LATERAL CAR COLLISIONS

Characteristics of lateral car collisions based on SWOV accident investigation

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Institute for Road Safety Research SWOV, The Netherlands

1. INTRODUCTION

During 1976 and part of 1977 SWOV carried out the field work for an accident study, involving passenger cars. The purpose of this crash-injury investigation was to evaluate the influence of relevant crash safety factors (like safety belts and head restraints) on the outcome of car accidents.

Total sample size was 8173 cases. The sample is designed to be representative of all Dutch car accidents during those years, excluding those cases in which the car had less than an minimum level of damage; in which the car was older than from 1969; in which the make and model of the car represented less than 0,5 % of the Dutch car population.

All cars (8173) have been examined by a group of technicians, supervised by SWOV, and damage reports were made.
Injury details for hospitalized occupants were provided on the request of SWOV by hospital physicians.
Injury details for less severe injured occupants were provided by these occupants themselves, on specially made forms, sent to them by SWOV.
General accident data (like date, time, place, use of seatbelt, etc.) were also asked from those involved in the accident.
In some cases (fatalities mostly) assistence of police was asked to complete the forms.
During 1978 all material was developped and transferred to computor tape.
Statistical analysis of the data then started and is still going on.

For the purpose of a EEC working group on lateral collisions meeting (March 1979,Delft,The Netherlands) relevant material was made available.

2. RESULTS

2.1. Frequency of lateral collisions with respect to other collision types

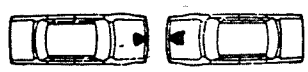
The total sample of 8173 cases may be divided into 6 main collision types, or rather damage types according to table 1.

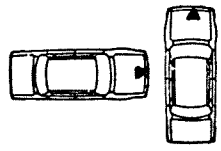
Frontal	55,7
Side	25,0
Rear	9,1
Frontal + rear	1,8
Rollovers	7,8
Other/unknown	0,6
	100 % (8173 cases)

Table 1. Percentage distribution of damage types.

The 25 % side damage (2044 cases) consists of left side and right side collisions.

The 55,7 % frontal damage represents 3 main types of collisions:

