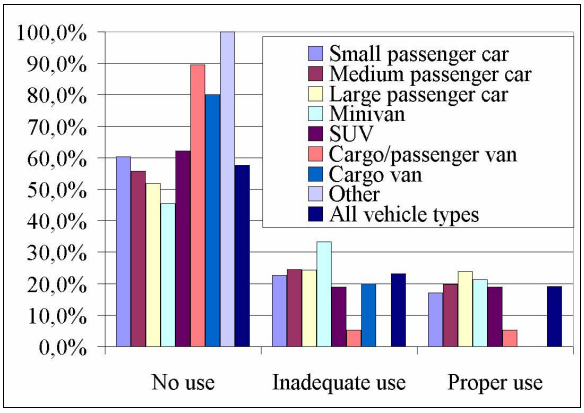

Figure 8. Vehicle type and CRS use.

Injury Outcome

It is worth pinpointing that most of the fatalities in the Spanish sample occurred in rollover crashes (see Figure 9 below). A contributing factor to this can be the low CRS use rate presented above. As a matter of fact, a very small percentage of the fatalities happen in frontal crashes, which is the only crash mode represented in the current European CRS regulation. This low significance of frontal crashes can be partially explained by the high protection levels offered by modern seats in frontal collisions.

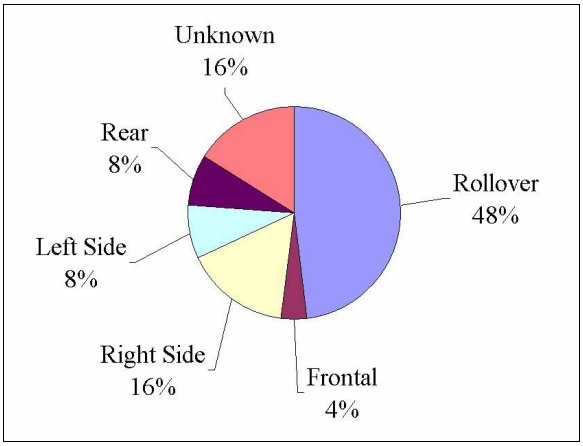

Figure 9. Fatality cases PDOF distribution.

The most frequently injured body region was the head/neck area, in 44.5% of the cases with any injury severity and in 72% of the fatality cases. Extremities (both upper and lower X.) are the second most frequently injured area, closely followed by the thorax. Due to the limitations of the data collection method (without the intervention of either emergency medical services or trauma centers), this item turned to be the field with highest proportion of "unknown" answers. The following table shows the injured body region distribution (because multiple answers were admitted in this field, percentages may add over 100):

Table 5.
Injured body region distribution

	All injuries (n=884)	Minor injuries (n=624)	Serious injuries (n=169)	Fatal injuries (n=43)
Head/neck	44.5%	42.3%	50.7%	72.0%
Thorax	9.3%	7.4%	11.9%	40.0%
Abdomen	5.6%	4.9%	10.4%	8.0%
Upper X.	13.4%	13.3%	15.7%	16.0%
Lower X.	10.7%	8.9%	18.7%	24.0%
Unknown	27.4%	28.3%	18.6%	12.0%
TOTAL	110.9%	105.1%	126.0%	172.0%

The total percentages in the previous table show that as the injury outcome severity increases, so does the number of injured body areas. Table A10 in the appendices section shows the distribution of injured body regions as a function of the age groups.

The next table shows the injury source as a function of the injury severity (multiple answer admitted). The share of "unknown" answers to this question is also significant (20,1 percent) and this can be attributed to the fact that this item of information is not routinely collected in the general crash report.

