

## **IMPLICATION OF CHILDREN IN ROAD ACCIDENTS IN FRANCE IN 2011**

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### **ABSTRACT**

This study intends to present the analysis of all road accidents that occurred in France during the year 2011 in which children (0-13y incl.) have been involved. Based on the data collected and coded in the French safety project (VOIESUR) accidents with children have been analysed by experts. Then, these data have been weighted to be representative of the French situation.

The paper proposes an analysis of the accident data for 5 categories of road users that are light vehicle occupants, pedestrians, cyclists, motorbike passengers and buses and coaches' occupants. A distribution of the different parameters of the accident and its outcomes such as the children's injury severity is available per different road user categories.

The repartition of children across the previously described user categories shows that the most common accident for children is being light vehicle occupants (64%), then cyclists (17%) and finally pedestrians (15%). Buses and PTW occupants are representing a very small proportion (approximately 2% each).

On the 101 fatally injured children, the repartition is different and as follow: 61% are light vehicle occupants, 11% are cyclists and 26% are pedestrians. No power two wheels (PTW) passengers or coach and bus occupants have been fatally injured in 2011 in France. The remaining 2% are not belonging to any of these categories of road users.

For each category, a comparison of accident data between fatal cases and the others is proposed ending in a list of some remarkable differences. Countermeasures for fatal accidents are also proposed in each respective category.

For light vehicle occupants, the analysis of usual data such as infrastructure and journeys have been completed by a sociological profile of children's drivers and specific psychological items such as alcohol and drug consumption, atmosphere in the vehicle. Concerning children involved in cars, the sample size for children in cars is 654 that once weighted to make it representative of reality correspond to 17748 children including 62 that were killed. Evidence of a restraint system used by children has been coded for 69% of children, but in only 44% of the cases, the restraint system was appropriate and correctly used.

For children in the other road user categories, the analysis is a little bit more limited but it includes the age distribution, infrastructure and journeys data, the responsibility of involved parts (including children). The presence of protection device such as helmets: it is about 8% for cyclists and about 82% for PTW passengers. For pedestrian children they sustained their accident while they were using a crosswalk in only 5% of the cases, and in 50% of the cases they were running across the road.

Conclusion: This paper opens the field of considering all children involved in a road traffic accident in a national safety study, not focusing only on fatal cases and not limited to the situation of children in cars. Even if some limitations due to the use of weighting factors exist, it gives a comprehensive picture of the situation in France.

## **INTRODUCTION**

This paper is presenting two visions of the implication of children in road accidents in France. First, the global picture for all children and secondly it is focusing on the characteristics of accidents per types of road users. It is based on the one year collection data done in the VOIESUR project that have been weighted to be representative of the French situation. The official indication of the implication of children in road accidents that have occurred in France in 2011 is given in the publication of the National data results for the year 2011. The figures shows there are lower than the ones presented in this study. This is due to the fact that this kind of data when collected on police report is underestimating the proportion of slightly injured and uninjured occupants, especially children (generally not interviewed by the police). That's why the weighting factors have been adjusted to be representative of the observed situation based on observations in hospitals. More information about the context has already been detailed precisely in the publication [1] presented at the 11th International Conference of child safety in cars.

## **VOIESUR project**

Despite a sharp reduction of the number of fatalities on French roads since 2000, road accidents are still one of the priorities of the French government. VOIESUR (Vehicle, Occupants, Infrastructure, Environment, and Safety of Users of the Road) is a National project of 40 months started in January 2012. This project, partly funded by the Agence Nationale de la Recherche (National Agency for Research) and the MAIF foundation fits with the EU declaration of the "Decade of Road Safety". Its consortium is composed of 4 partners: LAB - Laboratory of Accidentology, Biomechanics and Human behaviour, CEESAR - European Centre for Safety Studies and Risk Analysis, CEREMA - National Centre For Studies and Expertise on Risks, Environment, Mobility, and Urban and Country planning , IFSTTAR - French institute of science and technology for transport, development and networks. Among its multiple objectives, the VOIESUR project has a key-point: to keep moving forward in the field of road safety and thus place France among the safest countries in the world. To do so it is necessary to have complete and accurate information in line with current issues such as vulnerable road users. In the VOIESUR project, a new database of road accidents that occurred during the year 2011 in France has been built with the aim to be representative of the national situation. Based on in-depth police report studies, VOIESUR expands the fields of observation not only to fatal accidents but also to traffic accidents with injuries. The project is updating the comprehensive information system on road safety that dates from 2000. It is based on reports established by the police in France during the year 2011 related to road accidents in which at least one person was injured. People concerned by the coding will be all French fatalities, all Rhône area accident injuries and 1/20 random of national accident injuries. The database includes the details of the accidents and when available the full medical records of the people involved. A match between the VOIESUR database and the Rhône register injury database provides the basis for a data recovery methodology to propose a correction of the underreporting in the French national data.

The analysis of this database, allows to improve the general knowledge in accidentology and to focus on specific road users such as pedestrians, two-wheelers, children, seniors or to look at the evolution of the road safety in France over the last thirty years by comparison with data previously coded and analysed. In addition, this database is used to evaluate the method of data recovery and to suggest a correction on national data. The realization of thematic studies supplies a better safety diagnosis on specific road users and in the end these studies is providing raw material to elaborate new safety systems and to base statements to establish new road safety regulations. The version of the database used for this study is v19, on which the version 2 of weighting factors has been applied. One of the thematic studies of the VOIESUR project is dealing with the situation of children involved in road accidents. The motivations and the work organisation of that part of the project have been reported in the Child safety culture workshop held in 2012 prior to the Munich conference "children in cars", and are explained in the proceeding of the conference [2].

## **METHOD**

Every accident is described in details using general variables in three areas (vehicle, occupant, and infrastructure) and specific safety variables are coded by experts in the domain to understand all aspects of the accident. Up to 450 variables usable for future studies are coded for each accident. The analysis of injured children in a road accident that occurred in 2011 has been conducted using the VOIESUR database. Victims have been classified according to 5

categories, light vehicle occupants, cyclists, powered two wheels passengers, buses and coaches' occupants and pedestrians. Over-accidents have been excluded from the sample as the same person can change of user category between two events and make the analysis too complex.

