How safe are cyclists on European roads?

6th European Transport Research Conference
MOVING FORWARD:
Innovative Solutions for Tomorrow's Mobility
PGE Narodowy, Warsaw, Poland - 18-21 April 2016

Proceedings of 6th Transport Research Arena, April 18-21, 2016, Warsaw, Poland

How Safe Are Cyclists On European Roads?

Petros Evgenikos[a]*, George Yannis[b], Katerina Folla[c],

Robert Bauer[d], Klaus Machata[e], Christian Brandstaetter[f]

Pete Thomas[g], Alan Kirk[h]

[a]*Research Associate, National Technical University of Athens, Iroon Polytecheiou 5, Athens, 15773, Greece*
[b]*Professor, National Technical University of Athens,Iroon Polytecheiou 5, Athens, 15773, Greece*
[c]*Researcher, National Technical University of Athens,Iroon Polytecheiou 5, Athens, 15773, Greece*
[d]*Senior researcher, Austrian Road Safety Board, Schleiergasse 18, Vienna, 1100, Austria*
[e]*Senior researcher, Austrian Road Safety Board, Schleiergasse 18, Vienna, 1100, Austria*
[f]*Senior researcher, Austrian Road Safety Board, Schleiergasse 18, Vienna, 1100, Austria*
[g]*Professor, Loughborough University, Epinal Way, Leicestershire, LE11 3TU, United Kingdom*
[h]*Research Fellow, Loughborough University, Epinal Way, Leicestershire, LE11 3TU, United Kingdom*

Abstract

Cyclists, while relatively small in proportion with respect to motorized vehicles, have a high level of vulnerability, creating a significant need to better understand the characteristics specific to this user group. A good insight into the problem provides an opportunity to improve the road safety of this cheap, convenient and environmentally friendly mode of transport. In 2013, more than 2.000 cyclists were killed in road traffic accidents in 27 EU countries, constituting almost 8% of all road accident fatalities for that year. Although a considerable decrease by 32% in the total number of bicycle fatalities in noted within the decade 2004 – 2013, it is still smaller than the respective reduction of the overall road fatalities by 45%.The objective of this research is the analysis of basic road safety parameters related to cyclists in European countries, by 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 on road accidents involving cyclists from 27 EU countries over a period of 10 years (2004-2013) are correlated with basic safety parameters, such as road type, season of the year, age and gender. Data from the EU Injury Database are used to identify injury patterns and improve the assessment of injury severity, and additional insight into accident causation for cyclists is offered through the use of in-depth accident data from the EC SafetyNet project Accident Causation System. The results of the analysis allow for an overall assessment of the cyclists safety level in Europe in comparison to other modes of transport, thus providing useful support to decision makers working for the improvement of safety in the European road network.

Keywords: cyclists; EU CARE database; road accident causation; road safety; European countries

* Corresponding author. Tel.: +30-6945877578; fax: +30-2107721454.
E-mail address: pevgenik@central.ntua.gr

1. Introduction

An alternative way of everyday travels, gaining more followers worldwide each day, bicycle is becoming part of our lives. Environmental friendly, needing no fuel and the minimum of space, no noise pollutant, cycling is an important part of sustainable urban mobility and is becoming more and more critical for a balanced combination of economic development and living standards. In an era when the environment is in the limelight and efforts on health, safety, standards of living and economic prosperity are being made, it is commonly acknowledged that cycling is a very effective and contemporary way of commuting (Yannis et al., 2015).

In most European countries, a high proportion of people own a bicycle (in Norway, for instance, 70% of adults own a bicycle, in Switzerland, 69% of households own a bicycle). The number of bicycles per thousand inhabitants ranges from 52 in the Czech Republic to 1.000 in the Netherlands. What differs though considerably from one country to another is the way in which the bicycle is used. Some cyclists use it every day, as a means of transport, while others do so only occasionally (ECMT, 2000) and additionally, significant differences are noted in the driving behavior and culture of the other road users (cyclists are still often overlooked), as well as in the cycling infrastructure among the countries.

