# Passive safety of passenger cars

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*A pilot-study into the development of a ranking list of passenger cars*

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# Summary

## Passive safety of passenger cars

The SWOV Institute for Road Safety Research was commissioned to conduct a passive safety study for the Netherlands Transport Research Centre (AVV). The first part of this study (Tromp, 1998, [only in Dutch]) concerned rear-end collisions and neck injury. This second part (original Dutch version by Van Kampen, 1998) investigated the feasibility of constructing a list of individual or grouped types of cars which could be ranked according to passive safety. In so doing, differences in passive safety among these types of cars could be described. Due to the differences between composition of road traffic and collision conditions in other countries in comparison to the Netherlands, foreign ranked listings are rather limited in regard to this objective.
The report includes a consideration of the existing and the intended vehicular regulations in the area of passive safety. It also examines the complex issue of making vehicles compatible with one another and the often conflicting vehicle requirements, especially in regard to the safety of occupants as opposed to the safety of third parties.

A rank list was produced, based on accident data obtained from the National Register of Road Traffic Accidents (VOR) of the Traffic Accident Data Administration of the Department of Public Works (AVV/BG). Linked to the VOR data were vehicle data from the vehicle registration numbers of the RDW Department of Roads Transport.
Two measures for expressing the passive safety of individual vehicles were developed. One of these (EV) provides an indication of the occupant safety for a certain vehicle model while the other (AV) expresses the degree of injury caused by a certain vehicle model in relationship to other road users.

Practically speaking, the procedure for obtaining related data (accident data and vehicle data) left something to be desired. For reasons of privacy, SWOV could not obtain direct access to vehicle registration numbers. Because SWOV was not able to handle vehicle registration numbers directly, the quality of the obtained results was less than expected. It is therefore recommended that the AVV/BG still consider these quality aspects. Also recommended is that the vehicle license numbers be provided directly to SWOV during the follow-up, preferably permanently in the standard accident file.

This pilot study showed that linking vehicle data with accident data is quite feasible. The passive safety analyses provided reliable data. Also confirmed by this pilot study using Dutch data was the connection between vehicle size and the severity of personal injury as commonly noted in the literature. There appeared to be a very strong inversely proportional relationship between vehicle size and occupant safety: the smaller and lighter the vehicle, the more severe the injuries for the car's driver.

The key objective of the study was achieved: a ranked listing (although provisional) was drawn up of various types of vehicles occurring more than

one hundred times in the file. Criteria used were the EV and AV.
The provisional ranked listing shows a more or less logical progression of EV and AV while also considering the established tie between vehicular mass and the severity of personal injury. To make the ranked listing more complete and reliable, further analysis, both of the previously studied material and of data yet to be gathered, is recommended.

# Inhoud

# Abbreviations used

| | |
|---|---|
| AV | Aggression index of a vehicle type ('safety of others') |
| AVV/BG | Adviesdienst Verkeer en Vervoer, Hoofdafdeling Basisgegevens<br>The Netherlands Transport Research Centre AVV, Department for Statistics and Data Management |
| ECE | Economic Commission for Europe |
| EEG | Europese Economische Gemeenschap<br>European Economic Community |
| EEVC | European Experimental Vehicles Committee |
| EU | European Union |
| EV | Passive safety index of a vehicle type ('own safety') |
| RDW | Rijksdienst voor het Wegverkeer<br>RDW Department of Roads Transport |
| SEH | Spoedeisende Hulpafdeling<br>Accident and Emergency department of a hospital |
| TNO | Nederlandse Organisatie voor Toegepast Wetenschappelijk Onderzoek<br>Netherlands Organisation for Applied Scientific Research |
| VOR | Verkeersongevallenregistratie van AVV/BG<br>National Register on Road Traffic Accidents of AVV/BG |

# 1. Introduction

The Netherlands Transport Research Centre of the Directorate-General of Public Works (AVV) commissioned SWOV to find out the extent to which it is possible to develop a rank list of passenger cars (henceforth to be referred to simply as 'cars').
By rank list is meant a list of individual vehicle types, ranked by the extent of passive safety.
This list should be based on accident data from the National Register on Road Traffic Accidents (VOR) of the Department for Statistics and Data Management of the Directorate-General of Public Works (AVV/BG).
The missing vehicle data of this database was added, using the vehicle database of the RDW Department of Roads Transport.
Such a linking of these two databases has never been done before for the purpose of producing a rank list. This had however already been proposed as a result of a literature study of foreign rank lists. As it is in other countries, such a rank list could serve as a consumer guide when trying to buy the safest car. Schoon (1995) concluded however that there was not enough support in the Netherlands for something like this.

This study has another angle of approach. Not so much as a consumer guide but an instrument to interpret more validly the different degrees of passive safety of cars on Dutch roads.
This knowledge can be used additionally in different ways. Chapter 2 deals with the regulations regarding passive safety. The possible applications of rank lists are mentioned here.
Attention is especially payed to recent international research, in which both TNO and SWOV have been involved. This research aims at improved the crash compatibility of cars during crashes.

Chapter 3 discusses the design of the linkage between the accident and vehicle data which is essential for making a rank list.
Chapter 4 handles the developed method necessary to determine a rank list.
In chapter 5 an aid to the method, viz. a division of the characteristics of cars, is described.

In chapter 6 the unlinked databases (accidents and vehicles) are discussed.
The actual linkage and the analysis of the linked data is described in chapter 7.
A discussion and evaluation of this pilot-study then follows in chapter 8.
The report is concluded with conclusions and recommendations in chapter 9.

This study was accompanied by H. Roodbol of the Directorate-General of Public Works.

# 2. Regulations and passive safety of cars

## 2.1. Internationale regulations

At the beginning of the 1970s, the European Union (EU) (then still the EEC) paid, among other things, a lot of attention to Directives concerning passive safety. These were: the presence and strength of seat belts, safe steering wheels, the strength of seats and head rests, etc.
The Directives contained crash tests, which manufacturers had to comply with. If they did not, their product (or parts of it) could be refused by other EU countries.
In many cases these Directives were derived from so-called Regulations of the Economic Commission of Europe (ECE) in Geneva.
Regulations are established in a different way from Directives, if only because the technical consultation in Geneva contained many more European countries than the (now) fifteen EU member states.
In the meantime a complete system of car Directives has been completed as designed in the seventies.

A characteristic of the Directives is that they are meant to break down trade barriers. This means that, in general, compromises have been made about the level of passive safety, so that all manufacturers can comply without too many difficulties. The requirements can also be regarded as minimum demands. In general, manufacturers manage to exceed the demands, as they do regarding passive safety topics that are not (yet) regulated.
In fact these sort of developments are completely left to market forces until the reality shows that further regulation is desirable. Examples of these, as far as passive safety is concerned, can be found in the application of airbags and extra facilities to the existing seat belt system (pretension design). One can also include all developments of crush areas and rigid passenger compartments; for these there are no explicit demands.

From all this it would seem that, as far as vehicle safety is concerned, many manufacturers have successfully been able to produce a safe car, without there being legal requirements. This is certainly one of the reasons why manufacturers oppose (even) more legal demands in this field.

## 2.2. Recent developments

As far as passive safety of cars is concerned, the following three points of special interest are current:

- the frontal passive safety;
- the side passive safety;
- the passive safety of pedestrians and cyclists in a collision with the front-end of a car.

The first two subjects have already lead to Directives which will shortly be applied. This has certainly not been achieved without a fight, especially because of objections from the car manufacturers. Many years of research and consultation have preceded this. Eventually the European Parliament had to step in to force a break.

The objections of the car industry were mainly based on intrinsic grounds and have also lead to a lot of their own research.
Partly because of this, the present result in the form of Directives is, as such, so controversial that there are plans to adjust the demands.

Regarding side impact, the beginning of a two-sided approach can already be discerned in the intended Directive: The car to be tested (target) is hit by a moving trolley (bullet) having the mass and dimensions of an average car, and provided with a deformable surface, representing more or less the crushable front end of a car.

Improving the passive safety of cars in collision with pedestrians and cyclists by means of a Directive (which has existed for some time now in concept form) has not been successful as far as the legislative procedures are concerned. Since the proposed Directive involves further demands for the front-end of the car to be tested, car industry opposes collectively more regulations for this point. The industry has managed to postpone the discussion extensively by expressing great doubts about the cost-benefit ratio of the Directive.

## 2.3. Head-on crash tests and compatibility

Plans for adapting the new Directives, as far as those for the frontal crash test are concerned, are proving difficult. This is partly because of the problem of the correct test speed and compatibility, i.e. the influence of mutual relationships of colliding vehicles. The intended Directive takes this insufficiently into account.
Anyway, there is obvious tension as far as the question of whether all demands regarding the front-end passive safety can be regulated using *one* sort of test. This is what the manufacturers want. It would seem to be that the problem is extremely complicated to tune the mutual crash properties of vehicle structures.
The front-end crash test has attracted much interest the last few years because different organisations (of consumers, researchers, and manufacturers) have developed and applied different testing methods. These often deliver contradictory results, and have in turn resulted in a lot of new publicity.

### 2.3.1. *From single vehicle to two-sided approach (compatibility consideration)*

In the last paragraph, the desired, two-sided approach of the passive safety of cars was introduced.
This is a comparatively new line of thought. Until now, all existing Directives for cars were aimed at the safety of the car's own occupants.
The criteria for judging whether or not the demands had been complied with, have always been tuned to the outcome of an accident for the own occupants. This was usually determined via one or more measurement criteria using decelerations and movements of a test dummy. The tests did not take the outcome for the collision partner into consideration.
The exception to this is the existing Directive concerning the outside parts of a vehicle. These parts should prevent injury and damage to third parties, by rounding off the parts.

The one-sided approach to the passive safety of cars (all aimed at its own occupants) is being gradually broken down because in practice it's

becoming more and more clear that a fundamental tackling of the problem demands a two-sided approach. In many collisions involving cars, there are also other vehicles involved, very often another car.
The outcome of a collision of two vehicles is determined by the interaction of them both; the properties of the collision partner are therefore just as important.
This brings us to the subject of *collision compatibility* (simply compatibility). This term means adapting vehicles to each other (vehicles of the same type as well as different types). At this moment in time there is a great lack of compatibility. This means that a collision usually ends more favourably for one party than the other.

The problem of (in)compatibility has in the meantime become the subject of various studies in, among others, the fourth framework programme of the EU. This applies to research organisations (among others via the EEVC) as well as the industry (especially the BRITE EURAM programme).

Compatibility problems will remain so as long as there are vehicles with unequal size, mass, and structure.
The compatibility problem of different vehicle types (such as bicycles at one extreme and lorries at the other) is so large and unsolvable that only the complete separation of vehicle types (in time and space) is sufficient.
The problem is however also present (but less clearly visible) in the case of vehicles of the same type. Here there are also differences in mass, structure, and size. Collisions can therefore have completely different outcomes. Apart from the vehicle structures and properties themselves, the external crash circumstances (such as collision speeds and type of accident) are also important.
Being compatible during a collision means the vehicle properties being tuned to each other, given these external circumstances and given the fact that masses and dimensions may differ considerably.

### 2.3.2. *Radical changes necessary but difficult to realize*

The in § 2.2 mentioned stagnation in the developments of the safety of pedestrians and cyclists, in which introduction of a Directive was blocked by manufacturers, shows just how difficult it is to extend the idea of 'Partnerschutz', even though the nature of the solution to this problem is in fact completely different (constructively much less radical) than that of the mutual compatibility between cars.
The opposition of manufacturers was so fierce because they feared that a structural intervention would be necessary concerning the front-end (including longitudinals, wheel suspension etc.). Implementing this Directive was thought to be so expensive that a very negative cost-benefit ratio could result.
A flexible position of the European Commission with regards to the implementation sequence of the Directive, has not helped.
In the autumn of 1997 a new MIRA study appeared which once again added up the costs and the benefits.
Referring to this, there has come a (new) EEVC working group (WG17) which TNO is leading in an attempt to adapt the intended Directive to the new situation.