In the VOIESUR database, medical data of injured road users has been coded using AIS code revision 98 [3] when available. But in fact, there are not so many cases that contain such data as autopsy or complete medical report of people involved in road accident in France, because this is not mandatory but only performed if required by the justice. External post mortem inspections are sometimes performed but cannot be considered as a detailed medical report. They do not present a complete list of injuries, but can be useful for the determination of locations of impact across the children's bodies, and in a certain way the determination of restraint conditions for vehicle occupants. The present study focusses on all child injury levels including those fatality and such medical inspection reports are included in the sample. Children involved in a road accidents are split in four injury level categories: Uninjured, slightly injured, seriously injured, and killed, with clear definitions for each of them.

### **Weighting factors**

The purpose of this study is to be as far as possible representative of French situation. As it has been already highlighted in previous National projects, a recording gap between the number of accidents recorded by the police and the number of accidents that actually occurred in 2011. Thus, weightings have been determined in the VOIESUR project to correct the record found error. The document [4] refers to the VOIESUR deliverable explaining the calculation of these weightings.

Sampling at 1/20th the personal road accidents led us to the creation of the first correction factor. It is therefore assigned to each injury accident a weight of 20 to return to a condition called exhaustive (All fatal accidents have been coded, no correction is applied to them). After that, a recording gap in the sharing between the different entities of the security forces was found, which led us again to the creation of another correction factor to restore the right proportions. Finally, an under recording of some accidents has been also found while comparing the exhaustive list of hospital recordings of admissions following a road accident and the list of people recorded by the police. This last factor is depending on the category of road users, the injury severity level and the unit of police in charge of reporting the event. Therefore, on all the following results, the three weightings were applied to correct the raw data. There are of course limitations to use such factors to make the data representative of the real road situation, and questions on the validity of these factors for the situation of children on the road are sometimes possible. For example, children cyclists in the original sample are not very numerous, but they are also rarely recorded by the police if none of the people implied in the accident is severely injured. Therefore, the weighting factors to scale these cases to the road reality are often high. Unlike fatalities, the information obtained for personal accidents are not exhaustive, this can have an influence on the quality of the analysis that is performed.

## **GENERAL RESULTS**

The sample size for this chapter is 31636 children (0-13 years of age) involved in roads accidents in France in 2011. The material is coded data for 915 children on whom corrector factors were applied to obtain this sample representative of road situation reality. It is composed of all type of users and all injury severity levels.

### **Proportion of children involved in road accident in France -2011 per road user categories**

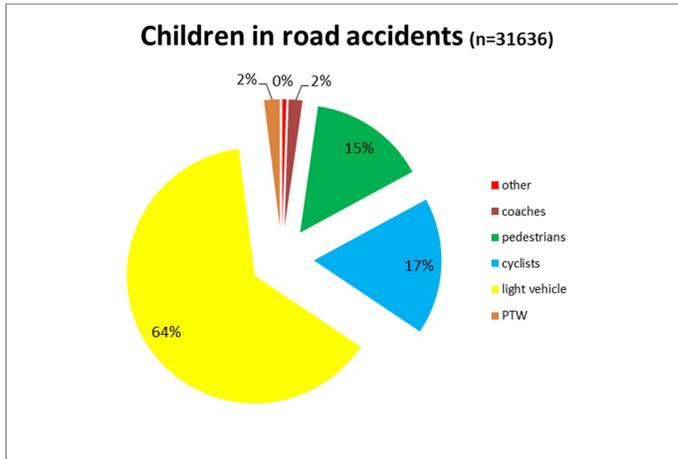
The distribution between the categories of road users is shown on Figure 1 and can be read as follow: 64% are light vehicle occupants, 17% are cyclists and 15% are pedestrians. PTW passengers and bus and coach occupants represent a little less than 2% each. The remaining children (0,5%) are not belonging to any of these categories of road users.

### **Implication of children in accidents occurring in France in 2011**

The situation of children needs to be compared with the one of adults involved in road accidents to underline differences. Children represent 6% of the total number of people involved in road accidents in France in 2011. Having a look on the proportions of children in the different user categories, it clearly appears that for the categories of PTW and "other vehicles", children are representing very low figures (less than 1%), but they represent 18% of the total number of the pedestrians having accidents, and 8% of cyclists. This underlines the fact that when they have to take decisions, such as crossing a street, being able to stop at crossroads, or riding

a bike in the traffic, they more often fail than adults. Children represent 7% of all people involved in road accident as occupant of a light vehicle.

The part of children considered in categories of vulnerable road users is 34% of the total number of children. The same figure for adults is 40%, but excluding PTW makes this proportion going down to 17% for adults while it remains to 32% for children. Therefore, accidents with children need to be treated with special cares.



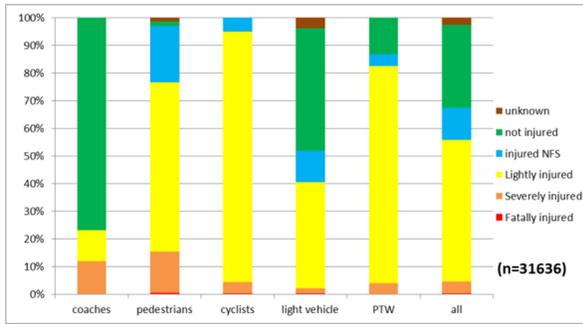
**Figure1. Proportion of children involved in personal road accident in France -2011 per road user categories**

**Distribution of injury severity per different road user categories.**

Once the implication of children across the different road users categories, it becomes important to analyse the severity of the injuries of children consecutively to their accidents. It is what is shown on Figure2. For that a relative simple way is to consider the duration of hospitalization of children, which is the official way to do it in France. Some children do not go to the hospital at all, they are considered as not injured, some others are conducted by rescue teams or parents to hospital but their stay there is shorter than 24 hours, these ones are considered as lightly injured. Children staying more than 24 hours are considered as severely injured, except for those who do not survive within the period of 30 days following the accident. In some cases, only the information that the child was transported to the hospital is available in the police report without any other indication of the injuries they sustained (from hospitals nor parents). These have been put in a separate category named injured NFS, but very often, not reported injuries are of a low level of severity.

The proportion of children fatally injured is 0,3% of the total number of children involved in road accidents. This proportion can be considered as relatively low as compared to the one of adults that is 0,8%, but it is important to remind the psychological impact of children’s fatality in the society and the relative costs. For the category of severely injured road users, children are showing lower figures (4,3%) than the ones of adults (7,7%). If just looking at the proportion of road users involved in a road accident but not injured, the proportion for adults and children is similar with 30% in each category and the proportion of light injured population is also very close (50%). The proportion of children for who no information at all on injury severity are available is higher than for adults.