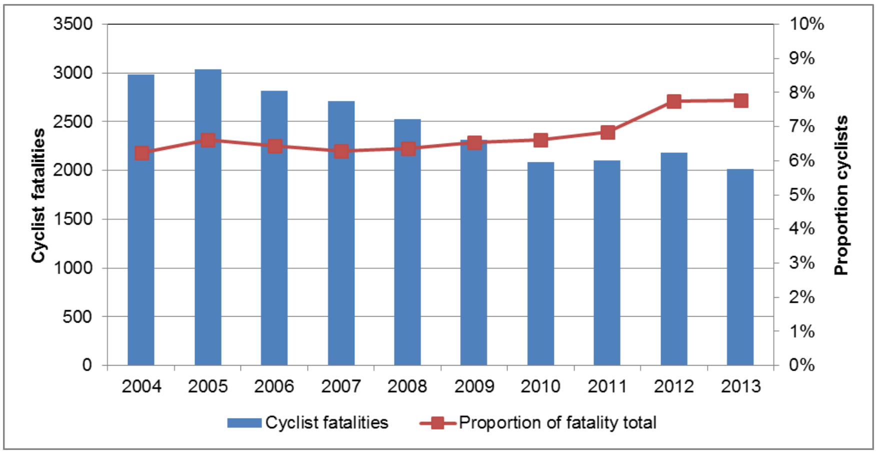
However, cycling cannot be considered as a safe mean of transport due to the greater vulnerability of the riders who are relatively unprotected road users interacting with traffic of high speed and mass, suffering the most severe consequences in collisions with other road users (DaCoTA, 2012). Thus, although cycling effects on health and environment seem to outweigh the costs related to crashes involving bicyclists (Kempen, van et al., 2010), it is still very important to improve cycling safety as much as possible.

The objective of this research is the analysis of basic road safety parameters related to cyclists in European countries, by the use of the EU CARE database with disaggregate data on road accidents, the EU Injury Database (EU IDB) and the SafetyNet Accident Causation System (SNACS). More specifically, time-series road accident data involving cyclists from CARE for 27 EU countries over a period of 10 years (2004-2013) are correlated with basic safety parameters, such as area and junction type, season of the year, casualty age and gender, as well as the day of the week and the time of the day. Moreover, EU IDB data for the period 2005 - 2008 are used to identify injury patterns and improve the assessment of injury severity. Additional insight into accident causation recorded for bicycle riders is offered through analysis of a set of in-depth data, collected for the period 2005 – 2008, 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 and the way that the different types of databases were combined, is obtained through the Traffic Safety Basic Facts 2015 – Cyclists (European Commision, 2015), as well as through SAFETYNET and DaCoTA EC co-funded research projects and the European Road Safety Observatory (ERSO - http://ec.europa.eu/transport/wcm/road_safety/erso/index-2.html).

The results of the analysis allow for an overall assessment of the cyclists safety level in Europe in comparison to other modes of transport, thus providing useful support to decision makers working for the improvement of safety in the European road network.

2. Overall road safety trends for cyclists in the EU

In 2013, 2.017 cyclists were killed in road traffic accidents in the 27 EU countries for which CARE accident data are available, whereas in the US only 743 cyclists were killed, accounting for 2% of all traffic fatalities (NCSA, 2015). In order to monitor the evolution of the cyclists' safety level in Europe, accident trends for the decade 2004 - 2013 were considered. According to the following Figure 1, although the number of cyclist fatalities has decreased by 32% over this period in these countries, the overall number of road accident fatalities has fallen faster (reduction by 45%) and the share of bicycle fatalities of all road fatalities in the EU increased from about 6% to almost 8%, especially from 2010 to 2012. In reality, the figures of cycling fatalities are actually higher since cyclist accidents are heavily and disproportionally underreported in the police accident statistics compared to what hospital records and other studies show (OECD, 1998), especially single-vehicle accidents in which the 'vehicle' is a bicycle (Petridou et al., 2009).

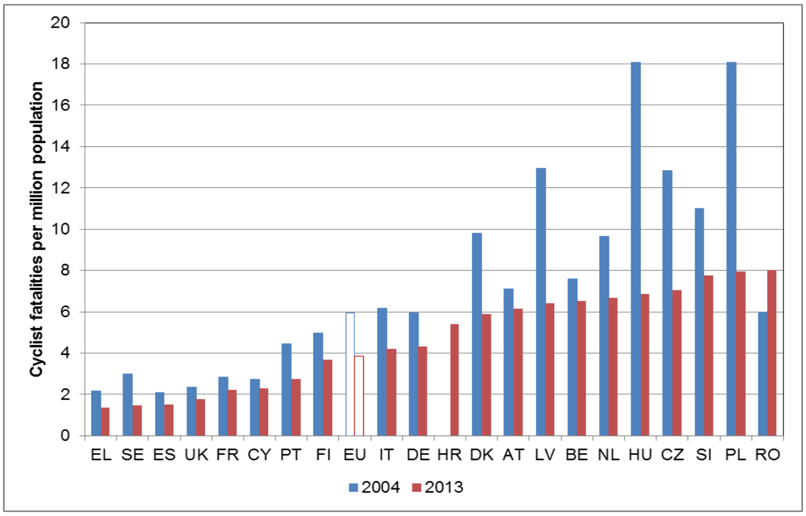


Source: CARE database, data available in May 2015

Fig. 1. Number and proportion of cyclist fatalities in the EU, 2004-2013.