### 2.3.3. *Common ground with the European project*

The actual subject of this present study is the mutual passive safety of cars. Within this vehicle category there are also large differences in mass and geometry, which lead to large differences in the outcome of a collision. This problem also requires a two-sided approach: characteristics of both cars involved in a collision have to be taken into account.

As already stated, this idea has already found acceptance, but also encounters many objections when being worked out. Problems are encountered both because the subject (compatibility) is very complicated, and because of practical aspects: the aim is to find one crash test only in which both the (frontal) passive safety of the test car, and that of the opponent car may be judged.
While looking for solutions to these problems, all possible methods are being used.
In the already mentioned two-year EU project ‘Compatibility’, in which TNO and SWOV represent the Netherlands, the following methods will be used: literature research, accident analysis, an inventory of car characteristics, mathematical simulation, and crash tests.

As far as the accident analysis is concerned, the Netherlands together with Germany, France and Spain are responsible for the analysis of statistical data such as that of AVV/BG in the Netherlands.
By linking vehicle data from the vehicle registration of RDW to accident data, analyses of specific vehicle types can be carried out. The main purpose is to analyse frontal collisions between cars (and vans) only.

The common ground with this present study is that we also want to look at the passive safety of separate car types; using linkage of accident and car data. We are however aiming at a broader scale of collisions, including both frontal, side, rear end, and vehicle against obstacle collisions.
The present study is aimed at researching the feasibility of a general method to determine the passive safety of a car type in two-vehicle accidents.

### 2.3.4. *EURO-NCAP and ranking research*

‘Ranking’ and rank lists are produced when cars are tested in the same way and the results can be compared. In this sense, the method used for the so-called EURO-NCAP programme is also a multi-stage rank list approach. This European programme, which is an initiative of consumer organisations and the British government, has been derived from a method applied in the United States (called NCAP). It charts the passive safety of individual, new cars by crash testing at a level above the legal requirements. Recently, the Dutch government participates in the EURO-NCAP programme, and a number of the crash tests planned in the Netherlands will be carried out by TNO.

The EURO-NCAP demands, just as the existing legal passive safety demands, are aimed primarily at occupant safety. They are, therefore also still an example of an one-sided approach.
A EURO-NCAP exception is the (not yet legally obligatory) part that looks into the safety of vulnerable road users in collision with a car’s front-end. This means that the EURO-NCAP anticipates the EU Directive that is still blocked by the car-industry.

In order to involve some idea of compatibility in the crash test, the EURO-NCAP will use a special testing method (just as the new Directive for the frontal collision). This testing method involves the following: crashing the test vehicle against a barrier, with a 40% overlap (the extent to which the front overlaps the barrier), on which barrier a honeycomb construction is mounted. The honeycomb represents the crushable front-end of a real car. A crash speed has been chosen that is higher than the legal limit of the new Directive (viz. 64 km/h instead of 56 km/h).
Both speeds are quite a way higher than the level that was used a few years ago (50 km/h). It is however certain that at a speed of 64 km/h a considerable greater amount of energy will be converted than at a speed of 56 km/h. This in turn makes greater demands on the crash performance of the vehicle involved.
The use of the overlap and the honeycomb are both considerable improvements in the crash reality in comparison with the standard that was often used in the past during such tests (the full frontal crash of 50 km/h against a rigid barrier).

There have been heated discussions with manufacturers about nearly every aspect of the EURO-NCAP crash test. Especially the high test speed was supposed to result in too stiff frontal structural properties of the car.
In the meantime, several series of crash tests of the EURO-NCAP programme have been carried out; new series are in preparation. As has already been mentioned in the introduction, the Dutch government has recently joined the steering committee and TNO will be involved in carrying out the tests.
The Dutch consumer organisation participated from the beginning in the programme. In fact, the consumer organisations have taken the initiative in this sort of testing. They also are the ones that publish the results.
The results of the first series of tests (small and compact cars) attracted a lot of attention from the manufactures as well as the public (for whom it was originally intended). The mainly negative reactions from manufacturers were more a matter of principle than because of the results themselves: the tested cars yielded reasonably good results. The results of more recent tests appeared even better, indicating that car industry might be adapting its designs fairly well to this kind of testing.

### 2.3.5. *Comparability of results a problem*

The results of crash tests such as EURO-NCAP are only directly comparable for cars within the same size category. The method does not yet permit the results of cars from different categories being compared. A car scoring well in its own class is not necessarily good in a collision with a car from another category, or even with a car of the same category!
This is again because of the fact that it still all concerns a single vehicle test with an injury criterion that belongs to a tested vehicle.

Though people have attempted to carry out a more realistic method than in the past by adding the overlap and honeycomb, the fundamental problem is not solved. In a mutual crash of vehicles, the strength of the structurally weaker of the two (usually the lighter and smaller) still determines the outcome. Furthermore, completely different parts sometime deform during a real crash than in a crash test of identical vehicles against the barrier, in spite of the honeycomb.

A single frontal crash test, such as with EURO-NCAP and the test in the new frontal Directive, is by definition incapable of representing sufficiently the collision partner.

There are plans to 'simulate' the two-sidedness by allowing a lower crash speed for heavy vehicles (which are usually more rigid) than for lighter cars (which are usually less rigid), but to employ the same injury-criteria. It is certainly worth the trouble of following up this line of thought; it is possible that there is a beneficial effect. In any case, one can imagine that heavy cars that have to comply with a relatively mild demand, do not have to be built so stiff as they are now. If they are less stiff they are better tuned to a less stiff, small car, thereby improving the compatibility. There is a greater chance of an 'equal' outcome in the case of a mutual collision.

### 2.3.6. *All cars should become 'equal'*

In the above-mentioned reasoning, 'the solution' to the problem of incompatibility is implicit. If one succeeds in adjusting the average stiffness (or rather, the force level for a deformation) of cars so that they are more or less comparable, the structure of both partners will be deformed simultaneously, whereby the available crush area of both partners will be used.

In the present (incompatible) situation, it is in fact only the crush area of the 'weaker' partner that is deformed to the full. That of the stronger partner is left mostly undeformed, with all the negative results for the occupants of the lighter partner.

The examples also make clear that the basic idea is perhaps good, but that the constructive implementation may encounter many practical objections. The car manufacturers continue to maintain that making vehicle structures of heavy vehicles less rigid is not attainable because these structures also have to be able to withstand other forces such as vertical loads. These are intertwined because they are all parts of a heavier vehicle.

In determining the extent of the passive safety of cars, as based on accident data from the real world (the purpose of this study), the problem of compatibility is automatically included.

If the theory of the influence of (vehicle) mass proves to be correct, the accidents of smaller vehicles are, on the average, more serious than those of larger vehicles.

### 2.3.7. *National data essential*

Using this method, the influence of mass can also be measured for the Netherlands situation; data for other countries is already known.

This is done in practice by, for example, calculating a mass ratio (the relation between both masses of the colliding vehicles). As the vehicle mix (and therefore the mass mix) in the Netherlands is different from other European countries, the results of passive safety analysis will also be different for the Netherlands.

As far as the average passive safety of a particular type of vehicle is concerned, there can also be other individual car ratings expected than in another country with another vehicle mix.

That is why rank lists from other countries are not directly usable for the Netherlands, even if they of course indicate the possible differences.

# 3. Design of the linkage study

## 3.1. Basis data files

The basic data for this study are to be found in two files: the National Register on Road Traffic Accidents (VOR) of the Traffic Accident Data Administration of the Directorate-General of Public Works (AVV/BG) and the vehicle data from the vehicle registration number database of RDW.
A recent development has been to formally acknowledge that the data in the VOR accident database is far from complete and also not representative. This applies even more so to specific groups of accidents (especially accidents with cyclists) and less serious ('light') injury accidents in general. This problem only applies to non-fatal accidents.
It has also been established that the registration level of injury accidents involving motor vehicles is higher than for other accidents. This applies to all those treated in hospital, whether having been admitted (In-patients) or treated by the Accident and Emergency (A&E) department of a hospital (Van Kampen et al., 1997; CBS, 1997).
Nevertheless, using the VOR database for the current problem, the results in terms of the number of accidents, may underestimate reality, especially regarding non-fatal accidents.
This problem is not regarded as a hindrance in achieving the actual goal of this study. In making a rank list of the passive safety differences between vehicles, we assume that the under registration is more or less the same for all relevant accidents.

## 3.2. Selection of target groups from VOR database

We began with the selection from the VOR database of 1996.
The steps were:

1. determine the target group;
2. select the target group;
3. look for VOR numbers and the accompanying object numbers;
4. contact AVV/BG and RDW about obtaining the vehicle registration data;
5. send a list of VOR numbers and object numbers to the VOR.

*Ad 1. Determining the target group*
This study is not only concerned with cars involved in collisions, but also (as a result of an American study) delivery vans. In the American study, unexpected differences in passive safety with cars were found within the category pick-ups and space wagons.
In the Dutch situation, such cars, even as those vehicles normally classified as cars, are to be found among the category cars (with a yellow number plate) as well as the category delivery vans (with a grey number plate). Both categories are limited to a maximum permissible weight of 3,500 kg., for which only a car driving licence is required.
Within the category delivery vans, pick-ups and space wagons cannot be distinguished from cars without specifying the vehicle properties of that particular vehicle registration number. In a previous SWOV study (School & Hagesteijn, 1996), where a linkage of delivery vans took place, the following was discovered. In injury accidents, approximately 25% were cars with a grey number plate and 15% were pick-ups/jeeps.

*Ad 2. Selecting the target group in the VOR database*

Based on this description of the target group, a number of selections from the 1996 VOR database were made. They have the following common characteristics:

*All accidents in which only two objects are involved (objects are vehicles, lampposts, trees etc.) and in which at least* one *car or delivery van is involved.*

This primary selection limited the number of accidents in 1996 to 31,401 (of the 41,041).

If this selection is limited further to those accidents in which only cars or delivery vans are mutually involved (including collisions with obstacles): 8,782 accidents remain.

This is illustrated in *Table 3.1*; the two objects in an accident are called object A and object B.

| Object A | Object B | | | | | | |
|---|---|---|---|---|---|---|---|
| | Car | Delivery van | Obstacle | lorry/bus | 2-wheeled veh. | Rest | Total |
| Car | 5.107 | 454 | 2.344 | 411 | 6.515 | 1.885 | 16.716 |
| Delivery van | 583 | 65 | 229 | 63 | 779 | 193 | 1.912 |
| Lorry/bus | 334 | 36 | 56 | 38 | 368 | 136 | 968 |
| 2-wheeled veh. | 5.573 | 560 | 930 | 299 | 2.900 | 1.103 | 11.365 |
| Rest | 94 | 8 | 21 | 10 | 192 | 115 | 440 |
| Total | 11.691 | 1.123 | 3.580 | 821 | 10.754 | 3.432 | 31.401 |

Table 3.1. *Accidents with only two objects by combination of objects (VOR 1996).*

The selected numbers of accidents are printed bold and total 8,782.

We can see in the table that of the non-selected accidents, there are nearly 15,000 (almost half of the total) accidents with two-wheeled vehicles. Of these, approximately 12,000 are collisions between cars and 2-wheelers. In this table, 2-wheelers are the sum of cyclists, mopedists, and motorcyclists.

Within the group of the 8,782 accidents which complied with the selection criteria, the following sub-groups were selected:

- frontal collisions;
- side collisions;
- rear-end collisions;
- collisions with obstacles.

All the above-mentioned sub-groups had to comply with the original criteria (only accidents with two objects, only cars and delivery vans). Furthermore, the following limitations in the collision configuration were introduced:

- in frontal collisions, only vehicles hit on the front-end;
- in side collisions, only combinations of vehicles in which *one* was hit halfway down the flank and the other in the front-end;
- in rear-end collisions, only combinations of vehicles in which *one* was only hit in the rear-end and the other only in the front-end;
- in collisions with obstacles, only vehicles hit in the front-end.

The purpose of all these limitations was to limit, as far as possible, the selected accidents and vehicles to the one collision type aimed at, without complications of secondary collisions and their damage and injury chances.

