Case Study:

Rear end or chain accidents

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1 Introduction

The main purpose of this case study is to demonstrate the possibilities and limitations of the use of the CARE-database, while focusing on a 'real life' traffic safety issue, in this case: rear-end accidents. In view of the emphasis on aspects concerning the data, this work is not a scientific study of all relevant items pertaining to the problem of rear-end accidents. For instance, no references are given, and analyses are not exhaustive with regard to contents; also, no statistical tests were carried out.

Therefore, findings with regard to contents are reported in chapter 4 (Discussion of results), while in the final chapter 5 (Possibilities and limitations of the data in CARE) conclusions with regard to this main item of the study are presented.

Rear-end accidents are considered to be a source of considerable harm to society, because of the high chance that occupants of cars that are hit from behind may suffer from neck pain complaints. In some cases these complaints become a source of long-lasting health consequences. Dutch accident data, analysed by SWOV, point to a very extensive increase of the number of rear-end injury accidents during the nineties. However, from these Dutch data it did not become totally clear whether the development was a real one, or one due to bias or other changes in the police registration on which the accidents data is based.

Therefore, it became desirable to compare the Dutch data with data from other countries.

The problem of whiplash injury from rear-end accident is already taken seriously by the EU, especially with regard to improvement of car safety, focussing on seats and head restraints. But proper accident data to establish the scope of the problem of rear-end accidents is still missing, so the study to be undertaken based on CARE data may help to gain more insight.

If we have established the scope of the problem and its development, we would like to know whether rear-end accident occur on all types of roads, or on certain types only. We would also like to know about traffic exposure on these types of road, since chances of having a rear-end accident may be linked to traffic density.

2 Study design and CARE database

The study of rear-end accidents is based on CARE data. Analysis of rear-end accidents within CARE data is possible because the relevant *type of collision* can be separated from other types, by means of the variable **Collision type,** using the category **chain or rear**. The name of this category implies that both simple rear-end accidents (two objects only), and complicated rear-end accidents or chain collisions, involving more then two objects, are included.

At the same time, we are interested primarily in rear-end accidents of *cars*, and this particular vehicle type (**car or taxi**) is available as category within the variables **Vehicle type** and **Vehicle group.**

By selecting these variables and categories, the base of our analysis is established, though we still have to see if enough countries have provided these particular categories.

We are also interested in a wide range of data, preferably all available years (currently: 1991-2001). This is possible since the CARE database contains the variable **Year.**

In view of the question relating to type of road and area, we also need the data to be specified accordingly. This is possible since the database contains two variables: **Area** (**urban/rural**) and **Motorway** (**yes/no**).

We both want to analyse the data at the *European Union level* (all 15 countries), and at the level of *individual countries*, to look for differences in development or magnitude of the problem of rear-end accidents. This is made possible by means of the variable **Country code.**

It is common practice, when using police reported data, to focus on fatal and severe injury, since the numbers of fatalities and severely injured tend have a relatively high degree of registration, while those concerning slightly injured do not.

However, in this particular case study, we also need data concerning the slightly injured, since it is well known from literature that the most common type of injury pertaining to rear-end accidents (often called whiplash injury) is of low severity.

Consequently, we need to know about the numbers of all types of injured from the accidents studied, and therefore we will use the variables available for that purpose: **Sum of killed**, **Sum of seriously injured**, **Sum of slightly injured** etc.

Though we are primarily interested in casualties (deaths and injured) from the cars that were struck in the rear ('rear-ended'), these cannot be separated from casualties from other cars ('striking cars') involved in these rear-end accidents. It may, however, be assumed that chances of being injured are higher for occupants of the rear-ended car, than for occupants of the striking car.

The design of this study is therefore:

Count the annual numbers of injured (using different severities) from rear-end accidents with cars and analyse these numbers over as long a period of years as available, both for all CARE countries, and for separate CARE countries; this will give the development and scope of the problem of rear-end accidents.

Relate these numbers to the injured from all accidents and all vehicle types, in order to establish the share of rear-end accidents within the total scope of traffic safety in the EU (or separate EU-countries).

Subdivide all data into categories of type of road and area in order to establish (different) developments concerning these conditions.

We would also like to study the influence of traffic exposure, related to the different types of roads. However, we know beforehand that such data is not (yet) available in the CARE database, so we have to find these elsewhere. For this purpose, we will use data from the IRTAD database.

The relevant variables, as mentioned above, have been selected from the main database for all years concerned, and put into an Excel based Pivot table for easy and reliable analysis, by means of tables or graphs.

3 Results

3.1 General comments

After selection of the relevant data as described in the previous part, we first looked at the selected data to determine empty cells.

It appeared that 5 countries did not offer particulars concerning the most important selection criterion (collision type).These countries are Denmark, Luxembourg, Finland and the United Kingdom. They were excluded from all further analysis. Therefore, 10 countries remained. These are Austria, Belgium, Spain, France, Greece, Ireland, Italy, The Netherlands, Portugal, and Sweden.

From the total CARE database it can be derived that these 10 countries represent about 75% of the total number of injured in the current 15 EU-countries.