In road safety analysis exposure data is often used to calculate risk estimates, those being defined as the rate of the number of accidents (or casualties) divided by the amount of exposure of a population over a time period (Hakkert and Braimaster, 2002, Hauer, 1995), on that purpose data from other international databases such as OECD/IRTAD, Eurostat etc. were also used. Since there is no reliable data available about vehicle kilometres or person kilometres travelled by cyclists in each of the above countries, the population is used as exposure data. The calculated risk figures may be used for different purposes, but their main objective is to enable the comparison of safety performance among different units, populations or countries.

Although in absolute figures in 2013 most cyclist fatalities occurred in Germany and Poland (354 and 306 people riding bicycles were killed in road accidents respectively), Romania, Poland and Slovenia have the highest cyclist fatality rate. As indicated in Figure 2, there has been a general notable decrease in bicycle fatality rates for almost all EU countries over a ten year period however, thirteen EU countries still have higher cyclist fatality rates than the EU average.

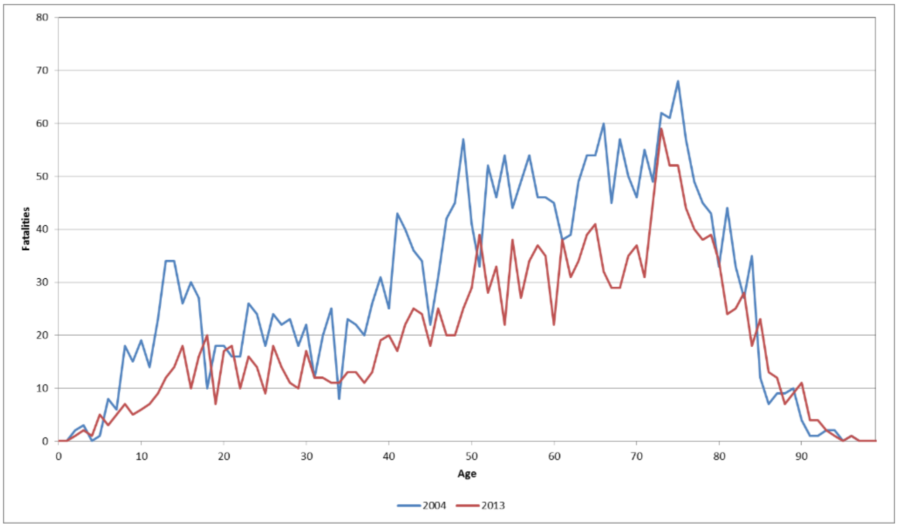


Source: CARE database (EUROSTAT for population data), data available in May 2015

Fig. 2. Cyclist fatality rates by country, 2004 and 2013.

The revealed strong regional differences, with the share of cyclist fatalities differing widely between countries, can mostly be attributed to the combination of two factors: the use of bicycles (exposure and cycling culture) and the infrastructure devices of a country. For instance in 2013, in the Netherlands and Denmark with high bicycle modal split, 25% and 17% respectively of all road accident fatalities are cyclists, whereas in countries such as Greece and Spain with low cycle use, cyclists constitute only a small part of the road accident fatalities (2% and 4% respectively).

According to the results of a more detailed analysis by age groups and gender the majority of cyclist fatalities are males (79%), however, with a considerable variation between countries (i.e. under 50% in Denmark and over 90% in Romania and Portugal). Additionally, in 2013 more than 40% of the cyclists who died in a traffic accident in the EU were at least 65 years old. Especially in the Netherlands, the related proportion of cyclist fatalities is increased (55%), since there is a growing number of bicycle injuries among elderly bicyclists, as also in several other countries, such as Austria, Germany and Belgium, the elderly (over 65 years old) tops the statistics both with respect to total number of fatalities among cyclists and of the number of cyclist fatalities per inhabitant and even though these last years older people cycle much less in many other European countries, making their risk exposure very low and accident figures small, at present this trend has stated to change across Europe.