The limitations resulted in a reduction of the original 8,257 to 6,702 accidents. See *Table 3.2* for the distribution of these accidents by type and vehicles by category.

| Accident type (VOR-1996) | Number of accidents | Number of vehicles | Of which cars | |
|---|---|---|---|---|
| Frontal | 831 | 1.662 | 1.512 | 90,9% |
| Side | 1.850 | 3.700 | 3.340 | 90,3% |
| Rear-end | 2.015 | 4.030 | 3.677 | 91,2% |
| Obstacle | 2.006 | 2.006 | 1.821 | 90,8% |
| Total | 6.702 | 11.398 | 10.350 | 90,8% |

Table 3.2. *Numbers of selected injury accidents by type and vehicles by category (VOR-database, 1996).*

We see that in our selection of 6,702 accidents there were 11,398 vehicle involved, of which nearly 91% were cars and the rest delivery vans. In the first three groups of accident types there were two vehicles per accident, and in the last group only *one*.
Of all these cars, the vehicle information would have to be obtained.

*Ad 3. Selection of VOR numbers and object numbers*
Simultaneously with the selection of the four sub-groups just described, the following information was retrieved from the VOR database 1996: the unique VOR (accident) number and the object numbers of the vehicles involved in that accident.
Due to the nature of the selection used, the object number was always 1 or 2. The unique combination of VOR number and object number made it possible for AVV/BG to extract the licence plate numbers from their file. For this, SWOV created and stored a file of only the VOR numbers and the object numbers.
Owing to the fact that this data was not only required for this study but also the EU study mentioned earlier, the VOR numbers and object numbers for both studies were selected simultaneously. The total numbers were as follows: 10,176 accidents and 18,346 cars and delivery vans.

*Ad 4. Communication with AVV/BG and RDW*
Informal contacts were made with AVV/BG and RDW in December 1997 to pave the way for the formal procedure of acquiring the vehicle data.
The form in which the data was to be delivered to RDW was already established, as well as the form that RDW would put its output on tape (RDW,1997).

*Ad 5. Sending list of VOR numbers and object numbers*
As a result of the informal contacts, the formal request was made on 15th January 1998. SWOV received a floppy with VOR and object numbers. A formal SWOV letter was sent to AVV/BG with a copy to RDW.

## 3.3. Pre-selection vehicle registration numbers database

RDW produced a publication for customers requiring (mass) information from the vehicle registration database (RDW, 1997). In this can be seen what sort of information, and in which form, can be ordered.
A list of the information available, from this publication, is reproduced in *Appendix 1*. For passive safety research there are thirteen useful items. The most important data is 'make' and 'model'. With this, information in other (written) databases can, theoretically, be derived, if the production year is also known.

## 3.4. Preparation of linkage

The practical preparations of the linkage include:

1. *To produce a file (or files) with accident numbers, with as common key variable the VOR and object numbers*
   Of the four separate sub-files (one for each of the collision types to be distinguished: frontal, side, rear-end, and obstacle; a common analysis file *Passive Safety 1996* was created. Apart from the general accident features, the vehicle properties of the cars and delivery vans involved, which are also in the VOR database were included. To these were linked: the data on the drivers of those vehicles involved, as well as the data on the victims. Because the common key variables (VOR number and object number) were included, the linkage with the RDW vehicle properties could be made.

2. *To write the software for the linkage of the above-mentioned analysis file to the vehicle data from RDW*
   This programme was completed and tested on a self-made trial file of RDW vehicle properties.

## 3.5. Further preparation

A programme was written to read and test the RDW vehicle data. RDW's publication (RDW, 1997) was used as the basis for this.
Previous experience had taught us that vehicle data should be checked on a number of points. Firstly, the validity of the vehicle category was controlled (in this case only cars and delivery vans were relevant). Any other vehicle categories were eliminated.
Furthermore, the consistency of the data needed to be checked. This was done by judging the counts and crossings of the variables. A number of adjustments were also necessary to simultaneously be able to work with car and delivery van data; this is because delivery vans have more variables (in the RDW vehicle file) than cars.

Once the data had been received, the formats worked out beforehand needed to be adjusted. This certainly applied to the list of makes and models. A 'textsearch' was necessary to allow for make and model being coded in the proper order.
An analysis programme was also written so as to analyse the data after linkage. Then the passive safety criteria, as described in chapter 4, could be determined.

For the time being, this will concern the counting of fatalities and severely wounded for a number of conditions. This in agreement with the two criteria, for aggression and occupant safety, as described in chapter 4.

## 3.6. Dealing with obtained vehicle data

The procedure for obtaining the vehicle data did not go entirely as planned. Several days after having sent the floppy to AVV/BG, SWOV was phoned with the announcement that the data requested was not received directly, but that it would be sent to RDW. This was because of privacy protection.
RDW was then supposed to send the required vehicle data to AVV/BG, who would then link them to the relevant VOR numbers and object numbers. Then they would send them to SWOV. To get this done SWOV, in contrast to the formal RDW procedure, had to specify the output data by telephone.

As far as it can be retraced, AVV/BG then quickly sent the vehicle registration numbers to RDW who then quickly linked the vehicle data to them and then sent the data to AVV/BG.

A noticeable feature of the output as provided by RDW is that RDW data is only available on tape or lists or labels; not on floppy! This increases the difficulty of data processing from tape to file. Many institutes (SWOV among others) no longer possess a tapedrive.
That also appeared to be a bottleneck at AVV/BG. There the vehicle data had to be obtained from tape in order to be able to link them to the VOR and object numbers.

About a month after requesting the data and sending the VOR numbers to AVV/BG, the vehicle data requested was sent by e-mail.
See chapter 7 for further details of this data.

# 4. Developing of rank list method

The purpose of this pilot-study is to investigate if it is indeed possible to make a rank list based on the analysis of linked accident and vehicle variables.

SWOV had already carried out a preliminary investigation into the (political) feasibility of rank lists in the Netherlands, as explained in the introduction. Because of a lack of the support of various relevant organisations, this study was not continued (School, 1995). However, a design for such a study was made and has formed the basis of this study.

## 4.1. What is a rank list?

A rank list is a ranking of clustered or non-clustered vehicle types in descending sequence of passive safety; scored using some judgement criteria.

The clustering involves the fact that there are few types of vehicles for which the necessary data is available. This means that because of the lack of statistical reliability/validity, no reliable, independent score can be made. Adding together the various types of vehicle is worth a study in itself, because there are many criteria which could be used (by size, mass, wheelbase, body shape, etc.).

A division of vehicle by wheelbase and size is often used in the United States, simultaneously with a division by vehicle class. There is a division in the categories:

- two-door cars;
- four-door cars;
- sports cars;
- luxury cars;
- wagons and vans;
- pick-up trucks;
- utility vehicles.

Through this there is a division by size/wheelbase:

- small;
- standard;
- midsize;
- intermediate (by utility);
- large.

In the United Kingdom they often use the following division, based on vehicle size:

- supermini's;
- small family cars;
- large family cars;
- executive cars.

Within such a clustering one can, of course, look at individual makes and models.

The disadvantage of clustering is that, although one can compare the individual vehicle types within a cluster, it is difficult to do this with vehicle types from different clusters.

Ordering in sequence, according to what ever safety score, is primarily for comparing vehicles within clusters.

## 4.2. Rank list and passive safety indexes

In this study we are attempting to develop a rank list at the level of the individual vehicle type.
To do this, a ranking criterium is needed that can be applied in the same way to all distinguishable vehicle types. Thus the result is mutually comparable.
For the time being, two types of criteria are being considered: one for occupant safety and one for the safety of third parties. In the recent literature on this subject, especially an American compatibility study (Gabler & Hollowell, 1998), applications of such criteria can be found. These have been adopted and have been worked on further in this study.

### 4.2.1. *Index of occupant passive safety*

In the first place, cars are compared for the aspect of occupant safety. A criterium is used that relates the number of victims in the vehicle type being studied to a measure of exposure. The index is called Occupant Safety; shortened here to EV.
Due to the variance of the exposure measure, there are a number of EV variants imaginable. One can use, for example:

- the total number of injury accidents of the vehicle in question;
- the total number of vehicles in question in the national fleet.

None of these measurements are excluded for the time being, and the choice will be made later when the numbers of records per vehicle type in the RDW database is known.
In contradiction to what one usually expects in a safety score (the higher the safer), a low EV indicates a high level of occupant safety (viz. few seriously injured).

### 4.2.2. *Aggression index*

As well as a measure for one's own safety (EV), we are also looking for a criterium for judging the extent to which a type of vehicle causes injury to a crash opponent. We call this measure the Aggression Index (shortened to AV). This can also be called the index of 'safety for others'.
For this measure also applies that it is a quotient of the number of victims (but now the number of victims in the other vehicle) and a measure of exposure.

The aggression Index AV requires a more complicated analysis than in the case of the EV. This is because with the AV the vehicle and its collision opponent are simultaneously playing a role.
For the AV also applies that the higher the score the worse the vehicle in question is for third parties.

## 4.3. Limitations of the method

A rank list based on accident statistics has a number of limitations which are a result of the sort of data registered.

*Damage*

What is unfortunately nearly always missing in the police registration, are objective figures for material damage: where is the damage exactly, how deep is it, how wide etc. At least one requires data on which an impression of the type and extent of the damage could be based. Such information is sometimes available, in the shape of documents necessary for a prosecution if the police decide to carry out a deeper study of a particular accident. However, such data is never available in coded (electronical) form.
For this reason so-called in-depth studies are useful.

*Speed*

Also missing in a police report are objectively (measured) crash speeds: this would be extremely useful criterium for judging the severity of a collision in relation to its outcome. This element is also difficult to reconstruct in in-depth studies; normally it is derived from the damage, the tyre tracks, and the final situation. This data is then entered in the form of a calculation method (using a reconstruction model).

*Other missing data*

In a rank list based on police data, which is what we are trying to produce, there are also a number of (passive safety) influences which cannot be explicitly controlled. These are: seat belt use, exposure, and seating position in the vehicle.
We assume that in influence of seat belt use (and non-use) will result in a more or less equal distribution among the vehicles involved, if the number of vehicles observed is large enough. It would have a lasting interference with the results of the analysis if reality shows that seat belt use is dependent on make and model of car.
For one aspect, control is possible: it is known that seat belt use is considerable higher within city limits than outside built-up areas. Since the location of the accident site is known, the data may be analysed with respect to this aspect.

As far as exposure is concerned, there is an almost direct relationship between this and the chance of having an accident. If one type of vehicle is driven much more often than another, this should be made visible by the fact that is involved in accidents more often; in any case, more often than its share of the national fleet.
This cannot, however, be controlled in the present analysis because no exposure by make and model is available. This is less relevant for making a passive safety rank list because the primary goal concerns the outcome of a collision.
There is the possibility that types of cars that are seldom or never used on rural roads (and are therefore seldom or never involved in collisions at high speed), score ‘better’ than the usually bigger and heavier cars that do use motorways frequently. Anyway, there is an average ratio of dependence between the outcome of collisions and the (collision) speed. This means that the average outcome on rural roads have a greater severity than those on urban roads, irrespective of the vehicle type involved in the collision. Differentiation by built-up area is therefore to be desired.

As far as the seating position in the vehicle is concerned, it is known that there is a difference in outcome between front and rear seats. A difference in outcome between left and right (and centre) may also be expected in collisions where the collision angle differs. For example, this is the case for side collisions; when a car is hit on its left-hand side, the occupants sitting there are usually more endangered than those sitting on the right-hand side. This present study uses police data which does not register where the occupants were sitting. There is not even any information at all about passengers who were not wounded. For drivers, there is always information, even if they were not injured; and their seat is nearly always front-left.

This is another reason to limit this rank list, for the time being, to drivers.

# 5. Development of division of car characteristics

## 5.1. Introduction

The analysis of linked data involves making a distinction between car makes. As mentioned in the previous chapter, there are two main streams for dividing vehicle characteristics:

- a division into individual makes and models (the lowest possible level);
- a division of general vehicle characteristics (clustering).