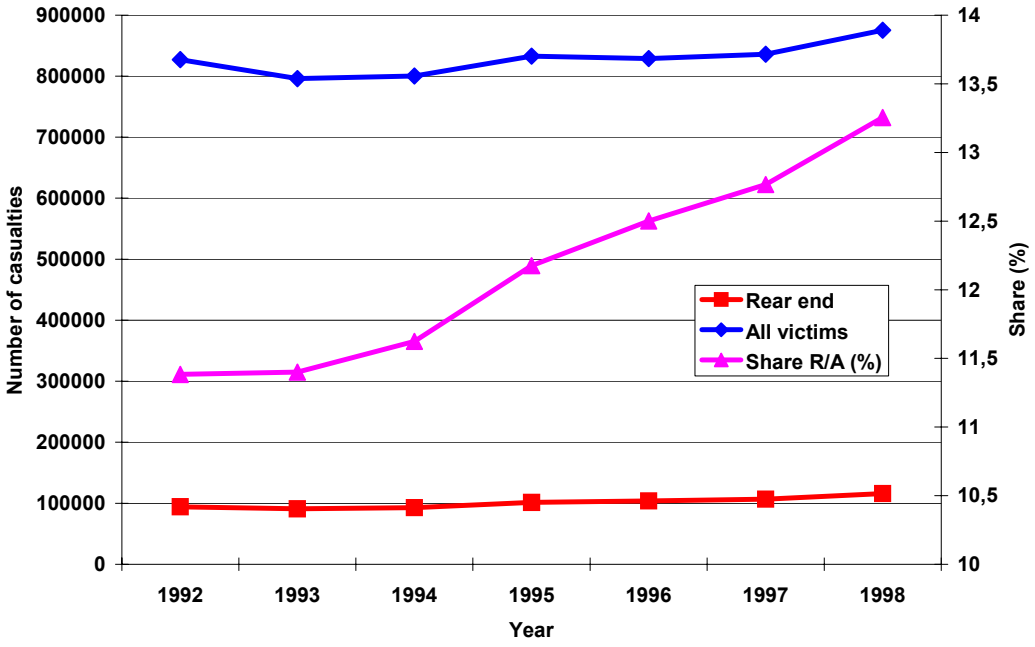
With respect to the data on which the graphs and tables are based, the common properties are as follows:

- *Rear-end accidents* is the term used for the selection of cases by means of variable **Collision type (=chain or rear)** and variable **Vehicle group (=car or taxi)**;
- Data from the 10 CARE countries generating relevant data is used, either separately (each of the 10 CARE countries) or combined (total of 10 CARE countries);
- The word *casualties* is used for the sum of all dead and injured (fatalities, serious injured, and slightly injured);
- Graphs always present the *number or share of casualties*, either from rear-end accidents, or from all accidents, excluding pedestrian casualties.
- Since from the year 1991 and from recent years no complete data was available, analyses were restricted to the years 1992-1998 (see also final observations);
- *Type of road* and *area* have been combined into a new variable with 3 categories: MW (Motorway), Rural (rural roads excluding motorways), Urban (urban roads excluding motorways and including unknown area and unknown type of road);

3.2 Analyses

3.2.1 The scope and development of rear-end accidents in Europe (first analysis)

From this first analysis, we present in figure 1 the number of casualties (i.e. all injured and killed) both from rear-end accidents and from all accidents in the EU, as well as their share. It should be noted that pedestrian casualties are excluded from all analyses in this chapter.

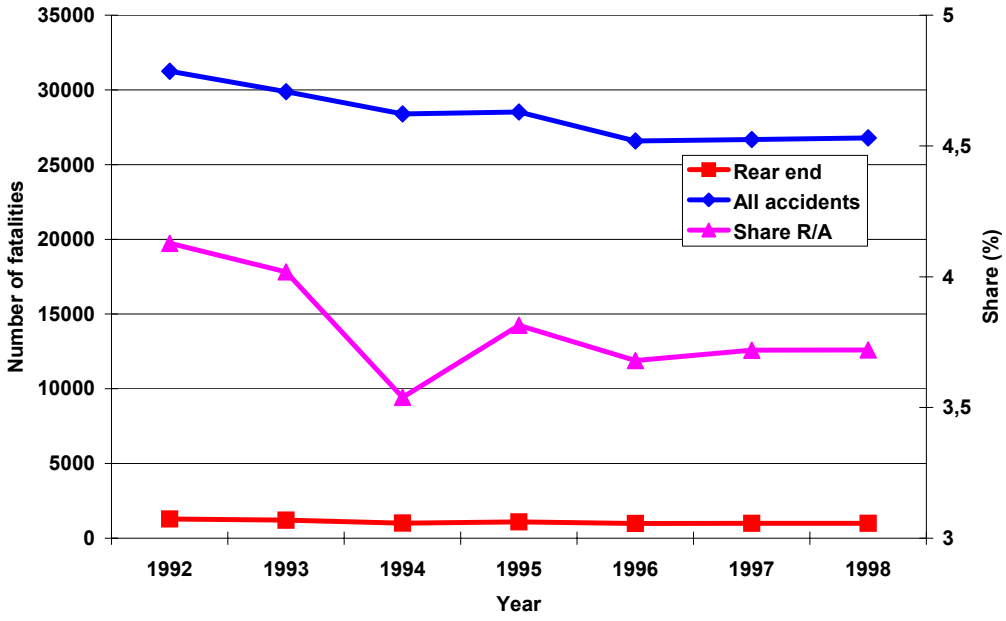


Type of accident	Number of casualties (10 CARE countries) Year 1992	1993	1994	1995	1996	1997	1998	1998/1992 (index)
Rear-end accidents	94,162	90,728	93,050	101,419	103,589	106,720	116,024	1.23
All accidents	827,210	795,883	800,464	833,003	828,672	836,001	875,382	1.06
Share **R/A** (%)	11.4	11.4	11.6	12.2	12.5	12.8	13.3	1.16

Figure 1. *The number of casualties from rear-end accidents, related to all accidents, and their share; 1992-1998.*

We can see that the number of casualties from rear-end accidents is increasing over the years, from 94,000 up to 116,000 (an increase of 23%), as is the number of casualties from all accidents, from 827,000 up to 875,000 in 1998 (an increase of 6%). More importantly, we also see an increase of the *share of casualties* from rear-end accidents, from 11.4% in 1992 to 13.3% in 1998, an increase of 16%.