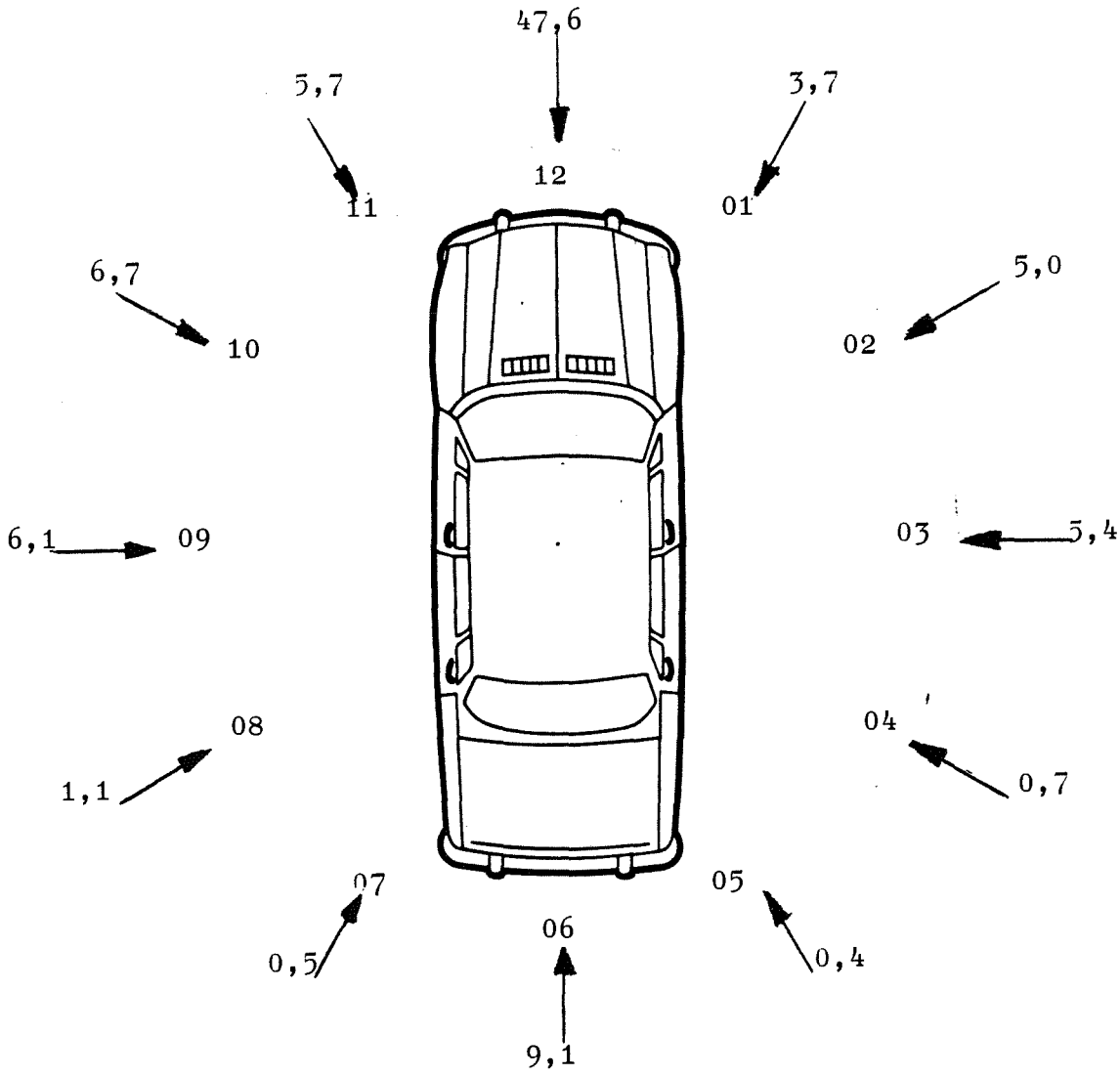
front to front 

front to side 

front to rear 

In the following part we will concentrate on the side collisions and use the front to front (26,2 % of all cases) and rear collisions as comparison.

A more detailed view of distribution of damage to the cars is provided by the "direction of impact force" parameter, using the 12 hours of the clock.



Rollovers = 7,8%

TOTAL = 100% (8173 cases)

Table 2. Percentage distribution of Direction of impact force.

The directions 02,03,04 and 08, 09,10 are considered to be lateral collisions.

Left side lateral collisions amount to 13,9 % of all cases.
Right side lateral collisions amount to 11,1 % of all cases.

2.2. Severity of injuries for lateral collisions and other types

SWOV used the AIS severity code to describe severity for every separate injury, according to the 1976 revisions of the well known AIS booklet.

To describe overall severity for individual occupants, SWOV used the highest AIS code of the most severe individual injury, creating the following scale (OAIS):

0 not injured
1 light injury
2 moderate injury
3 severe injury
4 dangerous injury
5 life-threatening injury
6 fatal injury

Though the highest individual AIS number in the new AIS system is 5, SWOV used the 6-code to seperate those who actually died from those who survived, thereby minimizing the OAIS 5 class.

Some changes were made to AIS ratings of certain injuries according to the opinion of SWOV physicians.
For instance fracture of the collum became AIS 3 instead of 2.
All other normal fractures of limbs became AIS 2.

According to table 3 front to front collisions seem to represent the most severe type of collision, followed by lateral collisions and rollovers.

Overall injury severity	Lateral collisions	Front to front collisions	Rear collisions	Rollovers	Total (incl. other types)
0	63,6	53,4	74,6	60,5	64,8
1	18,0	22,4	21,4	18,0	18,6
2	10,9	16,1	3,0	14,1	11,2
3	4,1	4,4	0,7	5,3	3,1
4	1,0	0,7	0,4	0,3	0,5
5	0,3	0,2	-	-	0,2
6	2,2	2,7	-	1,9	1,5
Total	100 % (2044 cases)	100 % (2138 cases)	100 % (743 cases)	100 % (640 cases)	100 % (8173 cases)

Table 3. Overall severity of injuries for some collision types, drivers only.

2.3. Injury patterns for lateral collisions and other types

Injuries may be divided into 9 main groups:

1 Skull & brain
2 Face
3 Neck
4 Thorax
5 Abdomen
6 Back (spinal column)
7 Pelvis
8 Arms
9 Legs

Table 4 presents these main groups of injuries for drivers in different collisions configurations.
In table 4 some of the differences between lateral and front to front collisions already show.
Another remarkable result is the 51,6 % neck injuries for rear collisions.

Obviously this is the result of the occurence of whiplash injury (normally a complaintof pain, AIS severity 1).