## 5.2. Make/model level

Partly because of the available RDW data, a minimum of each type of car (e.g. VW *Golf*, Opel *Astra*, Mazda *323*) will be differentiated. This is because it may be assumed that different types of cars have different (passive safety) properties. Even distinctions within one type of car will be necessary in some cases, for example by body shape (sedan, hatchback, station car). This is because the passive safety properties of the body shapes can differ. Furthermore, in many cases we will have to allow for differences in model year and model generations (VW Golf, second generation is built differently from the first generation).
In addition, one should think of further differentiation according to fuel type (petrol, diesel), place of engine (sideways, lengthways) because this can influence the outcome of an accident.
The fuel type is relevant because the mass of a diesel engine is greater than that of a petrol engine.
In fact, each of these attributes mentioned can be derived from an external source (reference book) once the main particulars: make & model with construction year are known.

In *Appendix 2* a number of lists of the present market/fleet car shares by make and model have been included. These lists are based on CBS statistics of motor vehicles, of which the last was published showing the national fleet as of 1st August 1996. There were then 5,740,489 cars. These lists are limited to those makes and models having more than a 1% share of the total. These lists were made as preparation for constructing a rank list using the linked vehicle data; keeping an eye on the differences to be expected between the various makes and models.

## 5.3. Clustering by general vehicle characteristics

As it turned out, many of the characteristics considered relevant for clustering were directly available in the RDW vehicle registration database. These were:

- empty vehicle weight;
- number of doors;
- wheelbase;
- vehicle code.

A number of other relevant details will have to be looked for, such as the length of individual types of vehicle, and those types/models that fit each other, and which can therefore be added together for the purpose of analysis.

There are, anyway, necessary details which are not available straight away; not via the RDW registration, nor in a standard handbook. These are 'observable' characteristics such as location, measurements and weights of parts (bumper location, bumper height, mass of the engine, sort of suspension, etc.).
There are furthermore additional, hidden characteristics such as the presence and strength of side members and cross-structures on the front end, and (with side collisions in mind) the side-structure.
Producing lists with these properties would take a great deal of time. In this stage of a study of a rank list, this has been put aside for the time being. This would seem to fit better in an activity for a future refined rank list, based on clustering. In fact, such activities are part of the before mentioned EU project on compatibility.

Instead of, or besides those characteristics that are more specific to each vehicle (see previous paragraph), in clustering vehicle properties one can also use even more 'anonymous' properties. Some have already been mentioned: body shape, type of engine. Such data is also available via the linkage; such as mass (curb weight is directly available) or length & width, as far as dimensions and weights are concerned.
This sort of main division is not unusual in existing rank lists because it appears that mass/size is of predominant influence on the outcome of a collision. One can, for example, consider the production year (which roughly goes together with technical developments).

In § 5.3.1 we will go into more detail the possibility of a division by mass (curb weight) because this detail is readily available in the motor vehicle fleet data as well as in the accident data via the linkage with the vehicle registration.

### 5.3.1. *Division by net weight of the national car fleet*

On the reference dat of 1st August 1996, and using the CBS data on motor vehicles, it is possible to apply them to the curb weight of cars. This is given in *Figure 5.1.*

Vehicle mass (in the form of curb weight) would seem to be developing considerably during the last few years. This can be seen in *Figure 5.2*, in which the average vehicle mass in the course of time is shown.

We see that the average vehicle mass was approximately 910 kg in 1986 and has, up and to 1996, grown to nearly 970 kg. There also appears to be no end (yet) to this development.

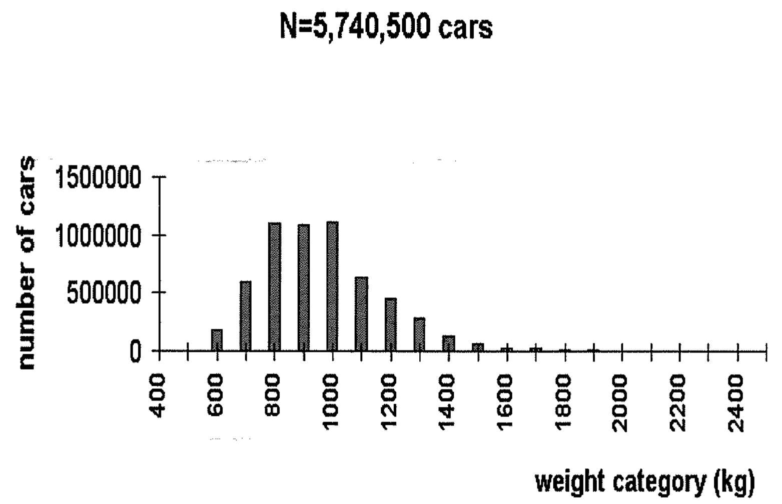

Figure 5.1. *The number of cars in the Dutch car fleet by curb weight (CBS, 1996).*

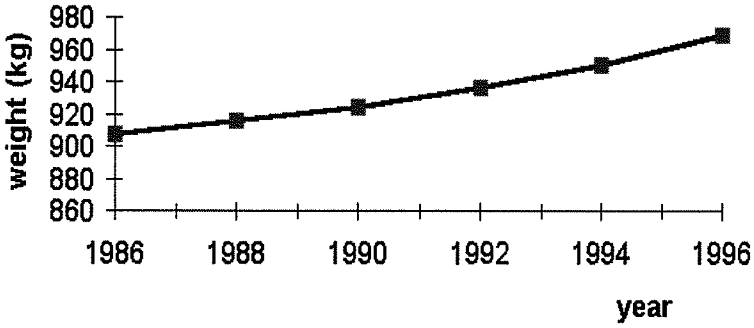

Figure 5.2. *Development of the average curb weight of cars (CBS 1986-1996).*

vehicles (and their safety). The increase in vehicle mass is apparently only partly being compensated by the ever-increasing use of light materials.

## 5.5. Consequence of available car characteristics for rank list

The above-mentioned changes in vehicle properties indicate current real world changes that may not be reflected in the available accident data.
This is inherent in analyses based on the use of 'historic' data. Even though these data are as recent as possible, emphasis is always on the older car makes and types, since they form the biggest shares in normal traffic. It is therefore virtually impossible in this type of accident study to 'catch' recent models, that are not yet represented in great numbers in the car fleet.
This is rather unfortunately in a period in which the development and application of new and different concepts of passive safety are apparent. These developments can be seen in small cars (such as the Ford Ka and the Mercedes A).
The analysis probably produces reliable data, but not about those models in which we are interested the most: the new car models.

In this sense, a ranking of different types of cars will indeed be mainly an *historical* one. This probably justifies avoiding the all too sensitive sides of this passive safety problem. Experiences with the results of the EURO-NCAP crash tests with *modern* cars (also aimed at ranking) have taught us that restlessness among customers and manufacturers cannot be excluded.

On the other hand, an *historic* listing of the passive safety of existing, but not very modern, cars can contribute to the increase in knowledge of this area, which is urgently necessary. This applies especially to the results of analyses based on the more general vehicle characteristics (mass, size, body shape etc.).

# 6. The unlinked data

## 6.1. Introduction

This chapter deals separately with both databases used in this study (the VOR accident database and the RDW vehicle registration database). It gives a further illustration of their important contents and distributions.

## 6.2. Accident data from the VOR database

We selected the following accidents, according to the procedure explained in chapter 3. There were, in total, 6,702 accidents and 11,398 vehicles, all from the 1996 database (see *Table 6.1*).

| Collision | Accidents | Vehicles |
|---|---|---|
| Frontal | 831 | 1.662 |
| Side | 1.850 | 3.700 |
| Rear-end | 2.015 | 4.030 |
| Obstacle | 2.006 | 2.006 |

Table 6.1. *Accident data from the VOR database, by accident type and numbers of vehicles involved.*

The percentaged distribution by accident severity is as follows:

| Accident type | Fatal | Hospital admission | Accident & Emergency dept. | Other injury | Total (N=) |
|---|---|---|---|---|---|
| Frontal | 3,3 | 33,5 | 29,2 | 34,1 | 831 |
| Side | 1,8 | 24,8 | 36,8 | 36,7 | 1.850 |
| Rear-end | 0,4 | 11,4 | 35,9 | 52,4 | 2.015 |
| Obstacle | 6,7 | 35,4 | 30,3 | 27,6 | 2.006 |
| Total | 3,0 | 25,0 | 33,7 | 38,3 | 6.702 |

Table 6.2. *Percentage distribution of the maximum accident severity by accident type.*

There are clear differences in severity between the four collision types: obstacles are the most serious, followed by frontal and side. Rear-end collisions clearly cause few seriously injured victims, while the share of victims with only slight injury ('other injury') is the highest of all.

In *Table 6.3*, only the severity of *one* party is shown, and only for the drivers. This means that an extra 'severity category' has to be introduced, viz. not injured.

| Accident type | Fatal | Hospital admission | Accident & Emergency dept. | Other injury | Not injured | Total (N=) |
|---|---|---|---|---|---|---|
| Frontal | 1,6 | 18,5 | 16,1 | 22,7 | 41,0 | 1.662 |
| Side | 0,7 | 10,8 | 16,8 | 20,7 | 51,0 | 3.700 |
| Rear-end | 0,1 | 4,3 | 13,2 | 21,7 | 60,7 | 4.030 |
| Obstacle | 5,8 | 31,2 | 25,5 | 25,9 | 11,6 | 2.006 |
| Total | 1,5 | 13,2 | 17,0 | 22,3 | 46,1 | 11.398 |

Table 6.3. *Percentaged distribution of injury severity of drivers by accident type.*

The severity distribution shown here follows the pattern of *Table 6.2*; the injury severity is also here by far the highest for drivers in obstacle collisions, and by far the lowest in rear-end collisions.

## 6.3. Vehicle data from the RDW database

### 6.3.1. *Processing and cleaning*

The data received by e-mail was in the form of a (zipped) Dbase file (dbf), which was converted by SWOV into a SAS dataset. The completeness was controlled in this way. All the intrinsic variables requested, and the three common key variables were available in the database.

The total number of records (N = 19,285) was actually almost 1,000 more than the expected total of 18,346. After searching for some time, it appeared that there were many duplicated, identical, and empty records (doubles) in the database. The reason for this is (still) not known. We suspect that this is an artifact as a result of the (re)linkage carried out by AVV; not so much a mistake by RDW.
After removing these identical records, the RDW database contained 18,338 records; only eight less than expected.

Only the records with a 1996 VOR number were then selected (N = 11,383). This was slightly less than the 11,398 records offered.

### 6.3.2. *Totals*

The marginal of this data, divided into cars (P) and commercial vehicles (B) is to be found in *Appendix 4*.
Some variables have been omitted, because they are too detailed or less relevant for describing the data. There appeared to be *one* record with details of a motorcycle (M) in the database.
The tables of *Appendix 4* show that, for more than 300 of the records provided, there were no vehicle or vehicle data to be found. The last table of *Appendix 4* shows why. These are either 'non-existent vehicle registration numbers' or numbers that cannot exist anymore because the vehicle concerned had already been destroyed before the accident.
This problem of numbers never having existed, or no longer existing registration numbers, is probably the result of the police not having

registered the correct number at the site of the accident, or VOR not having processed the correct number in its database. There could be a difference of just one letter (or number).
No (quality) control on this point could be conducted by SWOV, because the vehicle registration is missing altogether. It would seem advisable to inform AVV about this.

The totals show that there are other 'irregularities' in the RDW database; in any case as far as the selected target groups, cars and delivery vans, are concerned.
The maximum legal weight of both categories is 3,500 kg. However, according to the distribution by weight, (variables curb weight and total weight), several hundreds vehicles are heavier than this; but only in the category Commercial Vehicles.
These category B vehicles are probably real lorries/trucks that have been wrongly registered as a delivery van in the VOR database. This assumption is in agreement with the experience of School & Hagesteijn (1995) in their study of delivery vans and their type distribution.
In the linked database, this was checked by individually comparing the vehicle categories in the VOR and RDW databases. This showed indeed that they were delivery vans according to VOR.
In the tables it can be clearly seen that a) some variables are only used for delivery vans (engine power, width, total weight, design code), and b) other variables only used for cars (number of doors).

The variable 'make of car' results in a distribution that is very comparable with the distribution of the national fleet (*Appendix 2*).

Furthermore, a distinction was made, for this study, by make AND vehicle type for cars (and vans) that had a share in the database of more than 1%, irrespective of its production year. This distribution can be found in *Appendix 4*.
The distribution in *Appendix 4* is also well comparable with the national car fleet per 1st August 1996.