In the following figure 2 the number of casualties is restricted to fatalities only.



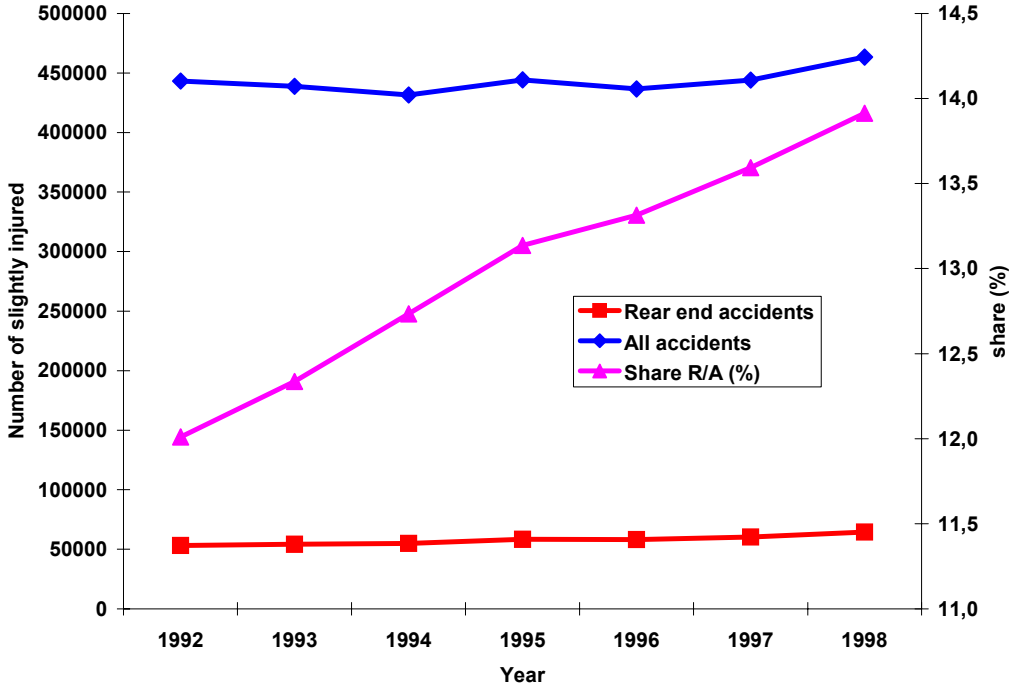
Accident type	Number of fatalities (10 Care countries) Year 1992	1993	1994	1995	1996	1997	1998	1998/1992 (index)
Rear-end accidents	1,290	1,201	1,005	1,088	978	992	997	0.77
All accidents	31,252	29,880	28,392	28,522	26,584	26,686	26,793	0.86
Share **R/A** (%)	4.13	4.02	3.54	3.81	3.68	3.72	3.72	0.90

Figure 2. *The number of fatalities from rear-end accidents, from all accidents, and their share; 1992-1998*.

Contrary to the developments in the previous figure, we see from figure 2 that both the number of fatalities from rear-end accidents, and the number of fatalities from all accidents, as well as their share are decreasing. The number of fatalities from rear-end accidents has been decreasing from about 1,290 in 1992 to about 997 in 1998, for the 10 CARE countries concerned, a decrease of 23% (index=0.77).

The average share of these fatalities is under 4%, far less than the share of all casualties (in 1998 about 13%) from rear-end accidents, as shown in figure 1, indicating that rear-end accidents are generally not severe collisions.

Since we must assume that the majority of casualties from rear-end accidents is only slightly injured, we will now look at the number of *slightly injured* (which of course is also included in the number of all casualties). Instead of the usual 10 CARE countries, we present now only 9 countries, since from Italy no details concerning slightly injured (or seriously injured) are available.

