Relevance of head injuries in side collisions in Germany – Comparison with the analyses and proposals of the WG13

Relevanz von Kopfanprallverletzungen bei Seitenkollisionen in Deutschland – Vergleich mit den Analysen und Vorschlägen der WG13

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1. Abstract / Summary

According to the White-book of the European commission, the number of fatalities in Europe has to be reduced by 50% until 2010 in comparison to the year 2000. For Germany this means a reduction of fatalities from 7503 down to 3751. This is the reason for different research institutes and committees to investigate all types of traffic accidents.
The Working Group 13 of the European Enhanced Vehicle Safety Committee therefore investigates in detail side impacts in vehicle crashes. The analysis is mainly based on real world accident data from NHTSA, LAB, TRL and BASt.
This paper analyse the used datasets, their representativeness and the main results in comparison to the current dataset of GIDAS and the federal traffic accident statistics of Germany.
One of the main results of this study is that the proposed test measures are not able to provide the aspired benefit in German real accident scenarios. One reason identified is, that the used datasets are highly different to real life accidents in Germany, regarding injury mechanism as well as injury severity.

2. GIDAS Dataset

For the creation of the GIDAS dataset for this study the database has been filtered for several criteria. From 11592 accidents in the database all accidents were selected that fit the criteria of the WG 13 report. All accidents were picked where a car has been struck into the side. Thus, the vehicle had to be hit from 2–4 o'clock or 8–10 o'clock and it had to be declared a side crash in the variable VDI in the database.
With this criterion 1290 accidents remain. Now only injured occupants were regarded in the sample. From these 1650 persons 670 suffered a head injury that was filtered with the AIS code and the GIDAS internal declaration. On the injury level these persons had 879 head injuries and 776 injuries with a known associated vehicle part. 58 of these injuries had a severity AIS 3 or higher (Figure 1). It seems, however, questionable if this high portion of AIS 1+ injuries should be the objective for optimization in passenger car safety.

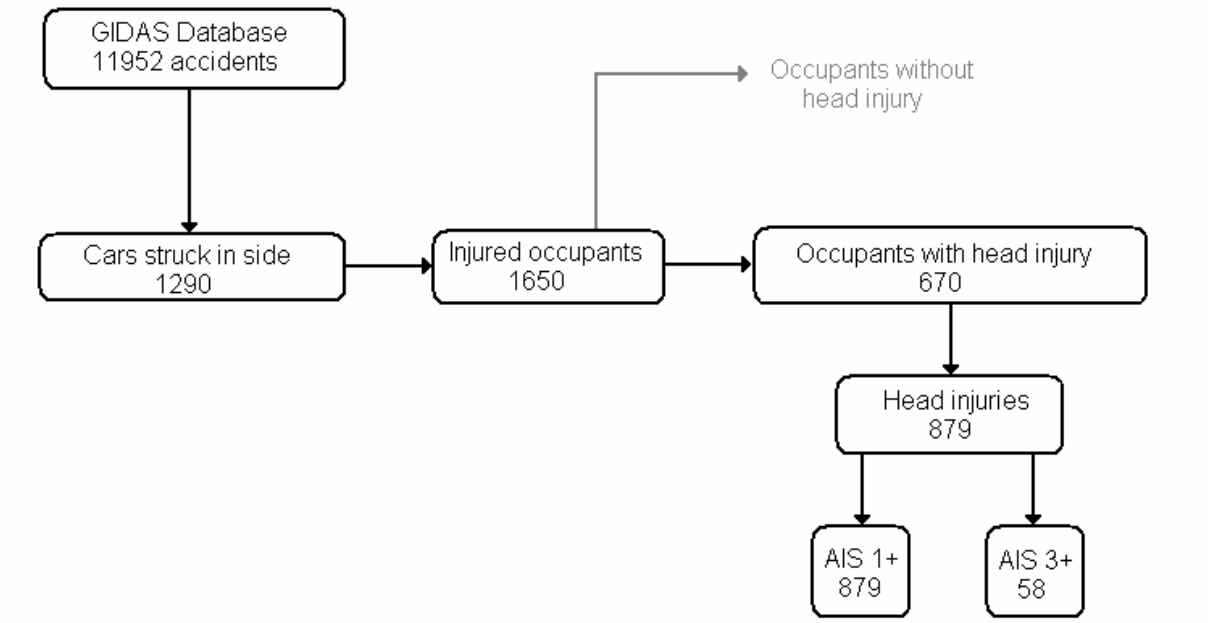


Figure 1 – GIDAS Dataset Side Collisions

3. Used Datasets of WG13

The WG13 used datasets of the accident databases of NHTSA, LAB, TRL and BASt. The used datasets are in each case only an excerpt of the databases. It is, however, very difficult to fathom the creation of the dataset or the filter criteria. Any analysis can thus only be obtained from and relate to these small data samples.

- The used NHTSA dataset consists of 160 injuries AIS 1+ including 45 injuries AIS 3+
- The used LAB dataset consists of 1345 injuries AIS 1+ including 36 injuries AIS 3+
- The used TRL dataset consists of 408 injuries AIS 1+ including 89 injuries AIS 3+
- The used BASt dataset consists of 94 injuries AIS 1+ including 33 injuries AIS 3+

Severe differences in the datasets can be found. The categories of the NHTSA and LAB datasets are rather fragmentary and not comprehensibly combined. Furthermore it seems that the category “unknown” has not been regarded in the NHTSA and LAB datasets.

Contact site	NHTSA		LAB		TRL		BASt		GIDAS	
	AIS 3+	AIS 1+	AIS 3+	AIS 1+	AIS 3+	AIS 1+	AIS 3+	AIS 1+	AIS 3+	AIS 1+
Airbag					0	1	0	0	3	31
A Pillar	11	50	2	10	2	11	2	6	4	42
B Pillar	22	64	8	40	6	26	11	18	8	94
Upper Anch' Point					0	2	0	2	0	3
C Pillar			1	3	0	0	1	2	0	8
Fascia Top					0	3	0	1	2	19
Header					0	3	0	0	1	9
Head Restraint					1	6	1	3	1	26
Mirror					0	5	0	0	0	11
Seat			0	1	1	9	0	0	0	13
Side Roof Rail	12	46	2	32	10	18	2	8	4	28
Side Other			4	33	8	17	1	6	0	7
Steering Wheel					2	10	0	7	3	48
Sunroof					0	1	0	0	0	0
Roof					2	6	1	4	3	30
Window Frame			1	22						
Flying Glass					0	25	0	7	0	16
Side Glass			0	104	4	92	4	15	7	242
Windscreen					0	8	0	2	1	53
Non Contact Injury					2	11	2	3	6	53
External Object			17	29	34	59	9	15	7	25
Occupant Contact					5	14	0	1	2	17
Unknown			1	71	22	143			3	104
TOTAL	45	160	36	345	99	470	34	100	58	879

Table 1 – Dataset Including GIDAS

Using four different databases there are of course fundamental differences in the data collection strategies, the described contact sites, the included accidents and data encoding. As stated in the WG 13 report it is naturally impossible to use the data as one large database. However, with the little information given about the single samples it is even hardly possible to compare the contact sides at all. In the WG13 report there are quite a lot of contact sites that are left blank (Table 2). Here it is mostly unclear weather these sites have not been investigated or if there has been no contact there. Especially due to the "unknowns" that are not filled in, a comparison is rather difficult or even impossible.

