A CRITICAL ASSESSMENT OF INTERSECTION SAFETY ACROSS EUROPE

Constantinos Antoniou[1], George Yannis[1], Petros Evgenikos[1],

Jackie Knowles[2], Jeremy Broughton[2] and Alan Kirk[3]

[1] National Technical University of Athens, Greece

[2] TRL, UK

[3] Loughborough University, UK

Abstract

Intersections are a critical part of the European road network, representing a small fraction of its overall size, but concentrating more than a fifth of the fatalities. More than 82.000 persons were killed in traffic accidents at junctions in 18 European Union countries between 1999 and 2008. In these 18 countries there were 30% fewer traffic accident fatalities at junctions in 2008 than in 1999. The objective of this research is the analysis of road safety related parameters in European road junctions through the use of the EU CARE database with disaggregate data on road accidents as well as of other international data sources (OECD/IRTAD, Eurostat, etc.). Time-series data from 23 EU countries over a period of 10 year (1999-2008) are correlated with basic safety parameters, such as junction geometric design, vehicle type, area type and gender of the driver. Additional insight into accident causation is offered through the use of in-depth data from more than 1000 accidents. The results of the analysis allow for an overall assessment of the road safety level in the European road junctions in comparison to the remaining road network, providing thus useful support to decision makers working for the improvement of safety in the European road network.

Keywords Intersections; Road accident data; Road safety; European countries

Introduction

Intersections are a critical part of the European road network, representing a small fraction of its overall size, but concentrating more than a fifth of the fatalities. Therefore, there is a clear interest for the analysis of road safety at intersections. The analysis of safety at intersections is hardly a new topic (see e.g. [1,2]), but this paper presents and critically assesses a wealth of macroscopic data that provides an up-to-date comprehensive view on the diversity of road intersection safety in the various European regions. The analysis can be used to develop strategies for the decision support of targeting infrastructure improvements so that they will be most effective (e.g. along the lines of efforts in Europe [3] and the US such as [4-7]).

The objective of this research is the macroscopic analysis and the critical assessment of road safety related parameters in intersections in the European road networks, using data from the EU CARE database with disaggregate data on road accidents, together with data from other international data files (e.g. IRTAD, as well as national sources). In particular, road accident data on intersections for a period of ten years (1999-2008) and 22 EU countries are correlated with basic safety parameters like the type of junction and the vehicle type. Additional insight into accident causation is offered through analysis of a set of in-depth data, collected using a common methodology for samples of accidents that occurred in Germany, Italy, The Netherlands, Finland, Sweden and the UK. The data, on which this analysis is based,

along with much of the analysis, is obtained through the SAFETYNET and DACOTA EC co-funded research projects and the European Road Safety Observatory (ERSO).

The paper is structured around the following main sections. An introductory section includes an outline of the overall trends in numbers of fatalities at intersections in the context of the overall evolution of traffic fatalities over a period of 10 years (from 1999 until the year of the latest available data, usually 2008). In the next section, the distribution of traffic accident fatalities by type of intersection is presented, while in the next section the number of fatalities by country is related to characteristics, such as the type of area in which the intersection is situated, the transport modes used by the involved persons and their basic socioeconomics characteristics. A section providing insight on accident causation in junctions based on the analysis of in-depth data follows. A concluding section integrates the main observations.

Overall trends

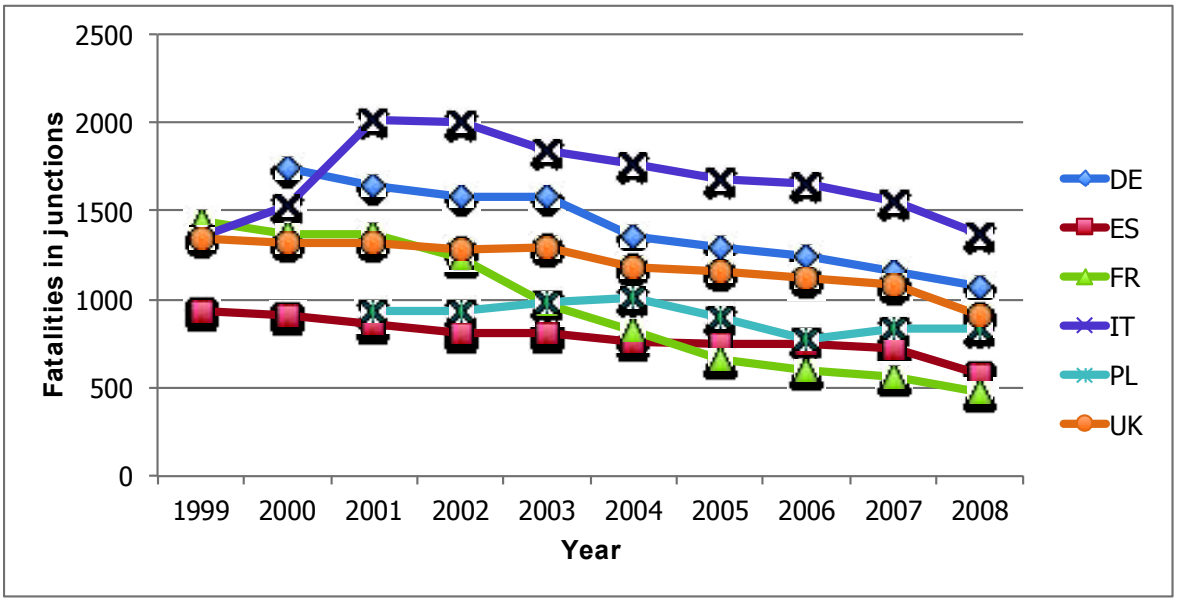
More than 82.000 persons were killed in traffic accidents at junctions in 18 European Union countries between 1999 and 2008. In these 18 countries there were 30% fewer traffic accident fatalities at junctions in 2008 than in 1999. The number of traffic accident fatalities at junctions increased by 5,4% in 2001 compared to 2000, whereas the overall number of fatalities fell by 1,8%. This increase is mainly attributed to Italy where accidents at junctions increased by 34%, although the total number of fatalities rose only by 0,6%. The proportion of fatalities in junctions over total fatalities has been steady at 21-22%.