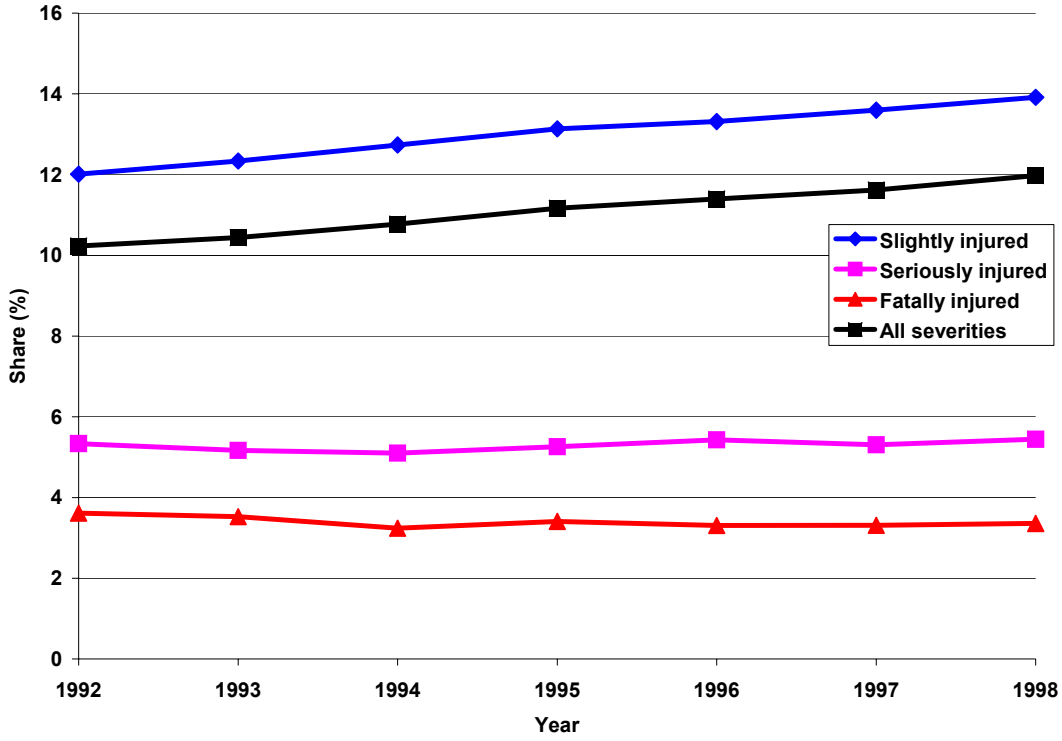


Type of accident	Number of slightly injured (9 CARE countries) Year 1992	1993	1994	1995	1996	1997	1998	1998/1992 (index)
Rear-end accidents	53,235	54,130	54,945	58,361	58,130	60,360	64,472	1.21
All accidents	443,215	438,782	431,484	444,273	436,596	444,010	463,383	1.05
Share **R/A** (%)	12.01	12.33	12.73	13.13	13.31	13.59	13.91	1.16

Figure 3. *The number of slightly injured from rear-end accidents and all accidents, and their share; 1992-1998 (9 CARE countries).*

We can see that the number of slightly injured from rear-end accidents has increased by 21% over the period 1992-1998, while the corresponding increase for slightly injured from all accidents was only 5%. Therefore, the total share of slightly injured from rear-end accidents has increased from 12% in 1992 to almost 14% in 1998, giving an increase of 16%,

In the next figure we present numbers from all different severity categories of injured, again for the 9 remaining CARE countries.



	Share of casualties in 9 CARE countries (%)							
	Year							1998/1992
Injury severity	1992	1993	1994	1995	1996	1997	1998	(index)
Slightly injured	12.0	12.3	12.7	13.1	13.3	13.6	13.9	1.16
Seriously injured	5.3	5.2	5.1	5.3	5.4	5.3	5.4	1.02
Fatally injured	3.6	3.5	3.2	3.4	3.3	3.3	3.4	0.93
All severities	10.2	10.4	10.8%	11.2	11.4	11.6	12.0	1.17

Figure 4. *The share of casualties from rear-end accidents related to all accidents, according to injury severity; 1992-1998; 9 CARE countries*.

For the 9 CARE countries considered, we observe an overall increase of the total share of casualties from rear-end accidents from about 10% to about 12%, an overall increase of 17%. This increase is obviously closely related to the increase of the share of the slightly injured.

We also see that the other shares (fatalities and seriously injured) show either a small decrease, or a very small increase.

It should be noted that the shares and indices from this analysis concerning 9 CARE countries are only slightly different from those based on all 10 CARE countries, as presented earlier.

It therefore appears that leaving out a big country such as Italy (representing about 30% of all casualties in the 10 CARE countries) does not substantially influences the results.

3.2.2 The scope and development of rear-end accidents in Europe according to type of road and area (second analysis)

Since we are interested in rear-end accidents for different road types, we will show this sub-division in the next graphs. We have put together area and type of road into a new variable, containing 3 categories: **motorways** or **MW** (both rural and urban), **rural roads** (excluding motorways), and **urban roads** (excluding motorways, including also type of road or area unknown).

We start with the number of casualties, i.e. all severities.