Contact site	NHTSA		LAB		TRL		BASt		GIDAS	
	AIS 3+	AIS 1+	AIS 3+	AIS 1+	AIS 3+	AIS 1+	AIS 3+	AIS 1+	AIS 3+	AIS 1+
Airbag	?	?	?	?	0	1	0	0	3	31
A Pillar	11	50	2	10	2	11	2	6	4	42
B Pillar	22	64	8	40	6	26	11	18	8	94
Upper Anch' Point	?	?	?	?	0	2	0	2	0	3
C Pillar	?	?	1	3	0	0	1	2	0	8
Fascia Top	?	?	?	?	0	3	0	1	2	19
Header	?	?	?	?	0	3	0	0	1	9
Head Restraint	?	?	?	?	1	6	1	3	1	26
Mirror	?	?	?	?	0	5	0	0	0	11
Seat	?	?	0	1	1	9	0	0	0	13
Side Roof Rail	12	46	2	32	10	18	2	8	4	28
Side Other	?	?	4	33	8	17	1	6	0	7
Steering Wheel	?	?	?	?	2	10	0	7	3	48
Sunroof	?	?	?	?	0	1	0	0	0	0
Roof	?	?	?	?	2	6	1	4	3	30
Window Frame	?	?	1	22	?	?	?	?	?	?
Flying Glass	?	?	?	?	0	25	0	7	0	16
Side Glass	?	?	0	104	4	92	4	15	7	242
Windscreen	?	?	?	?	0	8	0	2	1	53
Non Contact Injury	?	?	?	?	2	11	2	3	6	53
External Object	?	?	17	29	34	59	9	15	7	25
Occupant Contact	?	?	?	?	5	14	0	1	2	17
Unknown	?	?	1	71	22	143	?	?	3	104
TOTAL	45	160	36	345	99	470	34	100	58	879

Table 2 – Missing Information in the Datasets

For the comparing analyses with GIDAS the accidents in the GIDAS dataset were weighted according to the federal statistics regarding accident category, accident site, and type of accident. Due to this, the data is representative for the accident situation in Germany.

To be able to assess how representative the datasets of the WG13 report are, they have been compared to the weighted GIDAS data (Figure 2). The portion of severe head injuries AIS 3+ compared to all head injuries makes up 7% in the GIDAS dataset.

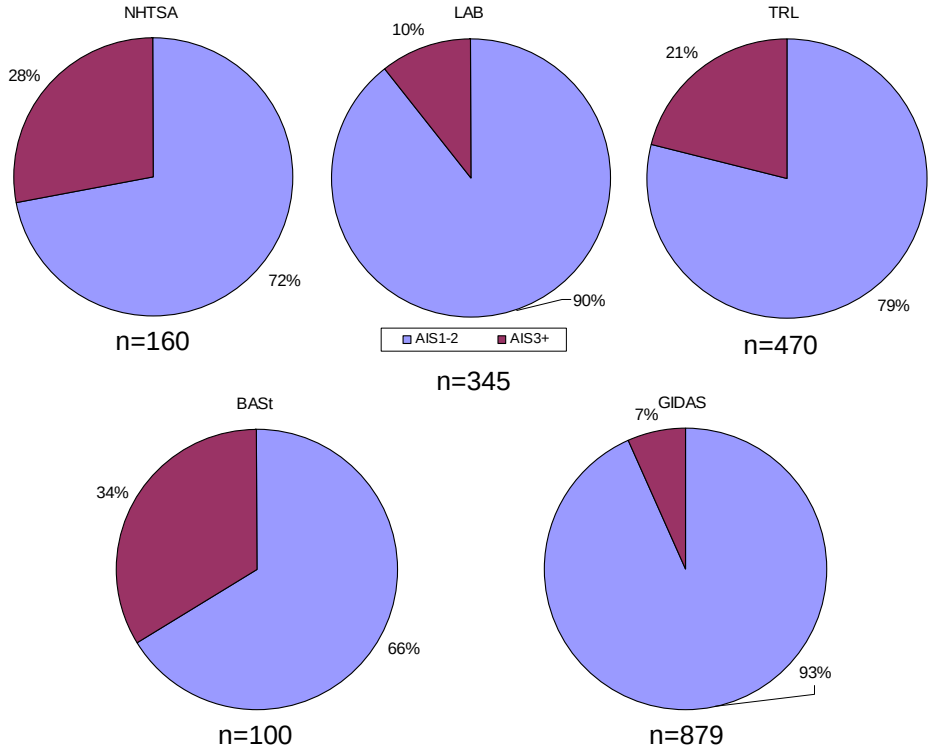
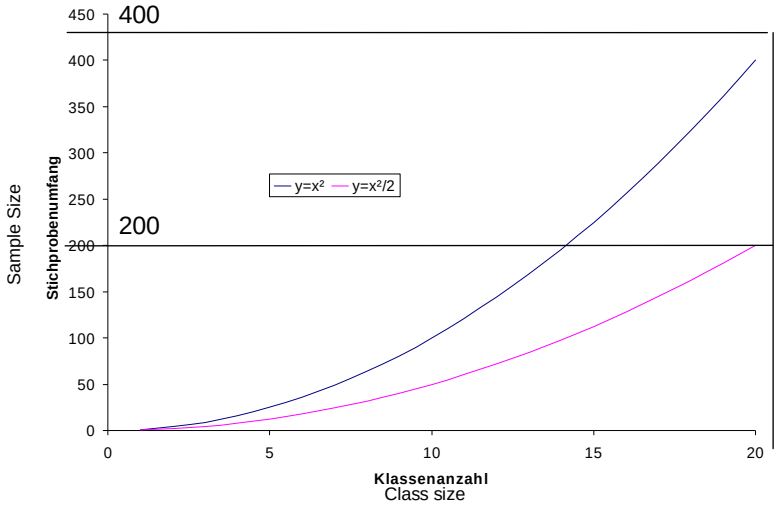


Figure 2 – Comparison with representative GIDAS data

The distribution of injury severity in the LAB dataset (portion 10%) is the closest one to the distribution in Germany. In the TRL dataset (portion 21%), the NHTSA dataset (portion 28%) and the BASt dataset (portion 34%) the fraction of severe and fatal head injuries is greatly higher. This comparison shows very well that the TRL, NHTSA, and BASt datasets do not describe the real accident situation in Germany at all. Thus all analyses done with this data cannot deliver representative results for Germany.

4. Sample Sizes and Possible Analyses

To obtain statistical useable results it is not only important that the used data is representative, but also that the number of cases is high enough. Due to the method of recording real accident data, statistical procedures to estimate robustness and reliability cannot be used. One reason is the fact that every contact site that was hit at least once has been recorded. Thus, it cannot be presumed that every contact side listed has relevance as an injury related part in reality. Then the available contact sites differ strongly in size and therefore in contact probability. In addition an equal distribution cannot be expected and using different datasets also leads to empty classes. All these facts lead to the problem that no statistical test procedure can be used to estimate the correctness and reliability of the found contacts. For this reason the formula presented in figure 3 has been used to at least estimate the necessary sample sizes.



For a statistical analysis a sample size of

n=(Classes)²

is needed.