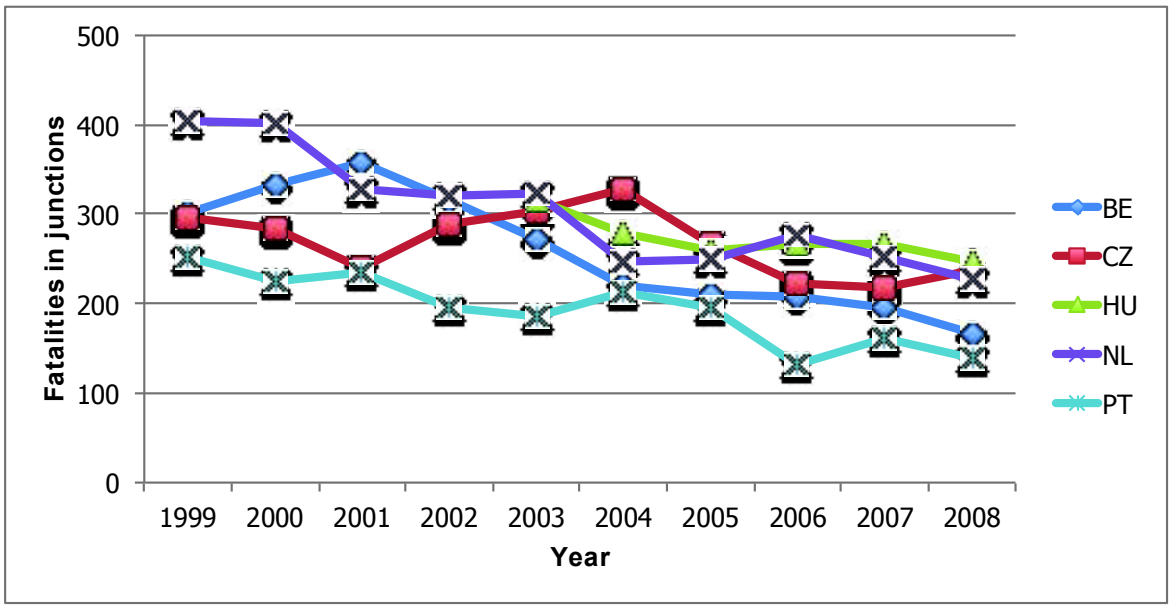
It should be noted that the analysis of samples of accident statistics becomes more difficult when one considers that for a large number of the accidents, specific information on key conditions, such as location, is often missing. For example, the following countries had a high proportion of "unknown" entries between 1999 and 2008: IE (82%), SE (41%), DE (39%) and AT (27%) (Source: CARE Database / EC; Date of query: October 2010).

Figure 1 shows the overall trend for fatality data in junctions for individual countries. Note that for certain countries the actual numbers are somewhat higher than the reported numbers because it is unknown whether or not a significant number of accidents occurred at a junction.

Distribution of traffic accident fatalities by type of intersection

The term "junction" can have a very broad range and include different configurations, or even definitions. In this section, definitions for the various types of junction configurations for each country are outlined and the number of fatalities by each type per country is presented. Table 1 presents the number of fatalities by type of junction by country for the year 2008. Like many road safety statistics, statistics related to junction road accidents should be read carefully due to the presence of a high proportion of "unknown" entries in specific countries (e.g. AT, EE, IE, MT, PT, SE), which might affect the percentages presented. Two (extreme) values are presented in the rightmost columns of Table 1 for the percentage of fatalities in accidents occurring at intersections: the minimum includes only fatalities at accidents that are known to occur at intersections and the maximum including also all fatalities at accidents with unknown location (i.e. that may or may not have occurred at intersections). The true number should lie within that range.