The chance that a special type is involved in an injury accident is mainly determined by its share in the national fleet; in any case as far as the selected types of accidents is concerned.
Small share differences can be the logical result of a difference in exposure.

A further, more detailed study of fleet and accident population, aimed particularly at a much more detailed distribution by car types, could produce interesting results.
The hypothesis as starting point for this, could be that certain types of vehicle can be expected in the accident population more often. For example: car types that are especially driven by youngsters; car types that could have a higher accident chance because of their high engine power or other extreme property.
Such a further analysis is hereby recommended.

# 7. Linkage results

## 7.1. The data linkage

The data as discussed in chapter 6 were linked using the common key variables VOR number and object number.
As appeared in chapter 6, there were less records in the RDW database than in the selected VOR accident records; some records had no vehicle data. Furthermore, vehicle data was missing because the registration numbers had never, or no longer, existed.

The linked database, before cleaning, contained the complete number of records from the VOR database that were expected (viz. 6,702 accidents and 11,398 vehicles).
By removing accidents involving vehicle heavier than 3,500 kg (they were all classified as delivery vans), there remained 5,680 accidents and 11,356 vehicles.

## 7.2. Some combinations of accident and vehicle data

Before constructing a rank list, we first look at a number of general ratios, such as between vehicle size and the accident outcome (severity for driver). Using the variable 'mass' for determining the vehicle size is rather obvious. This variable is available in the form of curb weight, whereas another obvious parameter (vehicle length) is not.
In *Figure 7.1* the shares of driver-victims is shown, irrespective of the accident type.

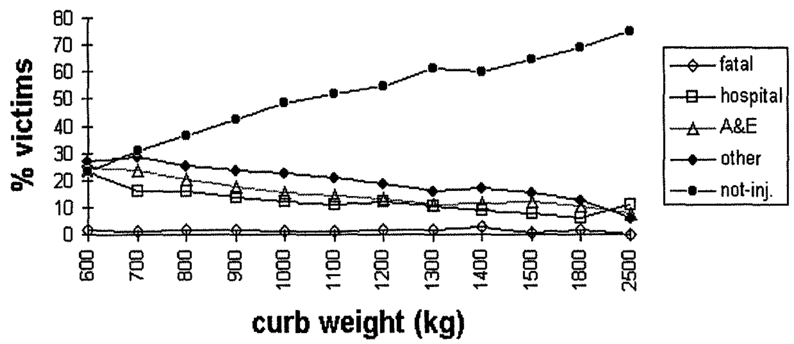

Figure 7.1. *The share of driver-victims per injury severity by curb weight of cars and delivery vans; all accident types.*

*Figure 7.1* shows very clearly the ascending line of the percentage of those not injured versus the descending line of the percentages of in-patients and A&E patients, and other injuries.
The percentage of driver deaths is (according to this graph) not at all or hardly dependent on the curb weight of the car. This is primarily because the average percentage is so low (2%). In the second place the graph shows the combination of all accident types, which can mask the mass effect on the most severe outcome.

Therefore, in *Figure 7.2* we show the ratios per accident type between curb weight and driver's injury severity; here, 'deaths' and 'in-patients' have been added together.

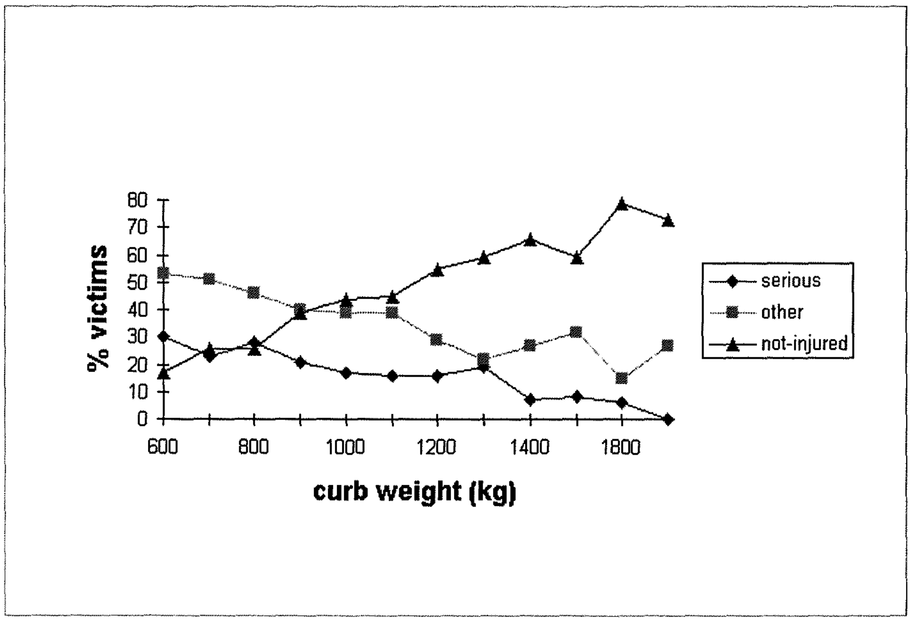

Figure 7.2. *The percentage of driver victims per injury severity category by curb weight of cars and delivery vans in frontal collisions.*

In frontal collisions (*Figure 7.2*) there is a fluctuating but clear connection between severity and mass. The percentage 'seriously injured' ('deaths' plus 'hospitalised') decreases to about 30% in the smallest/lightest vehicles to approximately 0% in the heaviest (delivery vans).
The percentage of non-injured drivers on the other hand, increases from about 16% in the smallest/lightest vehicle to more than 70% in the largest and heaviest vehicles.

In side collisions (*Figure 7.3*) there is a more slippery connection than in frontal collisions. For the rest, as far as minimums and maximums are concerned, they resemble frontal collisions. We have to bare in mind that here there are two types of collision overlapping each other: left-hand and right-hand collisions. In left-hand collisions, the driver runs a greater risk of being injured than in right-hand collisions.

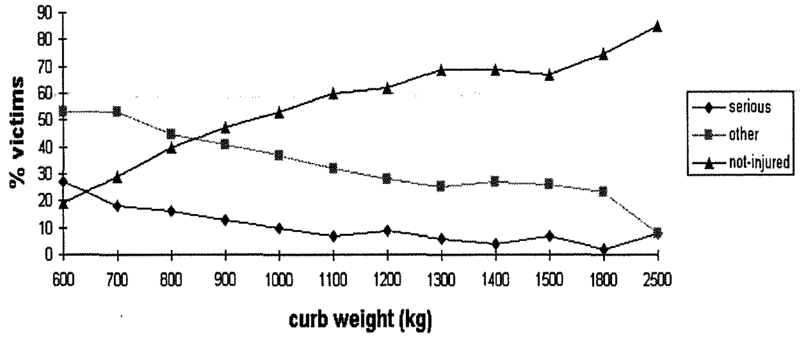

Figure 7.3. *The percentage of driver victims per injury severity category by curb weight of cars and delivery vans in side collisions.*

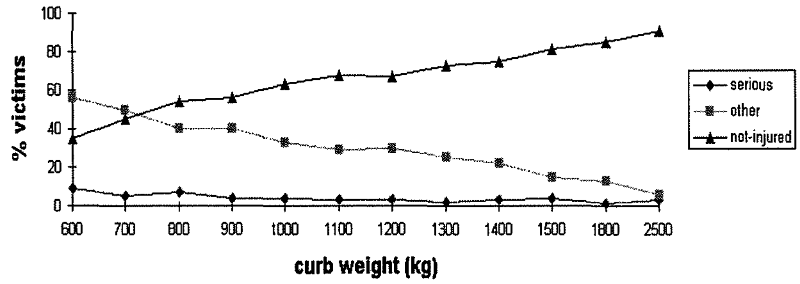

Figure 7.4. *The percentage of driver victims per injury severity category by curb weight of cars and delivery vans in rear-end collisions.*

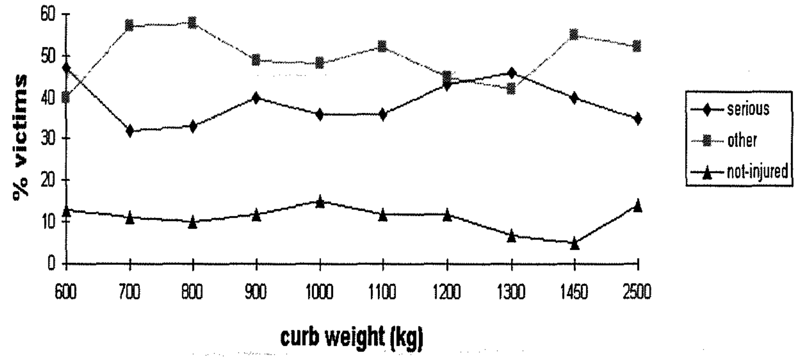

Figure 7.5. *The percentage of driver victims per injury severity category by curb weight of cars and delivery vans in obstacle collisions.*

## 7.3. A preliminary rank list based on EV and AV

It was our intention to base the rank list on the EV and AV.
As has been discussed in chapter 4, the passive safety index for occupants (EV) is determined by relating the number of driver victims in a particular vehicle type to the total number of vehicles of that type.
The aggressiveness index (AV) of a vehicle type is determined by the number of driver victims in the collision partner of that type of vehicle and the total number of vehicles of that type.

Many types of vehicles are not common enough to reliably score them on one or both indices. We assume that at least 100 vehicles per type are necessary to calculate a reliable score.
To allow for this lack of sufficient numbers (against a number of intrinsic considerations) we have, for the time being, proceeded without a distinction for production year and inside/outside the built-up area.
This of course has resulted in a substantial reduction in the rank list. Such a distinction of structural differences between vehicle types of the same make could be necessary. Now we get an average score of the combined production years of *one* vehicle type. By not making a distinction between inside and outside the built-up area, it is assumed that different vehicle types have the same distribution of accident severity.
Only those make/models are included in the table below that have at least 100 vehicles in both indices. The sequence is alphabetical.

| Make/model | EV (Own Safety Index) | AV (3rd Party Safety) | AV/EV |
|---|---|---|---|
| BMW 3 | 15 | 16 | 1,1 |
| CITROEN BX | 11 | 12 | 1,1 |
| FIAT Uno | 14 | 7 | 0,5 |
| FORD Escort | 10 | 9 | 0,9 |
| FORD Fiësta | 7 | 7 | 1,0 |
| FORD Sierra | 6 | 9 | 1,5 |
| HONDA Civic | 13 | 9 | 0,7 |
| MAZDA 323 | 11 | 9 | 0,8 |
| MAZDA 626 | 7 | 14 | 2,0 |
| MERCEDES (190-300) | 3 | 10 | 3,3 |
| NISSAN Sunny | 8 | 6 | 0,8 |
| OPEL Astra | 7 | 8 | 1,1 |
| OPEL Corsa | 12 | 7 | 0,6 |
| Opel Kadett | 13 | 8 | 0,6 |
| Opel Vectra | 5 | 10 | 2,0 |
| PEUGEOT 205 | 15 | 6 | 0,4 |
| SUZUKI Alto | 22 | 3 | 0,1 |
| TOYOTA Corolla | 6 | 9 | 1,5 |
| TOYOTA Starlet | 11 | 4 | 0,4 |
| VW Golf | 9 | 10 | 1,1 |
| VW Polo | 16 | 4 | 0,3 |
| Average of all cars | 10 | 10 | 1,0 |

Table 7.1. *Passive safety index EV, aggression index AV and the quotient of both for a limited group of individual vehicle types, of which the number in the sample was at least 100; alphabetical sequence.*

The vehicle types in the above rank list are in alphabetical sequence. This is because by ranking in order of EV or AV a wrong impression of those passive safety differences could be given.
This caution has to do with the limitations which have appeared unavoidable in this stage of the study (such as having to combine different generations of vehicles and not differentiating between the collision severity via the distinction of urban and rural).

The average for all vehicles (including also those types not shown) was 10, for EV as well as AV. The overall ratio between EV and AV was, therefore 1.0.
This ratio indicates whether a type of car offers more passive safety for its own occupants (AV/EV > 1) than for those of the collision partner (AV/EV <1).