Table 6.
Injury source and injury severity

	All injuries (n=764)	Minor injuries (n=565)	Serious injuries (n=141)	Fatal injuries (n=24)
Ejection	5.5%	2.0%	15.3%	36.4%
Airbag interaction	0.4%	0.4%	0.8%	0.0%
Contact with occupants	4.0%	3.6%	6.9%	0.0%
CRS Interaction	8.8%	11.0%	2.1%	0.0%
Windshield dashboard	3.1%	3.2%	3.8%	0.0%
Back of front seat	30.5%	33.3%	23.7%	9.1%
Vehicle interi. side/roof	25.1%	22.5%	32.1%	40.9%
Flying glass	2.8%	3.8%	0.0%	0.0%
Objects inside the vehicle	0.9%	1.1%	0.0%	0.0%
Other	1.8%	1.4%	1.5%	13.6%
Unknown	20.1%	19.4%	21.4%	9.1%
TOTAL	103.0%	101.7%	107.6%	109.1%

Table A11 in the appendices section shows the distribution of injury sources by age groups. Tables A12 and A13 include the distribution of injury severity by vehicle damage extent, while Tables A14 and A15 also in Appendix 2 show the injured body regions and the injury source disaggregated by CRS use (in the cases where this parameter could be identified).

The following table shows the injury severity distribution as a function of CRS use:

Table 7.
CRS use and injury severity

	No use (n=486)	Inappropriate use (n=196)	Appropriate use (n=162)
No injury (n=192)	14.4%	30.6%	38.3%
Minor injury (n=482)	60.3%	53.1%	52.5%
Serious injury (n=111)	16.9%	9.2%	6.8%
Fatal injury (n=21)	3.1%	2.6%	0.6%
Unknown (n=38)	5.3%	4.6%	1.9%

For properly restrained children, the following table shows the injury outcome by age group:

Table 8.
Injury severity and age group
(only appropriately restrained children)

	< 1 (n=49)	1-3 (n=80)	4-6 (n=29)	7-9 (n=4)
No injury	32.7%	46.3%	27.6%	25.0%
Minor injury	55.1%	46.3%	62.1%	75.0%
Serious injury	10.2%	5.0%	6.9%	0.0%
Fatality	0.0%	0.0%	3.4%	0.0%
Unknown	2.0%	2.5%	0.0%	0.0%
Total	100.0%	100.5%	100.0%	100.0%

And also for properly restrained children, the following table shows the injury outcome by PDOF:

Table 9.
Injury severity and PDOF
(only properly restrained children)

	Rollover (n=31)	Frontal (n=77)	Lateral (n=28)	Rear (n=25)
No injury	19.4%	41.6%	39.3%	48.0%
Minor injury	71.0%	51.9%	39.3%	48.0%
Serious injury	9.7%	2.6%	17.9%	4.0%
Fatal Injury	0.0%	0.0%	3.6%	0.0%
Unknown	0.0%	3.9%	0.0%	0.0%
Total	100%	100%	100%	100%

The number of properly restrained children with known injured body area is very limited once disaggregated by CRS type. Only for forward facing Group I safety seats the number of cases may enable this analysis, as shown in Table A16 in the appendix.

Airbag Interaction

The *CRS Use and Effectiveness Form* included two items aimed at collecting information regarding eventual child-airbag interaction. In the first place, the question titled "injury source" included the answer "airbag interaction" and, in the second place, the next question queried specifically about the type of airbag that had interacted with the child occupant.

A total of 12 questionnaires initially indicated some kind of airbag interaction, representing a 1.2% of the cases. But when these questionnaires were examined with closer attention, actual interaction between the child occupant and the airbag could only be confirmed in 7 cases. In the rest of the cases the so-reported "airbag interaction" turned to actually be reporting just an "airbag deployment" inside the vehicle (for instance, this conclusion was assumed when a child traveling in a CRS in the center rear seat resulted uninjured even though interaction with front passenger's frontal airbag). Next follows details of the seven cases with possible airbag interaction:

1. A 2 year old child seating on the front passenger's seat using no restraint sustained serious injuries in the head/neck region caused by the interaction with this position's frontal airbag and the dashboard/windshield area.
2. One 11 year old child seating in the right front passenger position and using the three point seat belt suffered minor injuries allegedly caused by the front passenger's frontal airbag and the adult safety belt.
3. One 8 year old child seating in the right front passenger position using the three point seat belt suffered minor injuries allegedly caused by the vehicle interior (interior side/roof) and by the deployment of a front passenger's frontal airbag during a head-on collision.
4. One 6 year old child traveling in the left rear position on a booster seat (ECE 44 group III) interacting with a rear side airbag and suffering minor injuries in lower extremities.
5. One baby (under 1 year of age) in a forward facing group 0/0+ (misused) seat installed in the right front seat, interacting with this position's frontal airbag and suffering minor injuries.
6. Another baby in a rear facing group 0/0+ installed in the right front passenger position, interacting with the frontal airbag in this position and the dashboard/windshield and suffering minor injuries in a head-on collision.
7. One 12 year old child traveling in the center rear position interacting with a rear side airbag (injury severity unknown, CRS use unknown).