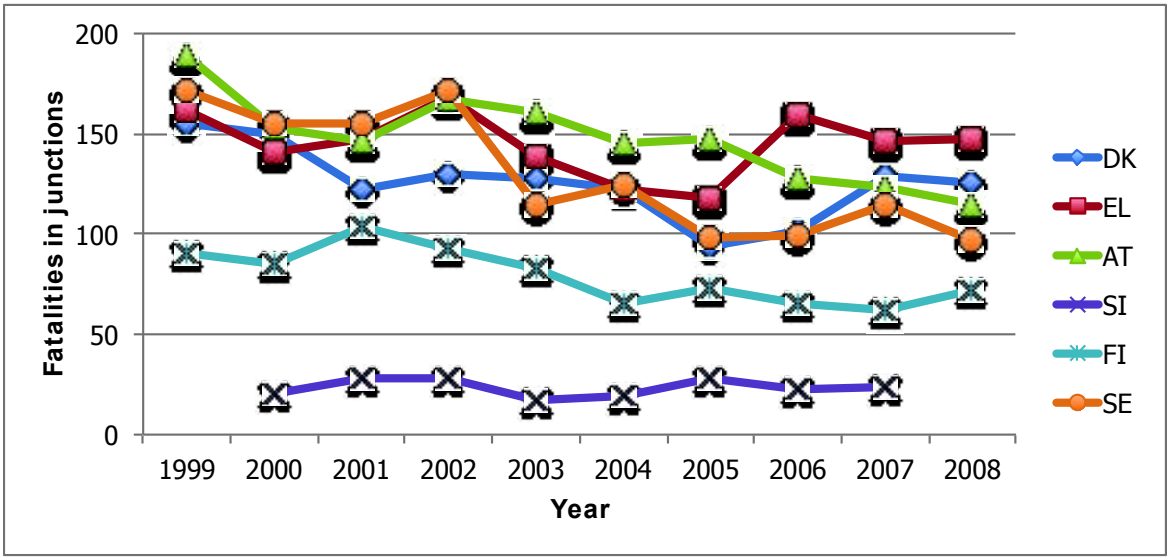


Figure 1: Number of fatalities in junction accidents per country, 1999-2008 (the country abbreviations are listed in the Appendix).

The definition of a junction is that of a road intersection with three or more arms and which is not grade separated. It includes the following categories: T-junction, Y-junction, crossroad (road intersection with four arms), railway level crossing (except for DK, FI, GB, NI), roundabout (circular highway, in some cases, i.e. GB, IE, NI, AT, includes sections of the road leading into it within 20m) (except for FR) and multiple junction.

Fatalities are classified as not being at a junction if their position is on a road more than 20m from a junction or roundabout (GB, IE, NI, NL, AT), or more than 50m from a junction (FR). For the other countries the classification is based on the opinion of the police officer who filed the report.

While the lack of exposure data, or even data on the number of each of the junction configuration, are not available, some observations can be made. For example, roundabouts seem to have a low number of fatalities; a finding consistent with prevailing expectations and the state-of-the-art (e.g. [8,9]).

Table 1: Number of fatalities in junction accidents, by type of junction per country, 2008

	Accidents at junctions					Accidents not at junctions	Not known	Total	% at junctions	
	Cross road	T or Y Junction	Round-about	Railway Level Crossing	Other/ Unknown				min	max
BE	0	0	5	1	161	777	0	944	18%	18%
CZ	101	108	0	28	1	836	2	1,076	22%	22%
DK	58	0	2	3	63	279	1	406	31%	31%
DE	906	0	0	63	148	1.561	1,799	4,477	25%	65%
EE	12	20	0	0	6	91	3	132	29%	31%
IE	15	23	2	0	2	0	238	280	15%	100%
EL	0	0	0	0	147	1.406	0	1,553	9%	9%
ES	203	216	66	0	92	2.523	0	3,099	19%	19%
FR	189	128	41	30	87	3.8	0	4,275	11%	11%
IT	604	0	87	6	675	3.359	0	4,731	29%	29%
LV	0	0	0	0	20	285	11	316	6%	10%
LU	0	0	0	0	8	27	0	35	23%	23%
HU	196	0	0	40	10	750	0	996	25%	25%
NL	193	0	11	16	7	450	0	677	34%	34%
AT	75	23	2	15	0	410	154	679	17%	40%
PL	823	0	7	42	0	4.565	0	5,437	16%	16%
PT	50	68	8	8	6	713	32	885	16%	19%
RO	230	0	0	39	0	2.792	0	3,061	9%	9%
SI*	24	0	0	0	0	260	9	293	8%	11%
SK	33	35	2	0	0	528	8	606	12%	13%
FI	0	0	0	0	72	271	1	344	21%	21%
SE	85	0	1	0	11	5	295	397	24%	99%
UK	145	511	55	0	196	1.738	0	2,645	34%	34%
EU-23	3.942	1.132	289	291	1.711	27.425	2,553	37,344	2%	8%
Share	11%	3%	1%	1%	5%	73%	7%	100%	21%	28%