•For n<(classes)²/2:	Sample too small
•For (classes)²/2<n<classes²	Trend estimation
•Für n>classes²	Valid prediction

Figure 3 – Necessary Sample Size

As shown in figure 3 a valid prediction for a distribution on 20 contact sites is only possible with at least 400 cases. With a number of cases between 200 and 400 not more than a trend estimation for the 20 contact sites is possible. If the number is below 200 however, no estimations can be made. So it is clear that an analysis of 20 contact sites with less than 200 cases cannot be carried out. It is therefore often better to group the contact sites to reduce the number of classes if not enough data is available.

Analogous to the WG13 report the contact sites have been broken down to seating positions and restraint use in the GIDAS analysis. As shown in table 3 the problem is that the number of contacts will be smaller the more detailed the filter criteria are, questioning the meaningfulness of these breakdowns from the basis.
Due to the detailed specification only the datasets of TRL, BASt and GIDAS could be used for these analyses.

	Contact Sites	Smallest necessary size		TRL		BASt		GIDAS	
		Trend	Valid	Number	Portion	Number	Portion	Number	Portion
All occupants (AIS 1+)	20	200	400	328	100,0%	99	100,0%	776	100,0%
All front seat occupants (AIS1+)	20	200	400	295	89,9%	94	94,9%	674	86,9%
Struck side front seat occupants (AIS1+)	18	162	324	194	59,1%	55	55,6%	446	57,5%
Non Struck Side front seat occupants (AIS1+)	18	162	324	102	31,1%	38	38,4%	225	29,0%
All restraint front seat occupants (AIS1+)	20	200	400	200	61,0%	71	71,7%	549	70,7%
Restraint struck side front seat occupants (AIS1+)	17	144,5	289	139	42,4%	43	43,4%	368	47,7%
Restraint non struck side front seat occupants (AIS1+)	18	162	324	61	18,6%	28	28,3%	174	22,4%
All unrestraint front seat occupants (AIS1+)	15	112,5	225	49	14,9%	8	8,1%	39	5,0%
Unrestraint struck side front seat occupants (AIS1+)	10	50	100	30	9,1%	6	6,1%	16	2,1%
Unrestraint non struck side front seat occupants (AIS1+)	12	72	144	19	5,8%	2	2,0%	23	3,0%
All rear seat occupants (AIS1+)	10	50	100	32	9,0%	6	6,1%	99	12,8%
Struck side rear seat occupants (AIS1+)	7	24,5	49	16	4,9%	3	3,0%	59	7,6%
Non struck side rear seat occupants (AIS1+)	4	8	16	16	4,9%	3	3,0%	31	4,0%
All restraint rear seat occupants (AIS1+)	10	50	100	9	2,7%	1	1,0%	63	8,1%
Restraint struck side rear seat occupants (AIS1+)	10	50	100	5	1,5%	1	1,0%	38	4,9%
Restraint non struck side rear seat occupants(AIS1+)	8	32	64	4	1,2%	0	0,0%	19	2,4%
All unrestraint rear seat occupants (AIS1+)	8	32	64	9	2,7%	4	4,0%	13	1,7%
Unrestraint struck side rear seat occupants (AIS1+)	8	32	64	3	0,9%	2	2,0%	6	0,8%
Unrestraint non struck side rear seat occupants (AIS1+)	6	18	36	6	1,8%	2	2,0%	2	0,3%
Valid prediction		Trend estimation				No estimation possible			

Table 3 – Overview – Contacs, Seating position, Restraint use

As explained in Figure 3 – the needed sample size for a statistical analysis for each analysis has been calculated. As seen in table 3 valid predictions are only in a few cases possible. Even trend estimations are futile for a breakdown to restraint use due to insufficient sample sizes in all datasets including the used GIDAS dataset.

The portion of the rear seat occupants makes up about 10% (GIDAS 12,8%, TRL 9%, BAST 6,1%). Any more detailed differentiation according struck and non struck side, belted or not belted does therefore not make sense (see table 3).

Figure 4 now shows a comparison of GIDAS data and the data sample of WG13 (NHTSA, LAB, TRL, BASt) with the rough classification of vehicle structures, glazing and non vehicle contacts. In the GIDAS AIS 1+ data there are more contacts on vehicle glazing and therefore fewer unknowns than in the WG13 data (Figure 4).

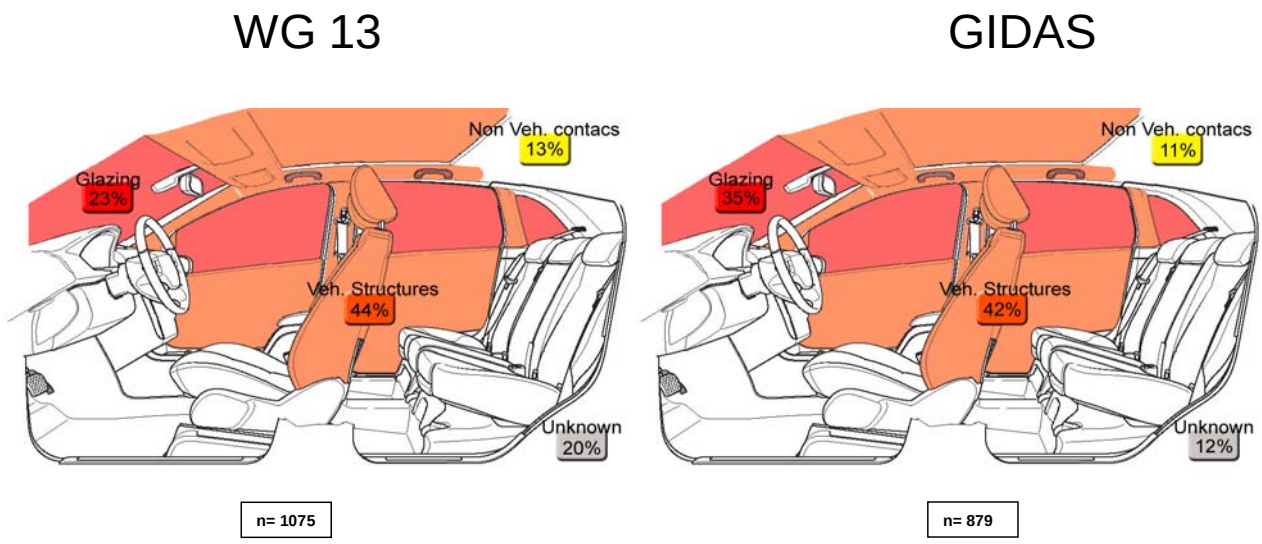


Figure 4 – Allocation Veh. structure, Glazing, Non Veh. AIS 1+

Comparing the AIS 3+ injuries there are bigger differences (Figure 5) in all categories.