DISCUSSION

The survey discussed in this paper has collected useful information and has shed light on the CRS use and effectiveness situation in Spain during 2002 in the rural environment. Answering rates for the majority of the fields included in the survey were satisfactory (under 5% of "unknown" answer for two thirds of the fields), but for a number of items additional sources of information might be necessary:

a) Interviews with passengers and rescue personnel to collect details on CRS attachment method and its position after the crash. Confidence on the answers to these fields suffered from a 15% "unknown" answer rate.
b) Access to emergency medical services and trauma center reports to complete the information regarding injury severity and injured body regions. The injured body area was "unknown" in one out of four cases.
c) In-depth investigations to increase the answering rates of the fields "injury source" (a 21% of "unknown" answers) and "airbag interaction" (one third of the questionnaires yielded an "unknown" answer to this item).

Though it can not be stated that the sample included in this study represents an unbiased picture of the entire child passenger population in Spain, it is still an issue open to discussion whether the occurrence of a crash is a random event for the child passenger or, on the contrary, it is dependent of other circumstances such as, for instance, adult belt use or attitude toward risk acceptance. In any case it is believed that the sample presented here is large enough to provide, to some degree, a credible representation of where and how child passenger casualties are occurring in Spain.

While the methodology utilized in this survey does allow for a preliminary assessment of CRS appropriateness based on the relation between type of restraint and age group, it does not enable any kind of finer CRS misuse assessment (in-depth studies are normally needed for this purpose). An additional limitation of this appropriateness assessment method arises from the fact that no child anthropometry information was collected and only age is used as a descriptor of use adequacy. The methodology did not provide specific details on CRS typology (type of harness, manufacturer…).

The extent of the CRS non-use problem in Spain can be condensed in the following remarks:

- Event the most vulnerable age group, babies under 1 year of age, is only properly restrained in less than half of the cases. For this age group, properly restrained babies are considered to be those using either a baby cradle (carry cot) or a rear-facing infant seat. The presence of forward-facing installations of group 0/0+ seats calls for a closer attention to this unnecessary hazard in future awareness campaigns.
- Most of the children over 4 years of age travel completely unrestrained.
- Extremely low use of booster seats, reaching a concerning 10.8% for the 4-6 year old group.

When defining "appropriate" CRS use, based on the link between age and ECE groups, the previous percentages substantially fall, and a worrying trend can be observed as children grow older (Figure 6). In fact almost no child age 7 to 9 is using booster seats and when they are restrained (only in about 20% of the cases), they use the adult safety belt. The general increase of injury incidence rate with age (26.2 of babies under 1 year result uninjured, but only 11.0% of children 10 and 11 year old suffer no injury) can be associated with this decrease of CRS use with age.

Most of the child fatalities in the sample occurred in the fastest routes (divided, high-quality roads), but at the same time CRS use rates maintains the same low levels observed in other (slower) roads.

PDOF data shows that even though most of the crashes are frontal crashes (44%), the higher risk is represented by rollovers, which account for 48% of all fatalities. Rollovers and no use of restraints are known to result in a highly dangerous combination, both for adult and child occupants, and since most of the children in the sample were unrestrained this could explain the prevalence of this crash mode in the fatal injury causation. Higher CRS use rates should partially reduce the percentage of rollovers in fatal crashes. This picture changes significantly when considering only appropriately restrained children, and Table 9 above clearly showed that lateral crashes resulted in the most severe injuries, in agreement with previous studies. This fact should provide additional arguments to push for the introduction without delay of a new side impact test in current CRS (European) technical standards.

The head continues to be the most commonly injured body region, and its share increased with injury severity (as seen in Table 5). Extremities appear to be the second most commonly injured body area, but other studies show that extremity injuries tend to be

less life threatening, although they often result in long-term disability. Thorax injuries were present in 9.3% of crashes, but in 40% of fatal ones.