As was expected, the smallest vehicles had on average a very high EV (>>10) and a very low AV (<<10), so that the ratio AV/EV lies below 0.5 (e.g. Suzuki Alto, Toyota Starlet, Fiat Uno, Peugeot 205, and VW Polo).

With middle-size vehicles such as Ford Escort, Mazda 323, and VW Golf, we see that the EV and AV are about the average for all vehicles (10). There are however a number of deviations from this pattern, among other in the case of the Opel Kadett, where the EV is higher (i.e. unfavourable) and the AV clearly lower than 10 (favourable). For the Opel Astra, both scores are relatively low (favourable).

There were not many heavier and larger vehicles in sufficient numbers, but for what there were, the EV was low (below 10) and the AV was high (10 or more). This means that the ratio EV/AV is 2 or more (e.g. Mazda 626, Mercedes 190-300, and Opel Vectra).

*Table 7.1* also shows that there are types that do not appear to fit logically in this ranking by vehicle size. The BMW-3 series has a relatively high EV and AV. Also some other car types, belonging to the same weight class, have distinctly different scores.
If these deviations are accidental (statistically) or really point to structural differences, can not be indicated in this stage of the study.
To be able to do this, a more complete and reliable list, based on a greater number of observations, is necessary.

# 8. Discussion/evaluation

## 8.1. The procedure

In this pilot study we have attempted to carry out a linkage between injury accident data and vehicle data. This for a selection of accidents involving cars and delivery vans.
To make such a linkage possible, the vehicle licence number acts as the (unique) common key variable. In order to obtain data from the RDW vehicle database, a certain procedure must be followed (RDW, 1997). This procedure assumes that the customer has the necessary registration numbers (as given on the number plate).
SWOV did have access to the VOR accident database, but the vehicle numbers have been removed for privacy protection reasons. That is why, first of all, this problem had to be solved. The planned approach for this was:

1. SWOV selects VOR numbers and object numbers.
2. SWOV sends these (by floppy) to AVV/BG.
3. AVV/BG selects relevant licence numbers and returns this to SWOV.
4. SWOV sends selected list of vehicle numbers to RDW, together with a specification of the required data per vehicle.
5. RDW selects the specified vehicle data and sends vehicle numbers with their details to SWOV on tape.
6. SWOV has to have tape read somewhere else in order to transfer the information on to floppy or other medium.
7. SWOV processes the vehicle information and links this to the accident data.
8. SWOV analyses the linked data and writes report.

The steps 1, 2, 7, and 8 went according to plan.
The steps 3-6 did not; they happened elsewhere or in a different way.
Probably to protect privacy, AVV/BG carried out steps 3 and 4 themselves (SWOV provided them with a specification of the vehicle details required).
Step 5 was carried out by RDW who returned the vehicle data to AVV/BG (on tape).
There were (unexpected) problems at AVV/BG with reading/processing the RDW tape. After this SWOV received this information back, linked to the VOR and object numbers, per e-mail.

This procedure that was followed for privacy protection reasons has had a number of disadvantages for the quality of this SWOV study. No control over the validity of the selection of licence numbers from the VOR database was possible. Neither of the quality of the numbers themselves. This last point showed a particularly large number of imperfections:

- non-existent licence numbers (n = 282);
- licence numbers removed before the date of the selected accident (n = 15);
- licence numbers missing from the database (n = 31).

The above numbers, given in brackets, only concern that part of the vehicle registration needed for this study; in total there were more than 500 of these vehicle numbers that could not be used.

The categories mentioned above should not be allowed to occur. This is separate from the small number of (writing) mistakes made by the police or VOR employees.
However, this number is large enough to warrant a sperate study of this problem (see also the recommendations).

Apart from use for the quality control of the linkage study itself, the licence numbers as well as relevant vehicle data could be used to update an instrument that SWOV uses for policy research. This concerns the so-called production year determinant using the (place of) the letters in the registration number. Such instrument is currently being used for studies concerning the presence and use of seat belts and child restraint systems (Mulder, 1997).
In this ongoing study, the first letters of the licence number of an observed vehicle are noted and later converted into a production year. This is done using a static list based on numbers issued by RDW. Such a list would become far more accurate, using real vehicle registration numbers and their registration dates.

If, in the future, it appears not to be possible to use licence numbers for this purpose, SWOV would like to suggest the alternative of at least being allowed to use the letter combinations. Preferably as a permanent variable in the VOR database.
After all, its use is entirely anonymous; no addresses are made known, nor are they available.

## 8.2. The sample

If one wishes to construct a rank list that can actually produce a reliable score for each vehicle type, a multiple of the numbers of accidents and vehicles will have to be applied. For a reliable score, a minimum number of one hundred vehicles per type is necessary. They must also match each other by structure. The market share of such a vehicle indicates how large the sample must be in order to contain a hundred of that vehicle type. For market shares of 1% or more, a sample of 10,000 vehicles is sufficient. There are, however, few individual vehicle types that have such a market share. Even with the Ford Escort, Opel Kadett, and VW Golf (the models with the highest market shares in the Netherlands), the present sample of 11,398 vehicles would hardly be big enough to distinguish between all the different groups (generations). Nor for distinguishing collision speed by in or outside the built-up areas.

It would therefore seem that a sample of approximately 25,000 cars is necessary to obtain more reliable results. This can, in theory, be obtained from the accident database for one year. But only if the selection criteria are less strict than in the present study. Furthermore, the advantage of this is that the rank list is even better tuned to (registered) accidents in practice, than in the present pilot study, in which the accident types were specified quite specifically.

## 8.3. The actual results

The actual goal of this pilot study, viz. to construct a rank list, was met. By defining the criteria beforehand (the index for the passive safety of occupants (EV) and the index for the passive safety of the collision partner

(AV)), a ranking of separate car types that are frequently registered in accidents, has been carried out.

This ranking is, however, only of a temporary nature because, just to obtain a number of more than 100 per type, it was necessary to combine a number of separate vehicle types. For the same reason it was also not possible to distinguish accidents by collision severity; a theoretically important distinction.

Both indices presented interpretive results indicating that small vehicle have a relatively high EV (many victims per type) and a low AV (few victims for the collision partner). Middle-size vehicles have an EV and a AV that are similar and are near the average of all vehicles. The largest vehicles had a relatively low EV and a relatively high AV.

A further analysis, based on a larger number of observations, is necessary to be able to make the rank list reliable and complete.

*Point of (special) interest; delivery vans*

Delivery vans also were an integral part of this study. Apart from the dozens that were actually turned out to be lorries (their mass was greater than 3,500 kg), all delivery vans, irrespective of their type, were included in the various analyses.

It can be derived from some of the tables that only a limited number of delivery vans is to be considered as having been redesigned cars; the rest were 'real' delivery vans with, in general, a high curb weight.

The favourable (low) injury severity of drivers of heavier vehicles, was mainly the effect of delivery vans.

*Point of (special) interest; vehicle size*

The analysis based on the clustered vehicle properties showed that the mass (in the form of the curb weight) was strikingly important parameter. This is, as already mentioned, in contrast to already published studies.

However, within the international world of passive safety experts, at present dealing with the already mentioned EU compatibility study, there is a heated discussion about this aspect going on. Rightly so, is being said that this influence of the mass is not really distinguishable from the other parameters that have to do with the size of a vehicle (such as length). It is quite logical that mass and length indeed are closely related, although nowadays this age-old connection is slowly shifting through the use of new constructions and lighter materials.

For the time being it can be maintained that the relationship found between mass and accident severity can just as easily be attributed to length or another vehicle parameter that is directly connected to vehicle size (wheelbase?).

It is strongly recommended, however, that analyses, using vehicle length instead of mass, are carried out. For this purpose, length has to be added (taken from other sources) to the data.

*Point of (special) interest; multi-variate analysis*

An earlier SWOV report about the political feasibility of a rank list for the Netherlands (Schoon, 1995) indicated that the sort of data available for making a rank list can be easily used for carrying out multi-variate analysis. That this is clearly a different approach to discovering the influence of vehicle properties on collision severity from this study which has made use of indices and the graphs shown.

This does not alter the fact that a multi-variate analysis is a better instrument for dealing with the complexity of the problem. It will certainly be recommended for a follow-up project.

*Supplementary analyses*

Apart from the above-mentioned multi-variate analysis (which tries to take all variables and influences in one and the same analysis) a large number of other, useful analyses can be employed.

The following can be considered as useful supplementary analyses:
- an analysis of the influence of length (instead of mass);
- an analysis of the influence of other specific vehicle properties;
- an analysis of the influence of the production year;
- an analysis of the differences in outcome of rear-end collisions between occupants hit from behind and those sitting in the other car;
- an analysis of the differences in outcome of side collisions between those occupants sitting on the left-hand side and those on the right-hand side.

In all these analyses it must be possible to measure the performance of different car types individually.

For all the above-mentioned analyses, except the first and the second, the necessary data is available in the present research file. This is with exception of a possible problem of too few observations for detailed classifications of car types.

For an analysis of the length of a vehicle (as well as other relevant vehicle parameters or explicit construction properties) an addition to the file is necessary. This can be solved by looking up required details of the individual vehicle type in a handbook, and linking these, per record, to the file.

*Relationship with EU-project 'Compatibility'*

In this present study, analyses were carried out of, among others, collision type (frontal, side, rear-end, and obstacle). They can be extended by the supplementary analyses mentioned above. This provides insight into the influence of vehicle properties, depending on the type of collision. The differences in outcome, irrespective of the vehicle type, are also dealt with.

In the EU project 'Compatibility' practically all attention is paid to frontal collisions (covering several years), but little to side collisions.

The EU project tries to dig deeper into the possible vehicle influence factors.

# 9. Conclusions en recommendations

## 9.1. Conclusions

First of all, conclusions will be made regarding the linkage procedure followed (§ 9.1.1). After that, those regarding the results of the study, including the rank list (§ 9.1.2 and § 9.1.3). This is because this is a pilot study into the feasibility of a rank list.

### 9.1.1. *The procedure and the linkage*

The linking of accident data to vehicle properties which was aimed at, has been achieved. Although not completely according to the route planned. For privacy protection reasons, the vehicle licence numbers (the common key variable) were exchanged directly between AVV/BG and RDW. This meant that SWOV could not carry out any quality control of this common key variable. Regarding some of the results, viz. the licence number itself, this was necessary.

The linking of accident data from the VOR database of injury accidents (property of AVV/BG) to vehicle properties from the RDW database went successfully.
11,054 of the 11,398 vehicle records required for this study proved to be suitable, and were linked to the appropriate accident records.

### 9.1.2. *The rank list*

A preliminary rank list has been made, based on the EV. This is a passive safety criterion that indicates the extent of passive safety for the driver.
The higher the score, the greater the severity of the outcome.
The rank list presents the EV score for twenty individual vehicle types.
These twenty had a market share in the linked database of at least 1%.
In general, the rank list presented understandable results of the differences in passive safety between those vehicle types distinguished. This comes down to a sequencing by size and mass.

The rank list is preliminary because vehicles had to be combined in spite of different model years. This was done because the numbers were limited.
The result of all this is that the real passive safety differences are masked.
Besides the EV score, an AV score was also determined. This indicates the extent of collision aggression of the individual vehicle types concerned.
The same limitations applying to the EV scores, also apply; the AV scores are therefore preliminary.

### 9.1.3. *Further intrinsic analyses*

Sound relationships between vehicle properties and the outcome (severity) of accidents for drivers, have been established. This applies especially to the influence of mass (curb weight). However, other vehicle parameters, related to vehicle size, would probably have produced the same type of result.

Vehicles with a low mass have a relatively high share of fatalities and injured, and a relatively low share of non-injured.
The greater the mass, the lower the share of injured, and the higher the share of non-injured.
Differentiation by accident type (frontal, side, rear-end, and obstacle) presents equally logical relationships between vehicle mass and outcome (severity) for the drivers.
In mutual frontal and side collisions a comparable relationship between mass and outcome can be found. In rear-end collisions, that usually have a low severity, we see the number of non-injured decreasing with increasing mass. There is, however, almost no influence on the number of seriously injured to be seen.
In obstacle collisions, finally, difference in vehicle mass would appear to have virtually no influence on the outcome (severity) of the accident. For all mass categories of the vehicle examined in this study, these sorts of accidents result in a comparably high severity.
This is a striking, but also theoretically explainable result. It all has to do with the way in which the frontal structure of vehicles (in any case until recently) is developed as far as frontal passive safety is concerned.