WG 13 GIDAS

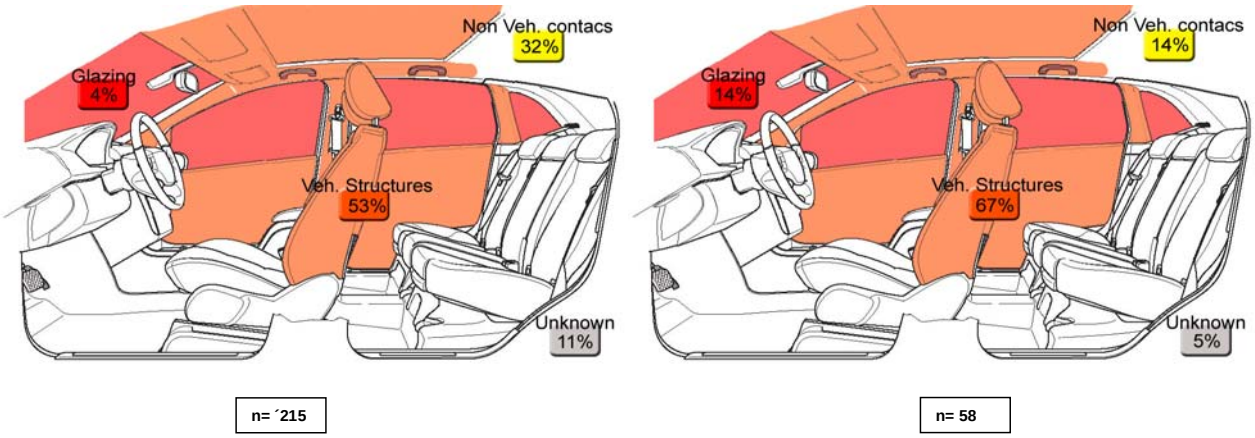


Figure 5 – Allocation Veh. Structures, Glazing, Non Veh. AIS 3+

Particularly conspicuous is the difference in non vehicle contacts with 32% of all AIS 3+ head injuries in the WG13 data sample and 14% of all AIS 3+ head injuries in GIDAS. Part of these non vehicle contacts are occupant contacts, external objects and non contact injuries. These specific categories can however only be found in the TRL and BASt data.

When all occupants (Figure 6) are taken into account it shows that there are fewer injuries because of external objects in GIDAS.

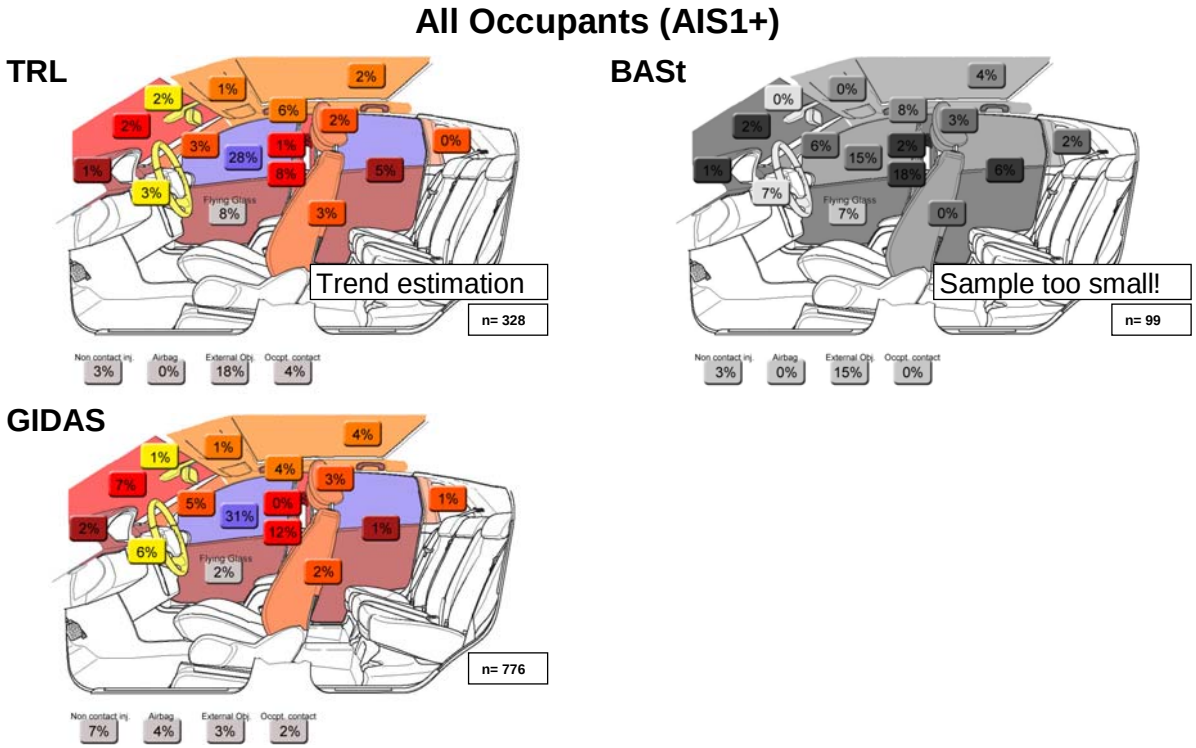


Figure 6 – Chart All Occupants

There are also less contacts in the region “side other”, which includes contacts with the inner door lining while there are more contacts with the B pillar.

Taking only front seat occupants into account (Figure 7) there are far less injuries caused by external objects in GIDAS. Furthermore there are more contacts with front parts (facia, steering wheel, windscreen…) and the B pillar. Analysing restraint and non restraint occupants separately the same differences can be found.