Main group	Lateral collisions	Front to front collisions	Rear collisions	Total (incl. other types)
1 Skull & brain	23,7	20,0	14,4	22,2
2 Face	11,2	21,1	7,2	16,1
3 Neck	4,4	3,7	51,6	6,9
4 Thorax	20,2	16,9	6,8	16,5
5 Abdomen	2,6	2,3	0,4	2,3
6 Back	2,4	1,3	4,0	2,4
7 Pelvis	5,0	1,3	0,4	2,0
8 Arms	16,0	13,6	7,2	14,2
9 Legs	14,5	19,8	8,0	17,3
Total	100 % (1444 injuries)	100 % (2076)	100 % (250)	100 % (5505)

Table 4. Percentage distribution of injuries, divided into 9 main groups, drivers only.

In the next table the individual injuries are presented, forming the injury pattern.
To avoid very small numbers of individual injuries, groups have been formed of injuries similar in origin and severity.
The injury patterns of table 5 clearly show where the differences are, though without further statistical tests no evidence as to the significance of these differences is given.

Comparing lateral collisions with front to front collisions we see:
- less face injury, both minor contusions and fractures.
- more thorax injury, both rib fractures and the resulting pneumothorax and contusions of the lung.
- more pelvis injury, both fractures and contusions of the kidney.
- slightly more light arm injuries.
- less leg injuries, especially fractures.

Injury pattern	Lateral collisions	Front to front collisions	Rear collisions	Total (incl. other types)
1. Skull & brain				
- contusion, abrasion	8,6	7,2	5,6	8,3
- concussion	10,8	9,7	8,4	10,7
- cerebral contusion	2,8	2,1	0,4	2,1
- fracture of skull	1,5	1,1	-	1,1
2. Face				
- contusion, abrasion	8,8	14,8	6,0	11,7
- fracture (jaw & nose)	1,5	5,1	1,2	3,2
- eye injury	1,0	1,3	-	1,2
3. Neck				
- contusion, abrasion	1,1	0,6	3,2	1,1
- whiplash	2,4	2,7	47,6	5,3
- fractures	0,8	0,4	0,8	0,5
4. Thorax				
- contusion, abrasion	11,8	12,2	5,6	11,6
- rib fracture	6,3	3,8	0,8	3,9
- pneumothorax, lung-contusion	2,1	0,8	0,4	1,0
5. Abdomen				
- contusion	1,6	1,5	0,4	1,5
- rupture	1,0	0,8	-	0,8
6. Back				
- contusion	1,9	0,9	3,6	1,9
- fracture	0,4	0,5	0,4	0,5
7. Pelvis				
- contusion	0,3	0,2	-	0,2
- fracture	2,6	0,5	-	1,0
- contusion of kidney	2,1	0,6	0,4	0,9
8. Arms				
- contusion, abrasion, distorsion	10,7	8,1	6,0	9,0
- luxation	0,9	0,5	0,4	0,6
- fracture	4,4	4,9	0,8	4,6
9. Legs				
- contusion, abrasion, distorsion	10,9	12,1	8,0	12,2
- luxation	0,3	1,0	-	0,4
- fracture	3,3	6,7	-	4,7
Total (injuries)	100 % (1444)	100 % (2076)	100 % (250)	100 % (5505)

Table 5. Injury pattern for same collision types, drivers only.

Since most of the injuries sustained have only AIS severity code 1, these injuries tend to influence the injury pattern a great deal.

In the next table all injuries of this minor severity have been left out, hereby reducing of course the remaining number of injuries considerably.

Injury pattern	Lateral collisions	Front to front collisions	Total (including other types)
1. Skull & brain			
-concussion	25,4	23,9	28,2
-cerebral contusion	6,7	5,1	5,5
-fracture	3,4	2,6	2,9
2. Face			
-fracture	3,4 →	12,5	8,4
-eye injury	2,3	3,1	3,1
3. Neck			
-fracture	2,0	1,0	1,4
4. Thorax			
-rib fracture	14,8 ←	9,4	10,4
-pneumothorax	2,9 ←	1,2	1,6
-contusion of lung	1,6 ←	0,7	0,9
-other serious inj.	0,3	0,1	0,1
5. Abdomen			
-serious contusions	1,8	2,1	2,1
-rupture	2,4	2,0	2,1
6. Back			
-fracture	1,0	1,2	1,2
7. Pelvis			
-fracture	6,0 ←	1,2	2,5
-contusion of kidney	4,9 ←	1,5	2,3
8. Arms			
-luxation	2,1	1,3	1,6
-fracture	10,4	12,1	12,1
9. Legs			
-luxation	0,7	2,5	1,0
-fracture	7,8 →	16,5	12,4
Total (injuries)	100 % (614)	100 % (842)	100 % (2095)

Table 6. Injury pattern for some collision types, injuries ≥ AIS2, drivers only.