The fact that vehicles, involved in mutual frontal collisions, show a mass-dependant course towards the outcome (severity) points to the necessity of improving the compatibility further. The results of this study can help in this.

## 9.2. **Recommendations**

### 9.2.1. *The linkage procedure*

The procedure for acquiring the necessary vehicle data via licence numbers in the AVV/BG accident database did not function optimally.
In order to protect the privacy (of the vehicle owner) the actual linking of the vehicle numbers in the VOR database was carried out by AVV/BG. This lead, partly through coincidental, to considerable delay.
It is recommended that, for this type of study, vehicle licence numbers should be added to the accident data so that SWOV can approach RDW independently. It is out of the question that the privacy of car owners can be encroached upon as long as names and addresses are not made available.

### 9.2.2. *Recommendations regarding design of study*

With regard to the fact that this study as a pilot study has been a success, and that the linking as well as an intrinsic result has been achieved, the following is recommended:

- In future linkages, a larger sample must be used. This to convert the preliminary rank lists and indices (EV and AV) into those with a greater validity by analysing vehicle types that match each other better.

- To further analyse the available, but not yet analysed information. Multi-variate analysis springs most to mind.

It is finally recommended that AVV/BG conducts further studies itself into the VOR database; especially the 'non-existent' vehicle numbers and the numbers for no-longer existing vehicles.

# Literature

CBS (1997). *Verkeersongevallen in 1996.* Centraal Bureau voor de Statistiek, Voorburg.

Gabler, H.C. & Hollowell, W.T. (1998). *The aggressivity of light trucks and vans in traffic crashes.* U.S. National Highway Traffic Safety Administration.

Kampen, L.T.B. (1998). *Botsveiligheid van personenauto's, deel 2; Een pilot-onderzoek naar de ontwikkeling van een ranglijst van personenauto's.* R-98-28. Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV, Leidschendam.

Kampen, L.T.B. van, Polak, P., Blokpoel, A. & Bos, J.M.J. (1997). *Schatting van de werkelijke omvang van de verkeersonveiligheid 1994 t/m 1996; Ophoogmethodiek en ophoogresultaten voor ziekenhuisopnamen en Eerste-Hulpgewonden.* R-97-41. Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV, Leidschendam.

Mulder, J.A.G. (1997). *Gebruik van beveiligingsmiddelen in 1997.* R-97-32. SWOV, Leidschendam.

RDW Centrum voor Voertuigtechniek en Informatie (1997). *Regeling massa-informatie.* RDW Centrum voor Voertuigtechniek en Informatie, Veendam.

Schoon, C.C. (1995). *Ranglijst veilige personenauto's; Eindverslag.* A-95-6. Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV, Leidschendam.

Schoon, C.C. & Hagesteijn, G.P.J.J. (1996). *Bestelauto's en verkeersveiligheid.* R-96-23. Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV, Leidschendam.

Tromp, J.P.M. (1998). *Botsveiligheid van personenauto's, deel 1; Achteraanrijdingen en nekletsel.* R-98-27. SWOV, Leidschendam.

# Appendices 1-4

1. *Vehicle data available in the RDW registration database*
2. *List of car properties and types, with more than 1% share in the national fleet*
3. *Vehicle data (unlinked RDW data)*
4. *RDW-database by make/model (car's with a share of approx. 1% or more)*

# Appendix 1 Vehicle data available in the RDW registration database

Addaptation of Appendix 1 from RDW, 1997.

*Data of car's*
- make;
- model;
- type of vehicle;
- vehicle code;
- colour code;
- vehicle class;
- number of wheels;
- number of doors;
- wheelbase;
- curb weight;
- fuel;
- number of cylinders;
- date of issue of registration certificate part 1 (to determine production year).

In the case of delivery vans, apart from the data listed above, also available is data referring to the vehicle width, the engine power, the carrying capacity, and the total weight.

# Appendix 2 List of car makes and types, with more than 1% share in the national fleet

CBS-statistics of motor vehicles per 1st August 1996.

| *Make list* | |
|---|---|
| Opel | (15.9%) |
| Ford | (10.0%) |
| VW | (9.7%) |
| Peugeot | (6.2%) |
| Renault | (5.6%) |
| Toyota | (5.1%) |
| Nissan | (5.0%) |
| Fiat | (4.6%) |
| Volvo | (4.5%) |
| Citroen | (4.4%) |
| Mazda | (4.3%) |

| *Model list* | |
|---|---|
| Opel Kadett | (6.1%) |
| VW Golf | (5.3%) |
| Ford Escort | (4.3%) |
| Opel Corsa | (2.7%) |
| Mazda 323 | (2.3%) |
| Peugeot 205 | (2.2%) |
| Opel Astra | (2.1%) |
| Toyota Corolla | (2.1%) |
| Nissan Sunny | (1.9%) |
| Ford Fiesta | (1.8%) |
| Ford Sierra | (1.8%) |
| Citroen BX | (1.7%) |
| Mazda 626 | (1.7%) |
| Opel Vectra | (1.6%) |
| Toyota Starlet | (1.5%) |
| Volvo 340/360 | (1.5%) |
| VW Polo | (1.4%) |
| Volvo 440/460 | (1.4%) |
| Fiat Panda | (1.3%) |
| Nissan Micra | (1.3%) |
| Peugeot 405 | (1.2%) |
| Renault 19 | (1.2%) |
| Fiat UNO | (1.2%) |

# Appendix 3 Vehicle data (unlinked RDW data)

Overview of the most important (unlinked) vehicle properties in the passive safety study

*Explanation abbreviations:*
B = Van
M = Motorcycle
P = Car

```
TABLE OF MAKE BY SORT OF VEHICLE

MAKE  SORT OF VEHICLE

Frequency          |       ? |       B |       M |       P |  Total
-------------------+---------+---------+---------+---------+
missing            |     328 |       5 |       0 |      20 |    353
-------------------+---------+---------+---------+---------+
ALFA ROMEO         |       0 |       0 |       0 |     121 |    121
-------------------+---------+---------+---------+---------+
ASIA               |       0 |       3 |       0 |       0 |      3
-------------------+---------+---------+---------+---------+
AUDI               |       0 |       0 |       0 |      18 |     18
-------------------+---------+---------+---------+---------+
AUSTIN             |       0 |       2 |       0 |      25 |     27
-------------------+---------+---------+---------+---------+
AUTO BIANCHI       |       0 |       0 |       0 |       4 |      4
-------------------+---------+---------+---------+---------+
AUTO UNION         |       0 |       0 |       0 |     170 |    170
-------------------+---------+---------+---------+---------+
BEDFORD            |       0 |       1 |       0 |       0 |      1
-------------------+---------+---------+---------+---------+
BMW                |       0 |       0 |       0 |     317 |    317
-------------------+---------+---------+---------+---------+
BUICK              |       0 |       0 |       0 |       4 |      4
-------------------+---------+---------+---------+---------+
CADILLAC           |       0 |       0 |       0 |       1 |      1
-------------------+---------+---------+---------+---------+
CHEVROLET          |       0 |       6 |       0 |      20 |     26
-------------------+---------+---------+---------+---------+
CHRYSLER           |       0 |       5 |       0 |      29 |     34
-------------------+---------+---------+---------+---------+
CITROEN            |       0 |      25 |       0 |     400 |    425
-------------------+---------+---------+---------+---------+
DAEWOO             |       0 |       0 |       0 |      12 |     12
-------------------+---------+---------+---------+---------+
DAF                |       0 |       9 |       0 |       2 |     11
-------------------+---------+---------+---------+---------+
DAIHATSU           |       0 |      19 |       0 |     111 |    130
-------------------+---------+---------+---------+---------+
DAIMLER            |       0 |       0 |       0 |       3 |      3
-------------------+---------+---------+---------+---------+
DATSUN             |       0 |       1 |       0 |       6 |      7
-------------------+---------+---------+---------+---------+
DODGE              |       0 |      11 |       0 |       0 |     11
-------------------+---------+---------+---------+---------+
EAGLE              |       0 |       0 |       0 |       1 |      1
-------------------+---------+---------+---------+---------+
FERRARI            |       0 |       0 |       0 |       1 |      1
-------------------+---------+---------+---------+---------+
FIAT               |       0 |      22 |       0 |     444 |    466
-------------------+---------+---------+---------+---------+
FORD               |       0 |     103 |       0 |    1099 |   1202
-------------------+---------+---------+---------+---------+
FSO                |       0 |       0 |       0 |       1 |      1
-------------------+---------+---------+---------+---------+
G.M.C.             |       0 |       0 |       0 |       1 |      1
-------------------+---------+---------+---------+---------+
GINAF              |       0 |       1 |       0 |       0 |      1
-------------------+---------+---------+---------+---------+
HILLMAN            |       0 |       0 |       0 |       1 |      1
-------------------+---------+---------+---------+---------+
HONDA              |       0 |       3 |       1 |     274 |    278
-------------------+---------+---------+---------+---------+
HYUNDAI            |       0 |      34 |       0 |      74 |    108
-------------------+---------+---------+---------+---------+
ISUZU              |       0 |       7 |       0 |       0 |      7
-------------------+---------+---------+---------+---------+
IVECO              |       0 |      14 |       0 |       1 |     15
-------------------+---------+---------+---------+---------+
JAGUAR             |       0 |       0 |       0 |       7 |      7
-------------------+---------+---------+---------+---------+
JEEP               |       0 |       3 |       0 |      10 |     13
-------------------+---------+---------+---------+---------+
JENSEN             |       0 |       0 |       0 |       1 |      1
-------------------+---------+---------+---------+---------+
KIA                |       0 |       2 |       0 |      10 |     12
```