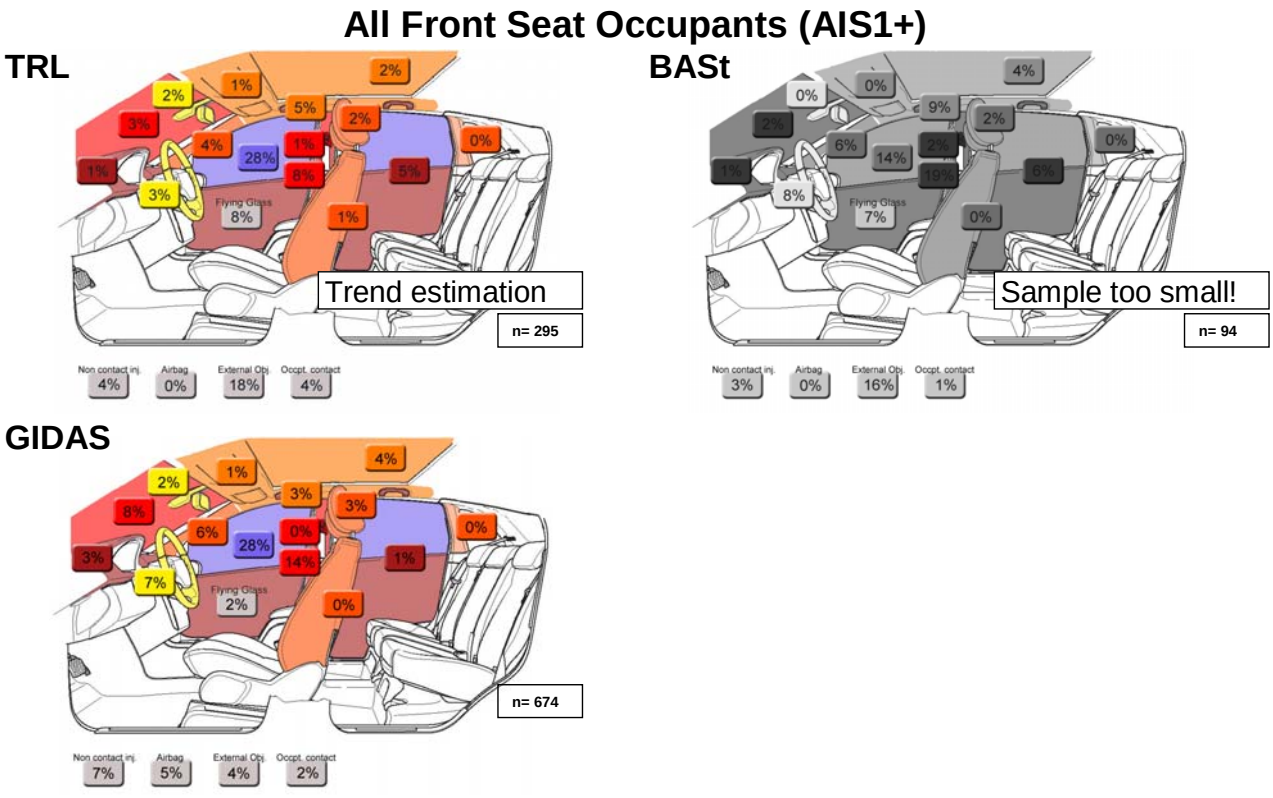


Figure 7 – Front Seat Occupants

Since only the GIDAS dataset provides sufficient sample sizes for rear seat occupants a comparison with the WG13 is hardly possible at all. Only for the non struck side rear seat occupants an analysis is possible, but there are differences in all contact sites.

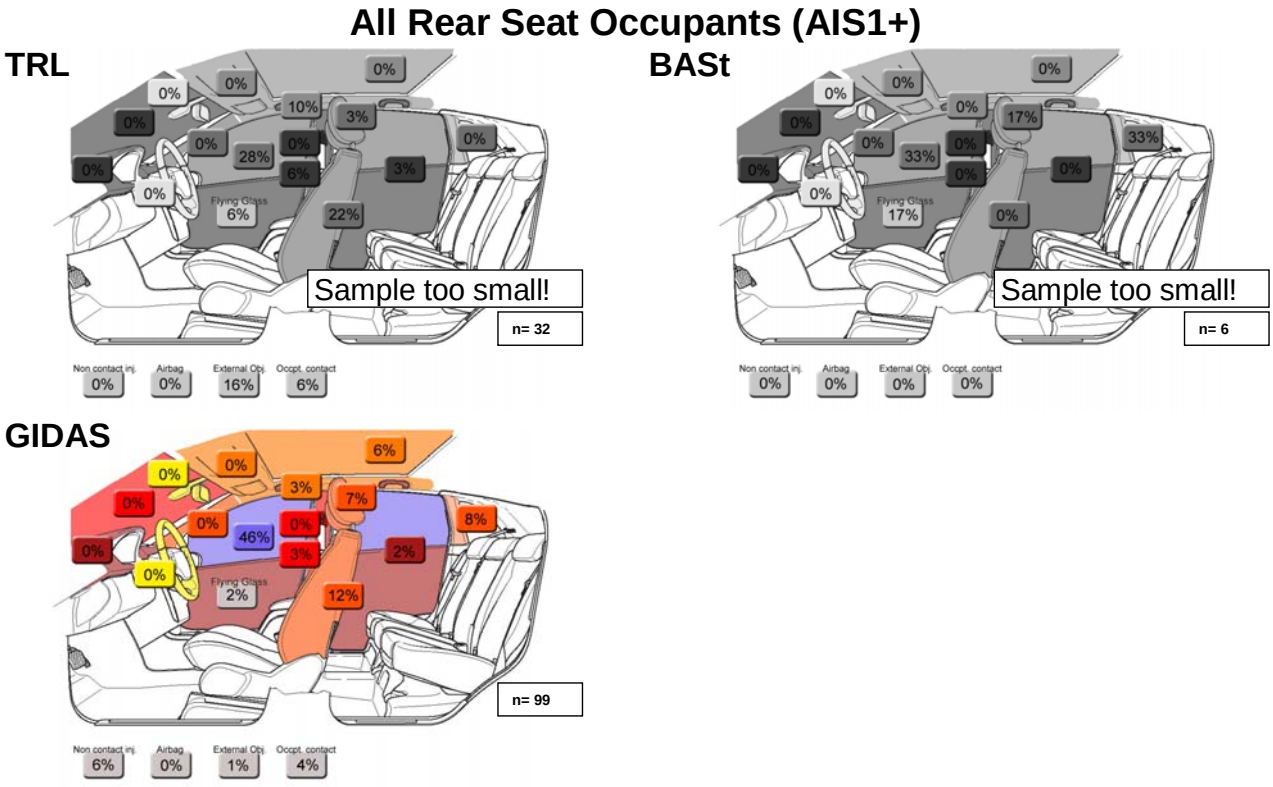


Figure 8 – Rear Seat Occupants

In the comparison regarding seating position, struck and non struck side, and restraint use, about 10% of all injured occupants in side collisions sat in the rear seats. A detailed differentiation as given in the WG13 report does therefore not make sense, because enough cases for at least a trend estimation are even in GIDAS only available for 11 of 19 analyses. Valid predictions with GIDAS are possible for 8 of 19 analyses. Due to the small number of cases in the used BASt dataset no analyses are possible here.

5. Specific Analyses

In this chapter different specific analyses were made.

1. Contacts with vehicle glazing only
2. Contacts without vehicle glazing
3. Relevance of Padding
4. Relevance of Cabriolets

5.1. Contacts with vehicle glazing only

Regarding only contacts with vehicle glazing there are more contacts with the windscreen in GIDAS and more “Flying Glass” injuries in the TRL and BASt datasets (Figure 9). Since there are hardly any AIS 3+ injuries caused by vehicle glazing there is no comparison possible in this group. Remarkably there are no AIS 3+ injuries caused by flying glass (Table 4).

Contact Site	TRL		BASt		GIDAS	
	AIS 3+	AIS 1+	AIS 3+	AIS 1+	AIS 3+	AIS 1+
Flying Glass	0	25	0	7	0	16
Side Glass	4	92	4	15	9	242
Windscreen	0	8	0	2	3	53
TOTAL	4	125	4	24	12	311