* data for 2007

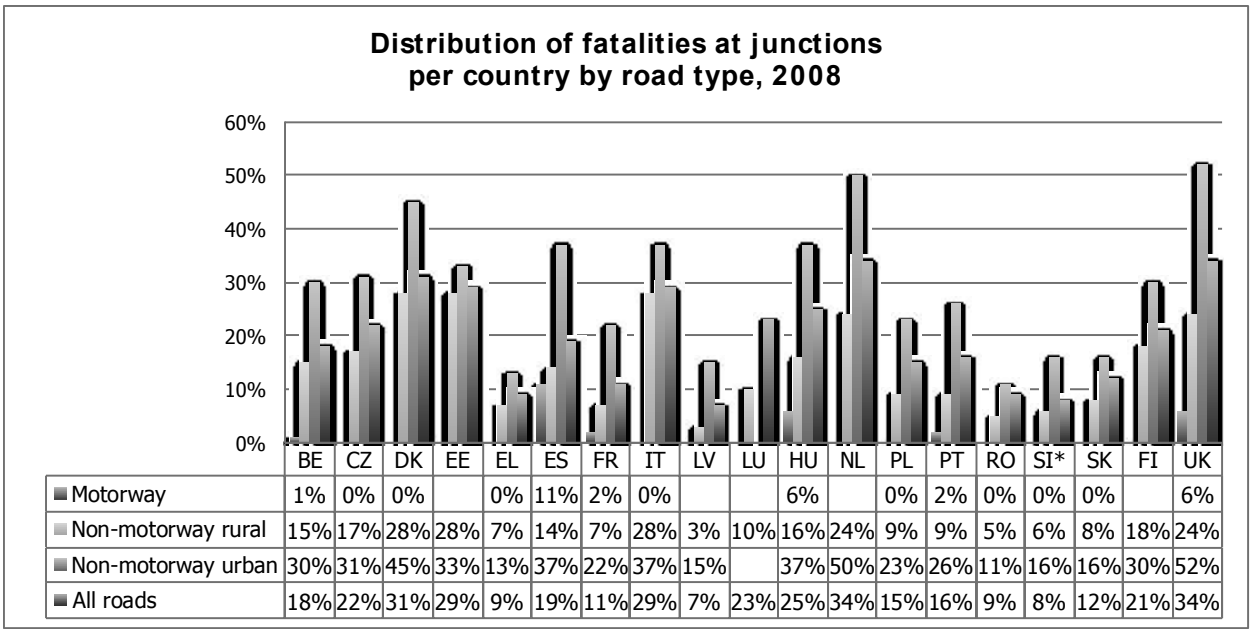
Source: CARE Database / EC

Date of query: October 2010

DISTRIBUTION BY DIFFERENT CHARACTERISTICS

Type of Road

Figure 2 shows the percentages of fatalities at junctions (over all fatalities) in various types of roads. As expected, road accident fatalities at junctions occur mostly within urban areas. Actually, in countries with higher road safety standards, about half of the fatalities from traffic accidents take place at junctions (NL: 50%, UK: 52%). Considering that a small fraction of the network consists of junctions, these ratios may suggest that these accidents are among the most difficult to prevent, even when accidents throughout the rest of the network have been considerably reduced.