As far as CRS effectiveness is concerned, the following conclusions can be derived from Table 7:

a) When CRS are appropriately used, and compared with unrestrained children, there are 2.6 times more chances a child suffers no injury.
b) The protective effect of CRS is less noticeable when considering minor injuries.
c) Unrestrained children suffer 2.5 times more serious injuries than appropriately restrained children, and 1.8 more than inappropriately restrained children.
d) Unrestrained children suffer over 5 times more fatal injuries than appropriately restrained children, and 1.2 times more fatal injuries than inappropriately restrained ones (since the fatality number is the sample is very limited, reliability of this conclusion can be questioned).

Table 8 attempted to offer some indication about the protection levels of different child restraint systems but it should be concluded that there are not significant differences between CRS of groups 0/0+, I and II since a similar percentage of 90% of the children in all these groups suffered either from no-injury or from a minor injury.

CONCLUSIONS

The conclusions in this section are based solely on the results presented and discussed in this paper, without making any inference beyond them:

a) This paper summarizes the main findings of the largest CRS survey conducted to date in Spain.
b) This study has been possible through a collaborative effort among the Royal Automobile Club of Spain, the General Directorate for Traffic and the Traffic Group of the National Civil Guard.
c) In Spain, as in many other geographical areas, non-use of CRS continues to be the major issue for concern, since the majority of children still travel unrestrained on the Spanish roads. It is clear that more efforts should be directed into increasing CRS use rates.
d) Early graduation to adult seat belts is also a serious problem in Spain, since almost no child between 7 and 9 years of age is using booster seats. When these children are restrained, they normally use the adult safety belt.
e) Rollovers account for almost half of the fatalities and this circumstance should suggest a review of the strategies of active and passive safety when dealing with this crash mode (stability controls, interior vehicle padding, advanced glazing, curtain airbags…).
f) For appropriately restrained children, lateral crashes are the most dangerous event, but still no lateral dynamic test is being considered in the European technical certification standard.
g) The effectiveness of CRS has been clearly shown one more time and, for instance, this study has shown that unrestrained children suffer 2.5 times more serious injuries than appropriately restrained children, and 1.8 times more than inappropriately restrained children.
h) There are still a number of important questions (such as misuse patterns or details on injury causation) that require additional research on child passenger safety, for example by means of hospital data examination or in-depth studies.

RECOMENDATIONS

The results and conclusions included in this article can be translated into some recommendations:

- Using the results of this survey, to design a vast national public awareness campaign focusing on issues such as CRS effectiveness in the real life, absolute necessity of their use in all trips, and preference for CRS installation in the back seat.
- To support the proposed public awareness campaign with enforcement activities, covering also those situations with higher risk, such as divided roads where most of the fatalities occur.
- To introduce the necessary changes in the Spanish and European traffic legislations in order to initially “require all children under the age of 12, passengers of vehicles under 3500 kg of gross maximum weight, to use adequate restraint systems during all trips except during justified short occasional ones”, until a different text of the law with no exceptions were compatible with actual behavioral and attitudinal patterns.
- To accelerate research on side impact test methodologies in order to incorporate as soon as possible a side impact test into ECE R44.
- To evaluate the practicability of routinely incorporating to the Spanish national crash reporting system more detailed information regarding child restraint systems.
- To evaluate the practicability of incorporating to the Spanish national crash reporting system more detailed coded injury information using,

for instance, internationally accepted scores such as ISS, AIS, MAIS…
- To consider re-running this survey in the mid-term (3 to 5 years) in order to monitor improvements or changes in the child passenger safety situation in Spain.
- To extent this survey to other geographical areas in order to enable comparison and gain insight into common issues and transferable solutions.