Table 4 – Contacts with Vehicle Glazing

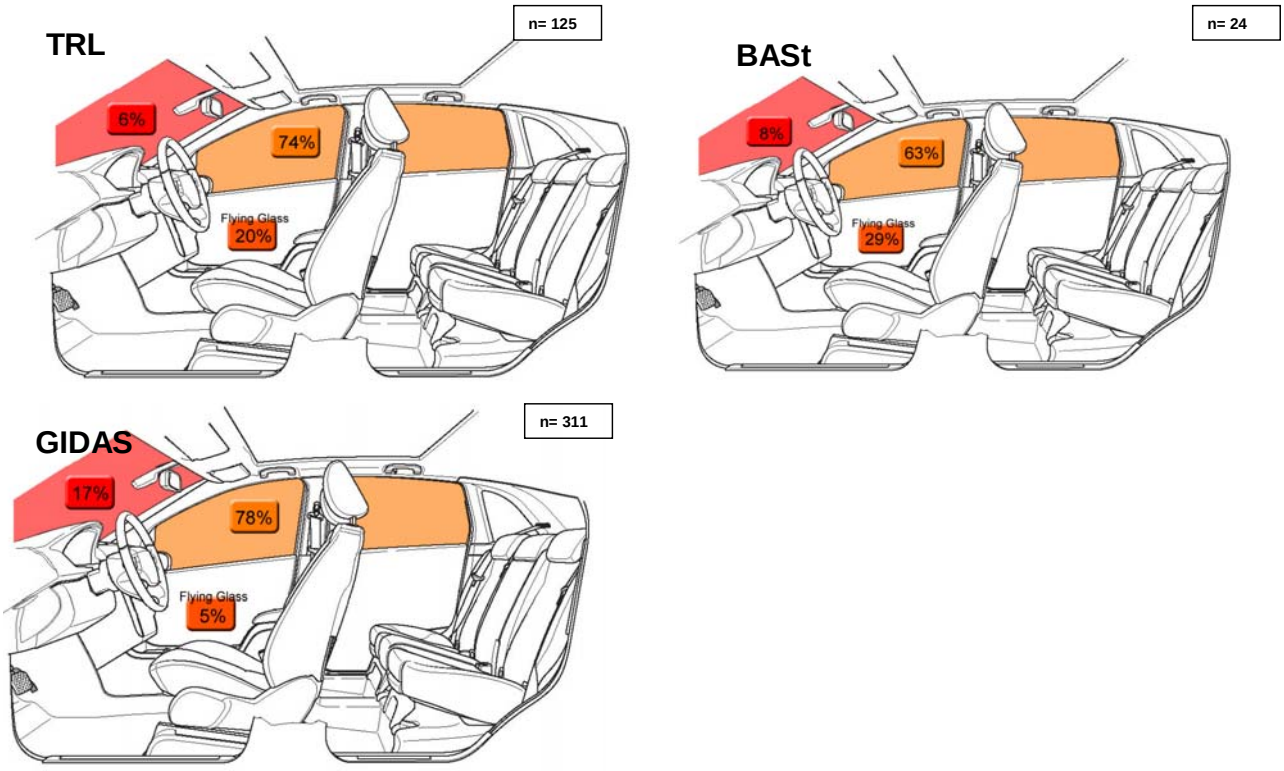


Figure 9 – Vehicle Glazing AIS1+

5.2. Contacts without vehicle glazing

If the contacts with vehicle glazing are excluded and GIDAS is compared to the TRL dataset the difference in the region ”side other” stands out (Table 5). This difference might be due to discrepancies in definition and allocation strictness and should therefore not be counted for door lining contacts solely.

Contact Site	TRL		BASt		GIDAS	
	AIS 3+	AIS 1+	AIS 3+	AIS 1+	AIS 3+	AIS 1+
Airbag	0	1	0	0	3	31
A Pillar	2	11	2	6	4	42
B Pillar	6	26	11	18	8	94
C Pillar	0	0	1	2	0	8
Fascia Top	0	3	0	1	2	19
Header	0	4	0	0	1	9
Head Restraint	1	6	1	3	1	26
Mirror	0	5	0	0	0	11
Seat	1	9	0	0	0	13
Side Roof Rail	10	18	2	8	4	28
Side Other	8	17	1	6	0	7
Steering wheel	2	10	0	7	3	48
Sunroof	0	1	0	0	0	0
Roof	2	6	1	4	3	30
Upper Anch' Point	0	2	0	2	0	3
TOTAL	32	119	19	57	29	369

Table 5 – Contacts with Vehicle Structures without Glazing

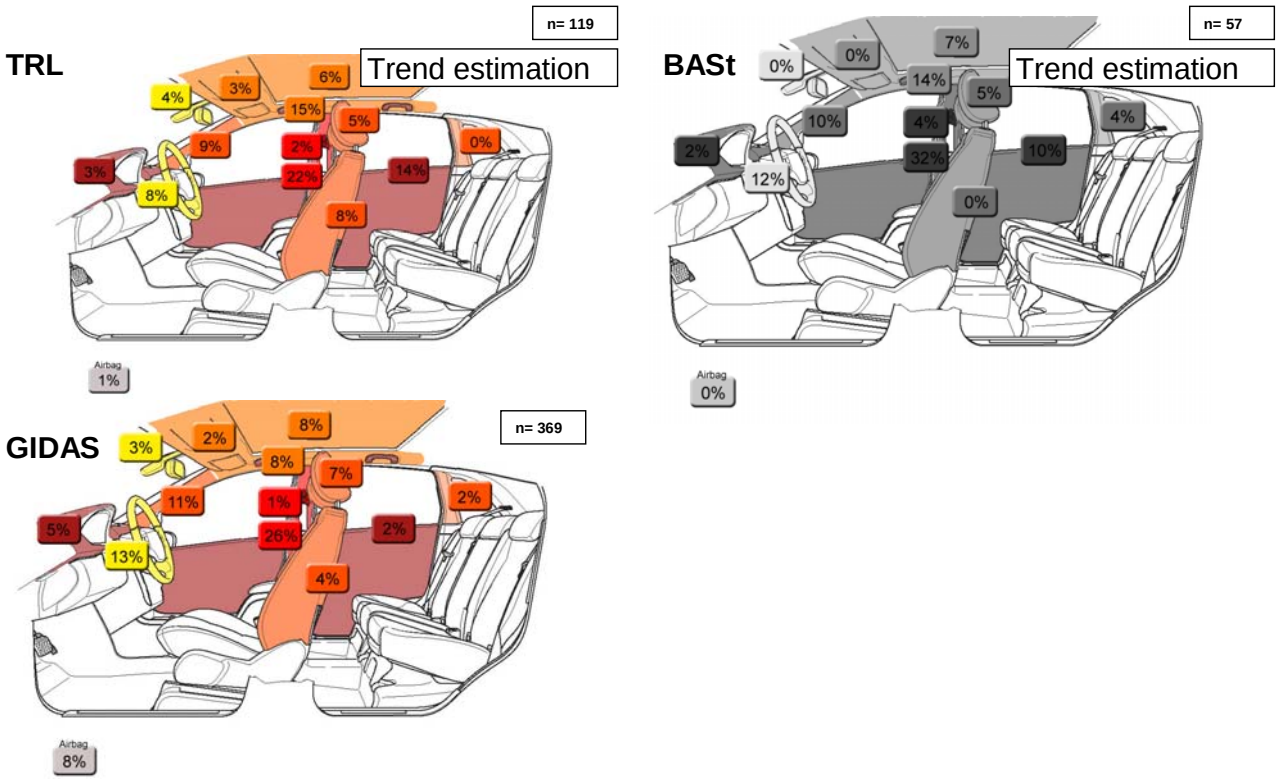


Figure 10 – Contact Sites Excluding Vehicle Glazing AIS 1+

An analysis without glazing cannot be made for AIS 3+ injuries because the numbers are too small in all datasets.

5.3. Relevancy of Padding

In another chapter the relevancy of padding of vehicle structures has been analyzed. For this reason all vehicle parts that can possibly be padded have been considered (Table 6).

Contact Site	TRL		BASt		GIDAS	
	AIS 3+	AIS 1+	AIS 3+	AIS 1+	AIS 3+	AIS 1+
A Pillar	2	11	2	6	4	42
B Pillar	6	26	11	18	8	94
C Pillar	0	0	1	2	0	8
Header	0	4	0	0	1	9
Side Roof Rail	10	18	2	8	4	28
Side Other	8	17	1	6	0	7
Roof	2	6	1	4	3	30
Upper Anch' Point	0	2	0	2	0	3
TOTAL	28	84	18	46	20	221

Table 6 – Contacts with Padding Addressable Vehicle Parts

It showed that 25% of all head injuries (AIS 1+) in side impacts could be addressed by padding (Figure 11). Especially the B pillar has to be mentioned. The portion of severe head injuries (AIS 3+) that could be addressed makes up 2.3% (Figure 12).