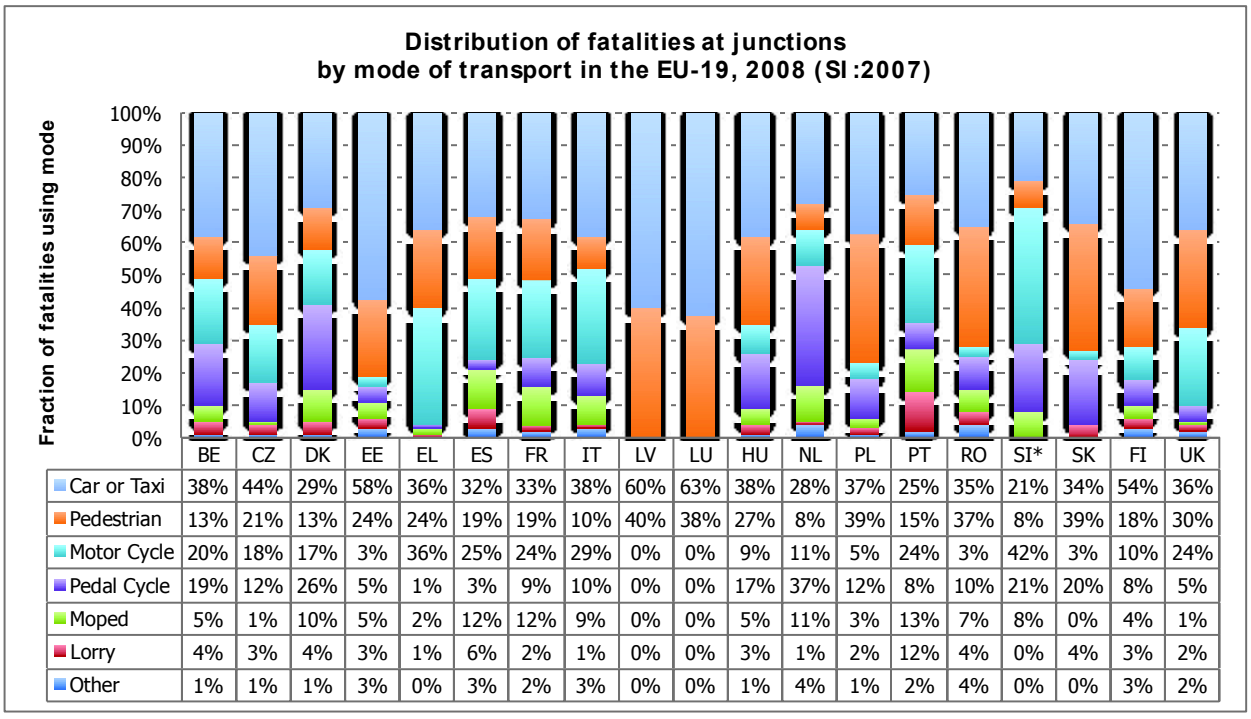


	BE	CZ	DK	EE	EL	ES	FR	IT	LV	LU	HU	NL	PL	PT	RO	SI*	SK	FI	UK
Motorway	1%	0%	0%		0%	11%	2%	0%			6%		0%	2%	0%	0%	0%		6%
Non-motorway rural	15%	17%	28%	28%	7%	14%	7%	28%	3%	10%	16%	24%	9%	9%	5%	6%	8%	18%	24%
Non-motorway urban	30%	31%	45%	33%	13%	37%	22%	37%	15%		37%	50%	23%	26%	11%	16%	16%	30%	52%
All roads	18%	22%	31%	29%	9%	19%	11%	29%	7%	23%	25%	34%	15%	16%	9%	8%	12%	21%	34%

Figure 2: Distribution of fatalities at junctions per country by road type, 2008

Mode of Transport

Figure 3 visualizes the distribution of fatalities at junctions by mode of transport in 19 European countries for the year 2008. Several observations can be based on this data. For example, in several countries (LV, LU, PL, RO, SK) the number of pedestrian fatalities at junctions is very high (between 37% and 40% of all pedestrian fatalities occur at junctions). Additionally, in Portugal the number of lorries occupants' fatalities at junctions is four times higher than the EU-19 average (12% compared to 3% for EU-19) and thus considerably higher than the respective rate in all other considered countries. In some countries (Italy, Portugal) the percentage of two-wheeler fatalities at intersections exceeds 45%, while in Denmark and the Netherlands it reaches 53% and 59% respectively and in Slovenia it exceeds 70%. It is noted that in this analysis the variation in the use of each mode across countries is not considered. This information could provide further helpful insight, by demonstrating what share of the fatalities per mode are due to an increased usage of that mode or some other pertinent characteristics of the country in question.



	BE	CZ	DK	EE	EL	ES	FR	IT	LV	LU	HU	NL	PL	PT	RO	SI*	SK	FI	UK
Car or Taxi	38%	44%	29%	58%	36%	32%	33%	38%	60%	63%	38%	28%	37%	25%	35%	21%	34%	54%	36%
Pedestrian	13%	21%	13%	24%	24%	19%	19%	10%	40%	38%	27%	8%	39%	15%	37%	8%	39%	18%	30%
Motor Cycle	20%	18%	17%	3%	36%	25%	24%	29%	0%	0%	9%	11%	5%	24%	3%	42%	3%	10%	24%
Pedal Cycle	19%	12%	26%	5%	1%	3%	9%	10%	0%	0%	17%	37%	12%	8%	10%	21%	20%	8%	5%
Moped	5%	1%	10%	5%	2%	12%	12%	9%	0%	0%	5%	11%	3%	13%	7%	8%	0%	4%	1%
Lorry	4%	3%	4%	3%	1%	6%	2%	1%	0%	0%	3%	1%	2%	12%	4%	0%	4%	3%	2%
Other	1%	1%	1%	3%	0%	3%	2%	3%	0%	0%	1%	4%	1%	2%	4%	0%	0%	3%	2%

Figure 3: Distribution of junction fatalities per country by mode of transport, 2008

Age and Gender

An analysis of the CARE data from the EU-19 countries in 2008 provides insight into whether the incidence of fatalities in junction accidents varies with age and gender. An analysis of the distributions of junction and non-junction fatalities reveals that 27% of fatalities in junction accidents were female, compared with 22% in non-junction accidents.