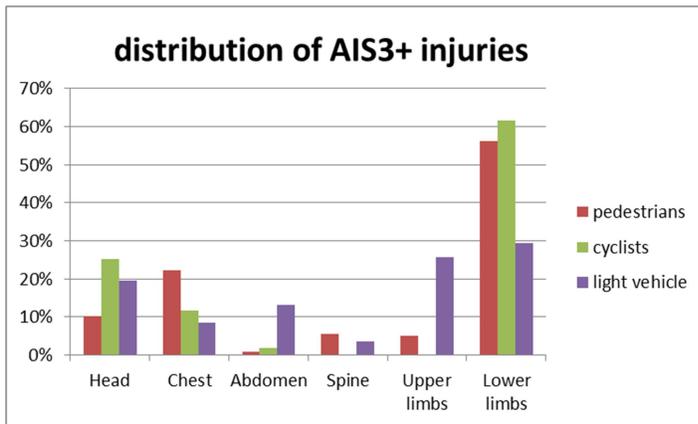
The previously described repartition is not uniform across all the road user categories. Details are on Figure2. The proportion of uninjured children is very high for bus and coach occupants with 77%, followed by light vehicle occupants for which the proportion is 44%. This proportion dramatically goes down when children are part of the most vulnerable road user categories such as pedestrians, PTW passengers, and cyclists. For these two last ones, the proportion of light injuries is very high, with respectively 80% and 90%. Pedestrians are showing the largest proportion of severely injured children with nearly 15%, and also have the higher rate of fatally injured children with 0,6%. They are followed by the light vehicle occupants with a fatality rate of 0,3% and finally by cyclists with 0,2%.



**Figure2. Injury severity per different road user categories for children involved in a personal accident**

As children passengers of light vehicles are representing nearly 2/3 of the total number of children involved in road accidents, even if showing a rate of fatality lower than pedestrians, their number is higher. On the 101 fatally injured children, 61% are light vehicle occupants, 26% are pedestrians and 11% are cyclists. No PTW passengers or coach and bus occupant has been fatally injured in 2011 in France. The remaining 2% of children fatally injured are not belonging to any of these categories of road users.

An important point in terms of protection of children as road users is to know the location and if possible the injury mechanisms that occurred during their accidents. To evaluate the injury severity, the AIS scale is used. In order to eliminate the lightest injuries, the present analysis is focussing on AIS3+ injuries that are defined on this scale as serious injuries. The number of AIS3+ injuries in the sample once weighted is 996. But having a look of their distribution makes no sense if they are not spread per user categories. Figure3 gives an overview for the categories of road users for which the number of severe injuries was sufficient to be dispatch across the different body segments. It is more detailed in the analysis for the different road user's categories, but what clearly appears is that limbs and more particularly lower limbs are the most often injured body segments at AIS3+ level, for all categories of road users and that this represents more than half of the total number of severe injuries for children pedestrians and cyclists. This has to be balanced with the fact that fatal cases of children are not often containing autopsy report, so fatal injuries or combination of injuries are missing in the database, but some external examinations can report injuries such as opened fractures. The head remains the first vital body segment in terms of frequency of severe injuries for cyclists and light vehicle occupants while this is the chest for pedestrians.



**Figure3. Distribution of AIS3+ injuries per body segments for the different road user categories (n=996)**

## RESULTS PER USER CATEGORIES:

From this point, the analysis is only considering the children for who the age is known. Their number is 28851 for the 5 categories of road users considered in the following analysis. When distributed according to the age of children it clearly appears that globally implication of children in road accidents is slowly growing as children get older from birth to 10 years of age, and that the increase is much faster from 11 to 13 years. This

is mainly coming from a combination of the fact that if the number of light vehicle occupant and pedestrians is more or less stable up to 10 years old and then going up, the number of cyclists, PTW passengers and occupant of buses and coaches is concentrated around 10 year old children and more, which is re-enforcing this phenomena. This statement can be attributed to the appearance of the child's autonomy and need of mobility.

### **Light vehicle occupants**

The number of children occupant of a light vehicle that has been involved in a road accident in 2011 in France is 17748. Children from birth to 10 years of age are more or less equally involved in road accidents as light vehicle occupants with an average value of 1200 for each year of age. As the sample is based on only one year of data collection, gaps and peaks are existing but could certainly be limited using a multi-annual sample. The extrapolation cannot be effective for the data that is missing in the sample. For children after 10 years of age, the number is rising up regularly to reach 2300 for children that are 13 year old.

**Infrastructure and accident conditions** About 50% of the accidents involving a child as light vehicle occupant occurred in built up areas. 75% happened during the day, 22% during the night and 3% at dawn or twilight. The most common obstacle is another light vehicle in 53% of the cases. Fixed obstacles represent 27% of the sample, 2 wheels 10% and 6% is heavy utility vehicles that are mainly trucks. Pedestrians have been coded as opposite obstacle for 2% of the cases. The 2% remaining of opposite obstacles belongs to the categories of "other vehicles".

52% of the accidents occurred on primary roads, one third on secondary roads, highways are "only" totalizing 16% of the total of accidents with children as car occupants. The typology of accidents is different according to the different road categories for children accidents. For highways, the most common accident type is roll-overs with 40% of the cases to which 10% of tip-overs could be added. Frontal impacts represent 32% and rear impacts 10%. Side impact is only scoring 4%, on this type of road. On primary roads, frontal impacts are the first accident type with 58%, rear impacts are following 19%, then side impacts with 11%. Roll-overs on such roads are only 5% of the sample and side swipe counts for 3%. On secondary roads, Frontal and side impacts are equivalent with 39% each, rear impacts are coming then with 14%. Very few roll-overs and tip-overs has been mentioned for this category of roads, but it has to be said that side swipe are showing their higher score with 6%. This can be explained partially by the fact that roads from this category are certainly narrower than the other ones, facilitating this kind of impacts.

30% of accidents occurred in or close to an intersection. From this particular configuration, 61% of the drivers intended to cross the intersection and 25% had the wish to turn left or right. It has to be noticed that 7% were stopped prior or in the intersection at the moment of the accident. For the 70% of accidents that did not happened at intersections it has to be noticed that in 71% of the cases, the vehicle was going strait, without any intension of changing direction, 8% are overtaking another vehicle, other 8% are slowing down, 5% are changing of lane and finally, 7% are stopped.