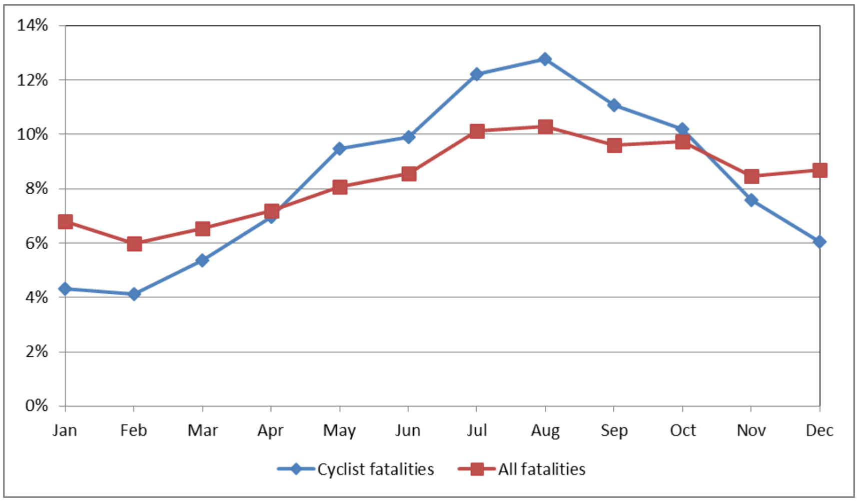
Source: CARE database, data available in May 2015

Fig. 3. Ten-year comparison of cyclist fatalities by age in the EU, 2004 and 2013.

Figure 3 indicates that over the period 2004-2013, there has been a marked reduction in cycling fatality numbers across almost all ages in the EU countries. The least reduction was noted for cyclists aged around 75 years old where the climax remained, confirming the results of studies showing that elderly cyclists (between 70-80 years old) are almost three times more at risk for a road accident injury than the average cyclist (Niska and Eriksson, 2013). On the other hand, the peak in fatalities of cyclists aged between 12 and 17 years old disappeared within the same period, with this age group having the most visible reduction, even though at that age children are likely to increasingly be undertaking independent.

3. Road safety parameters of the cyclists in the EU

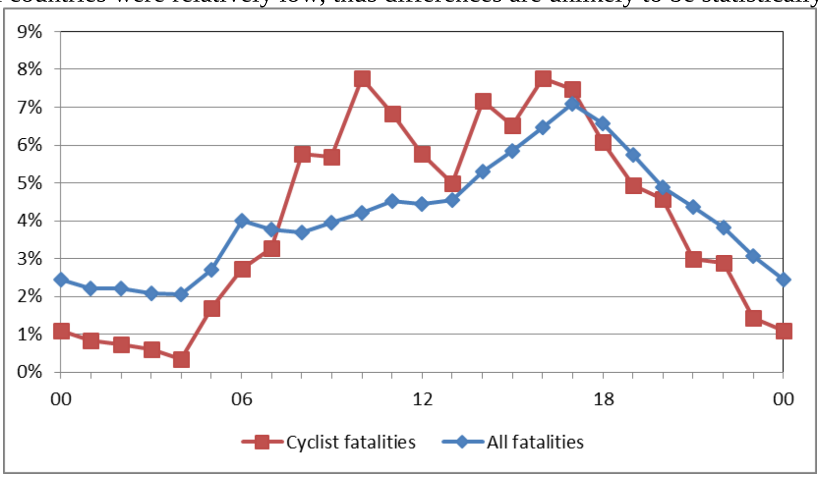
In order to answer the question when most cyclists' accidents occur, the analysis of the fatalities seasonal distribution showed that there is no clear trend in the incidence of cyclist fatalities by month among individual countries. In 2013, the peak for the EU countries occurred in August (13% of cyclist fatalities) and the fewest fatalities occurred in January and February (4% of cyclist fatalities). Figure 4 compares the distribution by month of cyclist and overall fatalities and shows that about one third of cyclist fatalities in 2013 in the EU countries occurred in July, August and September. The proportion of cyclist fatalities in January, February and March is slightly above 10%. This is less than the proportion of all fatalities during these months. As the slippery wet conditions of many European winters are conducive to high severity accident injuries, these analysis outcomes are likely to be associated with the actual number of cyclists on the road during these seasons rather than an indication of risk of injury per cyclist.



Source: CARE database, data available in May 2015

Fig. 4. Proportion of cyclist fatalities and total road fatalities per month in the EU, 2013.