Figure 4 shows the proportion of the total road accident fatalities occurring at junctions, stratified by gender and age group. Overall, Figure 4 indicates that 15-17 year old males and the elderly (at least 65 years) are more likely than others to be killed at a junction.

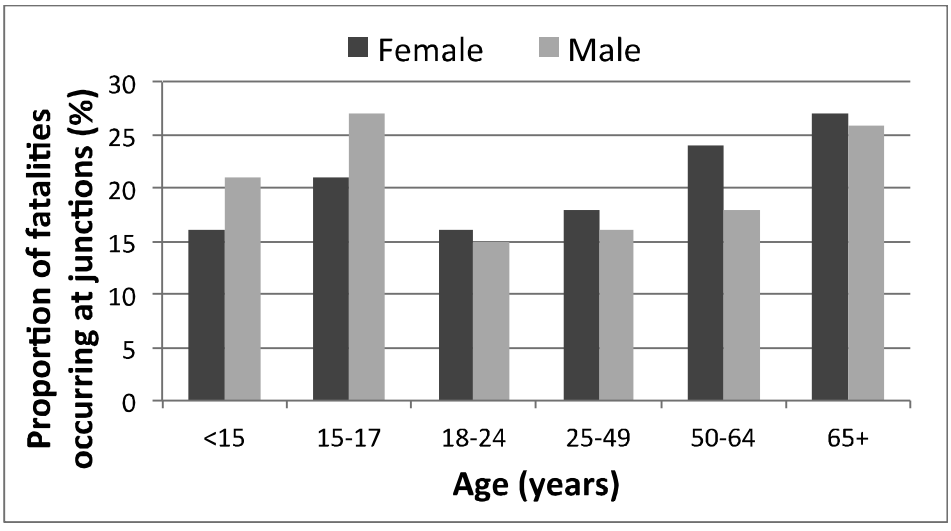
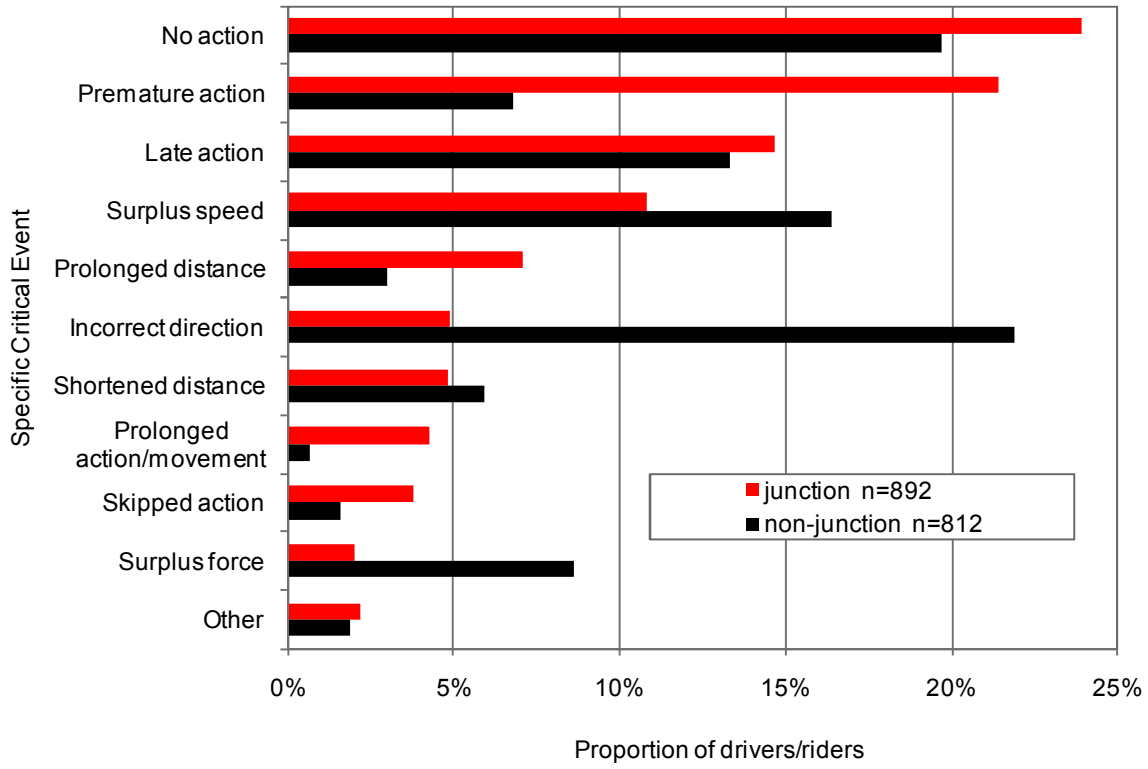