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DISCLAIMER & DATABASE AVAILABILITY

The responsibility for the results presented here rests entirely with the author. The conclusions drawn here are those of the author alone and do not necessarily reflect views of the Royal Automobile Club of Spain. The complete database discussed in this paper is available in SPSS format for research purposes at: jesus_monclus@race.es

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APPENDIX 1. CRS USE AND EFFECTIVENESS QUESTIONNAIRE

CHILD RESTRAINT SYSTEM (CRS) USE AND EFFECTIVENESS DATA COLLECTION FORM

MINISTERIO DEL INTERIOR — DIRECCIÓN GENERAL DE TRÁFICO

GUARDIA CIVIL — Subsector: — AGRUPACIÓN DE TRÁFICO — Base.:

Date (dd / mm / yyyy) _ _ / _ _ / _ _ _ _ | Page | Crash Report # (to be filled by JPT):

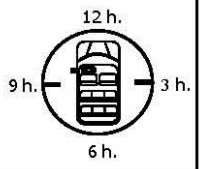
Road | Km. | Municipality:

A.- CRASH TYPE
Repeat here the answer to field **40 CRASH TYPE** included in the *Spanish Statistical Traffic Crash Data Collection Form*: _____

B.- ROAD TYPE
Repeat here the answer to field **20 ROAD TYPE** included in the *Spanish Statistical Traffic Crash Data Collection Form*: _____

C.- VEHICLE TYPE
1. □ Small-size car
2. □ Medium-size car
3. □ Large-size car
4. □ Minivan
5. □ SUV
6. □ Combined cargo and passenger van
7. □ Cargo van
8. □ Other_____
9. □ Unknown

D.- VEHICLE DAMAGE
1. □ No damage
2. □ Minor
3. □ Moderate
4. □ Important
5. □ Massive
6. □ Unknown



E.- PRINCIPAL DIRECTION OF FORCE, PDOF (see graph above)
1. □ PDOF (01 to 12): _____
2. □ Rollover (00): _____
3. □ Unknown

F.- CRS TYPE
1. □ Baby craddle
2. □ ECE R44 group 0/0+ rear facing
3. □ Group 0/0+ forward facing (misuse)
4. □ ECE R44 group I
5. □ Booster seat with back support (group II)
6. □ Booster without back support (group III)
7. □ Integrated seat
8. □ Two point adult safety belt
9. □ Three point adult safety belt
10. □ Child not restraint into CRS
11. □ Child sitting in another passenger's lap
12. □ None
13. □ Other _____
14. □ Unknown

G.- CRS INSTALLATION
1. □ Two point adult safety belt
2. □ Three point adult safety belt
3. □ Additionally retrofitted belt
4. □ ISOFIX
5. □ Integrated seat
6. □ Not secured to the vehicle
7. □ Other _____
8. □ Unknown

H.- CRS POSITION AFTER THE CRASH
1. □ Where it was originally installed
2. □ CRS inside the vehicle but not in its original positon
3. □ CRS outside the vehicle
4 □ Other _____
5 □ Unknown

I.- CHILD OCCUPANT AGE
1. □ Under 1 year of age
2. □ 1 to 12 years old: ___
3. □ Unknown

J.- CHILD INJURY OUTCOME
1. □ Not injured
2. □ Minor injury
3. □ Serious injury
4. □ Killed
5. □ Unknown

K.- *ONLY FOR INJURED CHILDREN*: INJURED BODY REGION (multiple answer possible)
1. □ Head/Neck
2. □ Thorax (also internal injuries)
3. □ Abdomen (also internal injuries)
4. □ Upper extremities
5. □ Lower extremities
6. □ Unknown

□ Right side □ Left side
□ Front aspect □ Rear aspect

L. *ONLY FOR INJURED CHILDREN*: INJURY MECHANISM
1. □ Ejection
2. □ Airbag interaction
3. □ Interaction with other occupants
4. □ Interaction with CRS itself
5. □ Windshield/Dashboard
6. □ Front seat back
7. □ Contact with roof, windows or other vehicle interior parts
8. □ Other _____
9. □ Unknown

M. AIRBAG INTERACTION
1. □ No interaction
2. □ Front passenger frontal airbag
3. □ Front passenger side airbag
4. □ Rear seat side airbag
5. □ Head, window or courtain airbag
6. □ Other _____
7. □ Unknown

N.- PRE-IMPACT CHILD SEATING POSITION INSIDE VEHICLE
1. □ Front right seat
2. □ Second row, right seat
3. □ Second row, central seat
4. □ Second row, left seat
5. □ Third row, right seat
6. □ Third row, central seat
7. □ Third row, left seat
8. □ Other _____
9. □ Unknown