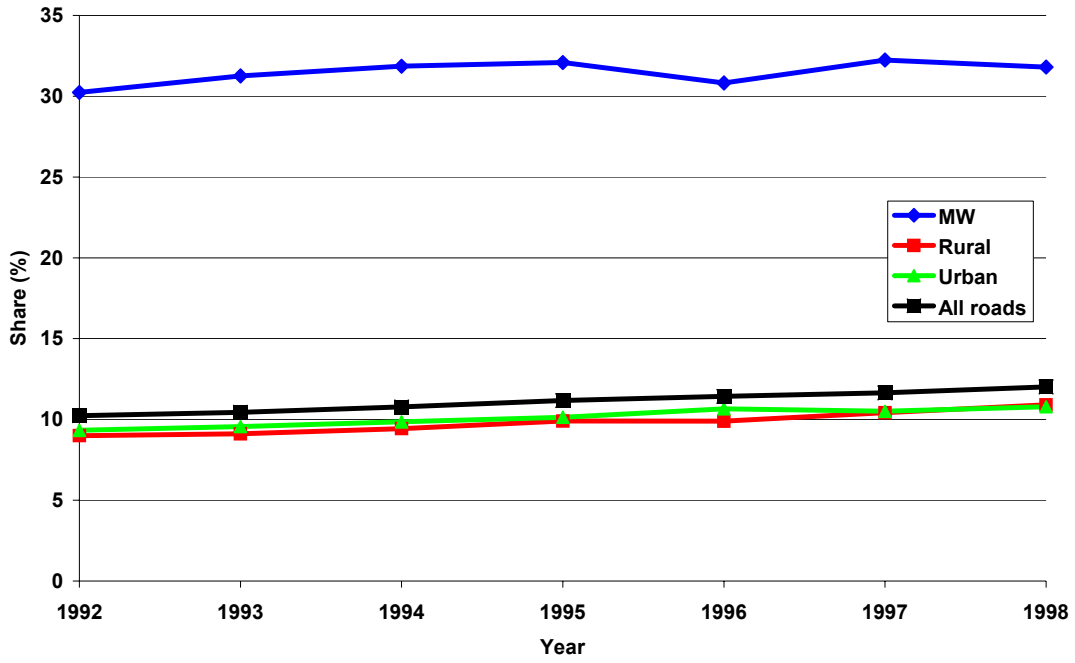


Figure 5. *The share of casualties from rear-end accidents related to all accidents, according to type of road and area; 1992-1998* (10 CARE countries)

In Figure 5 (and 6) we present again data from all 10 CARE countries.

Casualties from rear-end accidents on motorways represent more than 30% of casualties from all accidents in the 10 CARE countries concerned. Their share is also somewhat increasing. Both casualties of rear-end accidents on rural and urban roads, as well as the overall average share (all roads) of all casualties from rear-end accidents, have (increasing) shares of about 10 to11%.

Now we look at fatalities.

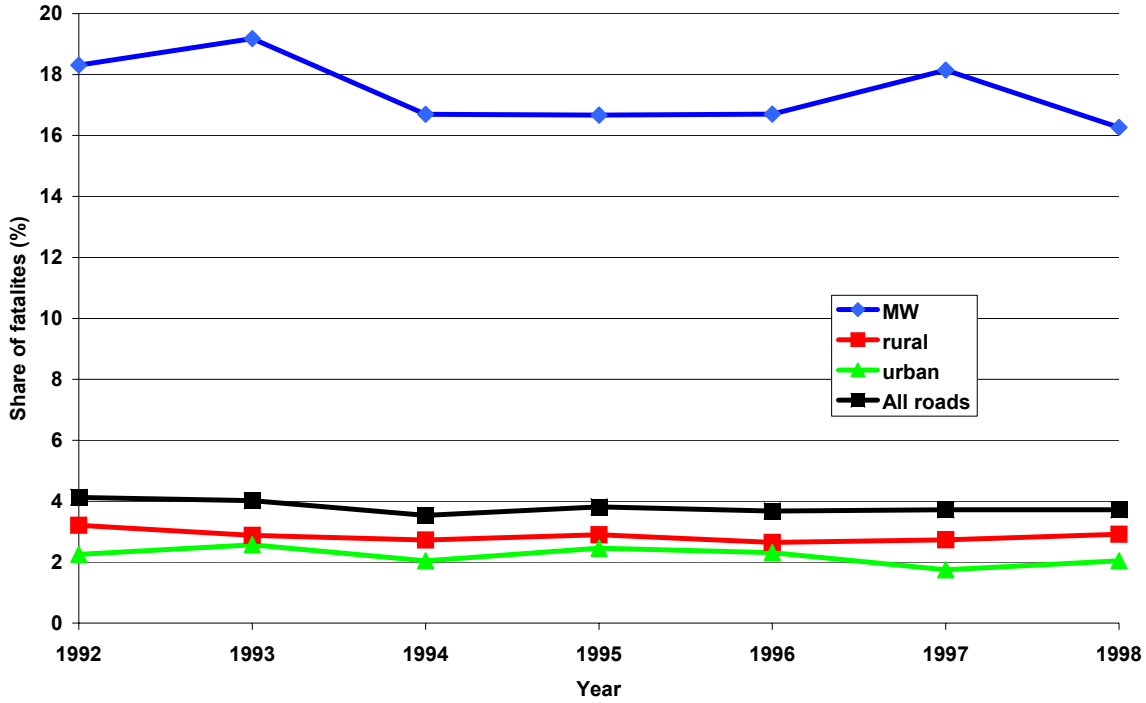
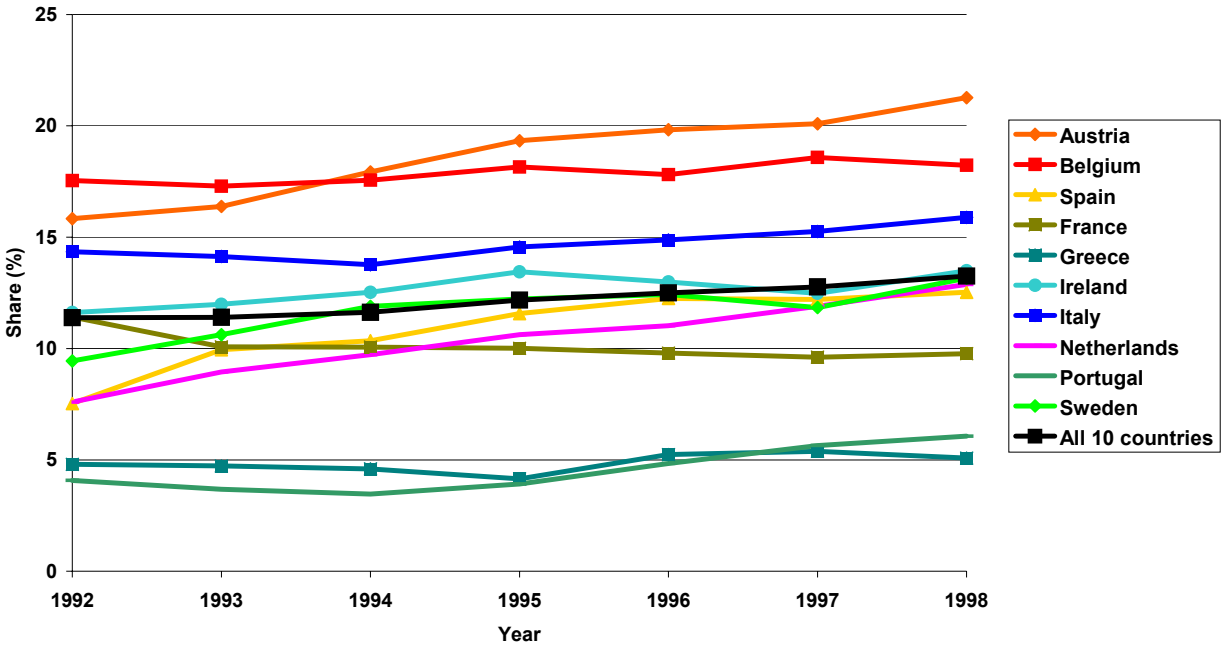