From that point, it is important to notice that for the analysis accident of light vehicles against pedestrians and two wheels (with and without engine) have been excluded as the loads are very often very low for the light vehicle occupants in this kind of road accidents. The number of children in the following analysis is 15236.

**Type of impacts** The distribution of the type of impacts for children light vehicle passengers is as follow: 51% of the children are involved in frontal impact, side impacts and rear impacts are very close one to the other with respectively 16 and 17%. Roll-overs count for 10% and tip-overs for 2%. Side swipe, falls and other accident configuration are representing approximately 1% all together.

**Sociological profile of children's drivers:** This point is not always considered in analysis of topics related to road safety and more particularly child safety in cars. The part of technical data is of course crucial to understand the situation and define axes of progress, but the knowledge of sociological and psychological data are also essential to be efficient in the communication campaigns and educational programs. [5] The number of variable that can be used for that and being present in the police reports are not so numerous. For example, the school level is not available, and information such as profession of the driver is not always reported, which makes more difficult the definition of a sociological profile. Nevertheless professional activity, the level of responsibility in the accident, the fact of having

an insurance for the vehicle, the relationship between child and the driver, the type journey, and the main reason of the accident have been coded in the VOIESUR database for accidents in which children were involved.

In 94% of the cases, vehicles in which children were transported were covered by an insurance policy. This is not totally surprising as this is mandatory in France to have one to use a vehicle.

Journeys for children are unknown for 31%, which is limiting a little bit the use of this data, but it's interesting to notice that leisure activities comes to the first range of known journeys with 21%, closely followed by the visit to family that scores 20%. Departures to holidays are not a negligible part of the accident with children in light vehicles with 10%. What can appear to be surprising in this list is that the activities conducted every day such as the travel to school, or nursery is only representing 4% of the total and that shopping activities is scoring 6%.

Drivers in a very large majority of cases are the parents or parents in law of the transported children mothers representing 49% of the cases and fathers 31%. The other members of the family such as grand-parents, sisters and brothers, uncles and aunts represent additional 8%. This means that information on child safety as to be focussed on the familial environment. Friends and neighbours are driving in 9% of the cases. They can also be good vectors for forwarding safety messages to parents of children but also need to receive information on the right way to transport children in cars.

Looking at the driving experience, the variable used to determine this parameter is the number of years of driving licence which is available for 78% of cases. The figures are showing that drivers with a shorter experience have tendency of being more involved in accidents with children and that the percentage of implication is going down as the number of years of driving license is increasing.: 33% for less than 10 year, 26% between 11 and 20 years, and 19% for more than drivers with more than 20 years of driving licence. This can be a bias due to the fact that people having children to transport are relatively young and therefore are relatively young in their driving experience. 59% of drivers have a professional activity, 20% are non-actives, and the professional situation is unknown for 21%. The responsibility in the accident has been coded using different method in the VOIESUR project. For this analysis, it is proposed to use the judgement of the expert on this point as when coding, he knows the facts and the involvement of the different parts in the accident. As results, the driver of the vehicle in which the child is transported is responsible in 47% of the cases. In 50% the driver has not responsibility in the accident. For 2% the responsibility is shared between parts and in 1% it was not possible to determine this parameter.

**Psychological items:** The consumption of alcohol or drugs prior to driving have been considered in the psychological profile of drivers. Other parameters sometimes more difficult to evaluate, or subject to interpretation have been when possible coded by experts such as the atmosphere in the vehicle, the influence of the presence of the child on the driving performance, and the time pressure on the driver to make the journey. Personal data for drivers such as the stability of the professional situation and the recent change of family status have also been taken into account.

First of all, the data is showing that the driver behaviour in terms of restraint use has a huge influence on the fact that the child is restrained or not: when the driver is using the seatbelt only 5% of the children are not restrained that has to be compared with a rate of unrestrained children of 26% when the driver is not belted.

Going one step further, the proportion of children that seems to be correctly restrained with the limitations indicated in the section dedicated to this item, is only 1% when the driver is not restrained versus 46% for the cases in which the driver is wearing the vehicle seatbelt.

The measure of the level of alcohol for drivers compulsory in France after an accident occurred, so this data is available for 91% of the cases of our sample. The maximum authorized alcohol level is 0,5 g/l of blood, which correspond to a limit of 0,25g/l of expulsed air. For 20% of the accidents, alcohol has been found for one of the drivers, and at least 8% of the drivers with children on board were over the legal limit.

The consumption of drugs in France is not legalized and if no medical treatment is declared, no drug should be found for drivers. The control of presence is not mandatory in all accidents, but more on request of the legal department in severe cases. Up to now the cost of such control was high. This could change in the coming years with

the apparition of saliva tests that seems to give satisfying results. The data is missing for 27% of the drivers in our sample. For 72%, drivers have shown no evidence of drug consumption but the test was positive for 1% of them. About 5% of the drivers with children on board had a recent change in their family status, to be compared with 69% for which no evidence of change has been recorded. This data is missing for the remaining 26%. Figures are relatively similar for the stability of the professional situation, with 67% without any change, about 5% recorded with a recent change and with 28% unknown.

The atmosphere in the vehicle at the moment of the accident is determined by expert according to the statement of the drivers when available, and by other occupant's and witnesses reports if any. In 27% of the cases, the data was not possible to determinate. It was considered as neutral if no evidence of one of the category was reported, or if the statements report that nothing special was on-going in the vehicle. This comes in the first row with 59%. On-going conversations are the second configuration with 5%, and playing or laughing is reported in 3% of the cases. Another category is that all passengers in the car are sleeping, this happened in 1% of the case. Some cases of fights or violent discussions between adults have also been reported but they are isolated cases. The 5% remaining were coded as other situations and a more in-depth investigation of these cases could be interesting but is not available at this day.

Another point partially link with the previous one was the estimation of the influence of the presence of the child in the following of events ending by accident. Experts have stated that for 90% of cases, children had no influence in the accident story, but they also stated that in 4% of the cases the child is clearly involved in the chain of events ending into the accident and that in other 4% they had potentially influence the driving performance. In 2% of the cases, it was not possible to status due to a lack of information.

The last point that has been studied is the fact that the driver was under time pressure to make the journey, which was the case for only 6% of them.