Without minor injuries, the differences we found in table 5 are even stronger in table 6.

Both lateral collisions and frontal collisions show a rather high percentage of injury to the skull and the brain, mainly existing of concussion, rated AIS2.

The main differences are still with:
- face fractures
- rib fractures and more severe thorax injury
- pelvis fractures and internal injury
- leg fractures.

Of course all these differences, for instance pelvis fractures also occur in frontal collisions but they tend to occur more often in lateral collisions.

2.4. Some other aspects of lateral collisions

2.4.1. Use of safety belts

Use of safety belts became compulsory in The Netherlands starting June first 1975, for front seat occupants of passenger cars. Since then annual SWOV surveys show a more or less stable use rate of 70 % outside city limits and 50 % inside city limits. In our accident sample we found a more or less similar use rate, though on a somewhat higher level than expected.

2.4.2. Objects contacted

"Another car" was the most common object contacted in lateral collisions (65,6 % of all 2044 cases) table 7 shows the distribution of the most important of these objects.

	Lateral collisions	Front to front collisions
cars	65,6	40,8
vans and trucks	12,0	6,0
poles and trees	15,5	36,3
motorcycles, mopeds	2,1	1,2
other/unknown	4,8	15,7
Total	100 % (2044)	100 % (2155)

Table 7. Percentage distribution of objects contacted in lateral and front to front collisions. (For each case only one object is given, being the one that caused the main damage to the case car).

2.4.3. Hospital patients

245 of 2041 drivers (12 %) involved in lateral collisions stayed in hospitals for treatment.
For front to front collisions there were 341 out of 2155 (16 %) hospitalized drivers.

3. CONCLUDING REMARKS

The scope of this preliminary report was rather limited.

No statistical tests have been made to check the significance of the differences found.

Difference due to safety belt use; seating possition; actual area struck; left or right side collision, and other relevant factors have not yet been taken into account.

LATERAL CAR COLLISIONS

Supplement

Voorburg, 1979
Institute for Road Safety Research SWOV, The Netherlands

Introduction

This supplementary report is based on the same data as the original report.
In the EEC-group on Lateral collisions the original report was discussed on its meeting in March 1979 at Delft.
Additional questions were asked there and these questions are answered in this supplementary report.

1. Cases or cars

The SWOV accident study on which the material in this report is based, defines each case as the group of accident data that belongs to one particular accident car.
Therefore the number of cases is identical to the number of cars. No reference is made (or can be made) to the number of accidents in which the cars were involved.

2. Male and female drivers

Differentation of the data with regard to sex (male/female) was only available for the overall sample.

The following table shows AIS distribution for men and women. Included are 30 drivers, with sex unknown.

OAIS	Male	Female	Total
0	67	56	65
1	18	24	19
2	10	15	11
3	3	3	3
4	0,5	0,5	0,5
5/6	1,5	1,5	1,5
Total	100 % (6732)	100 % (1411)	100 % (8173)

Table S1. Percentage distribution of OAIS for male and female drivers, total sample.

Conclusions

There are differences between male and female drivers as far as Overall AIS is concerned.

These differences are found in the lower AIS levels (0,1,2). Women seem to suffer more AIS 1 and 2 level injuries than men and therefore there are less women non-injured than men. These results are more or less consistent with those of the previous SWOV accident study.
It was noted there specifically that women suffered more AIS 1 level injuries (like cuts, bruises, wounds, etc.) and this seemed part of their habit to "care" more for this kind of injury than men, who tended to "forget" these injuries.

Without further examination and analysing it seems not possible to fully explain the rather great differences found in this study sample.

3. Area of contact

Apart from "Direction of impact force" SWOV registered "Area of impact".
For this purpose the car is divided by horizontal and vertical lines into areas.
Area(s) having the greatest amount of damage were noted either in the primary damage section (main damage) or the secondary damage section.

The tables below present some of these results.