Day of week and time of the day were also considered. The distribution of the cyclist fatalities within the week is almost the same (around 14%) in EU, with slightly less bicycle riders being killed on Sundays comparing to other days (12%). In Sweden though, almost one third of the cyclist fatalities occur on Mondays and in Croatia on Saturdays. Regarding the time of the day, compared to other transport modes, relatively many cyclists are killed between 08:00 and 18:00 and relatively few between 21:00 and 07:00, with two peaks being noted in the following Figure 5, one in the 08:00-12:00 period and another in the 14:00-18:00 period. Data analysis did not reveal a clear trend in the time of collision for individual countries. Some differences might be due to different daily cycling patterns due to climatic conditions (i.e. in Sweden and Croatia there is no peak between 08:00 and 12:00). Additionally, some of the fatality figures in individual countries were relatively low, thus differences are unlikely to be statistically significant.

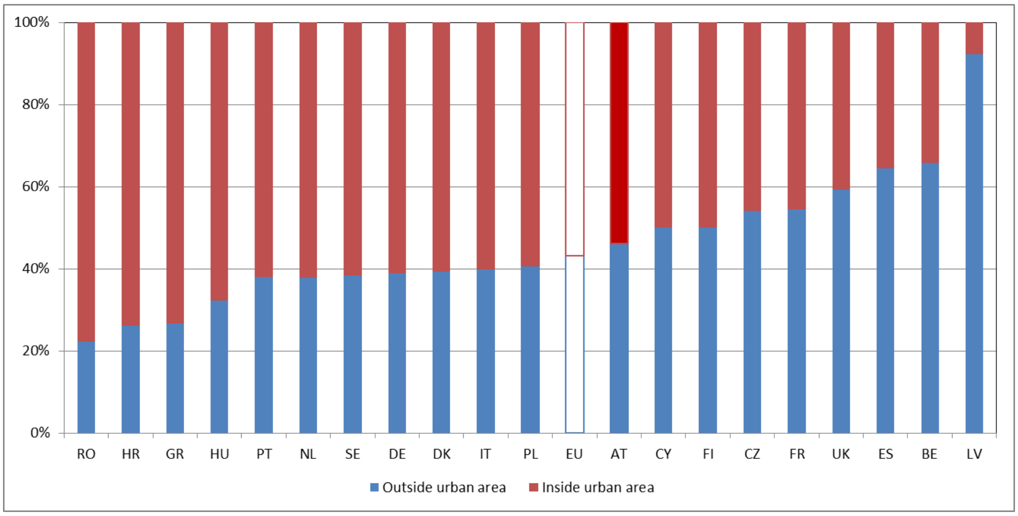


Source: CARE database, data available in May 2015

Fig. 5. Distribution of cyclist fatalities and of all road fatalities by time of day in the EU, 2013.

The role of light conditions on the incidence of cyclist fatalities is also important since some fatalities occurring between 16:00 and 20:00 may be related to lighting conditions. About a quarter of cyclist fatalities in the EU countries were killed when lighting was poor (twilight or darkness) with the proportion exceeding 40% in Croatia and Portugal.

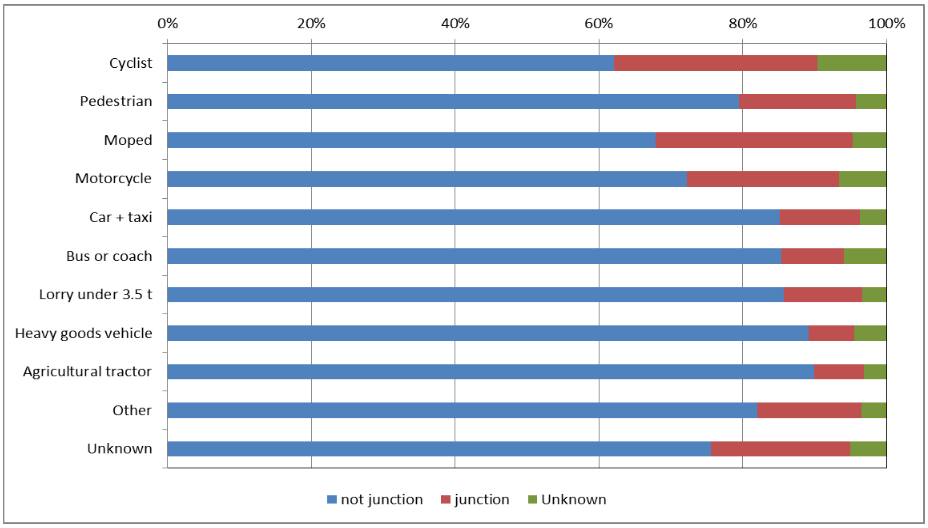
According to the analysis carried out 55% of the bicycle fatalities in the EU countries occurred inside urban areas but there are significant differences among the countries, as follows from Figure 6. In Romania, almost 80% of bicycle riders were killed inside urban areas, whilst in Belgium less than 40% (Latvia has small figures). In the US 68% of all cyclists who died in road accidents in 2013 were killed in urban area crashes (NCSA, 2015).