Figure 6. *Share of fatalities from rear-end accidents, related to all fatalities, according to type of road user and area; 1992-1998* (10 CARE countries).

The share of fatalities from rear-end accidents in the 10 CARE countries concerned is highest on motorways (around 18%), but far lower than the share of all casualties from rear-end accidents on this type of road, as shown in figure 5. Furthermore, in this previous graph, the shares were slightly increasing over the years, and in this graph all shares are somewhat decreasing.

3.2.3 Analysis concerning individual countries (third analysis)

In this part of the study of rear-end accidents we will show examples of developments in separate CARE countries. First we give an overview of all 10 CARE countries, concerning all casualties.



	Share of casualties (%)							
	Year							1998/1992 (index)
Country	1992	1993	1994	1995	1996	1997	1998	
Austria	15.8	16.4	17.9	19.3	19.8	20.1	21.3	1.34
Belgium	17.5	17.3	17.6	18.2	17.8	18.6	18.2	1.04
Spain	7.5	9.9	10.4	11.6	12.3	12.2	12.5	1.66
France	11.4	10.1	10.1	10.0	9.8	9.6	9.8	0.86
Greece	4.8	4.7	4.6	4.2	5.2	5.4	5.1	1.06
Ireland	11.6	12.0	12.5	13.5	13.0	12.5	13.5	1.16
Italy	14.4	14.1	13.8	14.6	14.9	15.3	15.9	1.11
The Nether-lands	7.6	9.0	9.7	10.6	11.0	11.9	12.9	1.70
Portugal	4.1	3.7	3.5	3.9	4.8	5.6	6.1	1.49
Sweden	9.5	10.6	11.9	12.2	12.4	11.8	13.2	1.39
All 10 coun-tries	**11.4**	**11.4**	**11.6**	**12.2**	**12.5**	**12.8**	**13.3**	**1.16**

Figure 7. *The share of casualties from rear-end accidents related to all accidents, according to CARE country; 1992-1998*.

In figure 7 we see that the shares of casualties from rear-end accidents for the separate CARE countries almost all increase during the years shown (1992-1998).

Shares (of the number of casualties from rear-end accidents related to casualties of all accidents) differ between countries; in 1998 these are relatively high for Austria (21%), Belgium (18%), and Italy (16%). They are relatively small for Greece (5%), Portugal (6%), France (10%).

All other countries have shares near the total average of 13%.

The indices from the last column of the table clearly show that the increase during 1992-1998 of the share of casualties from rear-end accidents is by far the highest for the Netherlands (+70%), followed by Spain (+66%), Portugal (+49%), Sweden (+39%) and Austria (+34%).

We can also see that only France shows a decrease (-14%), while the remaining countries (Belgium, Greece, Ireland and Italy) show relatively small increases.

3.2.4 Analysis concerningy kilometres (fourth analysis)

The reason we are interested in kilometres driven on the roads is twofold. In the first place, data concerning kilometres are often used to calculate risk (of being injured in a road accident), thus giving a more objective manner of comparing traffic safety from different countries, than based on only the number of accidents or casualties.

Secondly, an increase of the number of kilometres driven (generally the result of an increase of the number of road vehicles) may result in an increase of the number of accidents, especially when road infrastructure is not adapted to this increase (as is partly the case in the Netherlands).

So, if traffic density increases, we may expect an increase in accidents of any type. Especially on motorways, where rear-end accidents are far more common than on other types of road, this may well be the cause of even more traffic safety.

Of course, to study such assumptions properly, far more data such as the number of vehicles, the number and length of roads, and their traffic intensity, would be needed as well.

In the IRTAD database, some information about exposure is available, such as kilometres driven on different types of road, length of roads etc.

However, it appears that for few countries is this data complete with regard to the years considered in the previous analyses (1992-1998).

In the next table, we show IRTAD-data concerning motorvehicle kms driven at all roads, the item which is the most complete of all IRTAD-data relating to kilometres.

	Number of motorvehicle kilometres (million)							
	Year							1998/1992 (index)
Country	1992	1993	1994	1995	1996	1997	1998	
Austria	60,135	61,296	63,816	65,081	67,323	68,720	70,146	1.17
Belgium	75,228	76,557	79,248	80,257	81,423	83,000	86,065	1.14
Spain								
France	462,000	471,000	465,000	476,000	482,000	492,000	507,000	1.10
Greece		62,878	66,068	69,648	72,923	77,053	81,635	
Ireland	26,270	27,350	29,266	31,794	34,532			
Italy								
The Netherlands	103,645	104,418	108,753	110,158	110,736	113,890	115,865	1.12
Portugal								
Sweden	65,537	64,135	64,905	66,138	66,469	66,668	67,401	1.03

Figure 8. *The number of motorvehicle kilometres (million), according to CARE country; source: IRTAD 1992-1998 (empty cells = no data present).*

The table shows that from 5 out of 10 previously selected CARE countries complete data is available.