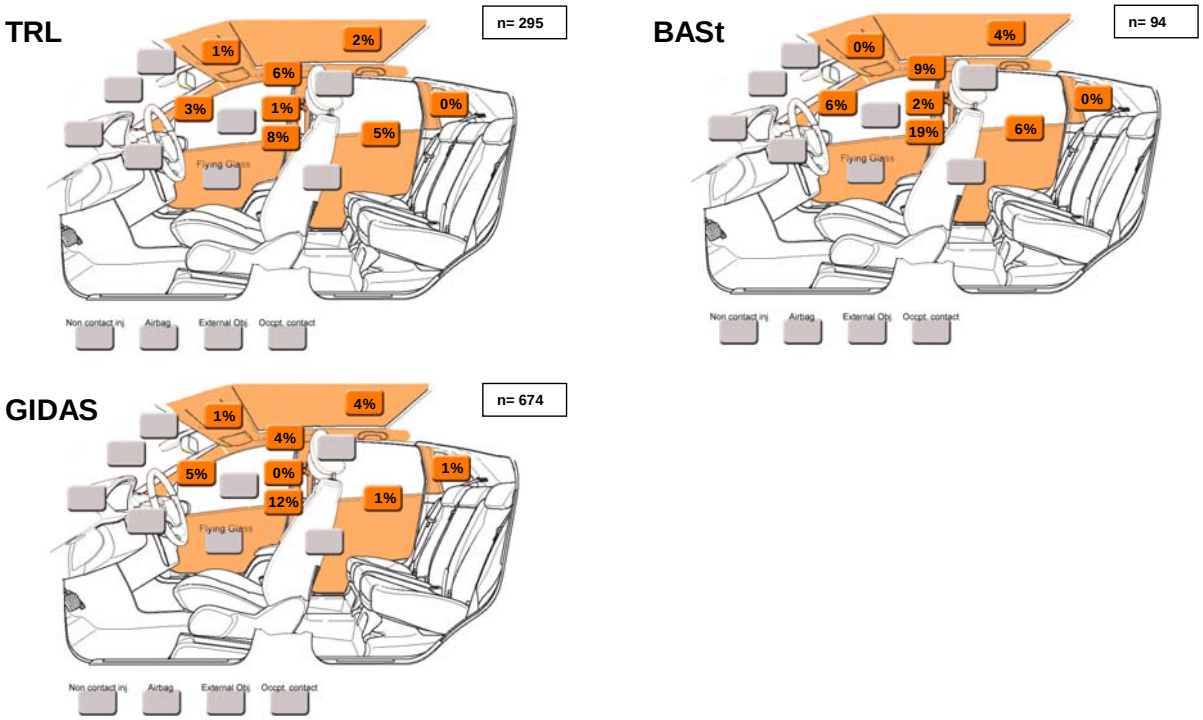


Figure 11 – Contacts with Padding Addressable Vehicle Parts

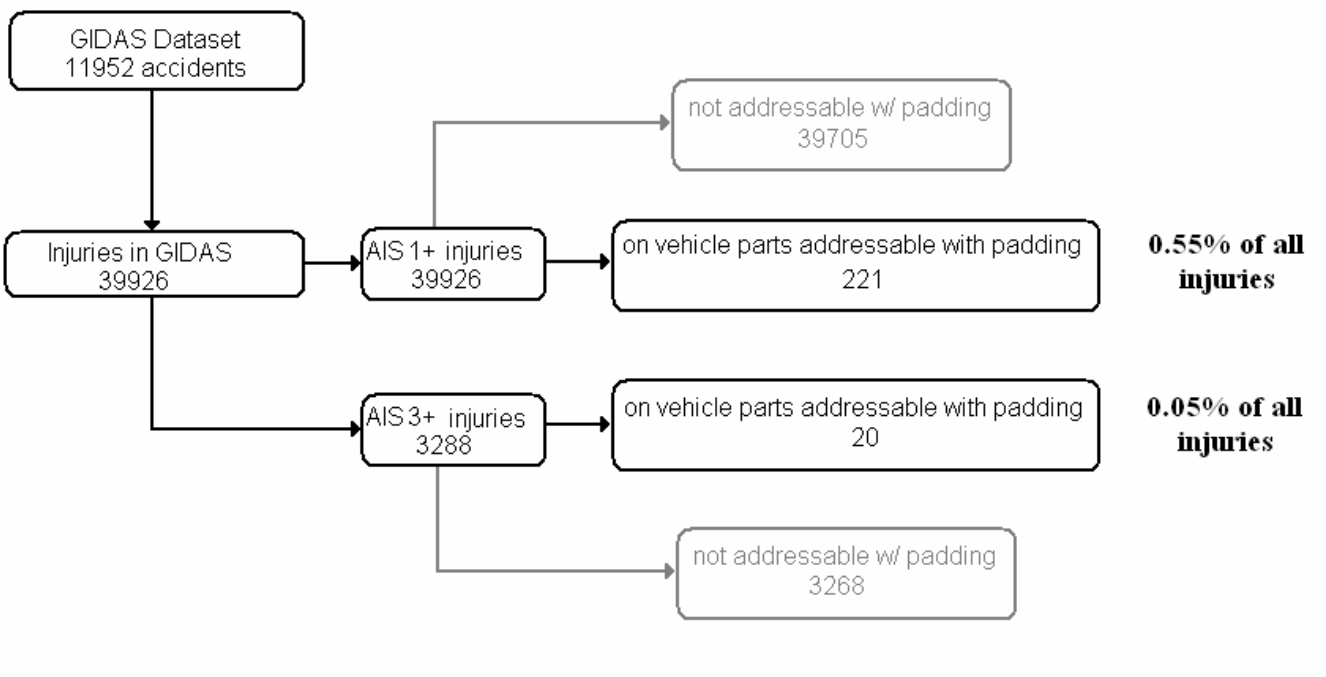


Figure 12– Overview Relevancy Padding For Side Collisions

5.4. Relevancy of Cabriolets

About 3.5% of all head injuries were suffered by cabriolet occupants. This portion is almost the same as the portion of cabriolets among the data itself (Figure 13). This shows that cabriolet occupants do not suffer head injuries more often. However, these injuries seem to be more severe. The portion of AIS 3+ injuries was 11.6 percentage points higher (Figure 14), while the EES was almost equal. For an analysis of relevant contact sites however, in cabriolets the sample size was too small.