Source: CARE database, data available in May 2015. Totals for EU include latest available data (Lithuanian data not included in totals)

Fig. 6. Distribution of cyclist fatalities by area type and by country, 2013.

Bicycles compared to other modes of transport have a highest share of fatalities at junctions in 2013 in the EU (approximately 30%) followed by the mopeds, as presented in Figure 7. Additionally, more than 55% of the cyclist fatalities occurred at crossroads, comparing to 24% occurring at T or staggered junctions. In the Netherlands (63%) and Denmark (58%) the highest proportion of cyclist fatalities at junctions were recorded in 2013.



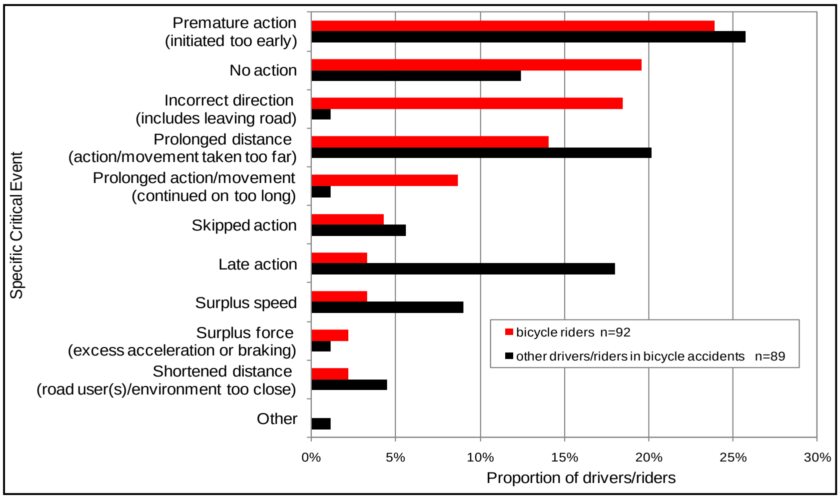
Source: CARE database, data available in May 2015.

Fig. 7. Fatality proportions involving cyclists at junctions compared to other modes of transport in the EU, 2013.

4. Accident causation analysis

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 (Bjorkman et al., 2008; Reed and Morris, 2008). 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. Links are established by trained personnel directly involved in the investigation according to the SNACS coding system, with full case evidence available to them. These data have been analysed to compare the causation recorded for bicycle riders and other drivers/riders in bicycle accidents. Of the accidents in the database, 9% (92 cases) involve the rider of a bicycle. Males account for 50% of this group and the mean age is 47 years old. Figure 8 compares the distribution of specific critical events for bicycle riders against the distribution for other drivers/riders in bicycle accidents.

Although 'premature action' is recorded most frequently for both bicycle riders and those others involved in bicycle accidents, it is the difference for 'incorrect direction' that is most striking. 'Incorrect direction' refers to a manoeuvre 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). 'Premature action' describes a critical event with an action started too early, before a signal was given or required conditions established. In combination with prolonged distance and prolonged action/movement - movements taken too far and manoeuvres that last for too long (for example, not returning to correct lane) - scenarios start to emerge of conflict between bicycle riders and other road users when sharing road space. 'No action' is also prelevant in the cyclist group, describing those drivers/riders who have not reacted at all (or at least in an effective time frame) to avoid a collision, for example, to avoid an oncoming vehicle. In general, in-depth analysis of SNACS data showed specific critical events related to 'timing' for more than 60% of cyclists involved in road accidents.



Source: SafetyNet Accident Causation Database 2005 to 2008 / EC;N=181.Date of query: 2010.

Fig. 8. Distribution of specific critical events - bicycle riders and other drivers/riders in bicycle accidents.

The following Table 1 gives the most frequent links between causes for injury accidents involving bicycle drivers/riders. For this group there are 74 such links in total. How often causes appear in the chains indicates their importance for the road users selected. Here, only the most common links are presented but further interpretation can take place by following the chains from critical event back to the first cause in the chain, as demonstrated by Talbot et al. (2009) for inattention and distraction.