O.- OTHER INJURED OCCUPANTS (multiple answer possible)
1. □ Not injured Number: _____
2. □ Slightly injured Number: _____
3. □ Seriously injured Number: _____
4. □ Killed Number: _____
5. □ Unknow

APPENDIX 2. ADDITIONAL TABLES

Table A1.
Principal Direction of Force (PDOF) and injury severity

	All severities (n=1003)	No injury (n=212)	Minor injury (n=588)	Serious Injury (n=134)	Fatal Injury (n=25)
Rollover	23.4%	15.6%	25.2%	25.4%	48.0%
Frontal	43.4%	46.1%	45.1%	35.1%	4.0%
Right Side	7.7%	8.9%	6.6%	8.9%	16.0%
Left Side	9.2%	8.0%	8.5%	12.6%	8.0%
Rear	15.3%	20.3%	13.8%	14.8%	8.0%
Unknown	1.1%	0.9%	0.7%	3.0%	16.0%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Table A2.
Vehicle extent of damage and injury severity

	All injuries (n=1011)	No injury (n=214)	Minor injury (n=594)	Serious Injury (n=134)	Fatal Injury (n=25)
No vehicle damage	0.8%	0.9%	1.0%	0.0%	0.0%
Minor	7.8%	18.2%	5.9%	0.0%	4.0%
Moderate	33.4%	35.0%	36.9%	14.2%	4.0%
Important	44.4%	38.8%	46.3%	51.5%	36.0%
Massive	12.1%	5.6%	8.6%	32.1%	52.0%
Unknown	1.5%	1.4%	1.3%	2.2%	4.0%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Table A3.
Vehicle type and injury severity

	All injuries (n=1007)	No injury (n=213)	Minor injury (n=591)	Serious Injury (n=134)	Fatal Injury (n=25)
Small passenger car	17.5%	15.5%	18.1%	18.7%	16.0%
Medium passenger car	40.0%	39.0%	41.1%	33.6%	28.0%
Large passenger car	21.9%	20.2%	22.7%	24.6%	16.0%
Minivan	8.2%	12.2%	6.6%	9.7%	8.0%
SUV	4.1%	3.8%	4.6%	2.2%	8.0%
Cargo/passenger van	6.9%	8.5%	5.8%	9.0%	16.0%
Cargo van	0.7%	0.0%	0.8%	1.5%	0.0%
Other	0.7%	0.9%	0.3%	0.7%	8.0%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Table A4.
Road type and injury severity

	All injuries (n=980)	No injury (n=210)	Minor injury (n=572)	Serious Injury (n=131)	Fatal Injury (n=25)
Controlled access divided road	43.3%	44.8%	38.1%	49.6%	68.0%
Single carriageway	52.6%	52.9%	56.6%	48.1%	32.0%
Other	3.9%	2.5%	5.2%	2.3%	0.0%
Unknown	0.0%	0.0%	0.0%	0.0%	0.0%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Table A5.
Seating position and injury severity

	All injuries (n=829)	No injury (n=179)	Minor injury (n=484)	Serious Injury (n=109)	Fatal Injury (n=21)
Right front	4.1%	3.4%	4.1%	5.5%	9.5%
2nd row, right seat	35.5%	36.9%	35.7%	29.4%	38.1%
2nd row, center seat	21.2%	18.4%	21.3%	26.6%	14.3%
2nd row, left seat	27.4%	29.6%	27.3%	27.5%	23.8%
Other	6.4%	3.3%	6.1%	8.3%	14.3%
Unknown	5.4%	8.4%	5.4%	2.8%	0.0%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