**Restraint conditions:** The use of restraint systems and the quality of use of these systems while travelling in light vehicles is one of the key point in the definition of ways of progress in child safety studies [6]. Data collections since years are reporting that the number of correctly installed children is very low. Even recent studies stated that this figure is between one quarter and one third, depending on the studies and their relative methods of collection [7].

On the sample of 15536 children, the restraint conditions are unknown for 25% of them, because no indication in the police report can help experts to status on this point. About 6% of the children were not restrained at all; this is not far from the figures obtained in real life observations previously stated as references. For the 69% remaining, experts have coded that restraint systems were used by children, and for 44%, it seems that the restraint system was correctly used. Misuse of restraint systems have been identified for only 2% of children of the sample, which is not close to the real situation. This clearly shows the limitation of the analysis that can be conducted on such detailed points by only using police reports, even if coded by accidentologists. For the remaining 23%, no indication was available to make a decision on the quality of use of the restraint systems.

**Injuries:** Injuries or absence of injury have been coded using the AIS scale for more than 10000 children involved in accidents as light vehicle occupants. This can give a more precise picture than the length of hospitalization used in the official national statistics, as it is based most of the time on medical information reported by hospital or in the statement of parents. The level of protection seems to be already high and 49% of the children have not been injured. 43% other percent receive injuries of a minor level. 6% of the remaining children received moderate injuries. The 2 % remaining received severe, serious, critical or fatal injuries. It is important to focus and these particular children and have a look on the repartition of these injuries of having a high level of severity. Looking at Figure3, it is clear that limbs represent a high percentage of them, but the head that is scoring 20%, the abdomen with 13% and also the chest are vital body segments that need to be better protected.

**Remarkable points between all accidents / fatal accidents:** This paragraph is presenting the main differences between all accidents and the fatal ones in which children are involved as light vehicles occupants. All the following statements on these differences are statistically significant.

First of all, fatal accidents occur for 94% in non-built up area which as to be compared the fact that this proportion is 50% for all accidents. Fatal accidents occur more often than other during the night time (35% versus 22%). Their proportion representing highways is a little bit higher with 20% against 16%, but the main difference in terms of road categories comes from the secondary roads that are two times higher than for non-fatal cases.

Focusing now on the driver, in terms of responsibility in the accident, the ones in fatal accidents have a part of responsibility in 70% of the cases to be compared with the 47% in other accidents. The proportion of drivers with alcohol is twice higher in fatal accidents than for others, and the same observation is done concerning the consumption of drugs. Human factors and more particularly psychological points are different when comparing fatal and non-fatal accidents: the change in family status is 13% in the first case and 5% in the second one. A similar observation is done concerning the professional stability. Drivers involved in accidents being not fatal for children have had a recent change in their professional activity for 5% and for the ones driving a light vehicle in which a child is killed this rate is 16%, which is more than 3 times higher.

Finally when looking at children themselves, two remarkable points: the number of unrestrained children is also different with 6% in accidents versus 22% in fatal cases and the proportion of children that are sleeping is 2% in non-fatal accidents and reach 26% in fatal cases.

**Main countermeasures for fatal accidents:** This part is an extract from the deliverable of the VOIESUR project dedicated to the situation of children fatally injured in road accident as light vehicle occupants [8]. More details are available on the referenced document. Countermeasures can belong to different categories, such as infrastructure, primary or passive safety devices. For the first two, the counter-measures are not specific to child safety but may also apply to all road users. It is important also to mention that multiple proposals could have been made for each accident. For the infrastructure, being not expert in the domain, this value has only been chosen when the infrastructure could have clearly been safer. For example, the separation in the traffic between train, trucks and light vehicles is the best possible solution to avoid collisions between them as there are few chances for car occupants to survive in an accident against a train. More simply to apply, in some cases the mere presence of guardrail could have avoided the vehicle to fall in water or in ravines. For the primary safety, systems based on the communication between cars and infrastructures with the decision of action such as automatic stops in case of a stopped vehicle in front, or arriving at a stop line could be helpful, automatic speed adaptation systems to location or weather conditions could also be beneficial in a large number of cases, and so would be systems keeping a safe distance between vehicles. The other types of systems that could participate to the reduction of the number of children killed in light vehicles are the ones giving information to the driver that something wrong is happening. For example line departure warnings, trajectory control aids and “falling asleep” control systems could be applied in some cases of this study.

In terms of passive safety, looking at the number of unrestrained children in vehicles, it is clear that the use of a restraint system is in this area the first and necessary thing to be done. Then the choice of the appropriate CRS and its correct use are the following step. It seems that these two first points could improve the situation in more than 40% of the fatalities. Once correctly used, restraint systems both on the car and CRS could be improved. Of course some countermeasures for the drivers are also necessary such as reinforcing the law application with regard to alcohol consumption or speeding.

Globally there is a big need of safety information for drivers, to respect the rules in terms of speed, distance between vehicles, and to adapt their driving to conditions. Messages dealing with the use of restraint systems for all car occupants are needed in combination with the message of adapted correctly used restraint systems.

## **Pedestrians**

4696 children have been involved as pedestrians in road accidents in 2011 in France. This represents 15% of the total number of children and 18% of the total number of pedestrians of all ages recorded. The number of children killed as pedestrians represent 26% of the total number of children killed on the road.

The distribution of ages of children pedestrians for all injury severities shows that as soon as they are able to walk, children are involved as pedestrians in road accidents. Their number is stable across the different ages but for the data of 2011 a peak is visible only for the 12 years old children without any evident reason for that.

### **Infrastructure**

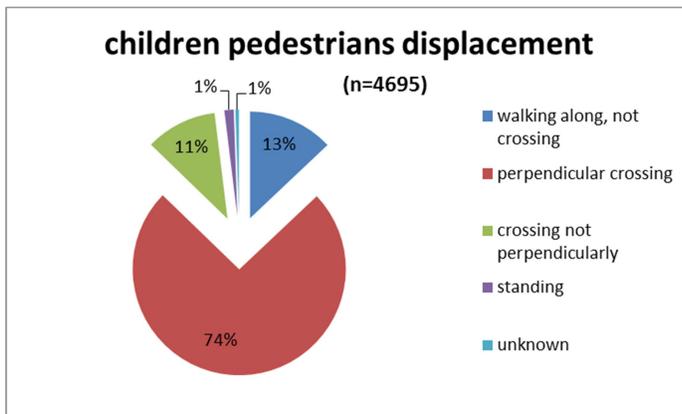
Nearly all accidents of children pedestrians have occurred in built up areas (98%), and mainly during the day time (86%). Night accidents are representing 9% to which 3% that have happened at the dawn or twilight as for the light vehicle occupants.