| | | | | | |
|---|---|---|---|---|---|
| LADA | 0 | 0 | 0 | 34 | 34 |
| LANCIA | 0 | 0 | 0 | 23 | 23 |
| LANDROVER | 0 | 2 | 0 | 2 | 4 |
| LEXUS | 0 | 0 | 0 | 1 | 1 |
| LINCOLN | 0 | 0 | 0 | 1 | 1 |
| M.A.N. | 0 | 2 | 0 | 0 | 2 |
| MASERATI | 0 | 0 | 0 | 1 | 1 |
| MAZDA | 0 | 17 | 0 | 420 | 437 |
| MERCEDES-BENZ | 0 | 120 | 0 | 367 | 487 |
| MERCURY | 0 | 0 | 0 | 2 | 2 |
| MG | 0 | 0 | 0 | 1 | 1 |
| MINI | 0 | 1 | 0 | 22 | 23 |
| MITSUBISHI | 0 | 61 | 0 | 197 | 258 |
| MORRIS | 0 | 0 | 0 | 1 | 1 |
| NISSAN | 0 | 72 | 0 | 467 | 539 |
| OPEL | 0 | 86 | 0 | 1690 | 1776 |
| PEUGEOT | 0 | 55 | 0 | 640 | 695 |
| PONTIAC | 0 | 0 | 0 | 11 | 11 |
| PORSCHE | 0 | 0 | 0 | 20 | 20 |
| RELIANT | 0 | 0 | 0 | 1 | 1 |
| RENAULT | 0 | 65 | 0 | 517 | 582 |
| ROVER | 0 | 2 | 0 | 42 | 44 |
| SAAB | 0 | 0 | 0 | 33 | 33 |
| SCANIA | 0 | 4 | 0 | 0 | 4 |
| SEAT | 0 | 14 | 0 | 139 | 153 |
| SKODA | 0 | 0 | 0 | 16 | 16 |
| SUBARU | 0 | 1 | 0 | 96 | 97 |
| SUZUKI | 0 | 38 | 0 | 282 | 320 |
| TALBOT | 0 | 0 | 0 | 12 | 12 |
| TERBERG | 0 | 1 | 0 | 0 | 1 |
| TOYOTA | 0 | 62 | 0 | 435 | 497 |
| TRIUMPH | 0 | 0 | 0 | 2 | 2 |
| UNIMOG | 0 | 1 | 0 | 0 | 1 |
| VAUXHALL | 0 | 0 | 0 | 1 | 1 |
| VOLKSWAGEN | 0 | 132 | 0 | 1075 | 1207 |
| VOLVO | 0 | 6 | 0 | 293 | 299 |
| YAMAHA | 0 | 0 | 0 | 2 | 2 |
| ZASTAVA | 0 | 0 | 0 | 2 | 2 |
| Total | 328 | 1018 | 1 | 10036 | 11383 |

```
TABLE OF NR of DOORS BY SORT OF VEHICLE
DOORS     SORT OF VEH

Frequency|       ? |       B |       M |       P |  Total
---------+--------+--------+--------+--------+
missing  |    328 |   1018 |       1 |       3 |   1350
---------+--------+--------+--------+--------+
       2 |      0 |       0 |       0 |   4863 |   4863
---------+--------+--------+--------+--------+
       3 |      0 |       0 |       0 |     98 |     98
---------+--------+--------+--------+--------+
       4 |      0 |       0 |       0 |   5068 |   5068
---------+--------+--------+--------+--------+
       5 |      0 |       0 |       0 |      4 |      4
---------+--------+--------+--------+--------+
Total         328     1018         1    10036    11383

TABLE OF WHEEL BASE SORT OF VEHICLE
WHEELBASE(cm) SORT OF VEHICLE

Frequency |        |       B |       M |       P |  Total
----------+--------+--------+--------+--------+
missing   |    328 |       0 |       1 |       0 |    329
----------+--------+--------+--------+--------+
  < 200   |      0 |      25 |       0 |     11 |     36
----------+--------+--------+--------+--------+
200-224   |      0 |      67 |       0 |    478 |    545
----------+--------+--------+--------+--------+
225-249   |      0 |     339 |       0 |   4632 |   4971
----------+--------+--------+--------+--------+
250-274   |      0 |     209 |       0 |   4362 |   4571
----------+--------+--------+--------+--------+
275-299   |      0 |     176 |       0 |    504 |    680
----------+--------+--------+--------+--------+
300-324   |      0 |      72 |       0 |     25 |     97
----------+--------+--------+--------+--------+
  > 325   |      0 |     130 |       0 |     24 |    154
----------+--------+--------+--------+--------+
Total          328     1018         1    10036    11383

TABLE OF Curb WEIGHT BY SORT OF VEHICLE
CURB WEIGHT
(kg)        SORT OF VEHICLE

Frequency   |       ? |       B |       M |       P |  Total
-----------+--------+--------+--------+--------+
missing     |    328 |       0 |       1 |       0 |    329
-----------+--------+--------+--------+--------+
  < 650     |      0 |       2 |       0 |    307 |    309
-----------+--------+--------+--------+--------+
650-750     |      0 |      37 |       0 |    971 |   1008
-----------+--------+--------+--------+--------+
750-850     |      0 |      90 |       0 |   2032 |   2122
-----------+--------+--------+--------+--------+
850-950     |      0 |     114 |       0 |   1987 |   2101
-----------+--------+--------+--------+--------+
950-1050    |      0 |      95 |       0 |   1824 |   1919
-----------+--------+--------+--------+--------+
1050-1150   |      0 |      41 |       0 |   1110 |   1151
-----------+--------+--------+--------+--------+
1150-1250   |      0 |      31 |       0 |    779 |    810
-----------+--------+--------+--------+--------+
1250-1350   |      0 |      54 |       0 |    509 |    563
-----------+--------+--------+--------+--------+
1350-1450   |      0 |     105 |       0 |    219 |    324
-----------+--------+--------+--------+--------+
1450-1550   |      0 |     113 |       0 |    115 |    228
-----------+--------+--------+--------+--------+
1550-2050   |      0 |     255 |       0 |    163 |    418
-----------+--------+--------+--------+--------+
2050-3500   |      0 |      59 |       0 |     20 |     79
-----------+--------+--------+--------+--------+
too heavy   |      0 |      22 |       0 |      0 |     22
-----------+--------+--------+--------+--------+
Total           328     1018         1    10036    11383
```

```
TABLE OF WIDTH BY SORT OF VEHICLE

WIDTH
(cm)    SORT OF VEHICLE

Frequency|       ? |       B |       M |       P |  Total
---------+--------+--------+--------+--------+
missing  |    328 |       0 |       1 |  10036 |  10365
---------+--------+--------+--------+--------+
125-149  |      0 |      40 |       0 |      0 |     40
---------+--------+--------+--------+--------+
150-174  |      0 |     578 |       0 |      0 |    578
---------+--------+--------+--------+--------+
175-199  |      0 |     281 |       0 |      0 |    281
---------+--------+--------+--------+--------+
200-224  |      0 |      95 |       0 |      0 |     95
---------+--------+--------+--------+--------+
225-249  |      0 |       8 |       0 |      0 |      8
---------+--------+--------+--------+--------+
  > 250  |      0 |      16 |       0 |      0 |     16
---------+--------+--------+--------+--------+
Total         328     1018         1   10036    11383

TABLE OF FUEL BY SORT OF VEHICLE

FUEL     SORT OF VEHICLE

Frequency|       ? |       B |       M |       P |  Total
---------+--------+--------+--------+--------+
missing  |    328 |       0 |       1 |      0 |    329
---------+--------+--------+--------+--------+
Benzine  |      0 |     170 |       0 |   7654 |   7824
---------+--------+--------+--------+--------+
Diesel   |      0 |     807 |       0 |   1502 |   2309
---------+--------+--------+--------+--------+
LPG      |      0 |      41 |       0 |    880 |    921
---------+--------+--------+--------+--------+
Total         328     1018         1   10036    11383

TABLE OF NUMBER OF CYLINDERS BY SORT OF VEHICLE

NO of CYL SORT OF VEHICLE

Frequency|       ? |       B |       M |       P |  Total
---------+--------+--------+--------+--------+
missing  |    328 |       0 |       0 |      2 |    330
---------+--------+--------+--------+--------+
        1 |      0 |       0 |       0 |      2 |      2
---------+--------+--------+--------+--------+
        2 |      0 |       3 |       0 |     59 |     62
---------+--------+--------+--------+--------+
        3 |      0 |       8 |       0 |    287 |    295
---------+--------+--------+--------+--------+
        4 |      0 |     871 |       1 |   9160 |  10032
---------+--------+--------+--------+--------+
        5 |      0 |      47 |       0 |     99 |    146
---------+--------+--------+--------+--------+
        6 |      0 |      78 |       0 |    387 |    465
---------+--------+--------+--------+--------+
        8 |      0 |      11 |       0 |     38 |     49
---------+--------+--------+--------+--------+
       12 |      0 |       0 |       0 |      2 |      2
---------+--------+--------+--------+--------+
Total         328     1018         1   10036    11383
```

```
TABLE OF TOTAL WEIGHT BY SORT OF VEHICLE

TOTAL WEIGHT
(kg)        SORT OF VEHICLE

Frequency |       ? |       B |       M |       P |  Total
----------+--------+--------+--------+--------+
missing   |     328 |       0 |       1 |   10036 |  10365
----------+--------+--------+--------+--------+
   < 1000 |       0 |       1 |       0 |       0 |      1
----------+--------+--------+--------+--------+
1000-2000 |       0 |     420 |       0 |       0 |    420
----------+--------+--------+--------+--------+
2000-3000 |       0 |     454 |       0 |       0 |    454
----------+--------+--------+--------+--------+
3000-3500 |       0 |     112 |       0 |       0 |    112
----------+--------+--------+--------+--------+
other     |       0 |      31 |       0 |       0 |     31
----------+--------+--------+--------+--------+
Total           328     1018        1     10036    11383
```

```
TABLE OF RDW MESSAGE BY SORT OF VEHICLE

MESSAGE                        SORT OF VEHICLE

Frequency                     |       ? |       B |       M|       P |  Total
------------------------------+--------+--------+--------+--------+
No message (OK)               |       0 |     568 |       1 |    4651 |   5220
------------------------------+--------+--------+--------+--------+
Signalled                     |       0 |       3 |       0 |      26 |     29
------------------------------+--------+--------+--------+--------+
In company stock              |       0 |      79 |       0 |     793 |    872
------------------------------+--------+--------+--------+--------+
Number not in database        |      31 |       0 |       0 |       0 |     31
------------------------------+--------+--------+--------+--------+
Number not valid              |       0 |      16 |       0 |      39 |     55
------------------------------+--------+--------+--------+--------+
Number removed from dbase     |       0 |     352 |       0 |    4527 |   4879
------------------------------+--------+--------+--------+--------+
Number non-existent           |     282 |       0 |       0 |       0 |    282
------------------------------+--------+--------+--------+--------+
Invalid/clean.reg.91          |       3 |       0 |       0 |       0 |      3
------------------------------+--------+--------+--------+--------+
Cleaning register 91          |       6 |       0 |       0 |       0 |      6
------------------------------+--------+--------+--------+--------+
Removed/clean.reg 89          |       2 |       0 |       0 |       0 |      2
------------------------------+--------+--------+--------+--------+
Removed/clean.reg.91          |       4 |       0 |       0 |       0 |      4
------------------------------+--------+--------+--------+--------+
Total                               328     1018        1     10036    11383
```

# Appendix 4 RDW database by make/model (cars with a share of approx. 1% or more)

*Explanation of abbreviations:*
B = van
P = car

```
Frequency      |       B |       P |  Total
---------------+---------+---------+
BMW-3          |       0 |     221 |    221
---------------+---------+---------+
CITROEN-BX     |       3 |     146 |    149
---------------+---------+---------+
FIAT-Panda     |       1 |     120 |    121
---------------+---------+---------+
FIAT-UNO       |       2 |     130 |    132
---------------+---------+---------+
FORD-Escort    |      20 |     533 |    553
---------------+---------+---------+
FORD-Fiesta    |      10 |     165 |    175
---------------+---------+---------+
FORD-Sierra    |       2 |     225 |    227
---------------+---------+---------+
HONDA-Civic    |       1 |     165 |    166
---------------+---------+---------+
MAZDA-323      |       5 |     214 |    219
---------------+---------+---------+
MAZDA-626      |       0 |     177 |    177
---------------+---------+---------+
MERCEDES-190   |       0 |     112 |    112
---------------+---------+---------+
NISSAN-Micra   |       0 |     103 |    103
---------------+---------+---------+
NISSAN-Sunny   |       5 |     194 |    199
---------------+---------+---------+
OPEL-Ascona    |       0 |     104 |    104
---------------+---------+---------+
OPEL-Astra     |      12 |     193 |    205
---------------+---------+---------+
OPEL-Corsa     |      19 |     264 |    283
---------------+---------+---------+
OPEL-Kadett    |      19 |     773 |    792
---------------+---------+---------+
OPEL-Vectra    |       0 |     170 |    170
---------------+---------+---------+
PEUGEOT-205    |      35 |     275 |    310
---------------+---------+---------+
PEUGEOT-405    |       4 |     110 |    114
---------------+---------+---------+
RENAULT-19     |       1 |     105 |    106
---------------+---------+---------+
RENAULT-5      |       2 |      96 |     98
---------------+---------+---------+
SUZUKI-Alto    |       0 |     154 |    154
---------------+---------+---------+
SUZUKI-Swift   |       4 |     106 |    110
---------------+---------+---------+
TOYOTA-Corolla |       3 |     175 |    178
---------------+---------+---------+
TOYOTA-Starlet |       2 |     121 |    123
---------------+---------+---------+
VW-Golf        |      22 |     697 |    719
---------------+---------+---------+
VW-Passat      |       3 |      90 |     93
---------------+---------+---------+
VW-Polo        |       5 |     108 |    113
---------------+---------+---------+
VOLVO-340/360  |       0 |     100 |    100
---------------+---------+---------+
VOLVO-440/460  |       0 |      91 |     91
---------------+---------+---------+
Rest/missing   |     836 |    3891 |   4727
---------------+---------+---------+
Total             1018     10036    11054
```