Table A6.
CRS use rates by CRS type and by group age

	All (n=1011)	< 1 year (n=103)	1-3 year old (n=253)	4-6 year old (n=251)	7-9 year old (n=246)	10-11 year old (n=155)
Baby cradle (carry cot)	1.6%	14.6%	0.4%	0.0%	0.0%	0.0%
Group 0/0+ rear facing	2.2%	15.5%	2.4%	0.0%	0.0%	0.0%
Group 0/0+ forward facing (misuse)	6.1%	19.4%	13.8%	2.8%	0.0%	0.0%
ECE 44R Group I	11.3%	17.5%	30.0%	8.0%	0.0%	0.0%
Booster with back rest (Group II)	2.1%	1.0%	2.0%	3.6%	2.0%	0.6%
Booster without back (Group III)	3.2%	0.0%	4.0%	7.2%	1.6%	0.0%
Integrated seat	1.2%	3.9%	1.2%	2.0%	0.0%	0.0%
Two-point adult seat belt	2.7%	0%	1.2%	3.6%	4.1%	2.6%
Three-point adult seat belt	6.3%	0%	0.0%	6.4%	10.6%	14.2%
Child Not strapped to CRS	0.5%	1.0%	1.2%	0.0%	0.0%	0.6%
Sitting in someone's lap	3.9%	11.7%	6.7%	2.4%	0.8%	1.3%
No restraint	56.3%	14.6%	34.4%	61.4%	77.6%	77.4%
Unknown	2.8%	1.0%	2.8%	2.8%	3.2%	3.2%
TOTAL	100.2%	100.2%	100.1%	100.2%	99.9%	99.9%

Table A7.
CRS use by age group (absolute numbers and percentages)

Age	No use	Inappropriate Use	Appropriate Use	No use	Inappropriate Use	Appropriate Use
< 1	27	26	49	26.5%	25.5%	48.0%
1 to 3	104	64	80	41.9%	25.8%	32.3%
4 to 6	160	59	29	64.5%	23.8%	11.7%
7 to 9	193	46	4	79.4%	18.9%	1.6%

Table A8.
CRS use rates as a function of road type

	No use	Inappropriate use	Appropriate use	n
Controlled access divided road	54.3%	25.0%	20.7%	348
Single carriageway	59.5%	22.7%	17.8%	437
Other	67.7%	6.5%	25.8%	31
All road types	57.6%	23.0%	19.4%	816

Table A9.
CRS use rates as a function of vehicle type

	No use	Inappropriate use	Appropriate use	n
Small passenger car	60.3%	22.6%	17.1%	146
Medium passenger car	55.7%	24.6%	19.8%	334
Large passenger car	51.8%	24.4%	23.8%	193
Minivan	45.5%	33.3%	21.2%	66
SUV	62.2%	18.9%	18.9%	37
Cargo/passenger van	89.5%	5.3%	5.3%	57
Cargo van	80.0%	20.0%	0.0%	5
Other	100.0%	0.0%	0.0%	3
All vehicle types	57.7%	23.2%	19.1%	841

Table A10.
Injured body regions as a function of age

	All ages (n=884)	< 1 year (n=77)	1-3 years old (n=183)	4-6 years old (n=227)	7-9 years old (n=238)	10-11 years old (n=157)
Head/neck	44.5%	38.2%	46.5%	44.1%	44.4%	45.7%
Thorax	9.3%	9.2%	8.2%	10.8%	10.1%	7.2%
Abdomen	5.6%	5.3%	3.5%	6.9%	6.8%	5.1%
Upper extremities	13.4%	3.9%	9.4%	10.8%	19.3%	18.8%
Lower extremities	10.7%	2.6%	10.6%	11.8%	12.6%	10.9%
Unknown	27.4%	42.1%	29.4%	27.0%	21.7%	26.1%

Table A11.
Injury source as a function of age

	All (n=764)	< 1 year (n=77)	1-3 years old (n=160)	4-6 years old (n=196)	7-9 years old (n=202)	10-11 years old (n=127)
Ejection	5.5%	5.5%	6.4%	5.2%	5.1%	4.8%
Airbag interaction	0.4%	2.7%	0.6%	0.0%	0.0%	0.0%
Contact with other occup.	4.0%	13.7%	4.5%	3.6%	2.1%	1.6%
Interaction with CRS	8.8%	23.3%	12.8%	7.3%	4.1%	4.8%
Windshield/dashboard	3.1%	5.5%	3.2%	2.6%	2.6%	3.2%
Back of front seat	30.5%	12.3%	23.7%	33.9%	35.9%	36.3%
Vehicle interior (side/roof)	25.1%	11.0%	22.4%	26.0%	28.2%	29.8%
Flying glass	2.8%	4.1%	4.5%	3.1%	2.6%	0.0%
Objects inside the vehicle	0.9%	1.4%	1.9%	0.5%	1.0%	0.0%
Other	1.8%	1.4%	2.6%	1.0%	2.1%	1.6%
Unknown	20.1%	24.7%	19.9%	18.8%	20.0%	20.2%