Figure 4: Distribution of junction fatalities by age and gender, EU-19, 2008 (2007 for SI)

Accident Causation

Additional insight into accident causation can be offered by in-depth data, such as those collected during the EU co-funded SafetyNet project. During that project, in-depth data were collected using a common methodology for samples of accidents that occurred in Germany, Italy, The Netherlands, Finland, Sweden and the UK [10,11]. The SafetyNet Accident Causation Database was formed between 2005 and 2008, and contains details of 1.006 accidents covering all injury severities. A detailed process for recording causation (SafetyNet Accident Causation System – SNACS) attributes one specific critical event to each driver, rider or pedestrian. Links then form chains between the critical event and the causes that led to it. For example, the critical event of late action could be linked to the cause observation missed, which was a consequence of fatigue, itself a consequence of an extensive driving spell.

In the database, 48% (483) of the accidents occur at junctions. Figure 5 compares the distribution of specific critical events for drivers and riders in junction accidents to those in non-junction accidents.



Source: SafetyNet Accident Causation Database 2005 to 2008 / EC

N=1704 Date of query: 2010

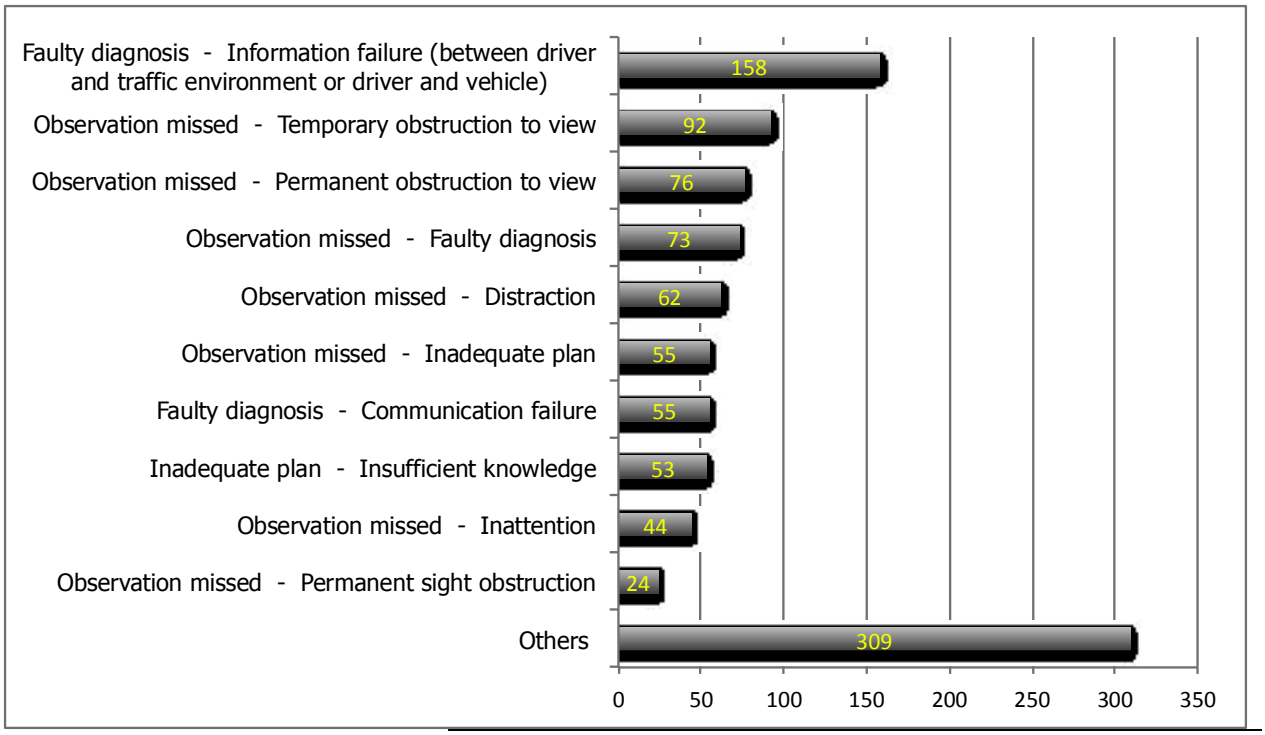
Figure 5: Distribution of specific critical events - drivers or riders by junction presence

The distributions are quite different for the most often recorded specific critical events. The specific critical events under the general category of 'timing', no action, premature action and late action, are recorded more frequently in junction accidents, especially acting prematurely. A premature action is one undertaken before a signal has been given or the required conditions are established, for example entering a junction before it is clear of other traffic.