Concerning the moment to which the accident occurs, there is no big differences between the months of the year, the two first ones being June and April with 13% each and the month with the lower number of accident being July with only 2%. Children pedestrians' accidents mainly took place on the week working days. Week-ends are only counting for 11% of the total. A large part of children pedestrians accidents happened between 4 and 6 pm, a peak is also visible at 8 am. Nearly no accident between 8pm and 8 am.

2/3 of the accidents, took place on primary roads, 30% in smaller streets and 3% on highways. About 1% occurred on other road categories such as private or public parking places.

About 71% of children are impacted by the front of the vehicle and about 22% are in contact with the side of the vehicle. In about 5% children are overpassed by one of the wheel not necessarily with another impact with the vehicle. In 58% of the cases, the child pedestrian is impacted by a light vehicle. The second category of opposite vehicles is motorbikes that are surprisingly involved in 27% of the accidents of pedestrian children. Heavy vehicles come third with 10%, and bicycles are representing 2%. The 3% remaining belongs to the category "other vehicles".

Figure 4 shows the distribution of the children's actions when the accident happened. About ¾ of them were simply crossing the street perpendicularly. To this it is necessary to add another 11% that were crossing not necessary perpendicularly which make this action at the top place with 85%. For children crossing the road, in 44% of the cases, it was noted that the child was crossing on a crosswalk, but in 47% it was coded that the child was crossing outside of cross walk. The data is unknown for the remaining 9%. This underlines that there is still a need of education for children to cross in fit areas. 13% of the children were walking along the street or road and have been impacted by an incoming vehicle and 1% of the children were just standing.



**Figure4: distribution of the displacement of the children pedestrians at the moment of the accident**

**Human factors** As for all accidents of the VOIESUR database, the responsibility of all parts involved in road accidents have been established by expert, based on the infrastructure configuration, the behaviour and actions of each part. As results it appears that children have been considered as the most responsible part in 49% of the cases, to which 6% have to be added for shared responsibility. It is important to look then at the children's activity when the accident occurred and on the journey they were doing. For that, one variable available in the database gives indication of the speed of the pedestrian at the moment of the impact. This data is unknown for 12% of the children but in 50% of the accidents, children were running while 31% were walking. In the 7% missing, the data has been coded as other, which can indicate that the child was not moving, or was trying to catch something under a car, or hidden in a game...

For 16% of them children have been coded as escaping from the vigilance of an adult. This shows the important not only to deliver safety messages to children but also to the accompanying people. It has to be underline that 90% of them are under 6 year old.

In terms of “journey”, child pedestrian accidents happened for 38% in a leisure activity and for 32% on their way from home to school or back. In 11% the variable is coded as other, 6% were going shopping, 3% were on their way to visit their family and this data is unknown for 10% of the cases.

**Injuries** 9% of the children have been over passed by the vehicle that is involved in the accident, 5% without any other impact, the others having being first impacted and then overpassed. The recording of injury severity using the AIS98 code has allow to have an overview of the severity of all children pedestrians involved in road accidents. Very few children are reported as not injured (only 2%) but the level of injury severity is unknown for 40% of the children. In this category all fatal accidents without autopsy are counted but also all the cases for which no medical data was available in the police report, very often because the injury severity if any if very low. This is confirmed when looking at the Figure2 for which the rate of lightly injured is 61% to which a large number of cases from the category of “injured NFS” that is scoring 20% could be added. For moderate and severe injuries, that are globally more reported in the police documentation, injuries of AIS2 level represent 13%, the ones of AIS3, 7% and the ones of AIS4, 2%

A distribution of AIS 3+ injuries across the body segments has been done to determine priorities in terms of protection for children as pedestrians based on the road reality. The sample is composed of 597 AIS3+ injuries, among which the most commonly body segment is lower limbs with 56%. It is followed by the chest with 22% and then by the head with 10%. The spine is representing 6%, upper limbs 5% and the abdomen about 1%.

**Remarkable points between all accidents / fatal accidents** As for the light vehicle occupants, this paragraph intends to show the biggest difference between accidents of all severities with children and the fatal ones. For pedestrians, there are more similitudes than differences for the infrastructure, the light, the fact that half of the children are running.

The repartition between the accident locations is a little bit different between all children pedestrian accidents that happen for 98% in built-up areas to be compared with 88% “only” for fatal accidents.

The order in the distribution of the pedestrian displacements is totally different. For fatal accidents, crossing not perpendicularly reaches 68% instead of 11% while perpendicularly is representing 4%, instead of 75% for all accidents. A bigger proportion of static pedestrians is also visible in the fatality sample with 16% versus 1%. The proportion of children that have been over passed is far higher in the fatality cases for which this injury mechanism represents 44% of the sample while it is only 9% when considering the totality of accidents.

**Main countermeasures for fatal accidents:** this part is an extract from the deliverable of the VOIESUR project dedicated to the situation of children fatally injured road accident in the section pedestrians [8]. Educational programs are needed: to change their general behaviour while being on the road is not a game place, and that you need to cross without running and after having check that no vehicle is coming. Some infrastructure could also be arranged: to slow down the speed of vehicles at crossing points would be effective; manage a clearer area so the vision of drivers could be better at pedestrian crossing points. This will be effective only if children are using these points to cross the street. To better arrange sidewalks in a way that it is only possible to cross the streets at given points. Solutions proposed on the infrastructure side can be combined for a better efficiency and would not only be profitable for children, but for all pedestrians. In addition, the detection of vulnerable road users is now becoming more common on vehicles but collision avoidance systems will only be effective if children (cyclists or pedestrians) are not hidden. The proportion of children being over passed by the vehicle in the sample of fatally injured children is 44%, and for them, no passive safety action is possible.

## **Cyclists**

5472 children have been involved in a road accident as cyclists in France in 2011. This makes the cyclists being at the second user category with 17% of the total number of children the road accident. By cyclist it is understood that the children were riding the bicycle. The number of children fatally injured in the sample is 11 that are representing 11% of the total number of children killed.

The youngest child in the sample is 4 year old but the number of children cyclists becomes more consistent after 8 years of age and regularly increase with the age from that point.