Table 1. Ten most frequent links between causes – bicycle riders.

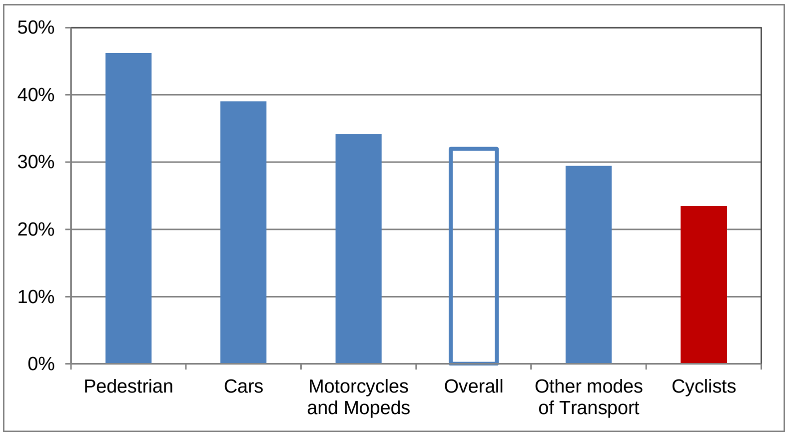
Links between causes	**Frequency**
Faultydiagnosis - Information failure (driver/environment or driver/vehicle)	13
Observation missed - Faulty diagnosis	6
Observation missed - Inadequate plan	6
Observation missed – Temporary obstruction to view	5
Observation missed – Distraction	4
Observation missed - Permanent obstruction to view	4
Faulty diagnosis - Communication failure	4
Inadequate plan – Insufficient knowledge	4
Observation missed - Inattention	3
Information failure (driver/environment or driver/vehicle) – Inadequate information design	3
Others	22
Total	74

Source: SafetyNet Accident Causation Database 2005 to 2008 / EC. Date of query: 2010

18% of the links between accident causes for cyclists are observed to be between ‘faulty diagnosis’ and ‘information failure’, closely followed by ‘inadequate plan’ (a lack of all the required details or that the driver’s ideas do not correspond to reality). ‘Faulty diagnosis’ is an incorrect or incomplete understanding of road conditions or another road user’s actions. It is linked to both ‘information failure’ (for example, a rider thinking another vehicle was stopped when it was in fact moving 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). The causes leading to ‘observation missed’ can be seen to fall into two groups: 'physical obstruction to view’ type causes (for example, parked cars at a junction) and ‘human factor’ type causes (for example, not observing a red light due to distraction or inattention).

5. Road accident health indicators

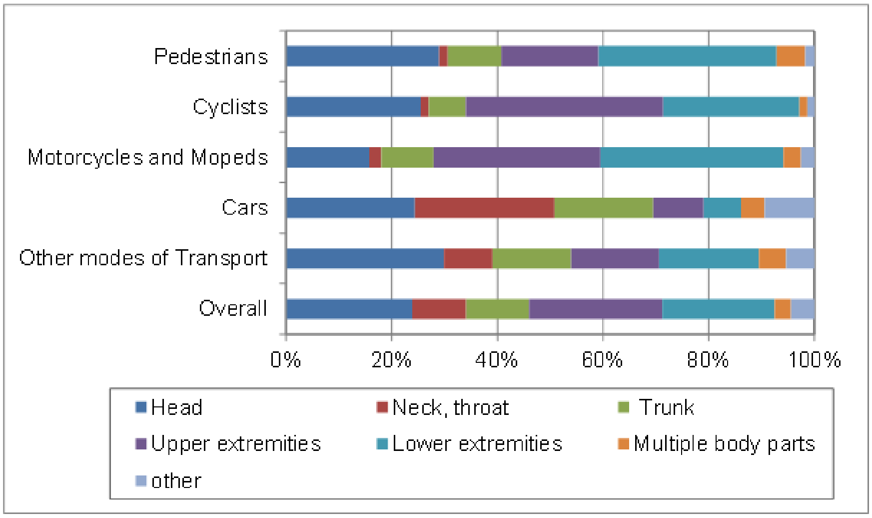
Injury data variables obtained through the EU Injury Database (EU IDB) can complement information from police records and thus, provide a better insight for injury patterns and the improved assessment of injury severity in road accidents. EU IDB is a system developed following a recommendation issued by the EU Council that urges member states to use synergies between existing data sources and to develop national injury surveillance systems rooted in the health sector. At present, thirteen member states are routinely collecting injury data in a sample of hospitals and delivering these data to the EC (http://ec.europa.eu/health/data_collection/databases/idb/index_en.htm). IDB data used in this research comes from nine EU Member States (DE, DK, LV, MT, AT, NL, SE, SI, CY) and concerns accidents that occurred between 2005 and 2008. Figure 9 shows that 32% of road accident casualties recorded in the IDB were admitted to the hospital overall, with the respective percentage being 23% for cyclists. Additionally, analysis of the IDB data showed that the average length of stay in the hospital for cyclists and also overall was almost eight days.