For these countries an index (1998/1992) is given in the last column.

During the years concerned, the overall increase of the number of motor vehicle kilometres varied between 3% in Sweden and 17% in Austria.

In figure 9 we compare these indexes with those based on the numbers of casualties from rear-end accidents (previous analysis).

Country	Index casualties (1998/1992)	Index kms (1998/1992)
Austria	1,34	1,17
Belgium	1,04	1,14
France	0,86	1,10
The Netherlands	1,70	1,12
Sweden	1,39	1,03

Figure 9. *The indices (1998/1992) of the number of casualties of rear end accidents, and motorvehicle kilometres, for 5 CARE countries.*

Figure 9 shows various combinations of indices within a given country. For instance, for the Netherlands we find the highest index for casualties (1.70), and a moderate index for kilometres (1.12), while Belgium has a higher index for kilometres (1.14), but a very moderate index for casualties (1.04).

Data concerning kilometres are often used to calculate casualty risk.

In the next graph, rear-end accident casualty risk is presented for those countries and years from which motor vehicle kilometres are available. Risk is expressed here as the number of casualties from rear-end accidents (data from analysis 3, last table) divided by the number of (million) motor vehicle kilometres as presented in the table above.

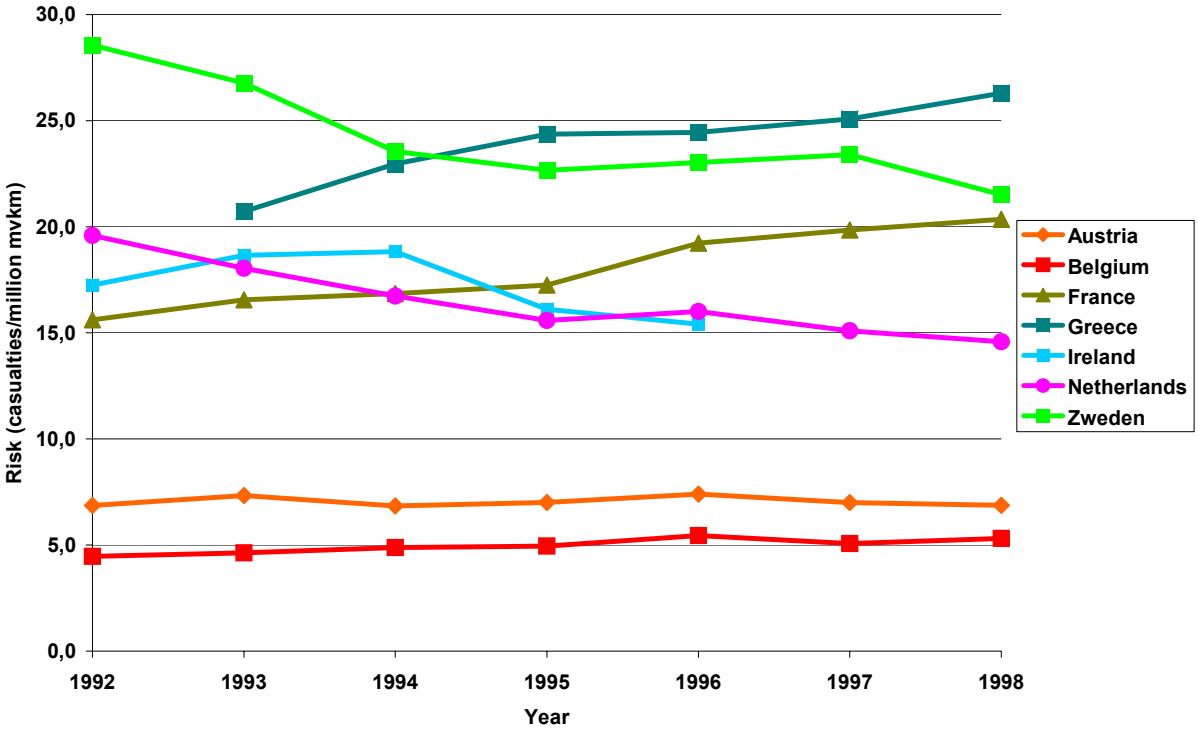


Figure 10. *Rear-end casualty risk (the number of casualties from rear-end accidents related to the number of million motorvehicle kilometres driven) for 7 CARE countries; IRTAD and CARE data, 1992-1998.*

The graph shows considerable differences between countries with respect to rear-end casualty risk.

It varies from about 5 (Belgium) to nearly 30 (Sweden, 1992).

Some countries show declining rates (Ireland, The Netherlands, Sweden), others increasing ones (Greece and France), while the risk in Austria and Belgium remains more or less stable.

4 Discussion of results

As stated in the introduction of this chapter, we did not explore all different aspects of rear-end accidents as in a proper scientific study. The following observations with respect to contents are therefore to be seen as true but limited with respect to the real problem of rear-end accidents in Europe.

Since from only 10 CARE countries data could be used, the total scope of the problem of rear-end accidents is at least underrepresented by about 25% with respect to the number of all traffic accidents in the current 15 EU-countries. The countries excluded were Denmark, Germany, Great Britain, Finland and Luxembourg.