On the other hand, incorrect direction, surplus speed and surplus force are recorded more frequently in non-junction accidents. Surplus speed describes speed that is too high for the conditions or maneuver being carried out, travelling above the speed limit and also if the driver is travelling at a speed unexpected by other road users. Similarly, surplus force describes excess acceleration or braking for conditions or actions. Incorrect direction refers to a maneuver being carried out in the wrong direction (for example, turning left instead of right) or leaving the road (not following the intended direction of the

road). Here it is likely that the wrong direction element will appear in junction accidents and the leaving road element in non-junction accidents.

Figure 6 gives the most frequent links between causes for drivers/riders in junction accidents. For this group there are 1.001 such links in total. "Observation missed" is recorded most frequently and the causes leading to it can be seen to fall into two groups: physical 'obstruction to view'-type causes (for example, parked cars at a junction) and human factors (for example, not observing a red light due to distraction or inattention). The second most frequent cause, faulty diagnosis reflects an incorrect or incomplete understanding of road conditions or another road user's actions. It is linked to both information failure (for example, a driver/rider thinking another vehicle was moving when it was in fact stopped and colliding with it) and communication failure (for example, pulling out in the continuing path of a driver who has indicated for a turn too early). Inadequate plan (a lack of all the required details or that the road user's ideas do not correspond to reality) is seen to lead to observation missed and be a result of insufficient knowledge.



Source: SafetyNet Accident Causation Database 2005 to 2008 / EC

Date of query: 2010

Figure 6: Ten most frequent links between causes - drivers/riders, junction accidents

Conclusion

In Europe about 22% of road accident fatalities occur at intersections, with the higher percentage (34%) being observed in the United Kingdom and the lower (<10%) in Greece, Romania and Latvia. During the period of analysis (1999-2008) an overall decrease of almost 31 percent in traffic accident fatalities in intersections was observed, with the largest decrease (67%) for France.

Tables and figures of the main analyses are presented and discussed, leading to findings such as the following:

- With respect to intersection geometric design, 52% of fatalities in accidents that occurred in junctions in 2008 occurred at crossroads and 14% at T or Y intersections, while only 5% occurred at roundabouts.
- About 36% of the fatalities at intersections across the considered European countries are car or taxi occupants (down from 40% for the period 1997-2006 [12]), followed by 34% two-wheeler

users and 26% pedestrians (up from 20% for the period 1997-2006 [12]). More than half (53% and 59% respectively) of the fatalities at intersections in Denmark and the Netherlands are two-wheeler users, while in Slovenia the percentage exceeds 70%. In Portugal the number of fatalities of lorry occupants at intersections (12%) is four times higher than the average.

- 27% of fatalities in junction accidents were female, compared with 22% in non-junction accidents.

An analysis of in-depth data from more than 1000 accidents (half of which occurred at intersections) provide an indication of the most frequently recorded accident causes and the most frequently recorded links between them. "Observation missed" and "faulty diagnosis" are found to be the two dominant causes for drivers/riders in junction accidents.

The results of the analysis allow for an overall assessment of the road safety level in the European road intersections in comparison to the remaining road network, providing thus useful support to decision makers working for the improvement of safety in the European road network. Of course, the effort of data-collection is an on-going challenge and there are additional data that could help shed light to the problem of road safety. Of particular interest are exposure data. Furthermore, the macroscopic analysis presented in this paper could in the future be combined with in-depth analysis of intersection accident data, thus providing further insight into the causes and impacts of accidents occurring at intersections.

Acknowledgements

This paper is based on work carried out within the scope of the SafetyNet (The European Road Safety Observatory) and DACOTA projects of the 6th and 7th (respectively) Framework Programs for Research, Technological Development and Demonstration of the European Commission.

Appendix: Country abbreviations used

BE	Belgium	**EL**	Greece	**LU**	Luxembourg	**RO**	Romania
BG	Bulgaria	**ES**	Spain	**HU**	Hungary	**SI**	Slovenia
CZ	Czech Republic	**FR**	France	**MT**	Malta	**SK**	Slovakia
DK	Denmark	**IT**	Italy	**NL**	Netherlands	**FI**	Finland
DE	Germany	**CY**	Cyprus	**AT**	Austria	**SE**	Sweden
EE	Estonia	**LV**	Latvia	**PL**	Poland	**UK**	United Kingdom
IE	Ireland	**LT**	Lithuania	**PT**	Portugal		

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