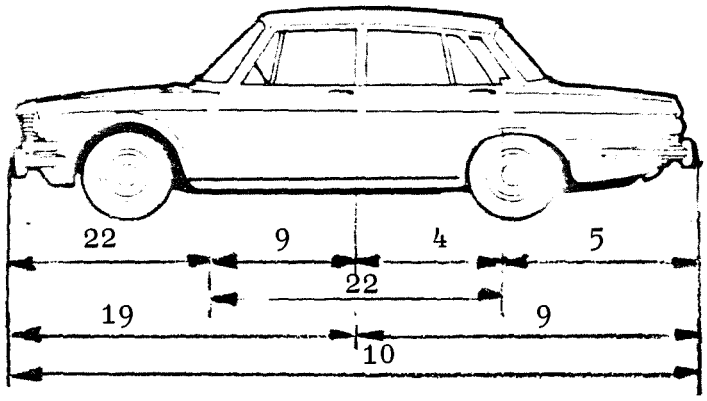


Table S2. Percentage distribution of horizontal damaged area; left side lateral collisions (1220 cases). *)

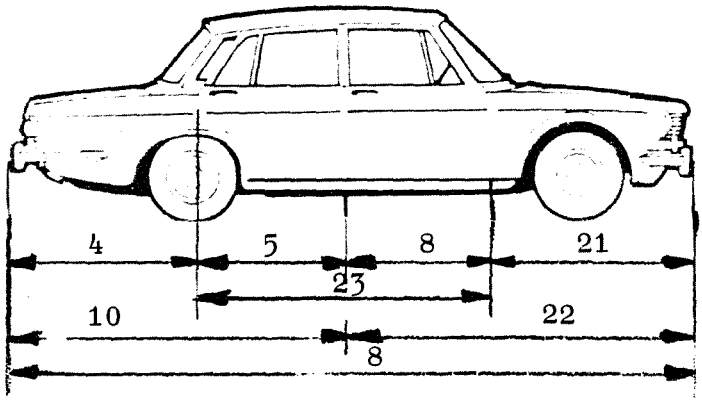


Table S3. Percentage distribution of horizontal damaged area; right side lateral collisions (969 cases). *)

*) Both numbers include cases with side damage due to rollovers.

Vertical damaged area information is available only for the total group of lateral damaged cars:

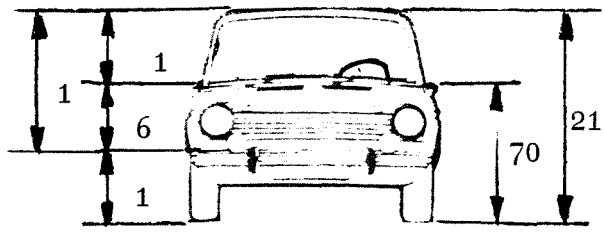


Table S4. Percentage distribution of vertical damaged area, all lateral collision cases.

4. Injury severity versus Direction of impact and Collision type

In table 3 of the original report the Overall injury severity (OAIS) is given for 4 different collision types.

According to this table pure frontal collisions (front to front) are the "worst" kind of collisions (the highest rate of OAIS = 6 and the lowest of OAIS = 0).

Lateral collisions, closely followed by Rollovers, are second and third on the list of most severe collision types.

All other types are much less severe, rear collisions being extremely "soft" since no OAIS 5 and 6 drivers resulted from this type and 75 % of all were not injured.

In the following table instead of Collisions type we use Direction of impact force, according to the distribution mentioned on page 3 of the original report.

The table is restricted to information about OAIS 5/6 and OAIS = 0, these rates being indicators for the complete range of injury severities.

	Direction of impact force (Clock system)											
OAIS	01	02	03	04	05	06	07	08	09	10	11	12
0	67,4	67,7	64,6	74,6	83,3	74,1	79,5	69,9	58,1	62,1	65,7	63,7
5/6	1,3	1,7	3,1	1,7	0	0,1	0	1,1	2,8	2,5	2,8	1,6
Total (cases)	304	409	443	59	36	740	44	93	497	549	464	3893

Table S5. Percentage distribution of some OAIS rates for Direction of impact forces, drivers only.

As in table 2 of the original report it can be noted that directions 04, 05, 07 and 08 are uncommon.

Directions 03, 09, 11 and 10 (in that order) are the "worst" force directions as far as OAIS 5/6 is concerned.
Directions 05, 06 and 07 (rear end) are clearly the "best" ones.