Table A12a.
Vehicle damage extent by injury severity

	No damage (n=8)	Minor (n=75)	Moderate (n=314)	Important (n=436)	Massive (n=119)	Unknown (n=15)	Total (n=967)
No injury	0.9%	18.2%	35.0%	38.8%	5.6%	1.4%	100.0%
Minor injury	1.0%	5.9%	36.9%	46.3%	8.6%	1.3%	100.0%
Serious injury	0.0%	0.0%	14.2%	51.5%	32.1%	2.2%	100.0%
Fatal Injury	0.0%	4.0%	4.0%	36.0%	52.0%	4.0%	100.0%

Table A12b.
Injury severity and vehicle damage extent

	All damage (n=1011)	No damage (n=8)	Minor (n=79)	Moderate (n=338)	Important (n=449)	Massive (n=122)	Unknown (n=15)
No injury	21.2%	25.0%	49.4%	22.2%	18.5%	9.8%	23.1%
Minor injury	58.8%	75.0%	44.3%	64.8%	61.2%	41.8%	61.5%
Serious injury	13.3%	0.0%	0.0%	5.6%	15.4%	35.2%	7.7%
Fatal Injury	2.5%	0.0%	1.3%	0.3%	2.0%	10.7%	7.7%
Unknown	4.4%	0.0%	5.1%	7.1%	2.9%	2.5%	0.0%
TOTAL	100.2%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table A13.
CRS use and injured body regions (absolute numbers and percentages)

	No use	Inappropriate use	Appropriate use	No use	Inappropriate use	Appropriate use	n
Head/neck	195	52	44	41.9%	34.7%	41.9%	291
Thorax	35	18	10	7.5%	12.0%	9.5%	63
Abdomen	21	11	6	4.5%	7.3%	5.7%	38
Upper X.	54	17	10	11.6%	11.3%	9.5%	81
Lower X.	50	16	4	10.8%	10.7%	3.8%	70
Unknown	110	36	31	23.7%	24.0%	29.5%	177
TOTAL	465	150	105	100.0%	100.0%	100.0%	720

Table A14.
CRS use and injury source (absolute numbers and percentages)

	No use	Inappropriate use	Appropriate use	No use	Inappropriate use	Appropriate use	n
Ejection	28	5	2	6.9%	4.0%	2.0%	35
Airbag interaction	1	1	1	0.2%	0.8%	1.0%	3
Contact with other occupants	24	2	2	5.9%	1.6%	2.0%	28
Interaction with CRS	3	23	33	0.7%	18.3%	33.7%	59
Windshield/dashboard	15	2	2	3.7%	1.6%	2.0%	19
Back of front seat	148	21	11	36.5%	16.7%	11.2%	180
Vehicle interior (side. roof...)	107	26	16	26.4%	20.6%	16.3%	149
Flying glass	4	6	10	1.0%	4.8%	10.2%	20
Objects inside the vehicle	2	4	1	0.5%	3.2%	1.0%	7
Other	3	5	3	0.7%	4.0%	3.1%	11
Unknown	71	31	17	17.5%	24.6%	17.3%	119
TOTAL	406	126	98	100.0%	100.0%	100.0%	630

Table A15.
Injured body region for properly used forward facing Group I safety seats (multiple answer possible)

	Rollover (n=19)	Frontal (n=33)	Lateral (n=14)	Rear (n=8)
Head/neck	58.8%	41.9%	28.6%	37.5%
Thorax	0.0%	12.9%	21.4%	25.0%
Abdomen	5.9%	12.9%	0.0%	0.0%
Upper X.	23.5%	3.2%	7.1%	12.5%
Lower X.	0.0%	3.2%	7.1%	12.5%
Unknown	23.5%	32.3%	35.7%	12.5%