### **Infrastructure**

Nearly all (99%) of the children cyclist accidents happened in built up areas, and during the daylight period. Looking at road categories, most of the accidents occurred on primary roads (68%) and 31% on secondary roads, the last 1% occurred on roads of other types. It has to be noticed that the presence of intersection has been coded for 84% of the cases. In 91% of cases children were going straight even at intersections, in 7% of the cases they intend to turn, but not necessary at intersections! 77% of cyclists have been involved in a frontal impact, 22% impacted on their side.

The light vehicles represent the first kind of obstacle, followed by heavy vehicles and fixed obstacles.

### **Human factors**

Children cyclist accidents are concentrated around April, May and June. They also happened more on Saturdays and Wednesdays which are days without school for children younger than 14 years of age. The proportion of accidents also recorded on Sundays is not negligible. All accidents happened between 11am and 9pm.

The journeys that children were doing are distributed as follow: visit to family comes at the first row with 93%, far behind come leisure activities with 3%, going or coming back from school only represent 1%, and shopping is at the same level with also 1%. The data is unknown for 2%.

Experts have coded the responsibility in the happening of the accident of the children as vulnerable road users and of the driver of the opposite vehicle for every accident case. 3 levels of responsibility have been defined: full, share, and none. Of course this is subject to interpretation bias but in the case of accidents of children on bicycles, the information is considered as reliable as accident scenarios were not too complex. Children on their bicycles have been found to be fully responsible in 96% of the cases, the responsibility was shared with another part in 1% of the cases and in only 3% the children were considered as not responsible at all.

**Protection** In France, the use of a helmet is only mandatory for riders of motorized two wheels. Cyclists are not included in this category and can therefore ride without any helmet. The only obligation for them is to wear reflecting jacket if they ride by night outside of urban areas. Bicycle helmet legislation appears to be effective in increasing helmet use and decreasing head injury rates in the populations for which it is implemented. However, there are very few high quality evaluative studies that measure these outcomes [9, 10]. Nevertheless, it is highly recommended by authorities to use a homologated helmet when cycling [11], especially for children as in half of their falls injuries to head occurred. Even if this seems to be an appropriate protection device, helmets approved for cycling are recognized to be efficient for falls up to 20 kph. Children are normally not riding very fast compared to adults but this could limit the number of cases for which helmets are useful. The proportion of children using a helmet in the sample is 8%, and the proportion not wearing any is 84%. The data is unknown for the remaining 9%. It is not possible to measure any efficiency of the system due to the low sample of children wearing protecting device.

**Injuries:** As for other road user categories, injuries have been coded using AIS98 code. None of the cyclists in the sample are uninjured, 85% only sustained light injuries, 10% received moderate injuries. Children cyclists seriously injured counts for 1%, the level of injury is unknown for 4% of the children.

As visible on Figure3, the repartition of the serious injuries (AIS3+ level) indicates that the lower limbs is the most often seriously injured body segment with 61%. Then comes the head with 25%, the chest with 12% and finally the abdomen with 2%.

**Remarkable points between all accidents / fatal accidents:** This paragraph is presenting the main differences between all accidents and the fatal ones in which children are involved as cyclists. All the following statements on these differences are statistically significant.

The main difference is the location of the accident that is occurring only for 44% at intersection for fatal accident while it happens 84% for all cases.

None of the children involved in the fatal cases was wearing a helmet. This has led to a case by case analysis of the cases concluding that a very limited benefit of helmet would be expected on the sample of fatal cases.

**Main countermeasures for fatal accidents:** this part is an extract from the deliverable of the VOIESUR project dedicated to the situation of children fatally injured road accident in the section cyclists [8].

Educational programs are needed: for children to better behave when riding bicycles and a need of awareness of for parents on the fact that their children are not necessary ready to be left alone in the road traffic.

To improve the visibility of the children on their bikes would allow a better prevention of their behaviours for other road users. It is known that separating road users ones from the others is one of the safest solution: it is necessary to encourage the development of dedicated infrastructures for riding bicycles with crossroads infrastructures specific for bicycle. In addition, as for pedestrians, the detection by vehicles of cyclists using Intelligent Technical Systems would also limit the number of fatalities of cyclists and by the way of children cyclists. Considering children killed on their bicycles it has to be remind that they are nearly all perpendicular to the opposite vehicle trajectory.

### **Powered Two Wheels passengers**

The number of children present as PTW passengers in the database is equivalent to 624 children that have been involved in 2011 in France. No fatality of children has been recorded as PTW passenger in the year 2011. The youngest children are 6 years old and it seems that the tendency of implication is growing with the age of children. Looking at the type of the vehicles on which children are passengers, the sample is composed about a little bit more than 1/3 by mopeds, the others being motorcycles. 30% of the PTW are fitted with engine lower than 50cc, 46% have an engine that is between 50 and 125cc, 15% are on motorbikes with an engine bigger than 125cc. The size of the engine is unknown for 9% of the cases.

**Infrastructure:** 95% of the accidents in this category happened in build-up areas. 78% mostly during the daytime, dawn and twilight represent 15% of the cases and 6% happened during the night time.

Looking at the road categories, there is a good balance between primary and secondary roads. The majority of collisions with PTW took place at intersections. Finally, concerning the opposite obstacle, it is very often another vehicle, light vehicles coming at the first row. Impacts against fixed obstacles count for 10%.

**Human factors:** Experts have coded the responsibility in the happening of the accident of the drivers of the PTW riding with children. The same levels as for the other children road users categories are used in this section. Globally the balance between responsible or not clearly goes for not responsible in the case of accident with children passengers of PTW. The distribution of the type of journey, when known, shows that leisure and rides come first, and that visit to family or friends is at the second row. Shopping is very far behind and no accident riding to or from school was registered.

**Protection use:** 91% of the children of the sample are wearing a helmet when being transported on a PTW. It has to be noticed that for 9% of them the helmet is not attached to the head and the data is unknown for the last 9%. Due to the low number of children on PTW with injuries, it is not possible to compare the situation of children travelling with and without helmets.

**Injuries:** Injuries, when known have been coded using the AIS scale. Very few AIS3+ injuries have been noted, and only 13% of the children involved in such accidents are uninjured, but the number of children that have being staying in hospital less than 24 hours is 79%. The seriously and severely injured children represent 4% of the

sample and the injury severity is not known and cannot be estimated for the last 4%. Results have to be taken with a lot of caution as the original number of children is not very high.