Source: EU Injury Database (EU IDB AI) - hospital treated patients. (code 6.n [public road]); n-all = 73 600: n-admitted = 23.568.

Fig. 9. Share of casualties who attended a hospital who were admitted to hospital, by mode of transport.

Fractures, contusions and bruises account for almost two thirds of all injuries inflicted on cyclist casualties attending hospital and as illustrated in the following Figure 10, presenting the distribution of body parts injured in casualties by mode of transport, cyclists show a high proportion of injuries of the upper extremities.



Source: EU Injury Database (EU IDB AI) - hospital treated patients. (code 6.n [public road]); n-all = 73 600: n-admitted = 23.568.

Fig. 10. Body part injured, by mode of transport.

6. Conclusions - Discussion

The various road safety parameters examined revealed that the cyclists are a special group of road users, with increasing numbers and different needs and characteristics than other road users, mainly due to their vulnerability, but also to their different mobility behaviour. The safety problem for cyclists vary systematically by region, reflecting different climates, cultures and behavioural characteristics, intensity of traffic, modal shares, levels of cycling infrastructure development and technology readiness levels.

Analysis of the cyclists' road accident data derived from the EC CARE database for the decade 2004 – 2013, showed that although the number of cyclist fatalities has decreased by 32% over this period in the EU countries, the overall number of road accident fatalities has fallen faster (reduction by 45%) and the share of bicycle fatalities of all road fatalities in the EU increased from about 6% to almost 8%, especially from 2010 to 2012, when the respective share is the US was only 2%. CARE accident data were also combined with exposure data (population), allowing the more accurate comparison of the calculated rates between EU countries. According to the results of the analysis, more than 40% of the cyclists in the EU were at least 65 years old when they died in an accident and about one third of cyclist fatalities occurred during July, August and September. Additionally, more than half of cyclist fatalities occurred on urban road network and a quarter of them in poor lighting conditions.

The analysis of other types of data such as in-depth accident data and injury data, allowed for additional insight into accident causation recorded for bicycle drivers and riders, as well as for the identification of injury patterns improvement of the assessment of injury severity for casualties of this road user group.

The results of the analysis allow for an overall assessment of the bicycle safety level in the European road network relative to other modes of transport, providing thus useful support to decision makers working for the improvement of safety in the European road network. Certainly, the effort of data-collection is an on-going challenge and there are additional data that could help shed light to the problem of the cyclists' road safety. Of particular interest are exposure data related to the mobility of road users (bicycle fleet, veh-kms, passenger-kms travelled). Furthermore, the macroscopic analysis presented in this paper could in the future be combined with more detailed analysis using statistical models, which is necessary for the identification of the combined correlation of the parameters with an impact on cyclists' road safety and the underlining reasons behind their casualties.

Acknowledgements

This paper is based on work carried out by the National Technical University of Athens (NTUA), the Austrian Road Safety Board (KFV) and the European Union Road Federation (ERF) for the European Commission DG Mobility and Transport, updating work carried out within the SafetyNet (The European Road Safety Observatory) and DaCoTA (Data Collection Transfer and Analysis) projects of the 6th and 7th (respectively) Framework Programs for Research, Technological Development and Demonstration of the European Commission.

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Appendix A - Country abbreviations

Belgium	BE
Bulgaria	BG
Czech Republic	CZ
Denmark	DK
Germany	DE
Estonia	EE
Ireland	IE
Greece	EL
Spain	ES
France	FR
Croatia	HR

Italy	IT
Cyprus	CY
Latvia	LV
Lithuania	LT
Luxembourg	LU
Hungary	HU
Malta	MT
Netherlands	NL
Austria	AT
Poland	PL
Portugal	PT

Romania	RO
Slovenia	SI
Slovakia	SK
Finland	FI
Sweden	SE
United Kingdom	UK