Apart from this, the total scope of the real problem may be even more underrepresented since police based accident data such as those in the CARE database, are always incomplete, especially regarding non-fatal injury cases.

It should also be noted that for reasons of comparison, pedestrian casualties were excluded at all from these analyses.

From the **first analysis** (paragraph 3.2.1) we know the scope of the problem of (casualties of) rear-end accidents in 10 EU-countries, here called CARE countries.

In 1992 about 94,000 casualties of rear-end accidents were registered, in 1998 the number was about 116,000; the increase being 23% during 6 years.

During that same period the number of casualties from all accidents in the 10 CARE countries considered was about 827,000 in 1992 and about 875,000 in 1998, and increase of 6%.

Therefore, the share of casualties from rear-end accidents increased from 11.3 % in 1992 to 13.3% in 1998, an overall increase of 16%.

So the overall scope of the problem has become absolutely and relatively larger during the period considered.

We also know from the first analysis that the numbers of fatalities and seriously injured occupants are relatively small compared to the number of slightly injured occupants. The overall share of fatalities from rear-end accidents in fatalities from all accidents is under 4% and somewhat decreasing; the percentage with respect to seriously injured is under 5.5% (based on 9 out of 10 CARE countries) and more or less stable, while the share of slightly injured is in the order of 13% and increasing.

The problem of rear-end accidents particularly concerns slightly injured.

From the **second analysis** (paragraph 3.2.2) we know more about the type of road and area where rear-end accidents take place. More than 30% of all casualties of accidents on motorways are casualties from rear-end accidents; this share is increasing.

Also increasing are the smaller shares of casualties of rear-end accidents on rural or urban roads; both are about 10%.

From the **third analysis** (paragraph 3.2.3) it appears that there are huge differences between CARE countries, both in magnitude and in development of the number of casualties due to rear-end accidents.

With respect to the scope of the problem of rear-end accidents, we see in 1998 that the shares of casualties from rear-end accidents range from 5% (Greece) tot 21% (Austria).

The development range during the period 1992-1998 was highest for the Netherlands (a 70% increase) and lowest for France (a 15% decrease).

Though the **fourth analysis** (paragraph 3.2.4) brought little result, due to lack of complete data concerning kilometres for the different CARE countries, let alone those concerning motorways, some observations could be made.

It appears that for those five countries for which these data were available for the years 1992-1998, various combinations of indices concerning casualties of rear-end accidents, and motorvehicle kilometres driven were found. This indicates that the increase of the number of kilometres driven is not a proper predictor for the increase of the number of casualties.

The numbers of kilometres from these EU-countries (and two others with less complete data) are used to calculate (rear-end accident) casualty risk. It appears that there are considerable differences between these countries, while also different trends (increasing, decreasing, stable) became apparent.

With respect to the very high rear-end casualty risk calculated for Sweden, this is especially interesting, since it is well known that Sweden belongs to the EU-countries with by far the lowest fatality risk.

Whether these incomplete findings present the true picture or not, remains to be investigated.

At least more complete, and more detailed data concerning kilometres are needed than those currently available in IRTAD.

5 Possibilities and limitations of the data in CARE

5.1 Possibilities

Contrary to most other international databases based on police registration, CARE-data contains much detail, such as collision type, vehicle group, motorway, and different injury severities, which ensures detailed analyses of relevant traffic safety issues.

The issue of rear-end accidents could therefore be reviewed both at the EU-level, and at a national scale. The scope of the problem, as well as increases or decreases over time could be analysed for both levels.

After extracting the relevant data from the international database (see observations concerning this topic elsewhere in the report), the very large amount of data could be conveniently handled, using Excel pivot tables.

5.2 Limitations

The most obvious limitation of the CARE data concerns the fact that not all EU countries are able to supply all detail. In this case study, the variable collision type (category chain or rear) was primarily needed to analyse rear-end accidents. This category appeared available for ten out of all fifteen EU-countries (from which of course Germany does not provide data at all).

From these ten countries, in one case another detail (some relevant injury severity categories) was missing, which reduced the selection of countries to nine considering that detail of the study.

Another relevant limitation to almost all studies to be undertaken are the missing years. This fact caused the case study of rear-end accidents to be limited to the years 1992-1998, instead of 1991-2002. Especially the missing four recent years are a serious draw-back, considering the fact that the number of rear-end accidents (or casualties from rear-end accidents) shows distinct developments over time, which developments are moreover different for different countries.

The fact that data from the Netherlands after 1999 are missing in the CARE-database, causes some concern, since they already exist, and are used by SWOV and others at the national level.

As was known beforehand, no other data than that concerning injury accidents is available in the CARE-database. Data concerning traffic exposure, such as kilometres driven, had to be found elsewhere, in this case from IRTAD. These data however appeared to be very incomplete, considering the fact that from only five out of the ten CARE-countries selected for this case study, total estimates of motorvehicle kilometres could be found for a range of years, comparable to those used in the case study.

We have been assuming that the numbers of casualties from cars involved in rear-end accidents, as used in this case study, are representative for the so called whiplash problem that is threatening the social life of many EU-citizens.

However, as stated in paragraph 2, we could not distinguish injured from 'rear-ended' cars involved in rear-end accidents, from those in striking cars involved in those same accidents, even though we may assume that the chances of being injured are higher in the former group.

To distinguish between the two groups of injured, another detail would have been needed, such as the damaged side or part of a car, a detail which is provided in the Netherlands by the police, but is not a detail in the CARE-database.