### **Bus and coach occupants**

**General data on buses and coaches:** The definition used in the analysis is the same as the one used in the French National data: buses are city buses in which you can either be seated or be standing. Coaches are vehicles in which only seated passengers can be transported and since 2009 have to use a restraint system if the vehicle is equipped. Transportation of children to school in France is done by bus inside the big city and their close suburbs but in rural areas, it is normally done using coaches. In the VOIESUR database, for buses and coaches, 6606 occupants of all ages are present. Frontal impact is first impact type with more than 40%, followed by side impact about 30%. Rear collision scores 15% of the total and surprisingly roll-overs only represent 2%. For frontal impact, most of the time, the accident severity, coded in EES (Equivalent Energy Speed) in the database is not known.

The projection at national level for children is 311. This represents 2% of the total number of children involved in road accident in a year. Of course, the number of accident with such vehicle can show fluctuation from one year to another one, so conclusions are only valid for the year 2011. What is remarkable in this year is that no fatality of children in buses and coaches has been observed in France. In addition, it can be noted that there is no child under the age of 4 in the sample. Children in the following analysis are all between 4 and 14 years of age.

#### **Infrastructure:**

A very large proportion (93%) of buses and coaches accidents with children on board happened in built-up areas, and for 97% during the day. They took place on primary roads for 85%.

The typology of accidents for the buses and coaches are globally at low severity. Some of them were against pedestrians that represent no real physical impact for the bus occupants. In other cases, some children standing in the vehicle felt down on the door and were ejected without any impact of the bus, but just during a steering manoeuvre. Some frontal cases are reported but most of them have a very low EES (Equivalent Energy Speed) which means that their occupants are submitted to relatively low loads. Very few cases with a EES over 15 kph, are part of the sample. That's the main reason why it has not been possible to study the efficiency for children of restraint systems in such vehicles. For that a sample big enough containing restrained and non-restrained children in different crash scenarios is needed. May be the VOIESUR database is one of the brick to build the scientific knowledge on this point, but the project itself cannot bring any conclusion on that point.

**Injuries:** Children from 4 to 11 are all uninjured or are slightly injured only, no severe injury was observed for this age group. For children from 12 to 14 years, the sample contains different levels of injuries and a part of non-injured children. The injury severity for all children involved in accidents as bus or coach occupants has been coded using the AIS code version 1998. This parameter is known for 91% of the children of the sample. 59% of them are uninjured, and 20% only sustained AIS1 level injuries (cuts, skin abrasions, contusions,...). Severe AIS3 injuries have been observed on lower limbs, but no cerebral injury, chest fracture, spine injury or abdominal injury has been reported.

### **CONCLUSIONS**

It is difficult to consider a global road child safety message as children involved in road accidents belongs to different kind of roads users in which they do not have the same level of responsibility. Children are globally not able to take decision by themselves to properly behave in the road traffic. That's an additional reason for them to be treated as vulnerable road users. But when adults are deciding for children as for example in cars, it is clearly shown that the way children are protected is not satisfying mostly because the restraint systems are not adapted or not correctly used.

Globally, children involved in road accidents are for a large proportion not injured or slightly injured but the proportion of severely injured is sometimes over 10% as for pedestrians. The type of severe injuries that can be sustained by children is linked to the category of road user as reminded on Figure3. In the VOIESUR sample, a

large proportion of severe injuries has been attributed to the lower and upper limbs. This is somehow surprising as this is not necessary the conclusions issued from the CASPER accident database [12] that was orientated to biomechanical works research and for which the data collection was not representative of the road reality. Nevertheless, it appears that to improve the protection of children the head is always an important body segment whatever the type of road user, that for pedestrians it seems important to consider the chest while for car occupants, the abdomen seems also to be one of the priorities.

Works on the infrastructures are possible but it has to be reminded that children's road accidents do not occur in the same locations, especially the ones leading to severe injuries or fatalities. This would be helpful to focus on pedestrians and cyclists in cities and on the communication that is forwarded to both parents and children in order that they improve their behaviour while walking or riding in the streets. For children car occupants, the most urgent points to improve the situation are the improvement of the quality of use of the restraint systems and the protection of vital body segments such as the head and the abdomen.

This study has some limitations because of the use of weighting factors calculated for each child. This is helpful when considering the complete data set but it can become a bias when working on selection of data in which one of the children is representing a large proportion of the total. In addition, this study is limited in terms of the size of the sample because it contains only one year of data collection, which is representing a large amount of data but relatively few for each category of road users. In addition, a multi-annual data collection would allow to eliminate the bias of exceptional events that are may be in the sample, and some other rare configurations that are not there. One speaking example could be a coach accident with multi fatality of children. This would completely change the picture compared to the one of the VOIESUR data set. This study has shown a picture that it representative of the situation of accidents with children in France compared them as different types of road users, and have brought data to construct ways of progress.

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## REFERENCES

- [1] Léopold & al. 2013. "VOIESUR: Analysis of all children's fatal road accidents in France in 2011" 11th Conference of child safety in cars (Munich 2013)
- [2] Léopold & al . 2012. "VOIESUR: Focus on child safety specificities" 10th Conference of child safety in cars (Munich 2012)
- [3] The Abbreviated Injury Scale – AIS, version 98
- [4] Amoros &al. 2014. "VOIESUR: L3 "Methodology Data recovery and extrapolation" ANR project reference: ANR-11-VPTT-0007
- [5] Langlois & al. 2012. "D3.1.1 Report on Social approach of Child Safety" CASPER project – FP7 – GA218564
- [6] Lesire & al. 2010. "D1.2-2 –Misuse effect analysis – Results of dynamic testing program" CHILD project – FP5 - G3RD-CT-2002-00791
- [7] Muller& al. 2012. "D3.1.2 –Report on misuse and relative tests" CASPER project – FP7 - GA218564
- [8] Lesire &al. 2014. "VOIESUR: L4.6.1 Report on the children fatally injured on the road" ANR project reference: ANR-11-VPTT-0007
- [9] Macpherson & al. 2008 « *Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries* » Cochrane Database of Systematic Reviews, no 3
- [10] Swedish official data 2009 – "Målstyrning av trafiksäkerhetsarbetet – Analys av trafiksäkerhetsutvecklingen"
- [11] <http://www.economie.gouv.fr/dgccrf/Publications/Vie-pratique/Fiches-pratiques/Casque/>
- [12] Kirk & al. 2012.DEL CASPER accident database analysis CASPER project – FP7 – GA218564