These observations confirm more or less what is stated in the first part of this chapter for collision types versus OAIS.

5. Effectiveness of seat belts in lateral collisions

In the following table we have seat belt users versus non-users for left and right side lateral collisions crossed against OAIS.
The table is for drivers only.

	Left side collisions		Right side collisions	
OAIS	users	non-users	users	non-users
0	63	57	73	54
1	18	22	15	19
2	12	10	8	16
3	4	6	2	5
4	1	0,5	1	1
5/6	2	4,5	1	5
Total	100 % (796)	100 % (341)	100 % (616)	100 % (291)

Table S6. Percentage distribution of OAIS for users and non-users of seat belt; left side lateral collisions and right side lateral collisions; drivers only.

Conclusions are that seat belts are effective in lateral collisions. They seem to be more effective in right side lateral collisions as far as drivers are concerned.
It should be noted again that these conclusions are not checked for statistical significance.

6. Damage index versus Injury severity

In the SWOV study no specific damage severity index (like the last part of the VDI) was used.
Instead damage as reported for each damaged area was provided with a depth and a width dimension, expressed in cm.

SWOV did not yet transfer these measurements into VDI ratings.

However SWOV thinks that depth (or depth combined with width) may be used to indicate damage severity.

In the following table we see damage depth (divided into classes of 10 cm) related to overall injury severity.
For convenience only OAIS classes 0 and 5/6 are reproduced.
These figures were available only for the total sample (all collision types).

	Depth of deformation (cm)								Total
OAIS	0-10	10-20	20-30	30-40	40-50	50-60	60-70	>70	
0	75,1	41,1	51,7	63,8	34,7	52,2	57,7	43,3	
5/6	0,2	3,1	1,0	0,8	7,7	4,1	2,9	12,9	
Total (cases)	5047	745	555	356	450	414	343	263	8173

Table S7. Percentage distribution of some OAIS classes over Depth of defirmation classes; all collision types; drivers only.

There is a distinct relation between OAIS and depth of deformation.
This relation is not as fluently as might have been expected.
Clearly in the lowest depth range we find the highest proportion of not-injured drivers and the lowest proportion of 5/6 injured.
Reversely we find in the highest depth categorie (>70 cm) the

highest rate of 5/6 injured and (almost) the lowest of not-injured. Between these two extremes there seem to be some inconsistent deviations from the expected relationship.

Of course this could be due to the fact that all collision types are taken together.
Detailed results of this relationship will be discussed in future SWOV reports.

7. Femur fractures

Though (according to table 5 of the original report) pelvis fractures obviously are much more common for lateral collisions than for other collisions, this is not so for femur fractures (see table below).

	Lateral collisions	Front to front collisions	All collision types
Femur fractures	22 (1,5 %)	39 (1,9 %)	75 (1,4 %)
Pelvis fractures	37 (2,6 %)	10 (0,5 %)	53 (1,0 %)
Total (injuries)	1444 (100%)	2076 (100%)	5505 (100%)

Table S8. Number and proportion of femur fractures (and pelvis fractures) for different types of collision; drivers only.

According to this table femur fractures occur more often in front to front collisions than in any other type of collision, and in lateral collisions the proportion of femur fractures (1,5 %) is more or less the same as the average proportion for all collision types (1,4 % of all injuries).

8. Concluding remarks

During this work some differences were detected between left side lateral collisions and right side lateral collisions. (See for instance part 5 of this report).
More detailed analysis of the data showed that cars with right side damage more often had been struck by trees than cars with left side damage.
Accordingly damage severity (depth of deformation) on the right side of cars was greater than on the left sides.

These facts seem fully explainable.
When cars leave the road, they will probably strike or be struck on that side of the car that was nearest the edge of the road.
Since trees are more common on the right side of roads than on the left side (where for instance crash barriers are more common) it seems probable the distribution of objects contacted is different for left and right sides of the car.
Of course these observations will have influence on the outcome of accidents, expecially for lateral collisions.
In later reports, SWOV will further analyse this interesting aspect of lateral collisions and check the representativeness of the differences found in the sample, against the real world accident situation in The Netherlands.

Another (more common) difference found in the study sample is the difference between the proportions of left side and right side lateral collisions. (See page 3 of the original report).
This is consistent with results of previous studies (in other countries as well) and seems to be related to right hand traffic and right of way regulations.