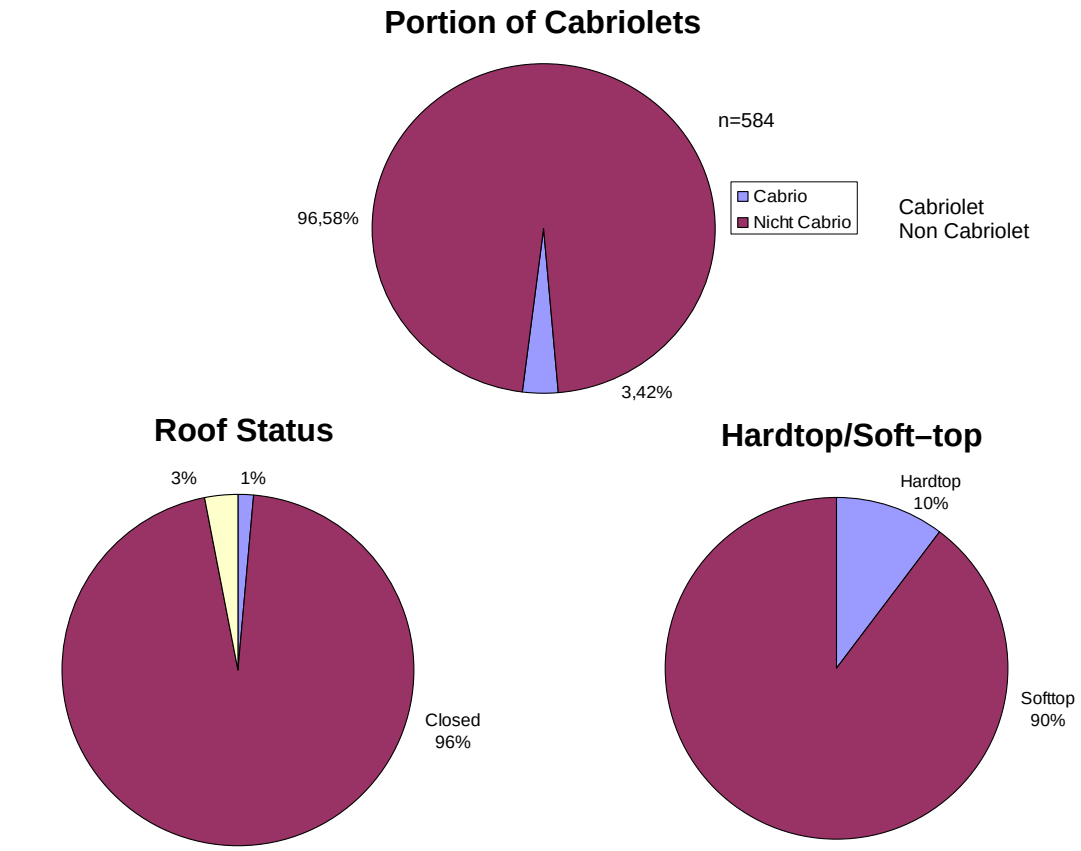


Figure 13 – Cabriolets in Dataset

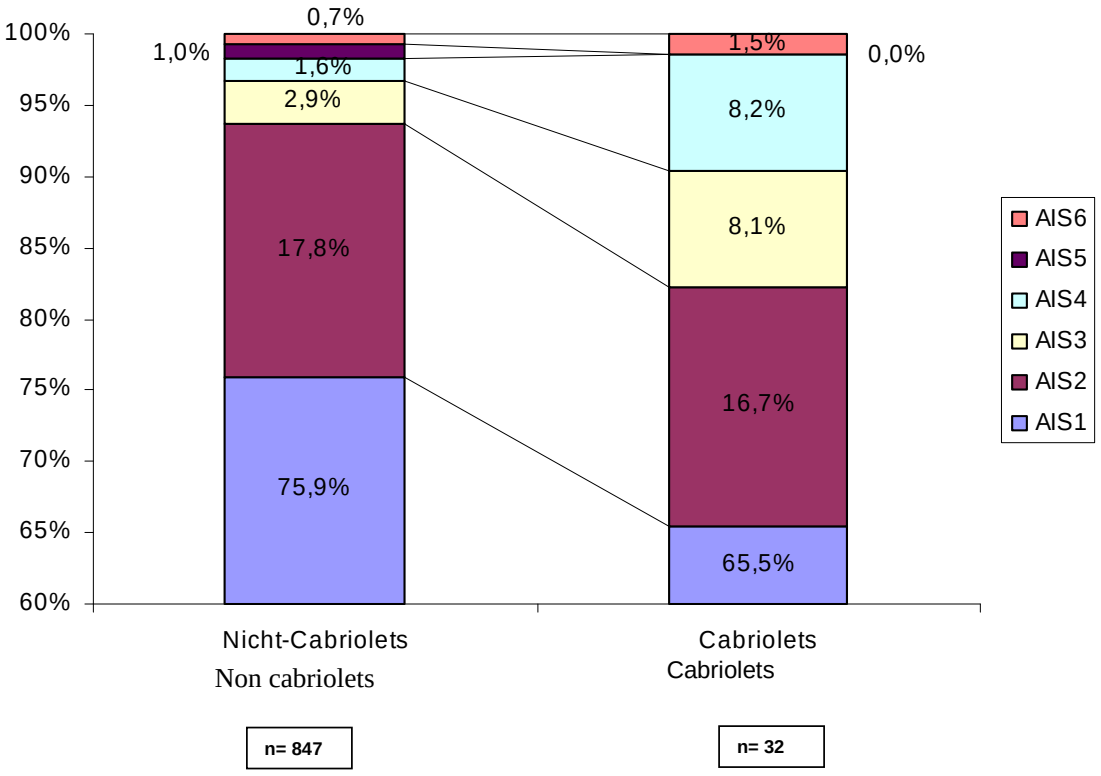


Figure 14 – AIS Comparison Cabriolets/Non Cabriolets

6. Summary

This study had the aim to analyse the GIDAS data regarding a possible reduction of head injuries in side collisions. In the following comparison to estimate the relevance of the proposals of the EEVC WG13 to reduce head injuries, the results of the WG13 report and the used datasets have been compared and evaluated in contrast to the GIDAS analyses.
As a main result it was found that the datasets used by the WG13 do not represent the real accident situation in Germany, due to the composition and actuality. The portion of severe head injuries AIS 3+ differ greatly. While there are 7% AIS 3+ head injuries in the representative dataset of GIDAS this portion is partly as high as 34% in the datasets used in the WG13 report. The distribution of these contact sites of severe and fatal head injuries can therefore not be compared with the real injury mechanisms in Germany.
Beside the use of not representative datasets the results are not direct pursuable due to the analysis methods. Databases and contact sites that cannot and must not be compared by definition have been compared. Furthermore not all injuries are mentioned in the datasets of which the injury related part could not be found. This so called “unknown” class has been included or excluded from the WG13 analyses depending on availability. Since this portion of “unknown” contact sites makes up as much as 62% however, it contributes highly to the large differences in the analyses.
Another criticisable point is the very specific distribution on up to 20 different contact sites with a far too small number of cases. This leads to statistically doubtable results regarding the distribution of the contact sites in side collisions.
A further breakdown to combinations of front or rear seat occupants, struck or non struck side and restraint use is also impossible. In such a way the portion of rear seat occupants for example is as small as 10% only.
Also the part of injuries on vehicle parts that can be addressed by padding is smaller than 1% in GIDAS, leading to the result that the relevance must be estimated as rather low, too.
The tests proposed by the WG13 are not suitable to bring the aspired benefit for the German traffic accident situation. A crucial reason is the fact that the used data differ greatly from the real world accidents in Germany regarding injury mechanisms and injury severity.

References:

[1] EEVC, Working Group 13, Report on the work of EEVC WG13, 1992–2005

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Abschnitt: Head Contacts in Side Impact (Introduction, Seite 1)

[4] Broschüre „Unfallerhebung vor Ort“ der VUFO /MHH

[5] Statistisches Bundesamt: Fachserie 8 Reihe 7 Verkehrsunfälle